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Note from the Editor-in Chief

Teaching and Research are the key elements of higher education. The importance of research as an integral part of higher education is emphasized in the undergraduate and postgraduate programmes offered at CINEC. Through research, students develop critical thinking and effective analytical skills that are necessary for their career advancement. In view of this, CINEC provides an opportunity for students undergoing their final year of studies to work on projects in collaboration with leading industries in the country.

The CINEC Academic Journal was founded to showcase outstanding research papers from staff and students of CINEC. The journal provides an opportunity for students at the undergraduate level to have their research published. We also encourage academics and researchers from other educational and research institutions to submit their research findings to the Journal for the benefit of the readers.

We are proud to complete the second volume of publication. As usual the Journal presents a diverse selection of stimulating articles from staff and students of CINEC.

Prof. N. Rajkumar

Analysis of the use of Seismic Dampers in Sri Lanka to Minimize Damages to Constructions in an Earthquake

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Abstract – **Earthquakes happen all around the world and they have now become a common threat to the mankind. Sri Lanka is also becoming more vulnerable to earthquakes due to recent geological changes. The aim of this study was to present modern methods of constructing earthquake resilient structures in the world and to study the most suitable solutions for Sri Lanka. Earthquake dampers reduce the vibrations and motions of a building during earthquakes. There are many types of earthquake dampers. Base-isolator is where the base is isolated from the building in the time of an earthquake reducing the motion of the building. Viscous dampers act as shock absorbers in the event of an earthquake, reducing the motion of the building. Friction dampers act like brakes due to its friction and reduce the motion of the building. Tuned mass dampers use the concept of inertia to keep the structure still by exerting an equal and opposite motion to the motion of the building. Core – wall method attempts to keep the centre of gravity in the centre of the building. There are many other innovative methods like the levitating foundation which creates a cushion of air between the building and the foundation at the time of an earthquake, seismic invisibility cloak which aims to make the building invisible to seismic waves, smart materials that have a larger elastic range, biomaterials that base their concepts on biological features of some creatures and cardboard tubes which presents a more affordable seismic damping solution. Considering the local conditions, the most suitable methods were studied and the following were concluded. For low and high rise buildings - friction dampers, for hospitals - base isolation, for bridges - viscous dampers, for stadiums and power distribution lines - tuned mass dampers and for towers - core wall method can be proposed.**

Keywords **– Earthquakes, Earthquake dampers, Resistance**

I. INTRODUCTION

An earthquake is the shaking of the earth's surface due to the release of energy by means of seismic waves from the earth's core resulting from the movement of tectonic plates inside the earth. Earthquakes cause devastations killing thousands of people each year. The loss of property exceeds billions of USD.

"Earthquakes don't kill people, buildings do" [1].

The above phrase explains the fact that majority of the fatalities from an earthquake is not due to the earthquake, but due to the inability of the structures to withstand the earthquake. Therefore, it highlights the importance of using ways to minimize the damages and to assure the structural integrity of the structures in the event of an earthquake. This is where **earthquake dampers** are of prime importance.

A. Definition of Earthquake Dampers

Earthquake dampers (seismic dampers / seismic vibration control devices) are instruments that minimize damages to constructions during earthquakes and typhoons (cyclones) which cause these structures to shake, sway and vibrate that can otherwise cause severe structural damages. Earthquake dampers are now widely used in high rise buildings as high rise buildings are prone to extremely high wind loads and the intensity of an earthquake is much severe on a high rise building than on a low rise building. It is also important to note that with the growing trend of "vertical living", it is essential that engineers have a sound solution to shield these constructions from earthquakes and other natural disasters as these constructions would be carrying thousands of lives at a single time.

Some examples for popular buildings considered as engineering marvels due to the technology of earthquake dampers used are Tokyo Skytree and Taipei 101. [2], [3]

Fig. 1 Tokyo Skytree [4]

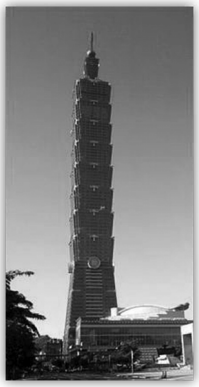

Fig. 2 Taipei 101 [5]

B. Usage of Earthquake Dampers

There are mainly 4 uses of earthquake dampers.

- To reduce the energy of seismic waves inside a structure in the instance of an earthquake, thus reducing the damages to the building.

- To divide and spread the wave energy between a wider variety of frequencies. The damage to the building becomes severe at an instance where the frequency of the seismic waves of the earthquake becomes equal to the natural frequency of the building. Therefore, by this method, it is made sure that the frequency of the seismic waves is dispersed

so that the intensities become very small in a particular range of frequencies, so a substantial damage is not done even if the natural frequency of the building is matched with the frequency of the seismic waves.

- To absorb the frequencies of seismic waves which have the same frequency as the natural frequency of the building with the use of mass dampers. [6]

- To reduce the motion of the building in the event of a typhoon (cyclone) which would exert enormous wind loads on the structure. It is important to note here the fact that outer design of the structure can heavily influence the performance of the structure in the instance of high wind loads. If the structure is designed in such a way that the air flow is not objected, the wind load on the structure would be dramatically reduced. Burj Khalifa, the tallest skyscraper in the world has been designed to withstand high wind loads. The rounded surfaces of the structure are letting the air to flow freely on its surface without objecting the flow.

Fig. 3 Burj Khalifa (The rounded design is clearly visible) [7]

C. *Effectiveness of Earthquake Dampers*

The motion inside a high rise building causes greater difficulties for the occupants in the building and repetitive motion would cause the structure of the building to weaken, and subsequently, collapse causing devastation.

The figure 4 below clearly shows how an earthquake damper reduces the motion inside a high rise building in the instance of an earthquake.

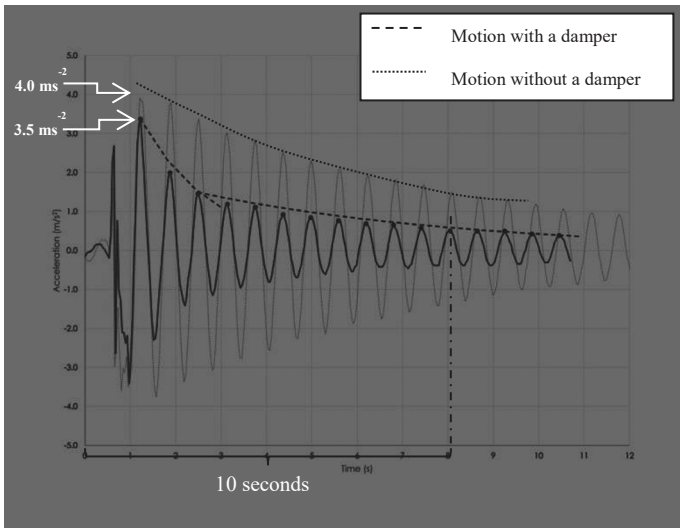

Fig. 4 Effectiveness of earthquake dampers [8]

a) The **light black** curve in figure 4 shows the acceleration of the building in the event of an earthquake without an earthquake damper. The building gets an initial acceleration of about 4ms^{-2} in 0.6 seconds [8]. This would be arduous for the occupants of the building as the human body is very sensitive to accelerations. The repetition of this high amplitude decaying motion for about 10 seconds would definitely make the building structure to weaken [8]. It is not the initial acceleration that matters, but it is the repetition of the motion that matters and would weaken the building structure due to its repetition [8].

b) The **dark black** curve in figure 4 shows the acceleration of the building in the event of an earthquake with an earthquake damper. There is a remarkable difference in the performance of the building. The maximum acceleration is 3.5 ms^{-2} which is a reduction of only about 12.5% [8]. However, the most significant change is how quickly the motion decays and the reduction of the amplitude of the motion. This is because the damper depletes the kinetic energy of the building. This reduction in the amplitude of the motion would make the building structurally resilient. [8]

D. *Earthquakes in the Sri Lankan context*

As Sri Lankans, our experience and knowledge about earthquakes are very low as we consider ourselves to be protected from earthquakes. But, recent studies carried out by James Cochoran of the Lamont-Doherty Earth Observatory have clearly shown that this is not the case. [9] Sri Lanka is also becoming more vulnerable to earthquakes as the 'Indo – Australian' tectonic plate is splitting and a new tectonic plate boundary is emerging just 500-700 km from the south – west coast of Sri Lanka. This has also been confirmed by the United States Geological Survey, (USGS) which is one of the most reputed geological institutions in the world. Hence, the possibility of a moderate sized earthquake cannot be ruled out from Sri Lanka as we did in the past.

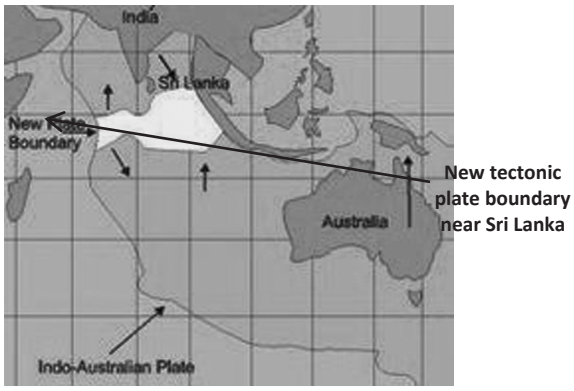

Fig. 5 New tectonic plate boundary that is emerging [9]

Therefore, these circumstances have made it extremely important to construct earthquake resilient structures in Sri Lanka. Hence, the objective of this study was to present the modern methods of constructing earthquake resilient structures in the world and to study the most suitable solutions for Sri Lanka.

II. Different Types of Earthquake Dampers

A. Normal Earthquake Damping Technologies

1) *Base Isolation:* This is where the foundation and the building are separated by means of some material that allows the substructure (foundation) to move separately without getting the superstructure (building) to move. The most popular material used to separate the building and the foundation is **lead – rubber bearings.** Here, the core is solid lead with layers of steel and rubber around it. Steel plates attach the building and the foundation to the bearings. Therefore, when an earthquake happens, the foundation moves without moving the upper building structure. There are other dampers that use this concept like **springs – with damper base isolator** and **simple roller bearing.** These are particularly used in high rise structures where there is a vast spread of the surface area (footprint) of the structure. [10]

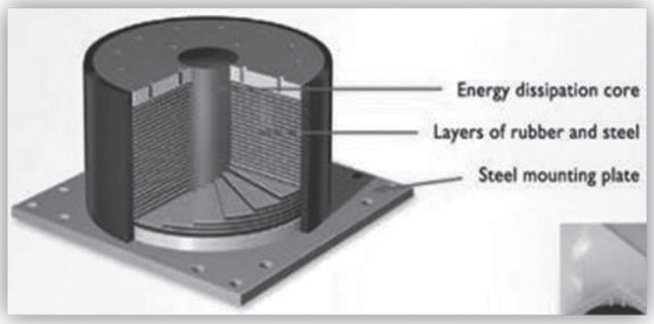

Fig. 6 Interior of a lead – rubber bearing [6]

Fig. 7 Lead – rubber bearing in use [10]

Fig. 8 Springs – with damper base isolator [10]

Fig. 9 Simple roller bearing [10]

2) *Shock Absorbers (Viscous Dampers):* Shock absorbers or viscous dampers are usually fitted in every floor of a building with one end attached to a column while the other end is attached to a beam. Inside the damper, there is a piston head inside a cylindrical arrangement with a silicon based fluid. This fluid has a soaring 'specific capacity of heat' so that it can absorb large amounts of heat. When an earthquake occurs, the piston starts to move and this causes the kinetic energy of the earthquake to be transferred into heat energy inside the piston due to the viscosity of the silicon based fluid. Due to the higher specific capacity of heat, the silicon based fluid can withstand the enormous energy induced by an earthquake. This helps in dissipating the large kinetic energy of the earthquake and slowing down the motion of the building. These are widely used in buildings, but its usage is constrained due to its bigger size and aesthetically unpleasing look.[2], [11]

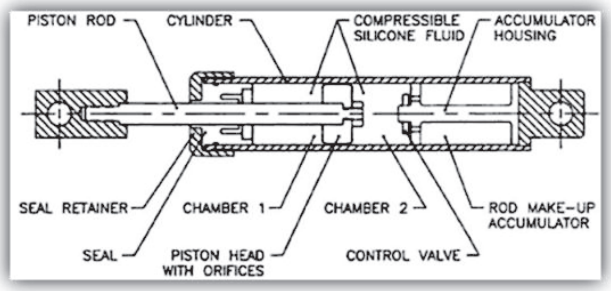

Fig. 10 Interior of a viscous damper [12]

Fig. 11 Viscous damper in use (Aesthetically unpleasing look is evident here) [2]

3) *Friction Dampers:* The joints of the friction damper are connected together in such a way that they can move on each other. High frictional forces are created between them as the surfaces of the friction damper are made with materials with a high coefficient of friction. Therefore, these friction dampers work like brakes and try to convert the kinetic energy produced by the earthquake to heat energy inside the joints. Friction dampers are not usually used for wind loads as the damper tends to wear out due to friction when doing repetitive movements and these have to be replaced every time an earthquake happens. Therefore, this is not suitable for high rise buildings in earthquake prone areas. [3], [13], [14]

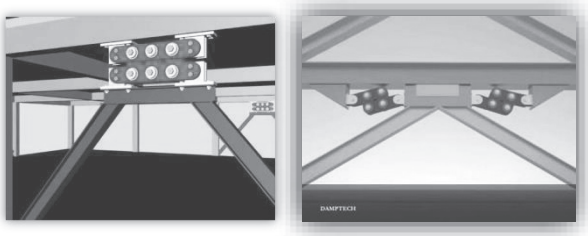

Fig. 12 Friction dampers [3]

4) *Tuned Mass Dampers (Harmonic Absorbers):* Tuned mass dampers or harmonic absorbers are used in buildings, bridges, stadiums and power distribution lines to prevent motions in these structures due to earthquakes, wind loads or other artificial vibrations. Tuned mass dampers are widely used in skyscrapers

to prevent discomfort to the tenants due to motion and vibration of the building in extremely high winds and earthquakes. A tuned mass damper is usually an extremely high mass that is hung by steel cables like a pendulum from the top and connected to the building using viscous dampers at its bottom. This setup is usually installed at the highest parts of the skyscraper because the motion is much higher in the upper levels of the building than in the lower levels. The mass damper uses the concept of *inertia.* Inertia is the tendency of an object to stay in its current state of motion or the aversion of an object to change its current state of motion. As inertia directly depends on the mass of an object, an extremely high mass is used for the damper. Here, when the building sways to the left, the mass damper tries to protect its state of motion (rest) by swaying to the right. This motion exerts forces on the viscous dampers in the opposite direction to the motion of the building and therefore, the kinetic energy of the motion is dissipated as heat energy by the viscous dampers. This results in a much calmer and safer building. Any structure vibrates violently at its natural frequency and this is known as resonating. The word *tuned* mass damper is specifically used as this mass damper is tuned to the natural frequency of the building. Therefore, the frequency and the amplitude of the motions of the mass damper are nearly equal to that of the building. These result in an equal and opposite push being exerted on the building by the mass damper minimizing the horizontal displacement of the building during times of earthquakes and typhoons (High winds). Taipei 101 skyscraper has a 660 tonnes tuned mass damper and it has been able to successfully withstand many earthquakes and typhoons since its inception in 2004. This is the only place that the tuned mass damper is open for the public to see. Tuned mass dampers are widely used in skyscrapers. The main problems with tuned mass dampers are the higher space needed for the damper and the higher maintenance cost. [5], [8], [12]

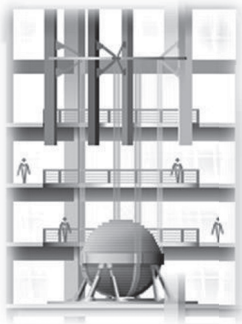

Fig. 13 Tuned mass damper inside Taipei 101 skyscraper (Outside view) [15]

Fig. 14 Tuned mass damper inside Taipei 101 skyscraper (Inside view) [16]

5) Core – Wall Method (Central Shaft Method): Core – wall method is constructing a thick and solid reinforced concrete column (pillar) through the centre (heart) of the building. This helps the centre of gravity of the building to be located near the centre of the building and this also acts as a backbone for the building. Human backbones keep humans straight and it also helps in balancing our body when some external unbalanced force is applied on us. The core – wall acts in the same manner and helps in reducing the motion and vibrations due to earthquakes and wind loads. Ancient Japanese earthquake resistant constructions have also been constructed using this concept. Tokyo Skytree, the tallest broadcasting tower in the world has been constructed using this technology. Here, there is an outer steel structure and this outer structure is directly attached to the main internal pillar up to the first 125m. After that, the outer structure is attached to the main internal pillar using viscous dampers. This is due to the fact that the effect of motion is relatively higher in the upper levels of the building. This setup helps to dissipate the kinetic energy that enters the building in the event of an earthquake or typhoon by converting the kinetic energy into heat energy inside the viscous dampers. This method is widely used in towers and even in normal high rise buildings as well. [17], [18]

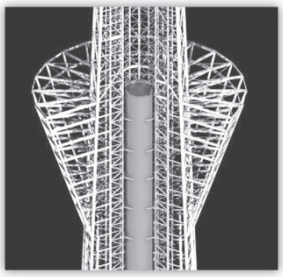

Fig. 15 Core – wall (Central pillar) of the Tokyo Skytree [17]

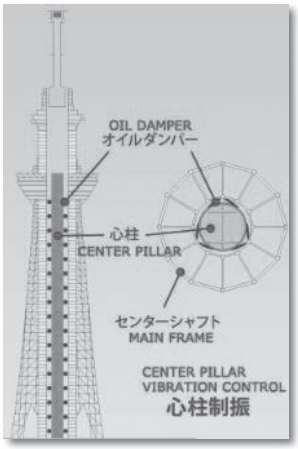

Fig. 16 The central pillar concept inside the Tokyo Skytree [18]

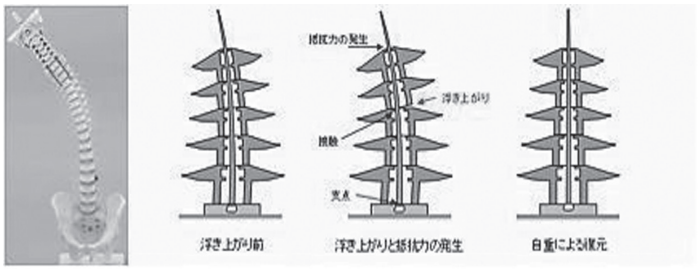

Fig. 17 How the concept of the backbone has been used in ancient Japanese earthquake resistant constructions [4]

B. Innovative Earthquake Damping Technologies

1) Base Isolation – The Levitating Foundation: Base isolation has been combined with innovative technology by some Japanese engineers and they are now developing a system which literally makes the building to levitate in the event of an earthquake. Sensors are fixed to the building to get notified when an earthquake happens. Immediately, with the use of air compressors, the building is lifted up and when the effect of the earthquake is materialised, the building would be floating on a cushion of air. When the earthquake subsides, the building comes back on to

its foundation. This would mean that the occupants of the building would not feel that an earthquake has happened. However, this design has a long way to go before it can be actually used due to the effects of the motion of the ground relative to the building and due to high maintenance costs as many sensors are used. [19]

2) *Seismic Invisibility Cloak:* Seismic waves have 2 main types as body waves and surface waves. Body waves travel faster inside the Earth than the surface waves which travel on the surface of the Earth. Surface waves cause almost all the destructions caused by an earthquake. There are 2 main types of surface waves. They are Love waves and Rayleigh waves. Love waves cause horizontal motions while Rayleigh waves cause vertical motions which are the most destructive. Engineers are now researching on making constructions invisible to these surface waves, Rayleigh waves in particular. When considering about the behaviour of waves, a stream of water would flow around a rock and continue its journey. Engineers are using that same preliminary concept for the seismic invisibility cloak. The concept is to bury 100 concentric plastic rings beneath the building's foundation. When the seismic waves enter the rings from one end, they are unable to transfer their kinetic energy to the foundation. Therefore, seismic waves would simply go around the rings and continue their journey just like how a stream of water would go around a rock and continue its journey. This concept has several drawbacks. The main drawback is the amount of sensitive calculations along with a number of estimates that are needed to exactly design the dimensions of the plastic rings and other apparatus used. The other main drawback is the fact that this can increase the harm to the structures surrounding the damped structure because the distribution of kinetic energy by the seismic waves is made unequal by the plastic rings. [19], [20], [21]

3) *Shape Memory Alloys (Smart Materials):* Normally, steel and concrete which are the 2 widely used materials in building construction reach their plastic ranges quickly and fail due to the permanent deformations that happen in the event of an earthquake. But, smart materials have a much larger elastic range. Therefore, they can withstand extreme motions (deformations) and return back to their original position without failing in the process. Nickel Titanium alloy is such a smart material. This can be used in the construction of bridges to minimize damages that happen to bridges during earthquakes. [19]

Fig. 18 Shape memory alloy tube [19]

4) *Biomaterials:* Engineers are now focusing on characteristics of some molluscs and spiders to develop much more efficient earthquake dampers. Molluscs who stick to different surfaces like rocks secrete sticky fibres known as byssal threads for this purpose. These sticky fibres contain some components which are stiff and rigid, but there are also components which are flexible and elastic. These flexible and elastic components in the byssal threads enable the mollusc to stay stuck to one surface as the kinetic energy applied by the sea waves is dissipated by the flexible components. Engineers are trying to use this concept to come up with innovative earthquake damping technologies. On the other hand, there are some spider webs which show very interesting characteristics. When strains are applied, they are initially stiff, then flexible and once again stiff. This behaviour shows an invaluable feature and engineers along with biological scientists are trying to understand the composition of the structure of these spider webs to come up with much improved earthquake dampers for the future. [19], [22]

Fig. 19 Byssal threads [22]

5) *Cardboard Tubes:* All the above mentioned methods are very expensive to set - up and maintain. Therefore, engineers have come up with much cheaper methods to minimize damages to buildings during earthquakes. One such method is the use of giant cardboard tubes reinforced with timber beams. As cardboard and timber have a much larger elastic range in comparison with concrete which is a brittle material, they would be able to withstand vibrations and motions much better than concrete. Another advantage is the light weight of the structure. Even if the structure was to collapse, number of fatalities would be much lower due to the light weight of the structure. The main outstanding advantage is the lower cost of the structure. But, this concept would only be useful in normal buildings without any stories and this design can be aesthetically unpleasing as well. [19]

Fig. 20 A structure designed using cardboard tubes [19]

III. Conclusions

Earthquakes happen all around the world and are becoming a common threat to the mankind. The above stated technologies and mechanisms can be used to make the lives of

people living in this planet much better as they are instrumental in preserving human life. It should also be noted here that the above discussed mechanisms are some of the major types and there are many more technologies and concepts that can be helpful in minimizing damages to constructions during earthquakes.

As stated in the introduction of this paper, Sri Lanka is also becoming more vulnerable to earthquakes due to the recent geological changes. Therefore, the suitability of the above discussed methods in Sri Lankan context was studied and the following information was obtained.

Base isolation – This method is suitable for high rise buildings with a vast area. In the Sri Lankan context, this is more suitable for major hospitals and high rise commercial buildings that have a wide geographic spread. This method can even be used to make existing buildings earthquake resistant. The issues of this method are the high initial cost of the damping devices and the lack of expertise about earthquake damping in Sri Lanka.

Viscous dampers – In Sri Lankan context, these can be used for high rise buildings, bridges and overhead railroads as these dampers are robust even in rough environments. The major issues of this method are the high initial and maintenance cost, lack of expertise about earthquake damping in Sri Lanka and the aesthetically unpleasing look of the large dampers which are fixed in every floor of the high rise building.

Friction dampers – Friction dampers are worn out every time an earthquake happens and they should be replaced. In the Sri Lankan context, these seem to be the most ideal solution as Sri Lanka does not experience frequent earthquakes and the cost of these dampers are much lower in comparison to the other earthquake damping technologies. However still, a proper cost – benefit analysis should be carried out considering the probability of an earthquake and future replacement costs along with the aesthetically unpleasing look of these dampers.

Tuned mass dampers – This type of dampers are mainly used in skyscrapers to make the structure resilient to earthquakes and typhoons. In Sri Lanka, as we do not have skyscrapers, this type of damping is not very appropriate. The cost of large tuned mass dampers is prohibitive as well. But, smaller tuned mass dampers can be fixed in sports stadiums to protect these structures in the event of an earthquake and in the event of heavy vibrations in the structure due to enthusiastic sports fans. These can also be fixed in high tension power distribution lines to protect them from earthquakes and extreme wind loads. The lack of expertise about these technologies is an issue.

Core – wall method – This method is mainly used in high rise towers. Sri Lanka only has the Lotus Tower as a high rise tower and this tower utilizes the lift core as their core wall. This design has only considered the effect of heavy wind loads due to its height and has not primarily considered the effect of earthquakes although effects of normal artificial vibrations has been considered. If Sri Lanka is to go forward with another tower project, considering the effect of earthquakes in the design stage and utilising the tried and tested core wall method to make the structure earthquake resilient would be crucial.

The innovative new technologies mentioned in this paper are still in the research stage and therefore are not suitable for Sri Lanka as yet.

Therefore, from the above findings, the following were concluded considering the local conditions.

The most cost effective and feasible yet safe solution is friction dampers for normal low rise and high rise buildings.

Base isolation is suitable for buildings with a vast area. This can be used for hospitals as the cost of the damper is justified by the importance of the structure.

For bridges, viscous dampers are the most suitable as they can withstand considerable vibrations and motions. Friction dampers are not recommended due to the wear and tear within the dampers due to the vibrations that happen due to the normal loads imposed on the bridge in its service period.

For sports stadiums and high tension power distribution lines, small scale tuned mass dampers are recommended which would be very useful in preserving these structures in earthquakes, artificial vibrations and heavy winds (typhoons).

For towers, the core – wall method can be used and it would be very useful to protect the structure from earthquakes and to dissipate the high wind loads applied on the structure.

The design of the structure also plays an important role when it comes to earthquake resistance. Therefore, the structural design is also crucial for earthquake resistance.

Sri Lankan construction industry should understand the importance of directing their focus towards this new development in the geological surrounding of Sri Lanka and should further focus on the precautionary measures for an earthquake without waiting to take action after a catastrophe has taken place which is like ‘closing the stable door after the horse has bolted.’

METHODOLOGY

Raising awareness about this threat of potential earthquakes would mean that more professionals would incorporate this threat in their designs, which could lead to greater savings in lives and property if an earthquake actually happens.

Pushing Sri Lankan construction industry towards the modern sophisticated technologies would make sure that threat of earthquakes are properly considered, identified and quantified and modern preventive measures are taken to preserve the constructions.

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Harvesting Energy Wasted from Footsteps Using Piezoelectric Technology to Utilize in Low-Power Applications: A Conceptual Approach and Design

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***Abstract* – The Earth, as proved by extensive scientific research, is at a critical juncture. With our rising Carbon Footprint and depletion of resources, the long-term future of the planet is in danger of an energy crisis and massive environmental changes. One of the primary culprits for this predicament is the burning of non- renewable sources of energy, which are drying up and results in massive carbon emissions. As a result, the world has been turning to renewable sources for a solution. Some of the most popular solutions are hydro, solar and wind power. The need for humankind to step up in order to prevent the damage to and save the environment is becoming more prominent, every second, because, it is the only solution available.**

Every day, billions of people place billions of footprints everywhere in the world, at their homes, transportation hubs, shopping malls: the list goes on. One of the facts that has been neglected is that these footsteps are a waste of potentially billions of mega joules of energy. This paper will describe a conceptual approach and a design on how to convert this wasted kinetic energy into electrical energy, providing a source of inexpensive electricity that can be utilized in low-power applications in our daily lives, as a solution to the rising carbon footprint of the Earth.

***Keywords* – Renewable Energy, Piezoelectric Technology, Energy Harvesting.**

I. Introduction

Energy is an important day to day source that every living being consumes. Since the beginning of time various methods of energy has been tried and tested from the simple friction between two dry twigs causing fire to nuclear power plants experimented in the era of the modern world. However, the availability of green energy sources have demeaned and new innovative methods have been brought up to solve the energy crisis.

Thousands of people walk in public railway stations, public malls, and commercial buildings every hour. The kinetic energy generated from each of these footsteps are just being wasted. According to research findings, on a daily basis, men take an "average of 7192 steps" and women take an "average of 5210 steps" [1]. With the population of the world ever increasing, these values will be multiplied every day. Hence it is clear that footsteps are a plentiful source of energy which is being neglected by the world.

During the past few years the field of energy harvesting has become more popular and it is growing day by day. Therefore, a number of researchers have carried out experiments to harvest wasted energy from footfalls. One research approach has been conducted to utilize wasted kinetic energy and transform it to usable electrical energy using piezoelectric technology embedded in various footwear [2-4]. A product in the form of a tile has been developed by a US based sustainable energy company called Pavegen [5] currently manufacturing tiles with the concept of kinetic energy conservation but using a different approach rather than piezoelectric technology.

Therefore, the proposed product, the Energy Harvesting Tile (EHT) which harvests kinetic energy from every footfall and produce electricity through piezoelectric technology is a much needed research area in this field. The idea was to store the harvested energy, and use it to power street lamps, advertising boards, electric doors of commercial buildings, lighting railway stations and other low power consuming applications. If one is placed in a crowded area, it will have the potential to generate several thousands of volts and contribute to a saving in the total electricity cost. This technology has the potential to revolutionize the way the world will source power in the future.

II. Methodology

Initially, a survey was carried out to understand how many people are aware of sustainable energy and its benefits in Sri Lanka. It was then identified that there is a high growing demand for sustainable energy based products and high curiosity for a product in the form of an Energy Harvesting Tile.

A. Consumer Survey

The consumer survey revealed that, many Sri Lankans are aware of the concept of sustainable energy being an alternative to the widely used and quite costly non-renewable forms of energy. Thus, the introduction of a new revolutionary concept shows much appreciation, interest and engagement. When surveyed on how fast the installation of a sustainable energy alternative would be agreed upon, 51% voted "as soon as possible". It was evident that more than

50% wanted to change into renewable energy as soon as it was available which implies to interested audience if a new product is released. One other important fact that was derived from the survey was the suitable application of EHT. Majority of the people believed that, EHT could be an ideal solution to be used in public places such as railway stations, conference halls, department stores and commercial buildings as depicted in Fig. 1 and Fig. 2, rather than domestic applications where thousands of people gather every day.

Fig. 1: Bandaranaike Memorial International Conference Hall

Fig. 2: Pettah Railway Station

B. Mathematical Model for the Piezoelectric Concept

When a mechanical stress or vibration is applied on a piezo crystal as shown in Fig. 3 below, it produces an electrical potential. This theory was used in the proposed project and the force created from a footstep generates a voltage. This voltage was used to charge a battery.

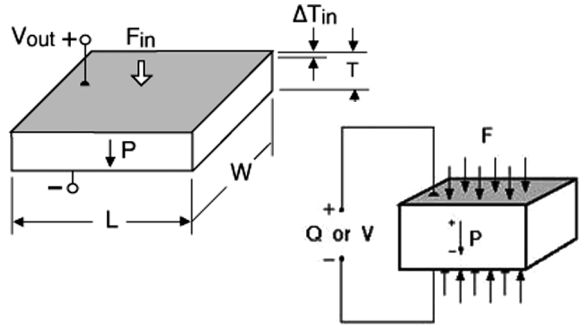

Fig 3: Piezoelectric effect

Generated voltage can be found using the following equation [6]:

$$V = -\frac{F \times T \times g_{33}}{A}$$

V = Generated Voltage
F = Force applied to the piezo element in the direction of its thickness
T = Thickness
g_{33} = Piezoelectric voltage constant
A = Surface Area

C. Experimental Phases during Development of the EHT

Two experimental phases were conducted to determine the most suited design for the EHT.

- Development of the design using piezoelectric film sensors
- Development of the design using piezoelectric transducers

The piezo electric film sensor used in the experiments is shown in the Fig. 4 and Fig. 5 below.

Fig. 4: Piezoelectric film sensor – LDT0 – 28K

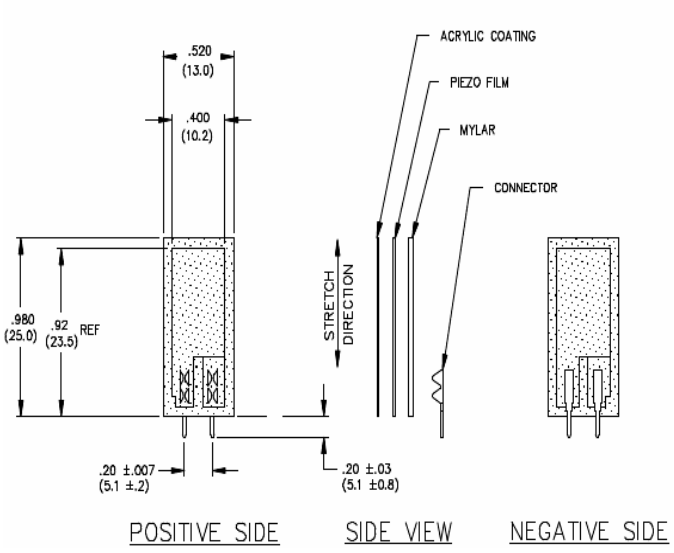

Fig. 5: Piezoelectric film sensor dimensions – LDT0 – 28K [7]

The theory behind piezoelectric films was slightly different from piezoelectric discs. In piezoelectric films, a voltage was generated on deflection of the sensor tip. According to Measurement Specialities [7], when the sensor was used with a charge amplifier, a 2mm deflection was sufficient to generate 7 V and voltages above 70 V could be obtained when the tip was deflected by 90^0. The voltages obtained for the relevant tip deflection are shown in the Table 1 below.

TABLE I
VOLTAGE OUTPUT RELEVANT TO TIP DEFLECTION OF THE PIEZOELECTRIC FILM SENSOR

Tip Deflection	Charge Output	Voltage Output
2 mm	3.4 nC	7 V
5 mm	7.2 nC	15V
10 mm	10-12 nC	20-25 V
Max (90E)	> 30 nC	> 70 V

The piezoelectric film sensor was tested using an oscilloscope to identify the peak voltage values. With the tip deflected by 2 – 4 mm, the piezoelectric film sensor was able to generate an alternating current (AC) voltage of 5 – 6 V without using a charge amplifier. But these values were not generated by a single deflection of the tip and were generated only when it was in constant deflection with an oscillatory movement (vibrating at a frequency). After conducting some research and experiments, it was concluded that creating an oscillatory motion inside the tile proved to be difficult since it will require a large volume of space and increase the complexity of the design.

Therefore, the second phase of testing was conducted using piezoelectric transducers as shown in Fig. 6 below.

Fig. 6: Piezoelectric Transducer/ Piezoelectric Disc

A transducer converts one type of energy form into another and piezoelectric transducer can perform the conversion of mechanical vibrational energy to electrical energy or vice versa. An active element is placed in the middle as depicted in Fig. 8 which is made of a polarized material. If an electric field is applied through the soldered wires the polarized materials will align with the electric field creating induced dipoles within the material structure causing dimensional changes. This is called electrostriction while the opposite phenomenon is called piezoelectric effect.

A prototype PCB was fabricated including a bridge rectifier comprising of silicon diodes for testing purposes and it was connected to a piezoelectric disc. A 100µF capacitor was used with the bridge rectifier at the output terminals and the voltage increment across the capacitor was checked. During initial testing, it was found that the voltage increment per tap on the piezoelectric disc was not sufficient enough to be used in the proposed project. This was mainly due to the high forward voltage barrier of the silicon diode of 0.7 V which caused the input voltage passed through the bridge rectifier to drop. The net voltage drop of 1.4 V caused due to the input voltage passing through 2 diodes was a significant loss.

Since four diodes were soldered in order to design the bridge rectifier, the increased resistance at the soldered points may also have been a reason for the voltage drop. Therefore, to avoid any added resistance from soldering, a S1WB s60 Bridge Rectifier was used in a new PCB instead of using separate diodes. There was a significant improvement in the voltage increment per tap on the piezoelectric disc but still the voltage increased by only 0.1 – 0.2 V per each tap. Once again, this low voltage reading may have occurred due to the forward voltage barrier of silicon diodes which were used in the S1WB s60 bridge rectifier.

During the next phase of testing, to amplify the charge stored, the single capacitor which was used during the initial tests was replaced by three 22µF capacitors in series connection. The voltage increment per tap increased from 0.1 V to 0.5 V. To further improve the system, it was decided to replace the S1WB s60 bridge rectifier by either a Germanium diode bridge rectifier which has only a 0.3 V forward voltage barrier or else by a Schottky bridge rectifier which not only has a low forward voltage barrier but is also more energy efficient than a standard bridge rectifier. The voltage efficiencies of using both types of diodes in a full wave bridge rectifier are compared in Table 2 below.

TABLE II
COMPARISON OF VOLTAGE EFFICIENCIES OF SILICON AND SCHOTTKY DIODES

Type of diode	Maximum forward voltage drop	Maximum voltage drop across 2 diodes	% Efficiency per tap
Silicon	0.7 V	1.4 V	$\frac{2.2\,V - 1.4\,V}{2.2\,V} \times 100 = 36\%$
Schottky	0.3 V	0.6 V	$\frac{2.2\,V - 0.6\,V}{2.2\,V} \times 100 = 73\%$

Therefore, for the final PCB design, MB12S Schottky bridge rectifiers were used and it was able to obtain over 1.5V increment in voltage per each tap on the piezoelectric disc. Then it was pass through a DC-DC converter to boost the voltage using a MOSFET. The final outcome was considered to be a successful result. These voltage values were tested for each 41mm piezoelectric disc and 9 piezoelectric discs per each tile were used for the prototype.

Also, the force given to the piezoelectric discs just by tapping will not be the case for the tile. Therefore, after several experiments it was concluded that the proposed EHT will generate over 9 V – 12 V per footstep and it was used to charge a Li-ion battery which is accommodated inside the tile housing so that we can use this energy to power different low power appliances as necessary.

D. Product Specifications

The CAD model of the EHT was designed using SOLIDWORKS as shown in following figures, Fig. 7 – 14.

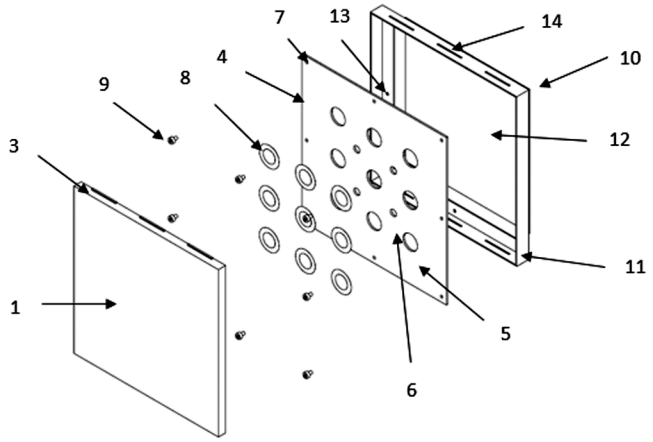

Fig. 7: Exploded view of the EHT design

Fig. 7 is an exploded view of the EHT design and the specifications for each of the components are described below.

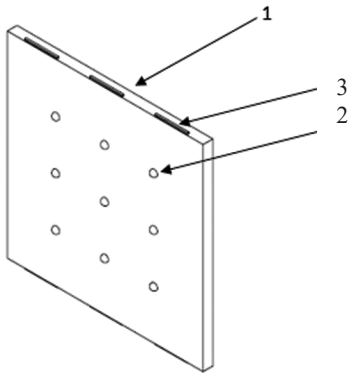

Fig. 8: Isometric view of the top rubber layer

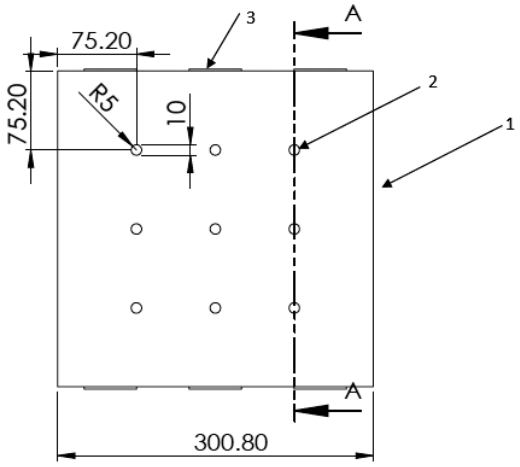

Fig. 9: Front view of the top rubber layer

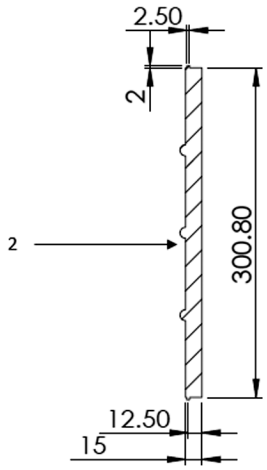

Fig. 10: Section A-A view of Fig. 9

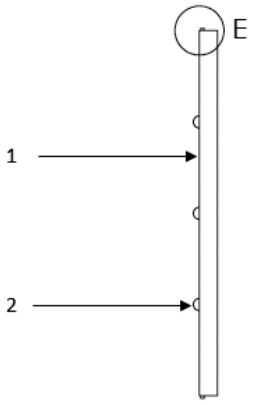

Fig. 11: Left side view of the top rubber layer

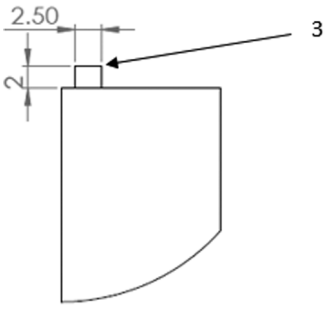

Fig. 12: Detailed view of Area E in Fig. 11

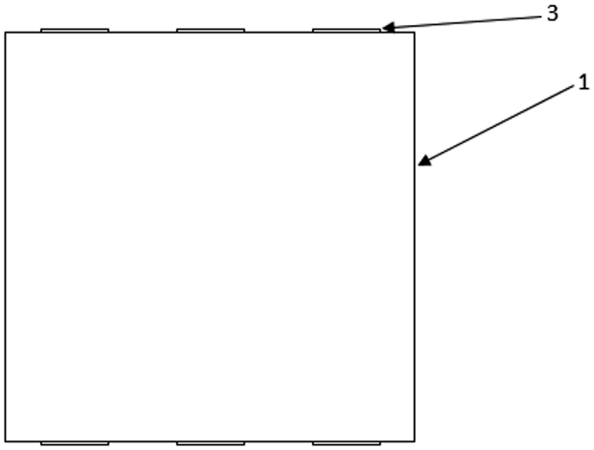

Fig. 13: Back view of the top rubber layer

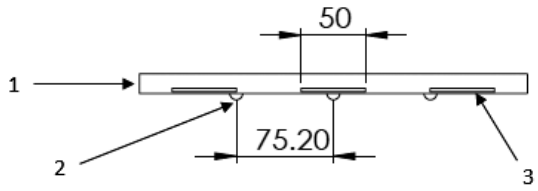

Fig. 14: Top view of the top rubber layer

Fig. 8 – Fig. 14 illustrate the product specifications of the top rubber layer (1) which is fully made of recycled hard rubber. This is a hard rubber layer (1) of 300.8 mm × 300.8 mm in surface area and with a thickness of 3 mm. It consists of 9 hemispherical outward projections (2) of radius 5 mm and 6 rectangular outward projections (3) as shown in Fig. 9, on two of the short sides of the rubber layer (1) with 50 mm × 2.5 mm × 2 mm in dimensions. These rectangular projections (3) will be fixed into the slits present in the outer metal housing making the top rubber layer removable. When a force is exerted on the top rubber layer (1), the hemispherical projections (2) will deflect its respective piezoelectric disc within the given tolerances to generate electricity.

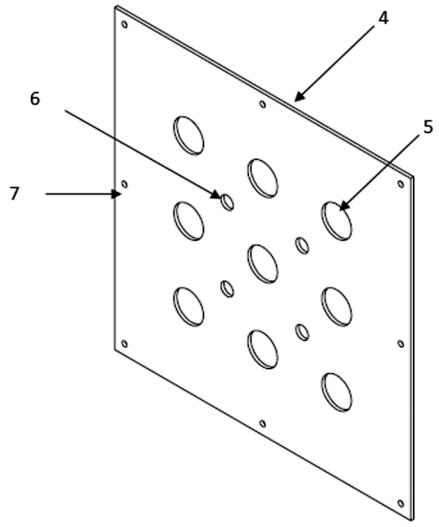

Fig. 15: Isometric view of the piezoelectric disc holder

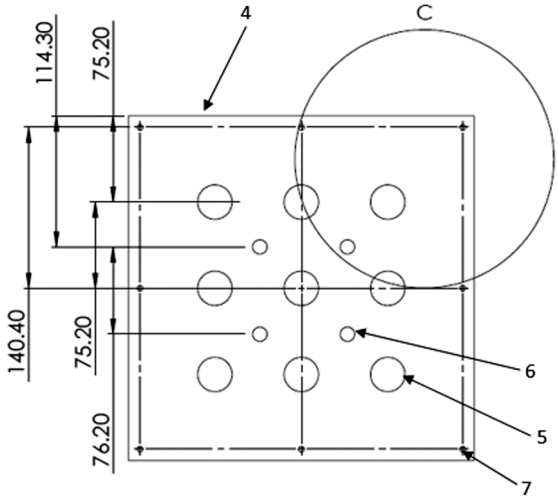

Fig. 16: Front view of the piezoelectric disc holder

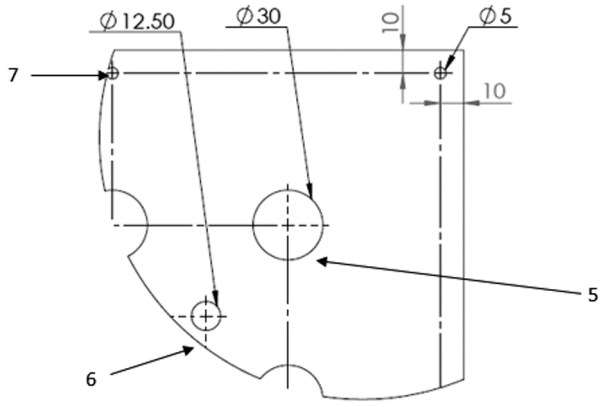

Fig. 17: Detailed view of the Area C in Fig. 16

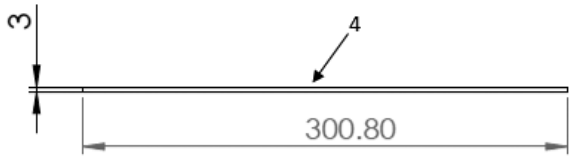

Fig. 18: Top view of the piezoelectric disc holder

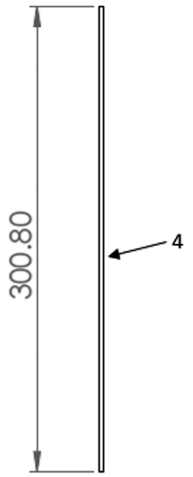

Fig. 19: Left view of the piezoelectric disc holder

Fig. 15 – 19 illustrate the specifications of the piezoelectric disc holder (4) of the EHT. This is a 3 mm thick metal layer with equal length and width as the top rubber layer (1) which is made of the alloy EOS Aluminium AlSi10Mg. This is manufactured using Direct Metal Laser Sintering (DMLS), which is a powder based rapid additive layer manufacturing process. The piezoelectric disc holder (4) consists of 9 holes (5) of diameter 30 mm. 9 piezoelectric discs (8) will be bonded onto top of these holes (5) such that they are centered to their relevant hole, using a metal bonding adhesive. Further it consists of another 4 holes (6) of diameter 12.5 mm which are used to draw wires that are soldered onto the top of piezoelectric discs (8). Another 8 holes (7) of diameter 5 mm are designed closer to the edges to fix the piezoelectric disc holder (4) onto the upper level (11) of the metal housing (10) using 8 bolts (9) of diameter 5 mm.

Fig. 20 – Fig. 25 illustrate the specifications of the metal housing (10). This is also manufactured by DMLS using the powder of metal alloy EOS Aluminium AlSi10Mg. The metal housing (10) consists of two levels, the upper level (11) contains the top rubber layer (1) and the piezoelectric disc

holder (4). It has a length and a width of 304.8 mm × 304.8 mm and a thickness of 25 mm. 8 holes of diameter 5 mm are available on the upper level (11) to fix the 8 bolts that come on top of the piezoelectric disc holder (4). The lower level provides room for containing the electronic circuitry and the rechargeable battery. As shown in Fig. 24 it also consists of two circular holes (15) of diameter 7.5 mm as the power output port of the EHT. It has a length and width of 258.5 mm and a thickness of 25 mm.

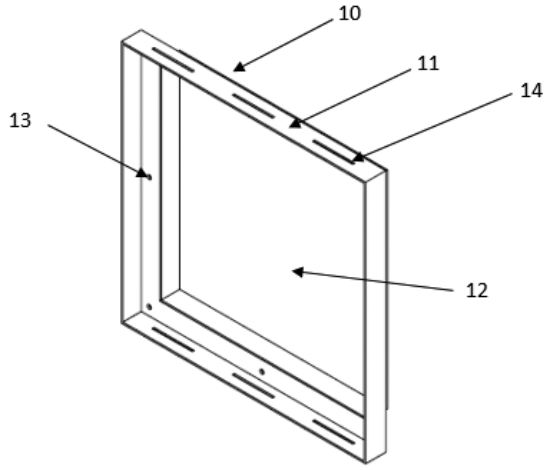

Fig. 20: Isometric view of the metal housing

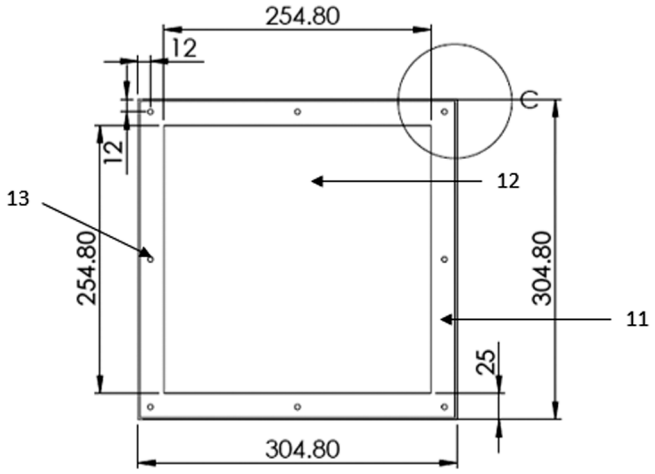

Fig. 21: Front view of the metal housing

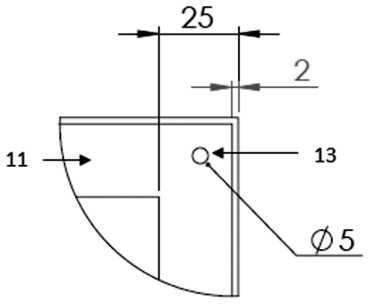

Fig. 22: Detailed view of the Area C in Fig. 21

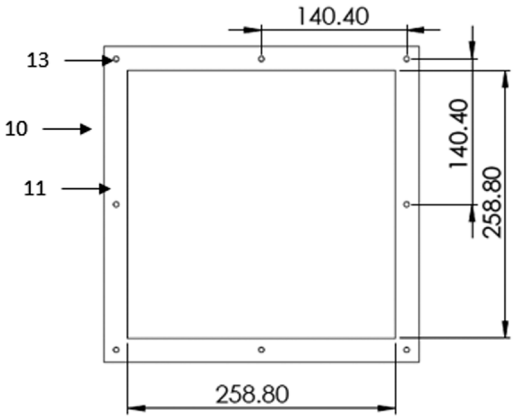

Fig. 23: Back view of the metal housing

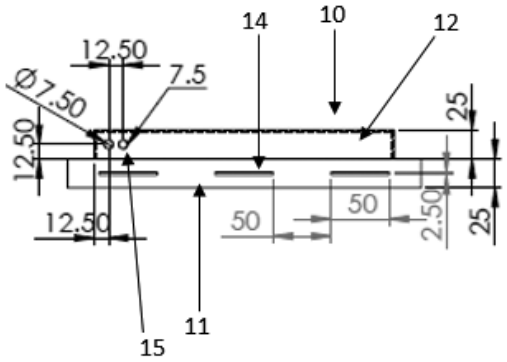

Fig. 24: Top view of the metal housing

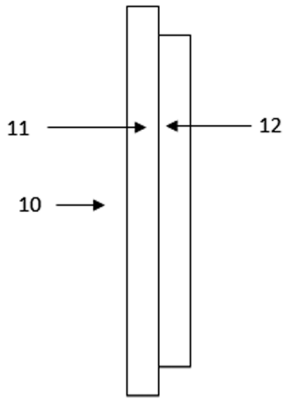

Fig. 25: Right side view of the metal housing

E. Functionality of EHT

The force of a footfall would cause the top rubber layer as shown in Fig. 26, to move downwards, making the hemispherical projections to force the piezoelectric discs to deflect. Since the thickness of the piezoelectric disc holder is 3mm, the maximum deflection caused by a piezoelectric disc will also be 3 mm. When the foot is raised, the piezoelectric discs return to their initial position. This vertical motion and the vibrations followed by the motion create pulses of AC voltage.

The EHT is capable of producing a DC voltage output of 9 – 12 V per every footstep (Average weight of a person was

considered to be 70kg) and the generated voltage is used to charge a 3.7 V 3600 mAh Li-ion battery.

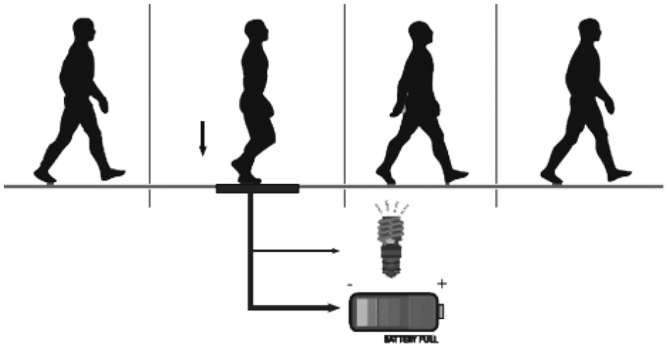

Fig. 26: Footfall on the top rubber layer

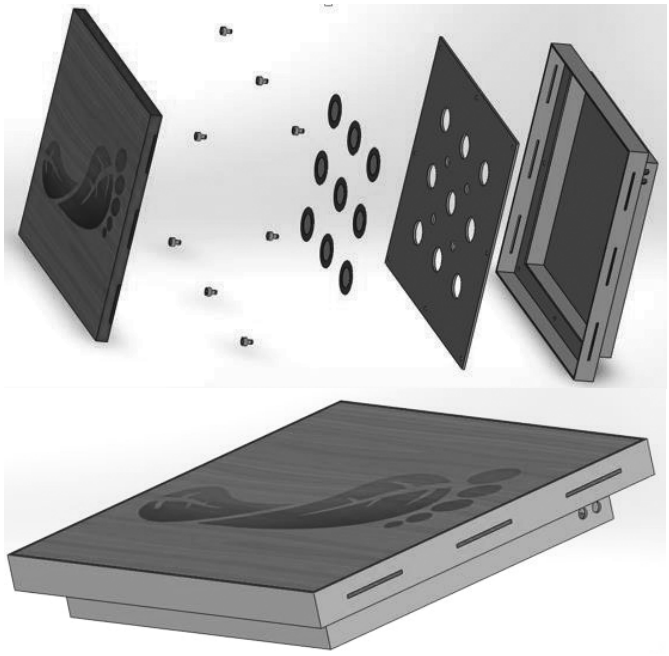

Fig. 27: Final design of the EHT

F. Proposed Manufacturing Technology, Material Selection and Material Properties

The EHT will be installed in crowded environments where thousands of people walk over every hour. Therefore the material used to manufacture the tile should withstand high impact loads and the product should be durable. Considering mass production with precise quality it was proposed to incorporate a very efficient rapid manufacturing process, Direct Metal Laser Sintering (DMLS). Required materials were selected considering properties such as good strength, hardness, low weight, good casting properties and also considering the material options available for DMLS. Therefore, EOS aluminium alloy AlSi10Mg [8] was selected for manufacturing the metal housing and the piezoelectric disc holder of the EHT.

If conventional casting processes were used, this type of aluminium alloy require heat treatments such as annealing, quenching or age hardening to improve the mechanical properties. But the rapid melting and re-solidification process of DMLS could produce a metallurgy and corresponding mechanical properties similar to heat treatment techniques. This also could reduce the number of manufacturing cycles and the above mentioned hardening heat treatments were not required when using DMLS.

The following technical and material data/properties were considered.

TABLE IIIII
GENERAL PROCESS AND GEOMETRICAL DATA

Typical achievable part accuracy	**100 µm**
Smallest wall thickness	approx. 0.3 – 0.4 mm approx. 0.012 – 0.016 inch
Surface roughness, as built, cleaned	Ra 6 - 10 µm, Rz 30 - 40 µm Ra 0.24 - 0.39 x 10-³ inch Rz 1.18 - 1.57 x 10-³ inch
Surface roughness, after micro shot-peening	Ra 7 - 10 µm, Rz 50 - 60 µm Ra 0.28 - 0.39 x 10-³ inch Rz 1.97 - 2.36 x 10-³ inch
Volume rate (measure of the building speed during laser exposure)	7.4 mm³/s (26.6 cm³/h) 1.6 in³/h

TABLE IVV
MECHANICAL PROPERTIES

Properties	**Direction**	**As built**	**Heat treated (anneal for 2 h at 300 °C)**
Tensile strength	horizontal direction (XY)	460 ± 20 MPa	345 ± 10 MPa
	vertical direction (Z)	460 ± 20 MPa	350 ± 10 MPa
Yield strength (Rp 0.2 %)	horizontal direction (XY)	270 ± 10 MPa	230 ± 15 MPa
	vertical direction (Z)	240 ± 10 MPa	230 ± 15 MPa
Modulus of elasticity	horizontal direction (XY)	75 ± 10 GPa	70 ± 10 GPa
	vertical direction (Z)	70 ± 10 GPa	60 ± 10 GPa
Elongation at break	horizontal direction (XY)	(9 ± 2) %	(12 ± 2)%
	vertical direction (Z)	(6 ± 2) %	(11 ± 2)%
Hardness	-	approx.119 ± 5 HBW	-
Fatigue strength	vertical direction (Z)	approx. 97 ± 7 MPa approx. 14.1 ± 1.0 ksi	-

III. CONCLUSION

A prototype design was developed to showcase the functionality of an Energy Harvesting Tile. The prototype was successful enough to light up a LED strip per each footstep. Real application of this technology will be, installation of these energy harvesting tiles on public railway stations, pavements, and commercial buildings where thousands of people walk over per hour. When this energy from thousands of footsteps is stored in a standalone battery

pack, it will be more than enough to light up a railway station at night where LEDs were used, it can also be utilized in other applications such as, lighting up LED sign boards and display screens, operating electric doors at commercial buildings and therefore, it is obvious that this concept can revolutionize the renewable energy generation in the future.

Further research will be conducted to improve the efficiency of the charging and discharging cycle of the EHT. It will be tested in future, on how to integrate more than one tile which will be the most important step and how to store the harvested energy from an array of EHTs in a standalone battery pack.

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Investigation into Natural Gas as an Alternative Fuel for Automotive Applications in Sri Lanka

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***Abstract*— Since recent past world researchers are in a quest to find the best possible alternative fuel to cater for the uprising global energy demand and to find a solution for the most threatening issue of 21st century, Global warming. In these circumstances, natural gas can play a vital role since it is considered as the cleanest fossil fuel which consists of high energy conversion efficiencies. This paper will investigate extensively, the usage of natural gas as an alternative fuel in both spark-ignition and compressed-ignition engines and will further discuss, why it is a promising alternative fuel for automotive applications in Sri Lanka.**

***Keywords*— Natural Gas, Engine Performance, Alternative Fuel, Sri Lanka.**

I. Introduction

Today we live in an era where the global energy demand is skyrocketing due to increased growth of population, advancement of industries and continuous increment in transportation needs. As a result, planet earth has been the ultimate victim due to adverse effects of burning fossil fuel to generate required power in various industries including transportation. Therefore, for developing countries like Sri Lanka, it is high time to find alternative fuel, invest in developing proper infrastructure and bring up relevant regulations which could reduce environmental hazards and achieve sustainable development.

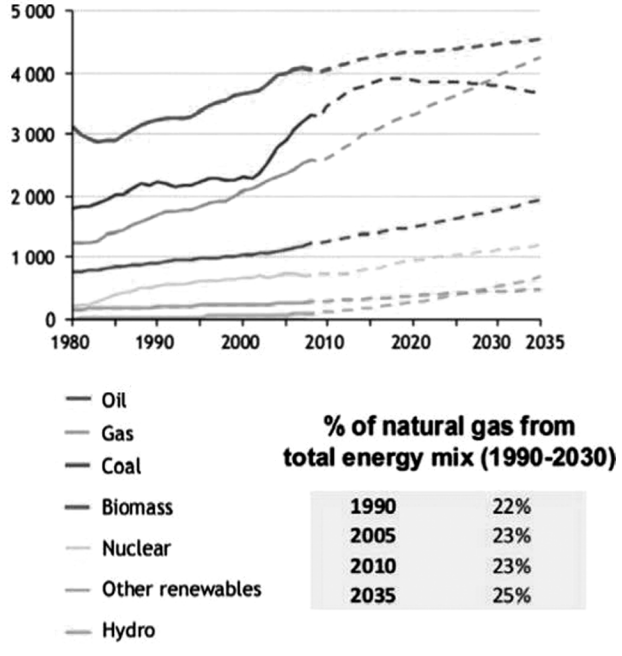

Fig. 1 World energy demand with respect to the type of fuel [1]

It is very much eminent from Fig. 1 since 1990, the demand for natural gas is growing at a much faster rate when compared to the other two main competitors, oil & coal. When considering the global energy demand by 2030, gas demand grows by 2% while the total energy demand grows only by 1.2% making it the fastest growing primary energy source in the future [1]. Therefore, it is obvious that natural gas is an ideal alternative.

II. Natural Gas as an Alternative Fuel

Natural gas is a fossil fuel which is obtained from gas wells or extracted together with crude oil production. Natural gas composition is mostly of Methane (88.9 % CH4) [2]. Other hydrocarbons such as ethane, propane and smaller quantities of nitrogen, oxygen, carbon dioxide, helium, sulphur compounds, water vapour may also be present when delivering through pipeline systems. Composition may vary according to the source of natural gas. Due to the high-octane number of natural gas, engine operates smoothly without any knocking. This is one of the safest and cleanest transport fuels available and it is lighter than air. Natural gas requires 5 – 15 % concentration in air for combustion to occur and its ignition temperature is about 600^0 C. Not only the tail pipe emissions but also the emissions during production are very low.

There are two methods to store natural gas as a fuel in automobiles.

- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)

Compressed Natural Gas is the most common method of storing natural gas in automobiles (NGV – Natural Gas Vehicle). It is normally stored in high pressure metal cylinders [3] at about 20 – 25 MPa (200 – 250 bar). Different types of metal cylinders are available with full or partiall wrappings made of glass, aramid or carbon to suit different vehicles. CNG is measured and sold in kilograms or cubic meters. They are also measured in Gasoline per gallon equivalent (GGE) or Diesel per gallon equivalent (DGE). One cubic meter of CNG approximately contains 38.3 MJ/m^3 [4] which is almost similar to the energy content of diesel per litre, i.e. 38.3 MJ/L. If the fuel tank capacity is as same as in a diesel, due to the lesser energy density NGVs will have to refuel much often.

Liquefied Natural Gas is natural gas stored at cryogenic temperatures. These are stored in metal cylinders with substantial insulation that will maintain relevant cryogenic

conditions. Typical cryogenic temperatures are -120^0 to -170^0 C (-184^0 to -274^0 F) but this can vary depending on the precise composition. The advantage of liquefaction over compression is that the fuel is at a higher energy density. Therefore, LNG offers an energy density of approximately 25 MJ/L [4] which is comparable with diesel and petrol fuels. Also, NGVs with LNG fuel will have an extended range than CNG fuel reducing refuelling intervals.

Refuelling of natural gas vehicles can be done at a dispenser similar to diesel or petrol fuel. This will also take the same amount of refuelling time as a gasoline or petrol vehicle. Only disadvantage of LNG is that it's higher cost on producing cylinders to store liquefied natural gas and maintaining cryogenic conditions. Another reason for limited popularity of LNG usage is that, companies or governments have to invest a higher capital on building stations for dispensing, transportation and other infrastructure.

There are different types of engines used in NGVs at present,

- Dedicated engines – Natural gas is the only fuel source used in this type of engines. They are optimized to maximize efficiency and minimize emissions.
- Bi-fuel engines – These operate on either natural gas or gasoline. Gasoline engines can also be converted to bi-fuel engines.
- Dual-fuel engines – These operate by a mixture of natural gas and diesel. The mixture varies according to the load and duty cycle of the engine.
- Tri-fuel engines – They can operate on gasoline, ethanol or natural gas, or else all blended together.
- High pressurized direct injection engines – Both diesel and natural gas directly injected into the combustion chamber at high pressure.

Dedicated and Bi-fuel systems are generally utilized in light-duty, passenger vehicles, while dual-fuel type and others are used in heavy-duty or commercial vehicles. One major advantage of using dedicated NGVs is that, it produces very little evaporative emissions during usage, even though 50% of total hydrocarbon emissions in a gasoline vehicle is through evaporating and fuelling emissions [1].

Some other advantages of using natural gas as an alternative fuel can be listed as follows,

- Low exhaust emission of carbon monoxide, carbon dioxide, nitrogen oxides and non-methane organic gas.
- Significant reduction in exhaust emissions can be achieved when much older vehicles were converted to natural gas vehicles.
- CNG engines can achieve high compression ratios since CNG has a high-octane number when compared to gasoline.
- CNG has a high dispersion rate and therefore it allows a better air/fuel mixture
- NGVs can be easily operated and driven at both hot and cold weather
- According to a report outlining a strategy for the development of a natural gas industry in Sri Lanka by the Sri Lanka Carbon Fund (Pvt) Ltd, NG could be sold to vehicles at a very competitive price, the cost per Mega Joule of NG will be only LKR 1.85. Even after taxes, profit margins, transport and infrastructure costs are added in, it is still cheaper than gasoline [5].
- CNG is a safe fuel and therefore it can even be used as a bi-fuel as shown in Fig. 2.

Fig. 2 Mercedes Benz E200 NGT Blue EFFICIENCY, which features bi-fuel natural gas drive [6]

III. NATURAL GAS ENGINE PERFORMANCES

To prove that natural gas is an ideal alternative fuel, information gathered from an intensive analysis of natural gas engine performance, are stated below.

According to Bakar, et al. [7] experimental and computational models of an original diesel engine (ODE), compression ratio modified diesel engine (14.5CR DE) and a multi-point injection natural gas engine (NGE) were simulated and tested to evaluate performance. Table 1 shows the specifications of the engines used during the test.

TABLE I
SPECIFICATIONS OF THE ENGINES

Engine parameter	**Original diesel engine**	**Modified diesel engine**	**Natural gas engine**
Bore (mm)	86.0	86.0	86.0
Stroke (mm)	70.0	70.0	70.0
Displacement (cc)	407.0	407.0	407.0
Compression ratio	20.28: 1	14.5: 1	14.5: 1
Ignition system	Compression ignition	Compression ignition	Spark ignition
Engine management	Mechanical control	Mechanical control	Electronic control
Fuel system	Direct injection	Direct injection	Multi point injection
Fuel	Diesel	Diesel	Natural gas

A. Cylinder Pressure

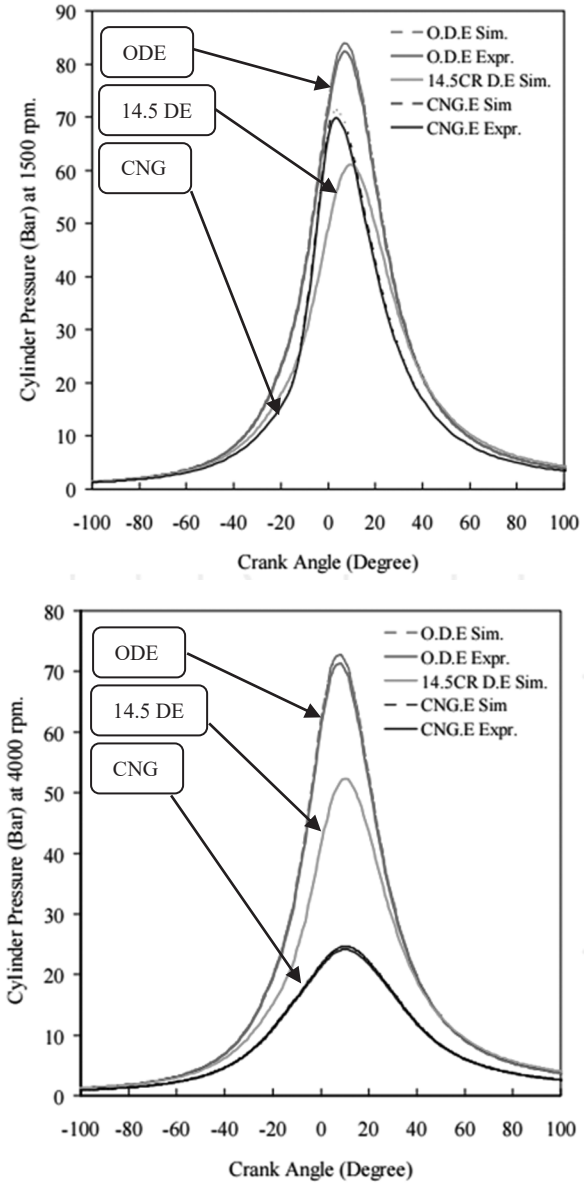

Fig. 3 Cylinder pressure of diesel engine convert to natural gas engine [7]

The maximum cylinder pressures at 1500 RPM,

- Original diesel engine – 84.0 bar
- Modified diesel engine – 61.1 bar
- Natural gas engine – 76.23 bar

Combustion process of both diesel engines and natural gas engine were highly efficient at 1500 rpm. Higher pressure, power and torque were developed than at other operation conditions. Maximum cylinder pressure was 8.97% higher in the natural gas engine compared to modified diesel engine. Maximum cylinder pressure was reduced with increasing engine speed in both diesel engines and natural gas engine.

The maximum cylinder pressures at 4000 RPM,

- Original diesel engine – 72.82 bar
- Modified diesel engine – 52.29 bar
- Natural gas engine – 25.0 bar

Combustion process was the least efficient at this operating condition. Maximum cylinder pressure has reduced due to the limited time for combustion, higher unburnt fuel content and inefficient air induction. In the natural gas engine, the maximum cylinder pressure was significantly reduced by 58.56% than the modified diesel engine at 4000 rpm. The density of natural gas is lower than the density of diesel fuel. Therefore the cylinder pressure in the same volume, with diesel fuel is higher than with natural gas.

Therefore, it was concluded that the conversion of diesel engine to a natural gas engine could increase the cylinder pressure at low engine speeds but it decreases the cylinder pressure at high engine speeds. This means that, the performance of the NG engine is better than the modified diesel engine at low speed. But, in high speeds, the performance of the NG engine is reduced.

B. Cylinder Temperature

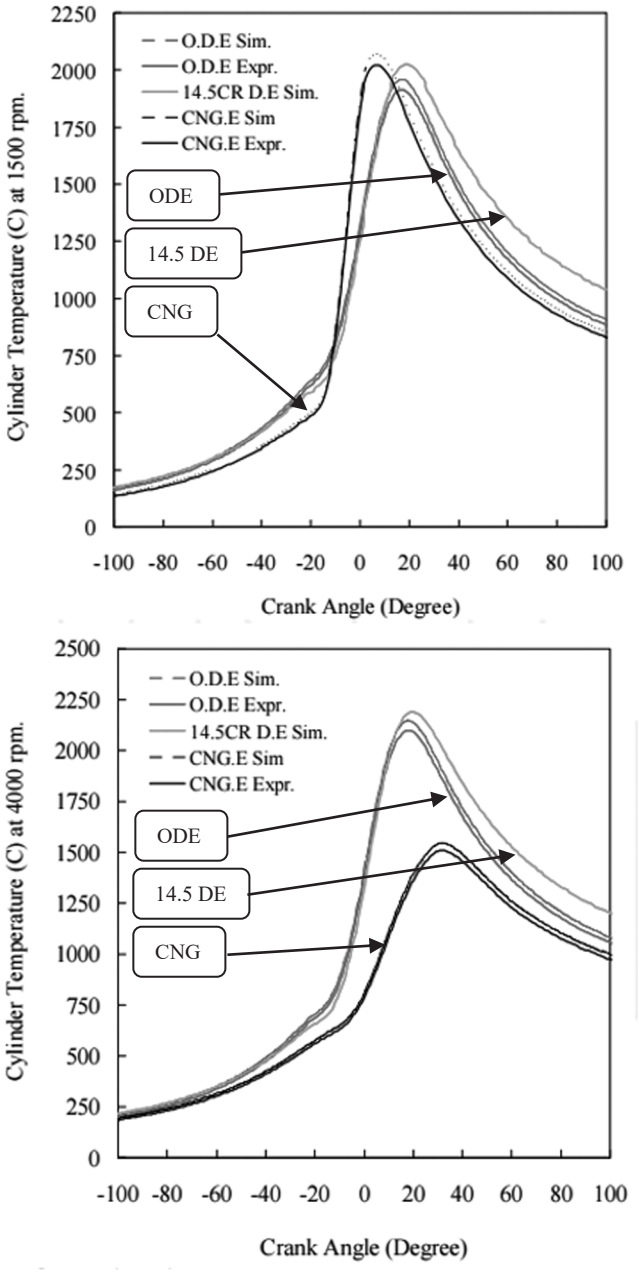

Fig. 4 Cylinder temperature of diesel engine convert to natural gas engine [7]

Combustion process of natural gas was highly efficient at 1500 rpm and it was reduced after that with increasing engine speed due to the lower gas density, lower air volume and high unburnt fuel content. Therefore, the maximum temperature of natural gas engine was at 1500 rpm and the lowest maximum temperature of natural gas engine was at 4000 rpm. The maximum temperature of both diesel engines was increased with increasing engine speed. The lowest maximum temperature of both diesel engines was at 1500 rpm. It was found that the highest engine temperature was not at the highest engine speed, but it was at 3500 rpm.

Therefore, it was concluded that cylinder temperature of the natural gas engine was higher than both diesel engines at low speeds and the cylinder temperature of both diesel engines were higher than the natural gas engine at high engine speeds.

C. Torque Performance

Following figure depicts the Indicated power performance of original diesel engine, modified diesel engine and port injection NG engine.

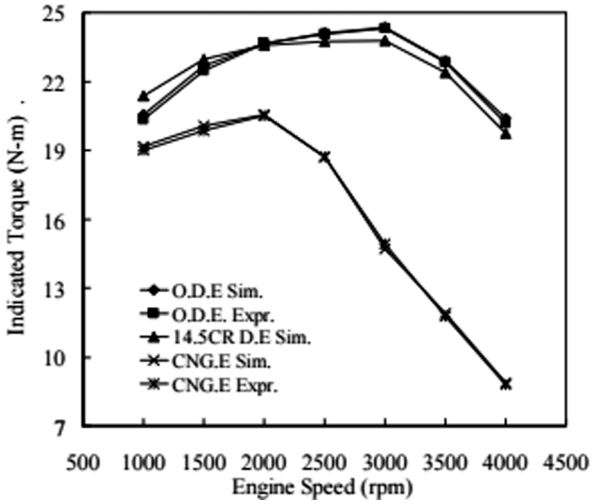

Fig. 5 Indicated torque of NG engine compared to diesel engine [7]

The maximum indicated torque,

- Original diesel engine – 24.3453 Nm at 3000 rpm
- Modified diesel engine – 23.76 Nm at 3000 rpm
- Natural gas engine – 20.4798 Nm at 2000 rpm

The indicated torque performance of both diesel engines was increased from 1500 – 3000 rpm and it was reduced after that with increasing engine speed. In natural gas engine, the indicated torque performance was increased up to 2000 rpm and it was reduced significantly after that with increasing speed. The indicated torque of diesel engine converted to natural gas engine was reduced by 15.88 %.

Therefore, it was concluded that the conversion of diesel engine to natural gas engine could reduce overall indicated torque performance.

The maximum friction torque,

- Original diesel engine – (-5.18 Nm) at 4000 rpm
- Modified diesel engine – (-4.85 Nm) at 4000 rpm
- Natural gas engine – (-4.44 Nm) at 4000 rpm

In both diesel engines and natural gas engine, the friction torque was increased with increasing engine speed. Compared to diesel fuel, lubrication properties of natural gas is less. Therefore when the friction torque is considered as a fraction of their indicated torque, it was concluded that the conversion of diesel engine to natural gas engine could increase the overall friction torque.

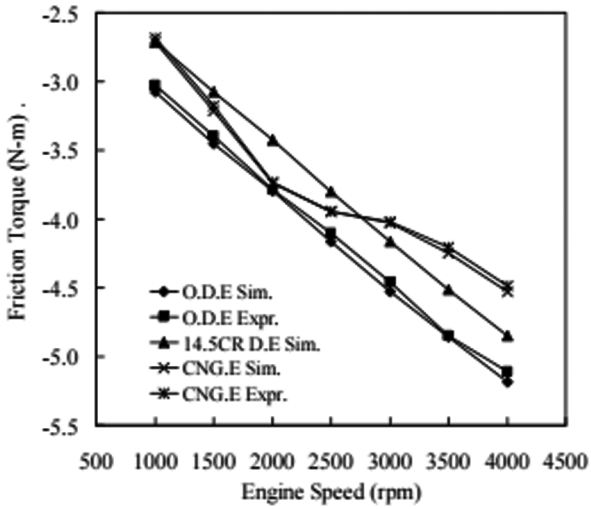

Fig. 6 Frictional torque of NG engine compared to diesel engine [7]

The maximum brake torque,

- Original diesel engine – 19.89 Nm at 2500 rpm
- Modified diesel engine – 20.12 Nm at 2000 rpm
- Natural gas engine – 17.14 Nm at 1500 rpm

The maximum brake torque of diesel engine converted to natural gas engine was reduced by 16.18%. This deviation was increased with the increasing engine speed. Therefore it was concluded that the conversion of diesel engine to natural gas engine could reduce the overall brake torque.

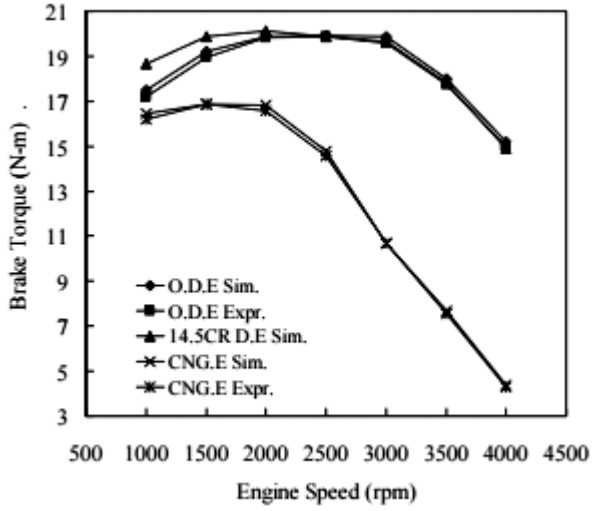

Fig. 7 Brake torque of NG engine compared to diesel engine [7]

D. Power Performance

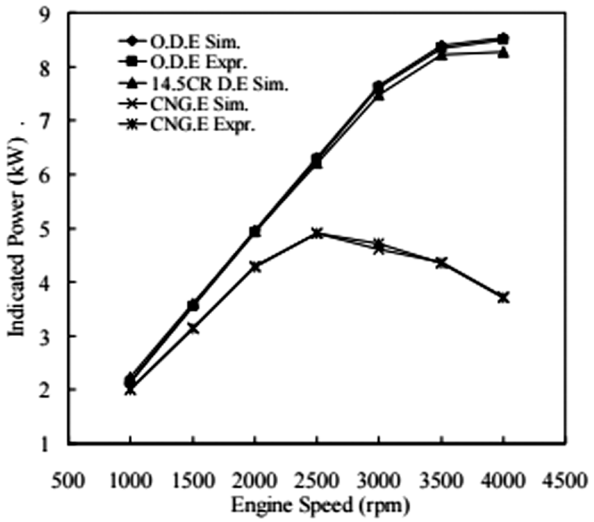

Fig. 8 Indicated power of NG engine compared to diesel engine [7]

The maximum indicated power,

- Original diesel engine – 8.54 kW at 4000 rpm
- Modified diesel engine – 8.27 kW at 4000 rpm
- Natural gas engine – 4.9 kW at 2500 rpm

The maximum indicated power of diesel engine converted to natural gas engine was reduced by 40.7%. The percentage deviation of indicated power of natural gas engine compared to diesel engine was increased with increasing engine speed. Therefore, it was concluded that the natural gas engines are not suitable to run at high engine speeds, but its power performance is very good at medium engine speeds.

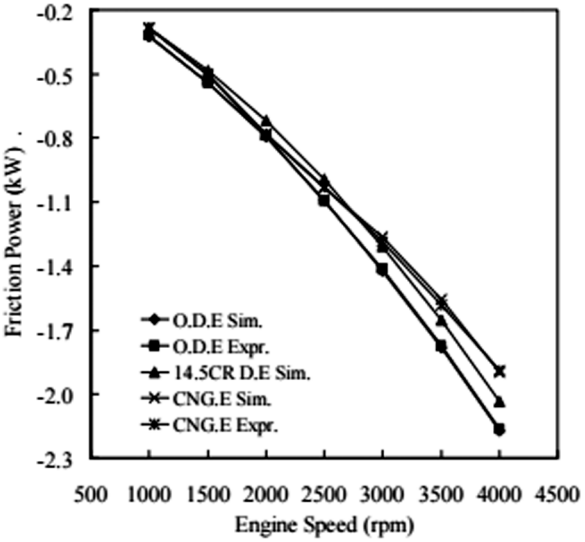

Fig. 9 Frictional power of NG engine compared to diesel engine [7]

The maximum friction power,

- Original diesel engine – (-2.17 kW) at 4000 rpm
- Modified diesel engine – (-2.03 kW) at 4000 rpm
- Natural gas engine – (-1.9 kW) at 4000 rpm

In both diesel engine and natural gas engine the friction power was increased with the increasing engine speed. When the friction power was considered as a fraction of their indicated power, it was concluded that the conversion of diesel engine to natural gas engine could decrease the friction power up to 1500 rpm and increase at higher engine speeds. This is mainly due to specific properties of the two fuels. Natural gas as a fuel, exhibits less lubrication properties when compared to diesel. Diesel as a liquid fuel, performs well as a lubrication to reduce friction at high speeds.

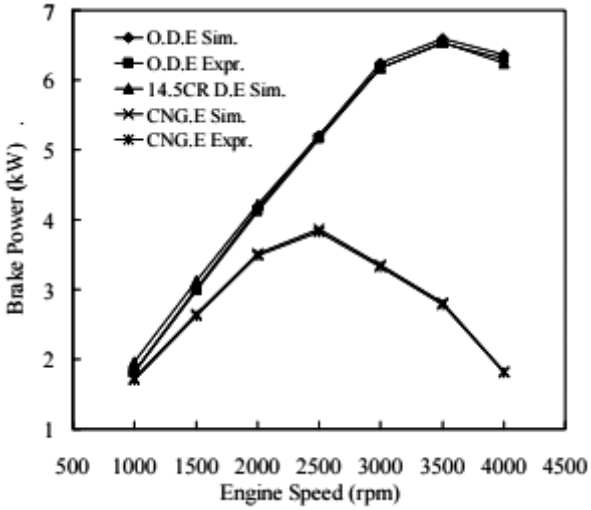

Fig. 10 Brake power of NG engine compared to diesel engine [7]

The maximum brake power,

- Original diesel engine – 6.6 kW at 3500 rpm
- Modified diesel engine – 6.54 kW at 3500 rpm
- Natural gas engine – 3.87 kW at 2500 rpm

The maximum brake power of diesel engine converted to natural gas engine was reduced by 41.374%. This deviation percentage was increased with increasing engine speed and it is mainly due to the reduction of brake torque with increasing speed (Fig. 7). Therefore, it was concluded that conversion of diesel engine to natural gas engine could reduce the overall brake power.

E. Mean Effective Pressure

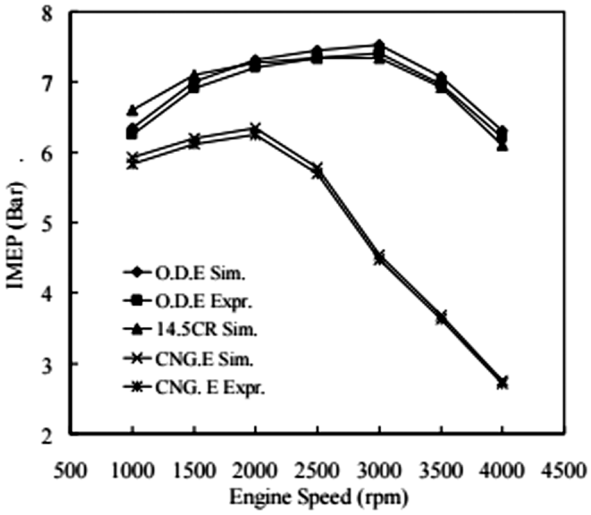

Fig. 11 Indicated mean effective pressure of natural gas engine [7]

The maximum indicated mean effective pressure,

- Original diesel engine – 7.524 bar at 3000 rpm
- Modified diesel engine – 7.34 bar at 3000 rpm

- Natural gas engine – 6.349 bar at 4000 rpm

Natural gas engine when compared to diesel engine, the maximum IMEP was reduced by 13.54%. It was concluded that conversion of diesel engine to natural gas engine is not suitable for high engine speed applications, but it shows good IMEP performance at low – medium speeds.

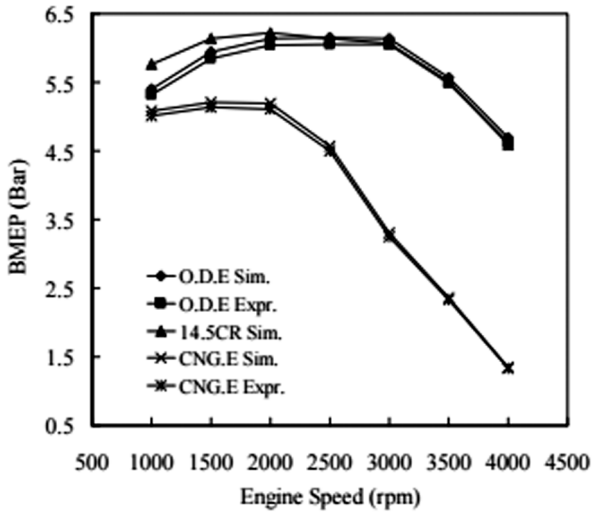

Fig. 12 Brake mean effective pressure of natural gas engine [7]

The maximum brake means effective pressure,

- Original diesel engine – 6.148 bar at 2500 rpm
- Modified diesel engine – 6.22 bar at 2000 rpm
- Natural gas engine – 5.21 bar at 1500 rpm

Natural gas engine when compared to diesel engine, the maximum BMEP was reduced by 16.18%. The highest brake mean effective pressure was at medium engine speed and the minimum BMEF was at highest engine speed. Therefore, it was concluded that conversion of diesel engine to natural gas engine is not suitable for high engine speed applications but it shows good BMEP performance at low – medium speeds.

F. Fuel Consumption

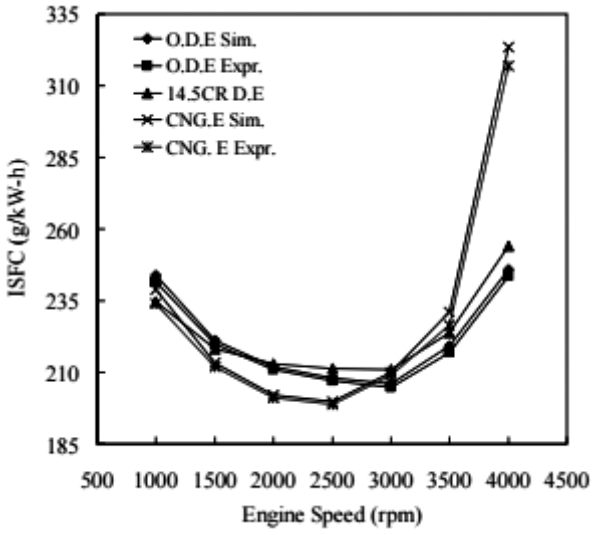

Fig. 13 Indicated specific fuel consumption of natural gas engine [7]

The lowest indicated specific fuel consumption,

- Original diesel engine - 205.93 g/kW-h at 3000 rpm
- Modified diesel engine - 210.9g/ kW-h at 3000 rpm
- Natural gas engine – 199.593 g/kW-h at 2500 rpm

The highest indicated specific fuel consumption (ISFC),

- Original diesel engine – 245.981 g/kW-h at 4000 rpm
- Modified diesel engine – 254 g/kW-h at 4000 rpm
- Natural gas engine – 323.532 g/kW-h at 4000 rpm

Natural gas engine when compared to diesel engine, the minimum ISFC of was reduced by 2.9% and the maximum ISFC was increased by 31.53%. It was concluded that the conversion on diesel engine to natural gas engine could reduce the ISFC at low – medium engine speeds but it could increase at medium – high engine speeds.

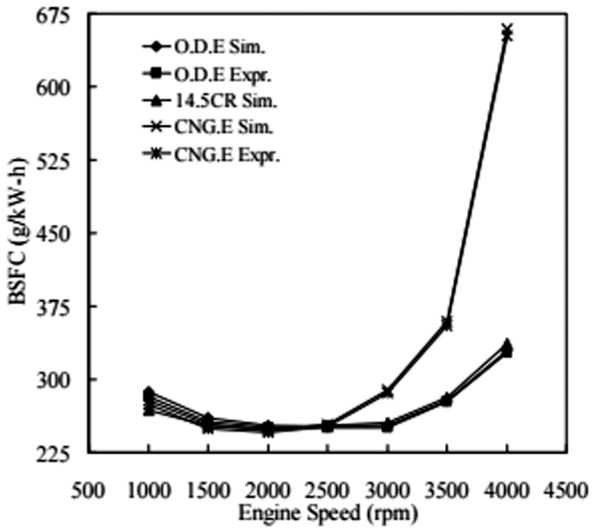

Fig. 14 Brake specific fuel consumption of natural gas engine [7]

The lowest brake specific fuel consumption,

- Original diesel engine – 252 g/kW-h at 2500 rpm
- Modified diesel engine – 249.18 g/kW-h at 2000 rpm
- Natural gas engine – 247.23 g/kW-h at 2000 rpm

The highest brake specific fuel consumption,

- Original diesel engine – 329.678 g/kW-h at 4000 rpm
- Modified diesel engine – 336.62 g/kW-h at 4000 rpm
- Natural gas engine – 659 g/kW-h at 4000 rpm

Natural gas engine when compared to diesel engine, the minimum brake specific fuel consumption of was reduced by 0.78% and the maximum brake specific fuel consumption was increased by 95.79%.

Therefore, it was concluded that the conversion on diesel engine to natural gas engine could reduce the brake specific fuel consumption at low – medium engine speeds but it could increase significantly at medium – high engine speeds.

IV. NATURAL GAS IN SRI LANKA

During the past few years the Sri Lankan government has been conducting explorations for petroleum oil and intensive research on effective utilization of natural gas in various industries in Sri Lanka. Recent investigations have proved using seismic data that natural gas deposits are available in deep waters off Kalpitiya Peninsula. Plans are already being developed to bring the extracted natural gas to land through sub-sea pipe lines and store in a Central Storage Terminal (CST) and then it will be distributed to the consumers [5]. Further, according to the report presented to the Petroleum Resources Development Secretariat (PRDS) by Sri Lanka Carbon Fund, the currently-explored field could produce 70 million cubic feet of gas per day (Mcf/d) commencing 2018 and that production could be increased to 140 Mcf/day in 2021 and to 210 Mcf/day in 2023.

A. Demand in Transport Sector

The usage of motor vehicles for transportation is ever increasing in Sri Lanka. This is applicable to both petrol (gasoline) and diesel vehicles and it is very eminent from Fig. 15 and Fig. 16 which depict the growth of gasoline and diesel operated vehicles during the period 2003 – 2012. At present this is incrementing at a much faster phase and it will continue to grow in future.

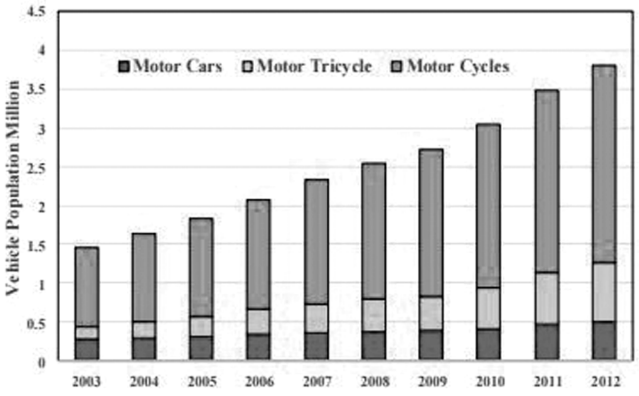

Fig. 15 Growth of gasoline operated vehicles during 2003 – 2012 [5]

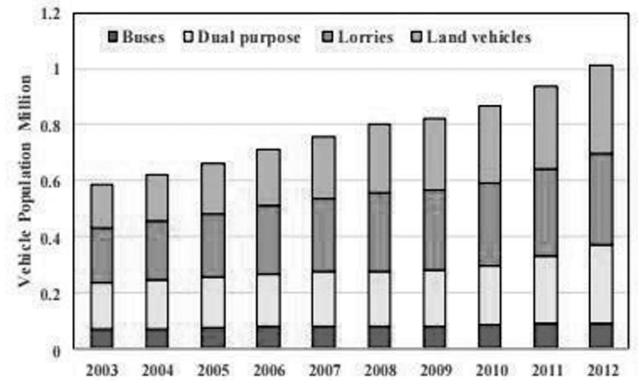

Fig. 16 Growth of diesel operated vehicles during 2003 – 2012 [5]

According to the above graphs, even though the growth of gasoline operated vehicles is higher than the diesel operated vehicles, the consumption of diesel as a fuel is much higher than gasoline and it is depicted in Fig. 18 below.

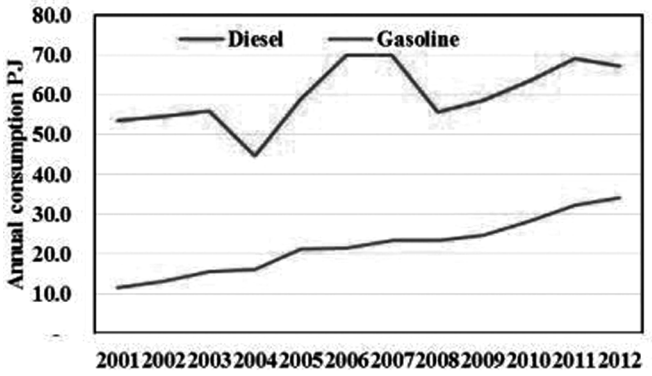

Fig. 17 Annual consumption of gasoline and diesel during 2002 – 2012 [5]

If these trends are to be assumed to grow in a similar pattern, Sri Lanka Carbon Fund predicts that by 2020, the consumption of diesel and gasoline will be 98 PJ (Peta-Joules) and 64 PJ respectively. When described in Mega-liters, it will translate to 2635 Ml of diesel and 1870 Ml of gasoline. But another report on Energy and Environment: Transport Policy Perspective (2014), predicts that these numbers will be almost 2 times the predicted values which corresponds to 4419 Ml of diesel and 3,737 Ml of gasoline by 2020. It is mainly due to expansion of road networks and rapid economic growth in Sri Lanka [10].

B. Natural Gas in Transport Sector

Many countries in the world are now shifting towards utilizing natural gas as an alternative, much greener, cheaper fuel, especially in commercial vehicles and public transportation i.e. Buses, Prime movers, Trucks, Lorries and etc. which consume diesel. This is practiced not only in developed countries but also in our neighboring country, India. Due to unprecedented increase in demand accessories necessary for the conversion of vehicles to natural gas, are readily available.

Therefore, it is high time, Sri Lanka, as a developing country to utilize available natural resources i.e. natural gas, in the most effective manner which can reduce the importation of millions of barrels of fuel and save billions every year. It is expected to introduce natural gas into the transport sector under two scenarios, NG1 and NG2. Under present circumstances, Sri Lanka carbon fund predicts that the conversion rate will grow with a share of 2% (NG1) - 4% (NG2) of oil consumption at 2023 and increase at increments of 2% (NG1) - 4% (NG2) each year with a share of 36% (NG1) - 72% (NG2) up to 2040 [5].

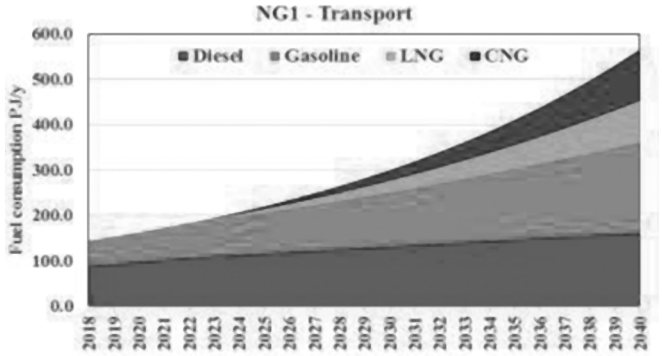

Fig. 18 Consumption of fuel under NG1 scenario [5]

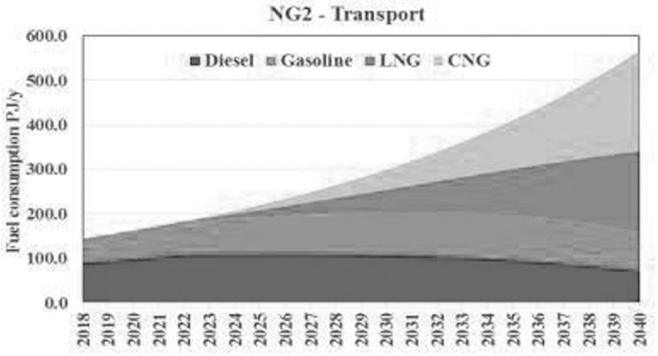

Fig. 19 Consumption of fuel under NG2 scenario [5]

V. Conclusions

From the above analysis and review, it is very clear that natural gas is a viable, greener, cheaper alternative fuel that can be effectively utilized in transport sector in Sri Lanka.

Further, analyzing the engine performance data it can be concluded that, conversion of diesel operated engines into natural gas engines showcase promising results in low to medium speeds while having some compromises at high speeds. But it must be thoroughly understood that, commercial vehicles and public transportation vehicles only require adequate performance in low – medium speed range. Therefore, it is eminent that, with the adoption of proper conversion accessories, natural gas engines can achieve good performance, low emissions and significant reliability. It should be also noted that, current researchers have already proven the fact that, not only the conversion of diesel vehicles but also natural gas can be used in spark ignition engines effectively.

Sri Lanka as a developing country, should invest now to develop infrastructure necessary for storage and distribution of natural gas and fortify infrastructure relevant to extraction of natural gas from deep sea off Kalpitiya Peninsula while expanding the exploration activities in search for other available gas pockets. The government should also enhance research capacity in this specific area since this can make a huge impact on the economic development of the country in the foreseeable future by saving billions of rupees invested on importing petroleum oil. Furthermore, due to reduction of emission of polluting gases such as NOx, CO2, CH4, N2O and particulate matter, it will eventually reduce health hazards on general public caused by these dangerous emissions.

If current plans are to be applied without any delay, Sri Lanka will sooner be able to provide natural gas at a very low-price tag comparable to diesel fuel. This will surely encourage both the consumers and vehicle importers to bring down brand-new natural gas vehicles and increase the popularity of these vehicles in Sri Lanka. The government can introduce easy payment schemes or VAT reductions to promote the usage of natural gas vehicles. In the meantime, Sri Lanka will be able to achieve sustainable development by reducing the carbon foot print on this beautiful planet earth.

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Fabrication of an Autonomous Lawn Mower Prototype with Path Planning and Obstacle Avoiding Capabilities.

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***Abstract*— Autonomous lawn mowers have been identified as one of the most famous innovations in the recent past. However, complex operational functions, data acquisition methods and the high costs of supporting items result in the expensive nature of these autonomous lawn mowers which in turn dissuades its use in domestic environments. Primary objectives of the research comprised of building a system to identify the working perimeter by means of waypoint identification and the development of an algorithm to detect obstacles in the path followed. This paper presents the completed mechanical design of an autonomous lawn mower prototype while innovating the art of lawnmower fabrication by using colour identification camera modules for path planning with the aid obstacle avoidance integrated in it.**

***Keywords*— Lawn mower, Obstacle avoidance, Path planning**

I. INTRODUCTION

With rapid improvements in technology, the fabrication of mobile robots have been utilised in various scale applications ranging from industries to the domestic environment. The foremost purpose of implementing such robots is to reduce the human involvement in executing a certain task and as well as to minimize the time consumed in performing it. Several key areas in which these mobile robots are utilized include its usage in hazardous environments, danger zones in nuclear power plants, industrial applications and in service applications such as cleaning and painting [1]. Among these applications, lawn mowing is one of the major aspects where the use of mobile robots is highly beneficial. Contemporary houses with gardens and areas such as golf courses and football fields need to be mowed regularly to maintain the grass at an even height. Lawn mowers are used for this purpose and they have evolved since the 19th century, where reciprocating mower suspension machines and rotary mowers started developing by the end of the mid-20th century [2]. These traditional lawn mowing techniques are often troublesome and time consuming since they are equipped with a minimum level of automation.

In order to focus on these limitations, automated systems were developed to minimize the human involvement. With the increasing popularity of outdoor mobile robots, manual lawn mowing systems were modernized such that they were enabled to carry out certain specified tasks. Several designs of lawnmowers created by manufacturers and researchers display similar features to robotic vacuum cleaners which consists of obstacle detection and avoidance features, the ability to work in a pre-defined workspace together with area identification and mapping methods.

Path planning is an important concept in designing autonomous robots. Certain autonomous lawn mowers require the installation of a current carrying boundary wire buried in the ground for perimeter identification purposes. Once a current passes along the wire, the electromagnetic field generated due to it is captured using the Hall-effect sensors in the mower thus directing it in the required path [3]. However, this method has been proved to be inefficient and costly in nature. Hence, engineers initiated the use of Simultaneous Localisation and Mapping (SLAM) techniques together with Neural Networks to address path planning and obstacle avoiding requirements. SLAM generates a map in an unknown environment based on the initial coordinates of the robot and sensor data which enables locating the robot on the map [4]. Alternatively, waypoint navigation systems have also developed increasingly although their use has not been widely used in the scope of lawn mowing.

Obstacle avoidance is another concept that is immensely important which guarantees the safe operation of the mobile robot in both static and dynamic obstacles. It can be defined as the procedure in which the autonomous vehicles path is designed in order to avoid unexpected barriers. Obstacle avoidance is categorised into two main segments which are obstacle detection and avoidance control [5]. Numerous approaches for obstacle avoidance have being carried out during the near past. One of the most common approaches include the use of vision systems. Mobile robots are generally designed using a behaviour based approach since it uses a sense-act methodology [6]. This makes it ideal in nature to be used in areas consisting dynamic obstacles. A number of modern sensor types including laser range finders, bumper sensors, ultrasonic sensors and infrared sensors have also been used in the recent past for obstacle avoidance. The type of sensor that can be used for mobile robots depends on the environment in which it is meant to be implemented on. Certain autonomous robots use a single sensor whereas others use several sensing devices. The resulting path and the current position of the mobile robot is determined using the

sensor readings [5]. Reference 7 demonstrates a research to investigate the use of tree detection sensors comprising of sonar and vision sensors to recognize the environmental conditions. This robot was designed to minimize issues that arose when determining the perimeter in which the lawn mower should operate. The position was estimated with the aid of the sensors which aided the robot to navigate past obstacles. Although this method was quite a development, the system was less reliable and was not ideal in areas where trees did not exist.

In considering the control system design of automated robots, a number of strategies have been developed in controlling dynamic systems to achieve the desired output. Among these techniques, Proportional-Integral-Derivative (PID) controllers are generally used. Reference 8 illustrates an instance where the speed of Direct Current (DC) motors have been controlled using PID and Proportional-Integral (PI) controllers. The motors were assumed to be a first order system and the speed of the motors were measured using optical switches with light emitting diodes (LED) and phototransistors. Responses from the two systems were analysed and the results suggested that the PI controller was ideal since the behaviour of the PID controlled system was not steady around the set point. Controllers to adjust the speed and the rotating direction of DC motors have been implemented in autonomous robots with the aid of PID controllers linked with the arduino interface. The same system was simulated using MATLAB and Proteus. Results indicated good performance in the PID controller but minor issues in the accuracy due to the selection of a lower sampling rate [9].

Considering these factors, the main objectives of this research paper were to fabricate an autonomous lawn mower in order to identify the working environment through a colour identification camera and navigate past obstacles to create safe working conditions for the user with improved accuracy. Together with these key objectives, cost minimisation was also another key aspect which was addressed.

II. Lawn Mower Design

Generally, traditional lawn mowers are designed using wheeled robot structures. However, these models face difficulties when travelling on uneven surfaces since there is a high tendency for the robots to fall inside hollow areas which may be present in areas of navigation. To eliminate this, a tank robot chassis was used in the design.

A. Mechanical Design

A tank robot chassis with caterpillar tracks was used to fabricate the prototype of the autonomous lawn mower. This was chosen since tracks have a higher performance along with an efficient power delivery system. The traction is considerably high even on slippery surfaces as well as in rough lands making it ideal to be used as the design for an autonomous lawn mower. The motors used to power the robot were of 12 Volts and a gear box attached with a ratio of 30:1. These had the ability to be coupled with encoders. In the design quadcore encoders were used with an operating voltage of 5 Volts. The wheels including the cog wheel were of 55mm diameter and were fixed to the chassis with the aid of copper spacers. Fig. 1 represents the tank chassis used whereas Table I represents the dimensions of the chassis and the materials which were used for the body and the caterpillar tracks.

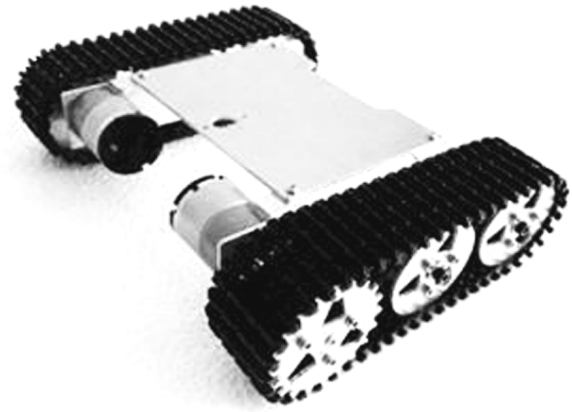

Fig. 1 Finalised design of the robot chassis

TABLE I
Chassis Dimensions

Dimension	Value
Length/mm	180
Width/mm	240
Height/mm	60
Body Material	Laser cut Aluminium Alloy
Caterpillar Track Material	Nylon

Acrylic sheets of dimensions 85mm×160mm, 200mm×120mm and 120mm×50mm were drilled and fitted as levels on the aluminium chassis to provide space for the motor controllers, arduino board and power circuit and sonar sensors. The model of the cutter used in the lawn mower is a mulching blade. Mulching blades usually have a greater curved surface. To facilitate a smooth cutting process a DC motor with a high revolution per minute (rpm) value and a lower torque was used. The blade was engineered using AISI 5160 grade alloy steel. Fig. 2 illustrates a model of the blade designed to be used in the mower.

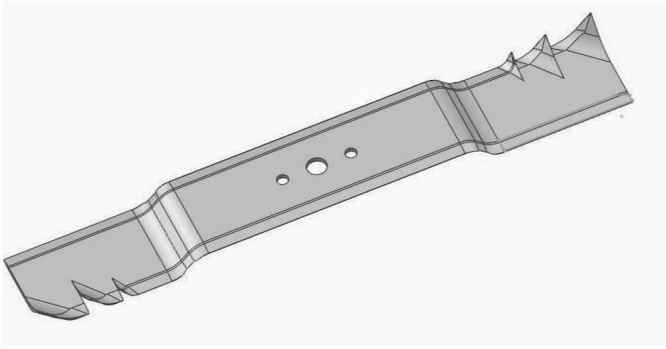

Fig. 2 Lawn Mower blade design

B. Control System Design

An arduino interface was used as the main control board for the lawn mower. The two DC motors were considered to be the two main individual actuators of the system. A PI controller was introduced to both individual systems in order to maintain a set velocity of the motors. Feedback from the quadcore encoders were fed into the main controller. The desired voltage for the motors is supplied through a motor

driver. Fig. 3 represents a figure that illustrates the system with the PI controller.

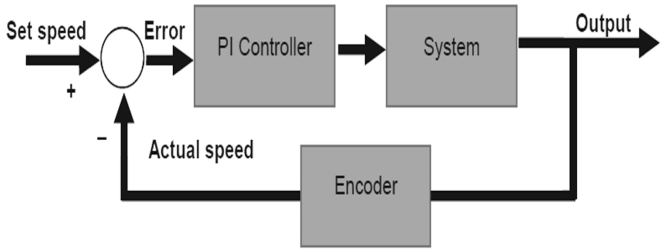

Fig. 3 Block system of the PI Controller.

The pixy camera module was used to identify waypoints. A specific colour is identified by the camera as the signature colour depending on the colours of the background. Waypoints of this colour were then fixed in the boundaries. The pixy camera is integrated with a pan tilt mechanism, thus enabling it to rotate and identify the closest waypoint with the highest image area. The coordinate points are identified using the digital magnetometer. The angle at which the waypoint is compared to the current position of the mower is being determined by the program and subsequently the mower moves in the direction of the waypoint. The camera simultaneously rotates in order to capture the next waypoint to enable continuous navigation.

C. Obstacle Detection and Avoidance

As discussed in the earlier sections, navigating around obstacles is key to ensure a smooth operation of the lawn mower. Three sonar sensors were aligned at an angle of 60 degrees each in order to cover a complete regional area of 120 degrees. Fig. 4 indicates how the sensors were mounted on to the chassis whereas Fig. 5 shows the finalised design of the lawn mower prototype.

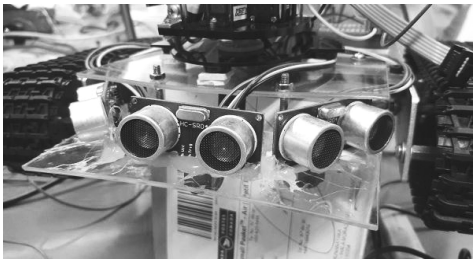

Fig. 4 Sonar sensors for obstacle detection

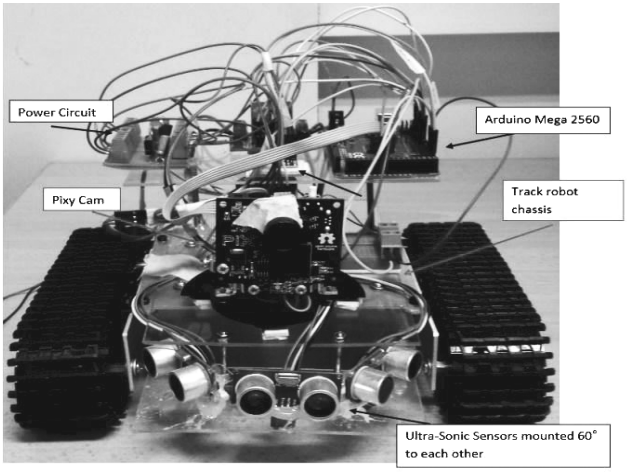

Fig. 5 Finalised autonomous lawn mower prototype

Further attention was given to the states that can occur due to the feedback of the sonar sensor readings. The main idea of this is to develop a concept where obstacles can be detected and avoided by taking the front, right and left sonar sensor readings. These readings will then be communicated to the motors via the motor driver in order to allow the lawn mower to steer around the obstacles. The data from all three sensors are combined to identify the direction in which the mower can proceed without interruption from any obstacle. Fig. 6 below represents the system methodology designed to detect obstacles based on the readings identified by the sonar sensors.

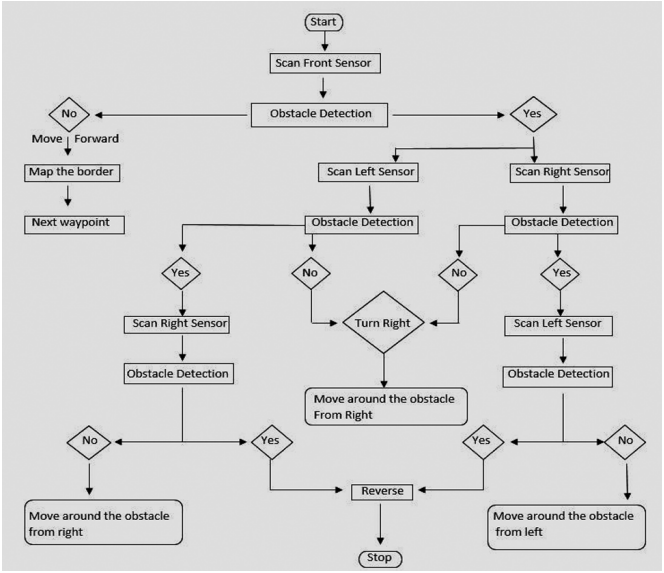

Fig. 6 Obstacle avoidance process chart.

III. Test Results and Discussion

The obstacle sensing system designed was tested by bringing in obstacles to nearby positions of the sensors. The results of the sensor readings is shown in Fig. 7. The set of readings on the left represents data when an obstacle was brought in front of the left sonar sensor. The three readings in the left column represents readings of all sensors at a particular instance. Similarly obstacles were brought towards the middle and the right sensor and the sensor readings corresponding to them are shown in the middle and right of the figure below respectively.

Sensor readings corresponding to the obstacle

Left Sensor	Middle Sensor	Right Sensor
5-61-27	49-10-49	5-64-4
5-80-26	49-10-49	3-64-4
5-80-26	50-10-50	5-64-4
6-60-26	50-10-50	6-63-4
7-61-26	50-11-50	0-50-5
6-61-27	50-11-50	0-63-5
7-80-27	50-12-50	2-66-5
7-60-27	49-11-49	5-50-5
7-60-26	50-11-50	6-52-4
6-61-26	50-11-50	6-50-6
6-60-27	49-12-49	8-50-4
6-61-26	50-12-50	4-52-4
6-60-27	50-12-50	7-52-3
7-60-27	50-10-50	6-52-5
8-60-27	51-11-51	5-53-5
7-79-27	51-11-51	5-63-4
9-81-26	49-11-49	2-64-5
3590-80-26	49-12-49	3-3558-4
3-81-27	49-12-49	0-5-5
8-82-27	50-11-50	6-50-6
7-80-26	51-11-51	5-52-5
7-63-26	52-11-52	6-52-4
6-61-27	50-11-50	5-71-6
6-62-26		8-70-5
6-80-26		6-69-4
6-81-26		6-53-3
6-81-26		7-52-3
6-81-27		0-69-4
		2-69-4

Fig. 7 Readings from the sonar sensors

The pixy camera module was used to choose which colour was best to be used for the waypoints during the testing process. Table II describes the test results.

TABLE II
COLOUR IDENTIFICATION RESULTS

	Distance from the pixy camera to the waypoint					
	5cm	25cm	50cm	100cm	150cm	200cm
Red	Yes	Yes	Yes	Yes	Yes	Yes
Orange	Yes	Yes	Yes	Yes	Yes	No
Green	Yes	Yes	Yes	Yes	No	No

All coloured objects were of the same size and were tested under outdoor lights. The results confirmed that red was the most suitable colour for the way points due to its easiness in identification over a long range. Fig. 8 displays an image where the pixy camera captures red coloured objects among other colours.

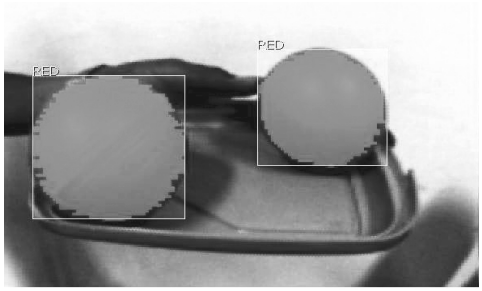

Fig. 8 Colour identification using the pixy camera

In order to achieve an accurate heading direction for the robot during path planning, the object being tracked needs be centred by the camera therefore the system was modified to achieve this objective. When the object being tracked is centred, the servo motors of the pan tilt kit stops and remain in the same position. Fig. 9 represents an instance when the coloured object was brought to a position approximately close to the centre. The heading direction compared to the current orientation of the robot was determined using the digital magnetometer.

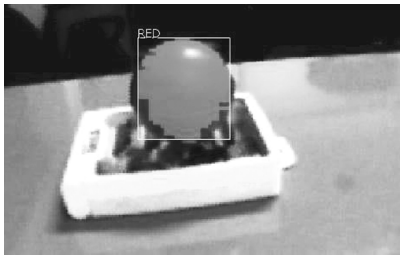

Fig. 8 Centred image of a waypoint using the pixy camera

The MATLAB identification toolbox was used to simulate the transfer functions response and then was compared against the actual response of the motors.

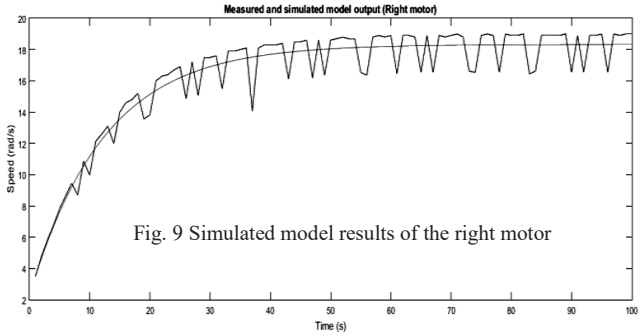

Fig. 9 Simulated model results of the right motor

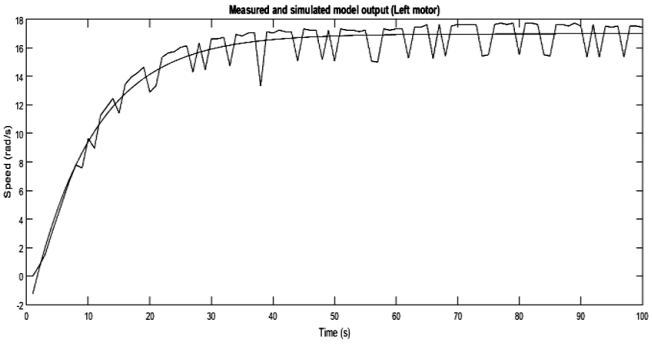

Fig. 10 Simulated model results of the left motor

Fig. 9 and Fig. 10 represent the responses of the motors against the simulated response. It is seen that the actual response lies close to the simulated thereby showing good stability in the system. The green and blue lines represent the simulated graphs in the above figures.

IV. CONCLUSIONS

This research paper has shown the capability of producing an autonomous lawn mower with path planning and obstacle avoiding systems. The results confirm the effective usage of sonar sensors for obstacle avoidance and PI controllers in maintaining a constant linear velocity. The mechanical design of the tank robot chassis provided good stability for the mower. Further this project proved the success of using a pixy camera for identifying waypoints based on the colour which has not yet been commonly implemented in the design of lawn mowers.

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Analysis of the Bond Performance Durability between CFRP and Steel with Changing Environmental Conditions in Sri-Lanka.

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***Abstract*— The use of Carbon Fibre Reinforced Polymer (CFRP) to strengthen steel structures is one of the recent innovative developments being made. However, much research hasn't been performed regarding how the bond performance varies under different environmental conditions during the installation phase of CFRP. This study was conducted in order to address these limitations by testing samples under different environmental conditions around Sri Lanka. Four-point-bending test was carried out on the eight test specimens and the research findings revealed that CFRP absolutely increased the strength of steel by 39% when bonded together. Additionally, it was found that extreme humidity conditions significantly degrade the bond strength. Nevertheless, with the increment of steel structures to be retrofitted and taking the environmental conditions into account, the application of CFRP was found to be a viable solution to increase the service life of steel structures in Sri Lanka.**

***Keywords*— Bond durability, CFRP, Environmental conditions**

I. INTRODUCTION

A large number of steel structures including bridges have been deteriorating in their functional performance in the recent past. The majority of the failure issues relate to fatigue loading conditions, corrosion, increase in service loads, improper maintenance or a combination of all these effects. It is imperative to repair and retrofit these structures in order to prevent any further catastrophic disasters which may arise. Traditional retrofitting techniques include using extra steel plates by welding or bolting, external pre-stressing of parts and inserting more supports. However, in the long run they tend to be ineffective as they increase the weight of the structure, chances of corrosion as well as future maintenance costs [1]. These factors led to the initiative of externally bonding CFRP on steel surfaces for strengthening purposes. CFRP comprises of exceptional mechanical properties such as its light weight, high strength – to-weight ratio and corrosion resistance which makes it a more preferable solution.

Fiber Reinforced Polymer (FRP) materials have been increasingly used in the recent past to retrofit concrete structures but its use to strengthen steel structures has not yet been a widely practised technique due to the indeterminate nature of the bond durability between CFRP and Steel. However, CFRP has been successfully installed in some steel bridges in the United Kingdom including the Hythe Bridge in Axford and the Slattocks Canal Bridge [2].

Surface preparation is an important concept that governs the quality of adhesively bonded joints. Proper surface treatment of steel produces a rough surface free from contamination and enhances the formation of chemical bonds between the steel surface and the adhesive [3]. Although various surface treatment techniques including physical, thermal and chemical exist, the most effective approach to achieve a high energy steel surface is by using mechanical surface pre-treatment methods such as grit blasting [4]. Reference [3] further shows that abrasive dust can be removed from abraded surfaces by using excessive amounts of solvent to restrict the chance of any removed contaminants to redistribute on the surface once the solvent has evaporated.

In determining the long-term durability of the steel-CFRP bond, environmental conditions play a significant role. They include temperature, moisture, relative humidity, presence of saline conditions, thermal cycles, Ultraviolet (UV) radiation and alkaline environments. The mechanical performance of CFRP-steel bonding systems subjected to elevated temperatures were found to prevail immensely by the adhesive layer. The ultimate load bearing capacity reduces as the temperature reaches the glass transition temperature (T_g). Reference [5] shows that the reduction in the ultimate load capacity was around 15%, 50% and 80% when temperature reached T_g, 10°C above T_g and 20°C above T_g respectively. Under freezing conditions, CFRP gets degraded due to the hardening of the matrix which results in the formation of micro cracks parallel to the fibres in the fibre-matrix interface [6].

Moisture and relative humidity are two major concerns which influences the bond durability between Steel and CFRP. Water absorbed by the FRP matrix reduces its T_g and causes swelling which leads to the plasticization of the polymer and in turn reduces its shear strength [7]. Reference [8] indicates that the moisture absorption of CFRP laminates generally lies in the range of 1% and the bending strength reduced by approximately 17% after 14 days of exposure. Saline conditions in the environment is another factor that affects the bond durability especially in coastal areas along which a majority of the steel bridges in Sri-Lanka are located. Steel samples bonded with CFRP have been tested in salt water at temperatures of 20°C and 50°C. The tensile strength of the sample at 20°C reduced by 14% of its initial value during the first four months of exposure and a further reduction of 3% was obtained after an exposure of 12 months. A higher strength reduction rate was seen in specimens at 50°C compared to the specimens exposed to salt water at 20°C. The tensile strength reduced by 15% of its initial value during the first two months of exposure and a further 11% reduction was obtained after an exposure of 12 months [9].

UV radiation is another critical aspect that CFRP composites face in terms of strength reduction. The radiation

is strong enough to split bonds between molecules in the polymer which may result in effects ranging from surface dislocations to extensive loss of mechanical properties [10]. Previous studies have shown that when FRP materials were subjected to artificial sunlight, the tensile strength and elastic modulus decreased by 15% - 20% due to the brittleness of the resin and Fibre matrix interfaces [11]. Although effects from different environmental conditions were analysed separately, steel structures experience a combination of these effects during their service life. Reference [12] shows that the strength of loaded steel/CFRP double lap joints reduced by 60% when exposed to one week of wet and dry cycles in a 5% Sodium Chloride solution at a temperature of 38°C for up to 6 months.

Nevertheless, the impact of environmental conditions on the steel-CFRP bond has not yet been widely analysed. This has led to the less popular nature of CFRP being used to strengthen steel. The main objectives of this research paper are to identify and document the improvement in the strength of steel with the installation of CFRP and to investigate the variation in strength of the Steel-CFRP bond with changing environmental conditions during the installation phase.

II. Bond Testing Procedure

The bond testing was carried out on eight different specimens. Mild Steel I – beam sections of standard ASTM A36 were used in this experimental program. Table I represents the dimensions of the specimens. I-sections were chosen due to the fact that they are commonly being used in steel structures.

TABLE I
CROSS-SECTIONAL DIMENSIONS

Dimension	Value
Height/mm	100
Width/mm	20
Flange thickness/mm	5
Web thickness/mm	4
Length/mm	600

A. Materials

M Brace CF130 CFRP sheets were used for the strengthening purpose due to its high tensile strength and elastic modulus. The structural adhesive used was JB Weld, a commercially available epoxy adhesive. Table II shows the material properties of the CFRP sheet and the adhesive according to the manufacturer.

TABLE II
Material Properties

Property	CFRP Sheet	Epoxy adhesive
Tensile Strength/MPa	2600	27.3
Set time/minutes	N/A	20-25
Cure time/hours	N/A	15-24

B. Specimen Preparation

Surface preparation is an important step in enhancing the bond durability. The specimens were grinded to remove any rust that was formed on the sample surface prior to bonding CFRP. The grinded specimens were then cleaned using a commercial solvent to remove any dust deposited on the surface. Fig. 1 shows the grinded and cleaned steel surfaces.

Fig. 1 Grinded and Cleaned specimen surface

A thin layer of the two-part epoxy was mixed according to their weight ratios and then applied on the lower grinded surface of the specimen according to the manufacturer's guidelines. Fig. 2 displays the specimen surface subsequent to the application of the epoxy.

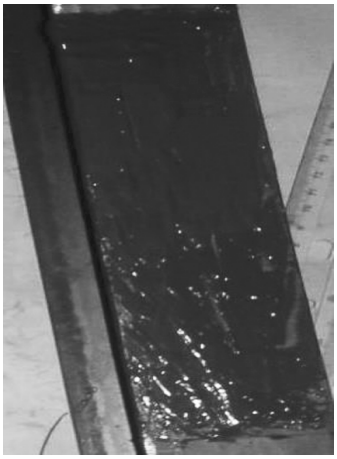

Fig. 2 Adhesive applied on the specimen.

CFRP sheets were cut into parts of 200mm length and 50mm width and a single layer of CFRP was bonded on the adhesive layer. Excess air bubbles and epoxy were removed by moving a roller uniformly in the direction of the fibres. Fig. 3 shows a specimen strengthened with CFRP.

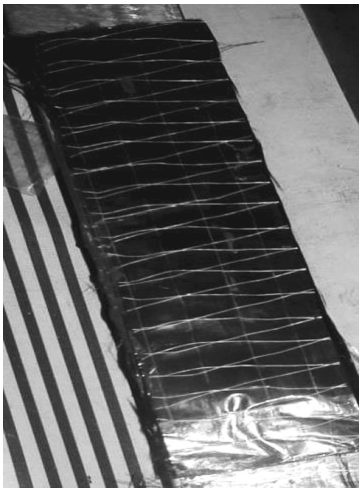

Fig. 3 CFRP strengthened Steel specimen surface.

The reason behind bonding CFRP on the grinded lower flange surface was to achieve maximum efficiency of the

bond. Fig. 4 shows the cross-section of the CFRP strengthened steel specimen together with the dimensions.

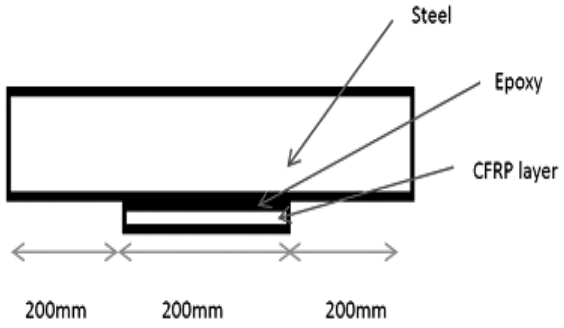

Fig. 4 CFRP Strengthened steel

CFRP was applied on six test specimens in three different environmental conditions around Sri-Lanka and two other specimens were used as control samples. Table III summarises the environmental conditions during the installation phase corresponding to these samples. All specimens were kept for an exposure time of 48 hours in their respective environmental conditions.

TABLE III
SPECIMEN SUMMARY

Specimen Series	Specimen Labels	Temperature/°C	Humidity/%
1	S1 and S2	29	79
2	S3 and S4	27	90
3	S5 and S6	33	68
4	S7 and S8	No CFRP	No CFRP

C. Experimental Setup

Four-point-bending test was carried out on the test specimens. The samples were loaded on to the CFTM-300D Digital compression and flexure testing machine. A surface gauge was placed at the midpoint of the top surface in order to measure the deflection at distinct loads. A constant loading rate of 0.45 kiloNewtons/second was used to load the samples. Fig. 5 and Fig. 6 shows a sketch of the experimental setup and an instance where the steel specimen was subjected to loading respectively.

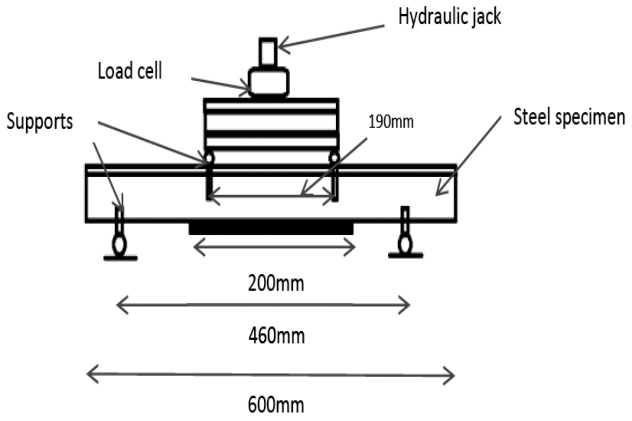

Fig. 5 Experimental test setup

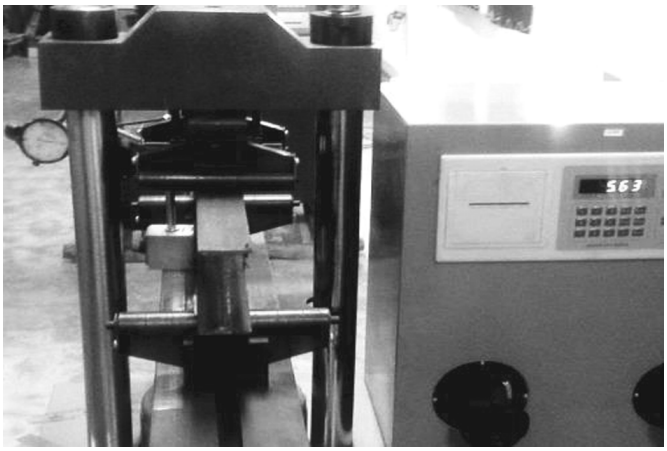

Fig. 6 Specimens loaded in the test machine.

III. TEST RESULTS AND DISCUSSION

The deflections exhibited by the specimens were measured using surface gauges at load increments of 10 kilo Newtons (kN). The average deflection was calculated for each specimen series which is represented in Table IV.

TABLE IV
EXPERIMENTAL RESULTS

Loading Value / kiloNewtons	Average Deflection in Specimen Series/mm			
	1	2	3	4
0	0.00	0.00	0.00	0.00
10	0.46	0.58	0.40	0.90
20	0.80	0.88	0.66	1.19
30	1.05	1.13	0.87	1.50
40	1.30	1.37	1.10	1.90
50	1.52	1.56	1.32	2.23
60	1.74	1.79	1.57	2.45
70	1.93	2.05	1.82	2.73
80	2.19	2.22	2.07	2.94
90	2.54	2.61	2.38	3.59
100	2.95	3.23	2.82	5.01
110	3.82	4.47	3.39	5.40

All specimens were loaded to a maximum load of 110kN and the deflections measured. Fig. 7 graphically represents the test results illustrated in Table IV.

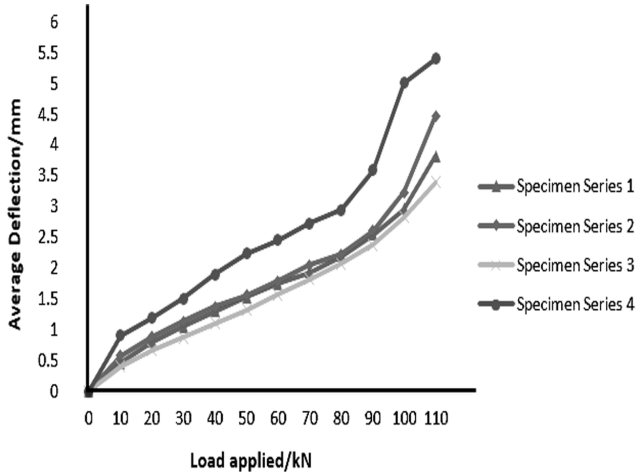

Fig. 7 Average deflection Vs. Load applied.

As shown in Fig. 5, the maximum average deflection was observed in specimen series 4 where no CFRP was externally bonded. Calculations were done using average deflection values to determine the percentage increase in strength of the specimen series. An increase in strength of 31% was observed in series 1. Series 2 showed an increase of 28% whereas the percentage increase in strength of specimen series 3 was 39%. The increments were measured relative to the deflection of the control specimen series 4 and is illustrated in Fig.8 below.

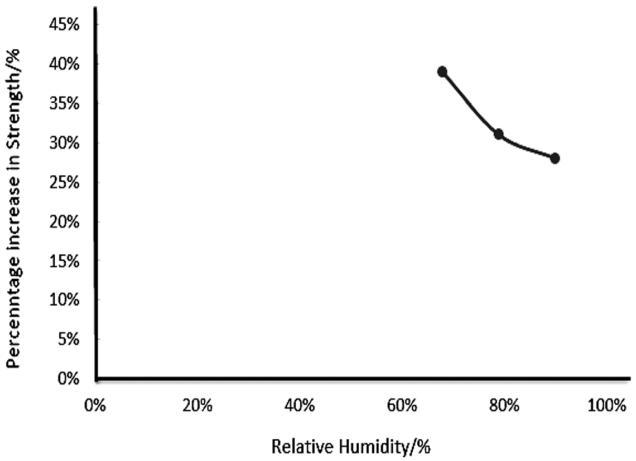

Fig. 8 Strength increment percentage Vs. Relative Humidity.

These results indicate the decrement in the bond strength between CFRP and steel with increasing humidity conditions which also aligns with the theory and the predicted behaviour of the bond. The strength was directly related to humidity since the temperature variations between the specimen series during the installation of CFRP was negligible.

Fig. 9 Crack Initiation sites.

Furthermore, the observation of specimens after being loaded at 110kN revealed that steel specimens contained crack initiation sites as shown in Fig. 9 above. Failure occurred due to a buckling effect but there was no delamination seen in the CFRP layer which signifies that the bond between steel and CFRP is still intact. This is an important finding when considering the durability of the bond.

IV. Conclusions

This research paper has produced a new platform to identify the effects of initiating the use of CFRP in strengthening steel structures including preferably steel bridges. The experimental procedure conducted along with this research proved the enhancement of the flexural strength of steel by 39% in ideal conditions which shows the significance in it. Further, the degradation of the bond strength due to harsh environmental conditions such as high relative humidity was also being evidenced. In comparison to the samples at a relative humidity of 65%, the strength of specimens at 90% relative humidity showed a strength reduction of 18%. This technology has not yet been implemented in Sri-Lanka due to the lack of information related to the bind performance. According to statistical information provided by the Road Development Authority (RDA) and Ceylon Government Railways (CGR), around 5000 bridges exist in Sri –Lanka and they require constant maintenance. With CFRP already been proved as a viable strengthening mechanism alongside the environmental conditions in Sri-Lanka, the most important conclusion that can be derived is that this innovative technique needs to be implemented sooner rather than later in order to improve maintenance standards and eliminate risk of catastrophic failures.

Acknowledgment

The author wishes to acknowledge at RDA and CGR offices for providing necessary information related to the research.

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Digital Household Energy Meter with GSM Communication for Home Energy Management

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***Abstract* – This design is developed with the main aim of assisting energy consumers and utility service providers with an enhanced feature for better home energy management. Automatic generation of the monthly electricity bill avoids the prevailing drawbacks of the current energy measuring system such as time wastage, accuracy issues, human errors and possibility for fraud activities. This system can be effectively used for real time measuring and analyzing of the household energy usage. The device utilizes GSM technology to alert the consumers with energy readings in Kilo Watt hours (kWh). Any individual or an organization with an approved electricity connection by the standard utility service provider can use this device. Crucial parameters of energy appliances such as Power Factor, Rated Power and Root Mean Square (RMS) Current were analyzed with the design obtaining results appropriately. Demand charge can be effectively controlled avoiding the overall household demand exceeding a preset demand value. As evident from the specifications and results this study fulfills a prudent requirement in the home energy management sector.**

***Keywords* – Digital Energy Measurements; Low cost, Home Energy Management; Power Factor; Peak Demand Controlling**

I. INTRODUCTION

The designed device as proposed in this paper calculates the monthly electricity bill automatically and communicates the payment amount to the consumers' mobile device at the end of each payment period. Generally, an authorized person from CEB visits every house for the meter reading activity. But, this method creates disadvantages such as wastage of time, accuracy issues of meter reading and the ability for customers and the meter readers to engage in any fraudulent activities. Moreover, the system proposed by this paper requires less labor since the energy metering device carries out the job role of the meter reader. This introduction of "Digital Energy Metering System" empowered through GSM communication shall do the job accurately and is convenient for both CEB and consumers due to automation of the system.

The current traditional energy metering devices installed at households consists of a lot of moving mechanical parts causing enhanced complexity to troubleshoot and debug the errors. However, the proposed energy meter consists less mechanical parts causing troubleshooting and debugging to be easier than in the traditional energy meter. Further, the digital energy meter was designed based on Atmega328P microcontroller with various novel features that can be equipped in comparison to the traditional energy metering devices currently in operation.

II. LITERATURE REVIEW

A. Digital energy metering system

In the present context, the bill is processed by the meter reader who visits the premises and goes through a manual process which clearly ascribes the probability of human errors. This process is reported as unreliable [1]. In case if the electricity consumer forgets to settle the bill, the service provider will disconnect the electricity without any hesitation [2]. Thus, to overcome aforementioned disadvantages an energy meter which can monitor and alert the energy usage digitally in real-time to consumers was proposed and designed.

B. Background Study

Recent approach by Kurkute, et al. [1] proposes an energy metering device with an Atmega16 microcontroller facilitated with low power consumption in 2016. Similarly, the same concept was bought forward by Gowsami and Hasarika [3] prior to Kurkute, Girase and Patil [1] in 2015. However, the less concern about the accuracy and the inability of communicating the measurements to a remote location have been major drawbacks of these systems.

Jose, et al. [4] proposed a smart energy meter with a PIC16F877A microcontroller and a MAX232 communication system which interfaces the microcontroller with the GSM modem. Moreover, a digital energy meter with an ARM LPC2119 microcontroller which is not commonly used in modern applications with IR transmitters and receivers has been proposed to use by Silviya, et al [5] in their journal paper which was published in 2014.

Another research was carried out by Siveram [6] in 2013. But the main feature in his proposed system is the usage of AT7751 energy monitoring IC and an Atmega8 microcontroller. The major drawback of this proposed system was the usage of an Atmega8 microcontroller containing limited input and output pins in the work space.

In addition, another rare type of an energy meter was built by Satheyamoorthy (2013) [7] using a PLC system. There are various disadvantages in designing a meter reading device using PLC due to its high initial cost and the complexity of programming environment. Moreover, unlike in Arduino PLC, this should be programmed using Ladder Logic, Function Block Diagram or List of instructions which is not user-friendly. The troubleshooting of this system requires high end expertise knowledge and special training as well. Further, libraries assisting for programming Arduino are not available in the PLC system. Hence, these facts depict that, designing an

energy meter reading system using PLC is not an effective approach.

Similarly, the microcontroller AT89S52 has been used in a project of prepaid energy metering system. A prepaid energy meter is an energy metering system that the consumer pays the supplier initially and when the paid credit limit is reached a SMS is sent to the consumer's mobile device through the GSM module alerting the usage of energy. This approach assists for the consumption of the energy with a control [8][9] reducing the overall energy cost in the household environment. However, accuracy of the energy measurements and the user-friendliness of the system is found to be in a very low state in this design. Further, Keerthi and Raju (2015) [10] designed a Digital energy metering system using MSP430F5529 series microcontroller due to its ultra-low power features. This series of microcontrollers offer a wide range of control features at a cost of more complexity in design.

Considering all the related background work, an outstanding research gap is observed to design a low cost Digital Energy Meter with highly accurate measurements in addition of features such as GSM communication and peak demand controlling. The authors have decided to utilize Arduino technology with user-friendliness in programming and troubleshooting with the accessibility to a variety of libraries. Real time Energy monitoring feature and user alerts is fulfilling a very prudent requirement in the modern world Energy industry.

III. METHODOLOGY

This chapter focuses about the hardware design of the proposed and designed digital Energy meter and the required calculations performed to achieve the required features of the design.

A. Block diagram of the designed system

The figure depicted in the fig.1 illustrates the functional block diagram of the system which was developed.

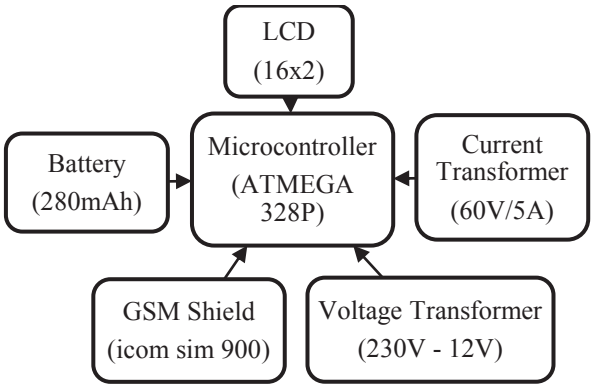

Fig. 1 Block diagram of the developed system.

230V – 12V step down voltage transformer was used in the design for two main purposes. The first main purpose was the stepping down of the voltage from the main grid to be provided as an input to the processing unit. Other purpose was to generate a pulse thus the Atmega328P microcontroller enabling the detection of the voltage in the grid at that time. Current transformer of 60A/5A was used to detect the current drawn by the electrical appliance plugged in to the digital energy meter. The objective of utilizing a LCD display in the following device is to display the required parameters such as Supply voltage, Supply current, Power factor and Energy usage in real time.

An Atmega328P microcontroller was used in the device as the main processing unit. This microcontroller was interfaced with all the other input and output components used in the design. Current transformer used to sense the current generates a pulse and transmit it to the Atmega328P via analog pins. Similarly, voltage transformer also generates a pulse and transmit it to Atmega328P microcontroller. Thus, the values received by the Atmega328P microcontroller is conveyed to consumer through the LCD display equipped in the design. Further, the device is facilitated with a GSM shield enabling SMS communication to consumers acknowledging about the monthly energy consumption cost of the household premises.

A battery of 280mAh is used in the device to fulfil the power requirements. Ensuring the integrity of the saved data of the calculations, a rechargeable battery was used instead of a normal battery.

B. Design Calculations

Several calculations were carried out to compute the parameters of the design achieving required specifications.

1) Voltage Transformer Calculations:

- *Calculation of number of turns*

If the number of turns in the primary and the number of turns in the secondary is denoted as N_p and N_s respectively while Voltage in the primary and the voltage in the secondary is V_p and V_s respectively,

$$N_S = \frac{N_P \times V_S}{V_P}$$

$$N_S = \frac{360 \times 12V}{230V}$$

$$N_S = 18.78\ turns$$

Hence, the number of secondary turns available in the transformer is practically obtained as 19 approximating 18.78 value.

- *Calculation of the input current*

If the current in the primary and secondary is given by I_p and I_s, we can use the following relationship to calculate the amount of current drawn by the primary of the voltage transformer.

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$$

$$I_P = \frac{I_S \times V_S}{V_P}$$

$$I_P = \frac{1A \times 12V}{230V}$$

$$I_P = 0.052A = 52.1mA$$

Therefore, the voltage transformer draws 52.1mA current to step down 240V to 12V with a maximum current output of 1A through the secondary winding according to the above calculation.

- *Calculation of the Power dissipation*

The following equation can be employed to calculate the power dissipation of the primary of the transformer.

$$Power_{primary} = V_P \times I_P = 230V \times (52 \times 10^{-3})A = 11.96W$$

Power dissipation is calculated as 11.96 Watts. Thus, it can be rounded off and stated as 12 Watts. However, to clarify the above answer the power dissipation in the secondary shall be calculated. Using the assumption that the voltage transformer is an ideal transformer where there is no power loss, the following equation can be derived.

$$Power_{primary} = Power_{secondary}$$

$$Power_{secondary} = V_S \times I_S = 12V \times 1A = 12W$$

Hence, the power dissipation of the voltage transformer is 12W from the above calculations.

- *Calculation of the Transformer Efficiency*

The conversion efficiency of the voltage transformer can be found by using the following relationship.

$$Efficiency = \frac{Output\ Power}{Input\ Power} \times 100\%$$

$$Efficiency = \frac{11.96W}{12W} \times 100\%$$

$$Efficiency = 99\%$$

Hence, the efficiency of the transformer is calculated as 99%. Usage of a transformer with high efficiency can lead to gain precise readings. In a digital energy metering design, low power consumption of the design and usage of a highly efficient transformer in order to map the pulse to be provided as input for main controlling unit is essential.

2) Calculations related to current transformer:

- *To calculate the number of Secondary Windings*

If the Current in the primary and the Current in the secondary is I_p and I_s respectively, the following relationship can be derived with the number of turns in the primary and secondary.

$$\frac{N_P}{N_S} = \frac{I_S}{I_P} \qquad N_S = \frac{1 \times 60}{5}$$

$$N_S = \frac{N_P \times I_P}{I_S} \qquad N_S = 12\ turns$$

The ratio of the current transformer used in the design to interface with the digital energy metering device is 60:5. Using this specification, the number of turns in the secondary is calculated as 12 turns according to the above relationship.

Similarly, to calculate the current drawn by each appliance tested during the testing procedure the following equation was used.

$$Current\ Drawn = \frac{Rated\ power\ of\ the\ appliance}{Operating\ voltage}$$

Power factor was calculated using the power triangle. Therefore, the equation used to calculate the power factor is as following.

$$power\ Factor = \frac{Real\ Power\ (kW)}{Apperant\ Power\ (kVA)}$$

IV. RESULTS

The operation of the device was tested appropriately using several tests. For testing purposes three filament bulbs of 40W, 60W and 100W were used as electrical appliances. These appliances were investigated for a range of tests of real power, testing for I_{RMS} and power factor. The results certified the device was operating according to the specifications.

A. Testing the Real power

The sources of energy were tested employing the digital energy meter in identifying if the rated power is mentioned accurately in the appliances. During the test, the appliances were fixed in to the digital energy meter in obtaining the reading of the rated power.

Fig. 2 illustrates the variation of the real power in Watts against time. It can be concluded that there are minor deviations of the real power and the appliance does not always deliver the rated wattage value. This is mainly due to the specified tolerance level of the manufacturers. This design can be effectively used to test the electrical appliances for their actual power consumptions and the accuracy of the specified tolerance.

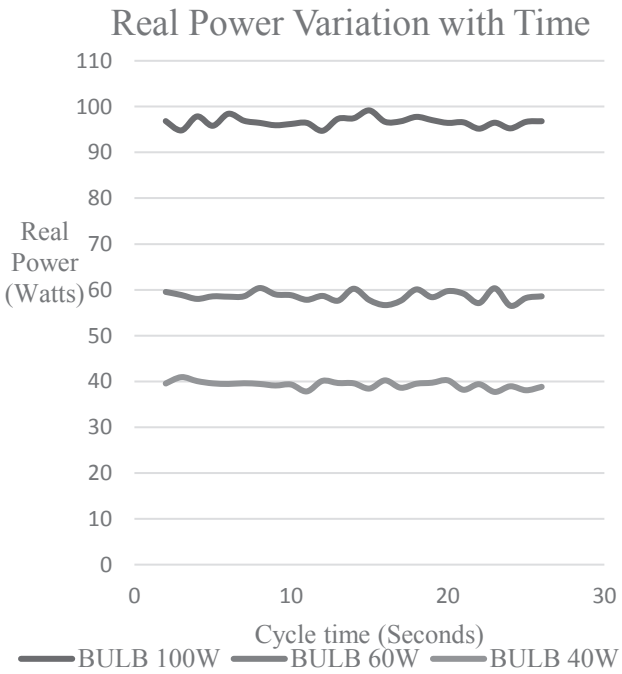

Fig. 2 Real Power Measurements of appliances against Time

B. *Testing the IRMS value*

This test is conducted to determine the I_{RMS} value of the appliance. In conducting this test same bulbs of 100W, 60W and 40W were used. Thus, it was identified that 0.44A, 0.27A and 0.18A will be the I_{RMS} values for 100W, 60W and 40W bulbs respectively. The results were justified from the current drawn equation mentioned in the calculations section.

Therefore, graphical representation was used to analyze the results obtained while conducting the above test is illustrated in Fig. 3. However, 0.01 Amperes deviation was observed analyzing the graphs plotted after computing the current drawn by the appliance.

These results prove that this design can be effectively used to analyze the current drawn from each appliance and ultimately troubleshoot and find out if any malfunctions present in the device.

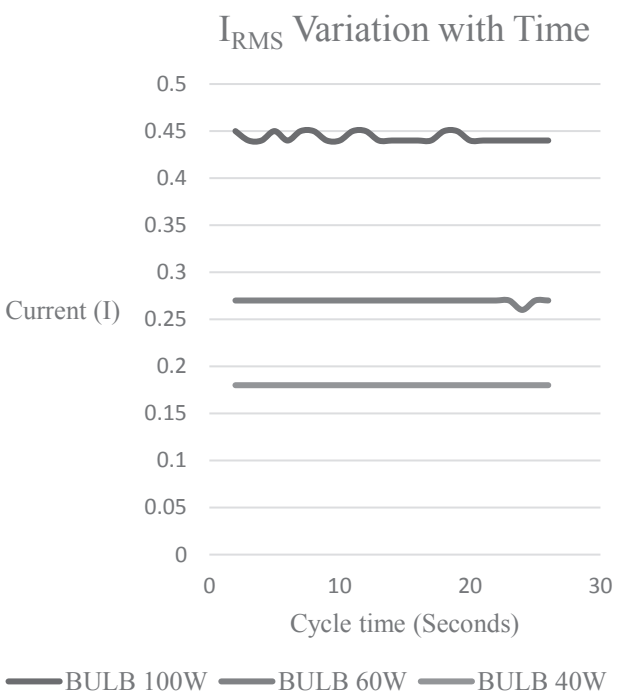

Fig. 3 I_{RMS} Readings of Appliances against Time

C. *Testing the Power Factor*

The power factor is a crucial parameter to be measured to get an idea about the efficiency of the device under operation. The Power Factor was calculated by multiplying the real power by the apparent power. Power factor in ideal operation was considered to be 1 making the appliance work with an efficiency of 100%. Hence, to analyze the efficiency of the appliances the power factor was graphically represented for the same bulbs used in the earlier tests and compared with the ideal power factor of 1.

Fig.4 below illustrates the variation of the power factor against time. The 100W bulb was reported to operate with a maximum efficiency of 95.12%. Similarly, 60W bulb demonstrated an efficiency of 94.92% while 40W bulb reported an efficiency of 94.76%. This results in generating the power factor values highlight the possible usage of the design for home energy management applications which is an upcoming trend and a prudent requirement in the modern world.

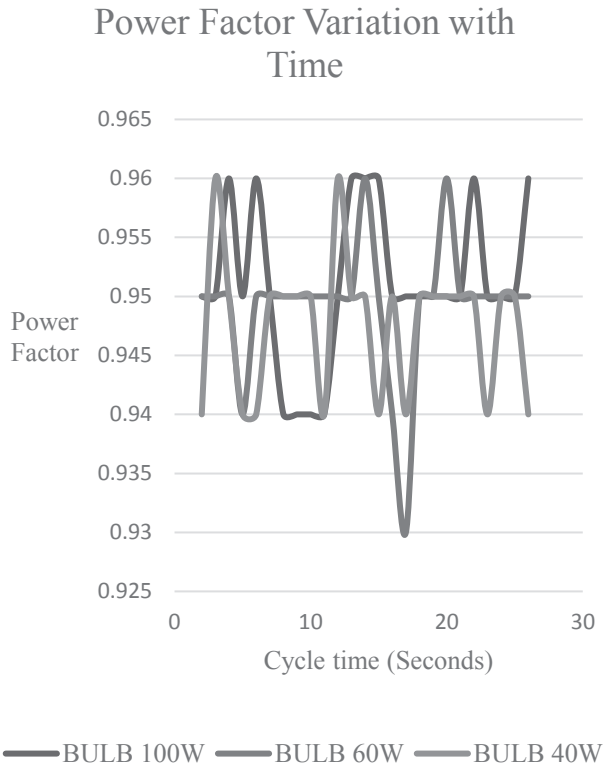

Fig. 4 Power Factor variation against Time

V. Costing of Design

TABLE I
Costing of the Design

Description of the Item	Cost (LKR)
Atmega328P microcontroller	250.00
SIM900 GPRS/GSM Shield	6000.00
LCD Display – 16x2	260.00
Voltage transformer (230v – 12v)	850.00
Current transformer (60A:5A)	1300.00
Wires	550.00
Multi – Socket plug base	750.00
Rechargeable battery of 9v	1115.00
Miscellaneous	2250.00
Total	13325.00

The low-cost feature of the design was a great achievement which fulfils a current market requirement. The total budget for the entire design was LKR 13,325 ensuring quality and accurate components meeting the required specifications as well as standards. Hence, it can be concluded that the design has achieved the low-cost feature costing less than 90 USD. This cost can be further reduced in the scale of mass production.

VI. Discussion and Conclusion

The digital energy metering device designed is a huge success achieving outstanding low-cost features compared to other similar caliber of products in the current market. The device generates real time data for better understanding of the energy consumption at the household premises. This assists home energy management for the customers and utility service providers. The ability to analyze the rated power, I_{RMS} and the Power factor of the electrical appliances enhance the importance of this device further. It is also possible to use this device for Peak demand controlling feature trimming the high demand cost. This extends the usability of the device from the household sector to the industrial sector as well.

Moreover, the energy monitoring device replaces traditional electricity bill calculation method overcoming multiple drawbacks. This is achieved by sending SMS messages to the consumer alerting on the usage of the bill at the end of each payment period. The device displays the real-time energy usage by the LCD display mounted on top of the device.

The device has been manufactured with easy clip on method. Thus, the device can be connected to the appliances with a user-friendly manner. Hence, it saves time of the customers with easiness to setup feature. The ability to use the device practically in investigating real power consumption of the electrical appliances provides the feature to compare the practical energy consumption with the rated value providing tolerance details of the power consumption of appliances.

VII. Future Developments

This design can be considered as an outstanding achievement with aims and objectives achieved as planned. This fulfils a timely requirement in the home energy management field. However, following modifications can be considered for further development of the device avoiding some drawbacks currently present in making the device much more user friendly to the energy consumers and utility service providers.

There is a possibility to develop an I2C communication system to interface the LCD display with the Atmega328P microcontroller. Hence the wiring can be further reduced making the device easy to use and troubleshoot. Moreover, another suggested development for the aforementioned device is programming the energy meter using high end languages and incorporating Raspberry Pi or Linux based system with much more additional features. This device can be incorporated with SMART HOME concept providing the feature to control the appliances to achieve optimum energy consumption required leading to better home energy management.

In the current design only one mobile device can be interfaced with the GSM Shield. Hence, it is suggested to allow multiple mobile devices to interface with the GSM shield of the energy monitoring device. This enables to communicate with multiple subscribers including energy consumers and energy utility service providers providing better information exchange as alerts. Developing a web based Graphical User Interface (GUI) for the energy monitoring device can be suggested as well as incorporating high-end security protocols. This will allow the consumer to monitor real-time energy usage over the internet using an e – portal.

Outcome of this research is highly satisfactory as the design fulfills a prudent requirement especially in third world countries including Sri Lanka. Further research will be carried out incorporating above suggested modifications to facilitate consumers with better features and enhanced usability.

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A Case for Domain-Specific Research into Seafarers' Use of English as a Lingua Franca

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***Abstract*— Due to ships' crews and offshore personnel being multicultural and multilingual, more than one variety of English is used in communication in ship-to-ship, ship-to-shore and on-board domains. Among these speakers of many Englishes, English is being used as a lingua franca. The use of English as a Lingua Franca (ELF) in this domain is characterized by features of the many varieties of English spoken by the interlocutors as well as characteristics of the native languages of the speakers engaged in ELF. Therefore, the incorporation of both World Englishes (WE) and ELF knowledge into the pedagogy of Maritime English (ME) is crucial. Prior to this inclusion, however, more domain-specific research should be conducted into the use of ELF in maritime contexts in order to understand the manner in which ELF interactions take place among seafarers.**

***Keywords*— English as a Lingua Franca (ELF), World Englishers (WE), Maritime English (ME), domain-specific research**

I. Introduction

In a study conducted into causes for miscommunication between ships and Japanese Vessel Traffic Service (VTS) officers it was found that poor communication between ships and VTS officers in Japan result not necessarily due to a lack of proficiency in the English language but as a result of varying accents spoken by seafarers who communicate with the VTS officers. In addition, contrary to the belief that native speaker's English is 'authentic' and thus easier to understand compared to non-native speakers who speak with accents, many of the informants of the study had rated English spoken by Korean, Indonesian and Thai seafarers as being clearer than English spoken by British seafarers [1].

These findings emphasize two points. Firstly, in the maritime industry in particular, more than one variety of English is spoken and, secondly, native-speaker English is not always more comprehensible than English spoken by non-native speakers. Therefore, these survey results mark the point where Maritime English, World Englishes and English as a Lingua Franca meet.

While theories pertaining to WE highlight and call for the acknowledgment of the diverse "nativized" varieties of English that have emerged due to exposure of the language to varying cultural and linguistic contexts, ELF refers to instances when English is used as the common language for interactions between people from diverse first language (L1) backgrounds. Both these perspectives then are applicable to contexts in which ME is used, since the usage of ME is characterized both by the presence of more than one variety of English and the usage of English as a lingua franca, i.e., a common language used between seafarers whose native languages are different. However, the pedagogy of ME is yet to fully embrace the fact of the usage of Englishes on board ship and the consequent use of ELF among seafarers.

This paper endeavours to highlight that ME pedagogy should be looked at from the perspective of ELF and then revised. Prior to this revision, however, in order to fully understand the manner in which ELF interactions take place among seafarers in ship-to-ship, ship-to-shore and on-board contexts, domain-specific research should be conducted into the use of English as a lingua franca in the maritime industry.

The first section of this paper engages in a description of the concepts of World Englishes and English as a Lingua Franca. Then, the evolution of Maritime English as English for Specific Purposes is discussed. Subsequently, the *Model Course 3.17: Maritime English* (2015) will be analysed from a World Englishes perspective. Lastly, suggestions will be made regarding factors that can play a significant role in research that will be conducted in the future into English as a Lingua Franca in the maritime industry.

II. 'World Englishes' and 'English as a Lingua Franca'

Within the term 'World Englishes' is the acknowledgement of the fact that there is not just one but many forms of English that are being used all over the world. This term can be used as an "umbrella term" which covers "all varieties of English worldwide and the different approaches used to describe and analyze them." World Englishes also "refers to the so-called new Englishes in Africa, Asia and the Caribbean" [2, p.139]. Speakers of English as a second or foreign language flavour the language with features of their own native tongue. This has caused the emergence of many Englishes, such as American English, Indian English and Sri Lankan English. In addition to highlighting the plurality of the English language, World Englishes assert that each of these varieties of English should be considered as being on par with the other. This claim has resulted in the attempt to blur the distinction between 'native' and 'non-native' speakers and suggests that each variety of English deserves equal status.

The multitude of Englishes that exists today is an end result of the unprecedented spread of English worldwide. Kachru [3] describes the three phases in which this dispersion of the language is considered to have taken place. The first phase occurred between 1535 and 1707 and was restricted to the British Isles. The next phase was brought about by the movement of English speaking people to different parts of the world like North America, Australia, Canada and New Zealand. The final phase brought the English language into contact with South and South-East Asia, the Philippines and South, East, and West Africa.

The third phase saw the English language being introduced to non-English speaking communities. English, therefore, came into contact with other major languages

which were neither genetically nor culturally related to the English language. In addition, the pedagogy of English took place in these regions with almost no input from native speakers of English. As a result, the language went through a process of acculturation and was influenced by the cultures and languages of the new users of the language [3]. This resulted in the emergence of many Englishes which did not abide by the rules of native speaker English.

Although each of these diverse types of English merits acceptance and recognition, due to theoretical, acquisition and pedagogical factors (among others), the study of the language gives prominence to English spoken by native speakers. The proficiency level of the "native speaker," for instance, acts as the standard that should be achieved by "non-native" speakers of English. Despite criticisms levelled against this dichotomy between "native" and "non-native" speakers, when it comes to acquiring the English language, what both the teacher and student of English as second/ foreign language aspire to is "native-like competence" [3, p. 141]. This lopsided framework is further strengthened due to the pedagogy of the English language not being revised, especially in the context of English for Specific Purposes, to meet the new challenges posed by the existence of many Englishes as opposed to one [3]. Since ME is a branch of ESP, the above-mentioned accusations can be considered true (in some instances) of the pedagogy of ME as well.

English as a Lingua Franca (ELF), on the other hand, is defined as "a 'contact language' between persons who share neither a common native tongue nor a common (national) culture, and for whom English is the chosen foreign language of communication" [4, p.211]. However, the words 'lingua franca' in the term 'ELF' do not refer to a monolithic language. Instead, ELF researchers believe that "anyone participating in international communication needs to be familiar with and have in their linguistic repertoire for use, as and when appropriate, certain forms (phonological, lexicogrammatically, etc.) that are widely used and widely intelligible across groups of English speakers from different first language backgrounds" [2, p.161]. Such a collection of features shared by varieties of English will be useful in the maritime industry where people from different cultural and linguistic backgrounds come into contact.

Research conducted into the use of ELF include the Lingua Franca Core (LFC) and Vienna-Oxford International Corpus of English (VOICE). The LFC is a culmination of Jennifer Jenkins's research conducted to "assess which phonological features are – and which are not – essential for intelligible pronunciation when English is spoken in lingua franca contexts" [5, p. 16]. For the formation of the LFC, field observations and recordings of interactions between non-native speakers of varying national and linguistic backgrounds were analyzed. What were identified as 'errors' which led to miscommunication between the speakers were identified as belonging to the LFC. What would be considered as 'errors' by native speakers but still would not interfere with mutual intelligibility were considered to be "non-core" and therefore not an issue where mutual comprehensibility in ELF interactions was concerned [5, p.16]. Therefore, the LFC contains 'errors' students should be taught to avoid, and syllabi should propose to be taught to students, if ELF interactions are to be meaningful and successful.

The VOICE is a corpus of ELF interactions based on which further research can be conducted. Some of the findings yielded by examinations into ELF data provided by this corpus point to several features of ELF communication; features that would typically be considered 'errors' by English language teachers but which do not necessarily trigger communication break-down between the speakers [5]. Therefore, both the LFC and the VOICE pave the way for a redefinition of what accurate pronunciation and grammar is in the modern world where English is widely being used as a lingua franca even in "influential networks" such as "global business, politics, science, technology and media discourse" [5, p.211].

Despite WEs and ELF being two different perspectives from which the use of English language is analyzed, they share a common ground in that both are "engaged in the same shared Endeavor to understand and confront the sociolinguistic challenges of a rapidly changing world" [6, p. 243]. As a result, ELF merits acceptance as being a part of the wider WE research community [6].

Although ELF interactions are very much part of today's world where people from different language backgrounds interact through various media, the conceptualization of ELF at present is characterized by "an inverse relationship" that exists between "perceived significance and relevance of English in the world at large" and "linguistic description focusing on the core native speaker countries" [5, p. 213].This observation is true, to a certain degree, of the pedagogy of ME as a branch of English for Specific Purposes (ESP).

III. Maritime English as English for Specific Purposes

ME is described as the device of communication that is used within the international shipping community. It contributes to the safety of navigation and facilitates seaborne business [7]. Today, ME is taught in Maritime Education and Training (MET) institutes as English for Specific Purposes or English for Special Purposes (ESP). ESP has been described as the teaching and learning of language skills needed by language learners in their professional careers [8]. Since ME is used by seafarers in a professional context, the teaching-learning process of ME is considered as an ESP.

After the United States Department of Transportation (USDOT) and the United States Coast Guard (USCG) conducted examinations into the role of the human element in maritime disasters, amendments were made to the Seafarers' Training, Certification and Watch-Keeping (STCW) Convention in 1995 and 2010, stressing the benefits of using a common working language on board [9]. Evidence showed that over 80% of all maritime accidents were the result of human error. The term 'human error' includes lack of "competence in English" [9, p. 216]. The STCW Code now mentions that the "adoption of a common language for maritime communications would promote safe practice by reducing the risk of human error in communicating essential information." It also states that, "although not universal, by common practice, English is rapidly becoming the standard language of communication for maritime safety purposes" [10, pp. 265-66].

In Chapter 5, Regulation 14 of the Convention for the Safety of Life at Sea (SOLAS) states that "on all ships, to ensure effective crew performance in safety matters, a working language shall be established and recorded in the

ship's logbook." The company to which the ship belongs, or the ship's captain, is bestowed with the power of determining what the appropriate working language should be. Every crew member of that ship should be able to understand, give orders and instructions and report back in that language which is decided as the working language on a particular ship. If the working language is not an official language of the ship's flag state, "all plans and lists" should be available in the working language [11, p. 465].

Where ship-to-ship and ship-to-shore communication is concerned, the SOLAS states that "English shall be used on the bridge as the working language for bridge-to-bridge and bridge-to-shore safety communication as well as for communications on board between the pilot and bridge watch-keeping personnel." The same sentence goes on to say that this should not be the case if "those involved in the communication speak a common language other than English" [11, p. 465]. This makes evident the fact that, with regards to ship-to-ship, ship-to-shore and onboard communication, although a working language on board a ship is of utmost importance, it does not have to be, and always cannot be, English.

This fact notwithstanding, in 1973, the Maritime Safety Community concluded that where language difficulties arise in seafaring, "a common language should be used for navigational purposes" and that this "language should be English" [12, p.iii]. Since then, attempts have been made to form a standardized language which could be used on board. The Standard Marine Navigational Vocabulary (SMNV) and its sequel, the Standard Maritime Communication Phrases (SMCP) along with the research project named Sea speak are examples of endeavours made to address the issues of communication in the maritime industry [13].

The stress laid on seafarers' ME proficiency caused the instruction of this subject to receive much attention. The International Maritime Organization (IMO) Model Course 3.17 (*Model Course 3.17: Maritime English)* is an elaboration and standardization of the ME curriculum and is designed to meet the requirements of the STCW 1978 as amended in 1995 and 2010 [14, p. 112].

IV. Model Course 3.17: Maritime English

The *Model Course 3.17: Maritime English* does take into account the fact that students of any maritime subject come from diverse "educational systems and cultural backgrounds" which has resulted in the need for the identification and definition of basic entry requirements in terms which are "universally acceptable" [15, p.1] That these model courses have been prepared keeping in mind the cultural diversity that characterizes the student population of maritime subjects is laudable. But the belief that diversity of this nature could be addressed and neutralized by using 'universally applicable terms' is problematic, especially in the context of teaching ME. Such notions, in the long run, make the pedagogy of the subject fall into the trap of advocating a monolithic language as a solution to communication issues faced by multinational and multilingual crew members on board ship.

The entry levels for the Specialized Maritime English (SME) courses described in the Model Course require students to have "at least a lower intermediate level of English." In other words, for these students to be considered 'suitable' to follow these courses, they should at least be able to "understand native speaker English talking at a measured pace with some rephrasing and repetition" [15, p. 24]. The courses in question are the SME courses for

1. officers in charge of a navigational watch on ships of 500 gross tonnage or more
2. officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine room
3. Electro-Technical Officers (ETO)
4. GMDSS Radio Operators

Similarly, the 'Intermediate' and 'Advanced' proficiency levels described in the Model Course involve the 'native speaker factor.' The former level of proficiency includes students who are "able to understand the essence of native speaker's English but may misunderstand detail." The latter refers to students who possess "near native-speaker proficiency in all aspects of communication" [pp. 24-5].

Should an MET institute follow the entry levels set down in the Model Course, the decision taken regarding whether a student is eligible to follow a ME course or not would be influenced by the extent of her/his ability to comprehend native speaker English. But in a context like the maritime industry, where speakers do not always have to converse with native speakers of English in ship-to-ship, ship-to-shore and onboard domains, the entry levels pivoting on 'native speaker English' does not make sense.

Although, with regards to ME entry levels, the Model Course seemed to promote native speaker English, it also does establish the fact that

> so many varieties of English are spoken worldwide that there is no single model of pronunciation and it is certainly not necessary to aspire to speak 'Queen's English.' There are more people now speaking in English as their second language than there are native speakers. We also have to remember that there are a range of 'Englishes' i.e., accepted variations of English with particular accents and linguistic styles, e.g. Indian English, Sri Lankan English, Malaysian English, Australian English; this is a very pertinent discussion area in EFL in this era of global communications [p. 143].

Despite the emphasis laid on World Englishes, the model course still seems to be caught in the native/non-native speaker dichotomy. In the Instructor Manual, the section that focuses on pronunciation advises teachers of ME to "minimize [students'] first language interference with English" [p. 143]. The phrase "first language interference" alone is suggestive of a variety of English that is not desirable and therefore should not be allowed to 'interfere' with a more desirable variety of English, i.e., Standard English. Once again, the Model Course seems to have steered away from the fact that both seafarers and teachers of ME are multilingual and multicultural and therefore will be at a loss about the type of English that should be aspired to and the variety that should be considered as 'interfering.'

While the emphasis made in the Model Course on limiting first language interference seemingly advocates the teaching of native-speaker English pronunciation, the section titled 'Teaching Listening' focuses on students' ability to comprehend non-native speakers of English. This section calls for the preparation of students "for the international

world of seafaring" which requires them to be able to comprehend "non-native speakers of English from many countries." In order to address this issue, it has been suggested that students be exposed to a variety of accents and be given practice in "recognizing and producing the common characteristics of informal speech" in order for them to understand and be understood by seafarers from different countries [p. 151].

V. Maritime English as a Lingua Franca

The encouragement made in the Model Course for seafarers to have a repertoire of common features of the varieties of the English language invites theory pertaining to ELF into the ME teaching-learning process. Unlike accent neutralization and the development of a common language that have been suggested as solutions to the issues of pronunciation and miscommunication in the maritime industry ([16], [17]), ELF does not refer to English as a single language. Instead, ELF researchers believe that those who participate in international communication should be familiar with certain phonological and lexicogrammatically structures of English which are used and understood by English speakers for whom English is not the first language. Seafarers too should ideally possess knowledge of such structures that would help them communicate with their colleagues in ELF interactions.

In Sampson and Zhao's study [13] which proposes that a 'bottom-up' approach to teaching ME is more favourable than a 'top-down' approach, many characteristics of ELF interactions that take place on board ship are highlighted. It has been found how, in maritime contexts where many Englishes are spoken, the several varieties of English merge and "common words and expressions enter into the "discourse of stable and long-established crews" [p. 40]. Indian and Bangladeshi officers, and Filipino ratings have been observed sharing a number of expressions that they had borrowed from each other. Speech patterns frequently used by Hindi speakers were then picked up by the Filipino ratings. Phrases used by Hindi speakers had been translated into Tagalog by the Filipino crew and used in communication. In addition, the Hindi word for 'small' and 'less' is the same, causing the Hindi speakers to use the English word 'less' to express both meanings. The Filipino seafarers had followed suit [13]. Therefore, not only is maritime ELF characterized by features of English spoken by non-natives, they are also inclusive of features of first languages spoken by the ELF speakers.

This new 'variety' is referred to as a pidgin language, "a language which develops when groups of people who speak different languages try to communicate with one another on a regular basis" [13, p. 40-41]. These features peculiar to maritime contexts point to the fact that, as opposed to using the LFC to achieve mutual intelligibility among seafarers and to aid ME instructors to approach English pronunciation teaching in a more systematic manner, research can be conducted into the nature of ELF interactions in the domain of the maritime industry.

The significance of incorporating ELF research findings into ME pedagogy has been highlighted by Choi and Park [18]. The writers suggest the usage of the LFC in ME teaching and then emphasize that, prior to including ELF in the ME classroom, several issues should be solved. These questions are regarding

> ~ the "critical phonological factors" that would "enhance intelligibility in a global context"
>
> ~ the number of accents that are "tolerable in general"
>
> ~ how speakers can be assisted to make themselves be understood despite their accents
>
> ~ how this can be achieved through classroom activities or self-study [p. 47]

The above are questions that a ME instructor has to grapple with while deciding what the "common characteristics of informal speech" mentioned in the Model Course are. Conducting domain-specific research would help solve these issues.

Domain-specific research is essential also because the already existing LFC findings will not necessarily represent the features of ELF interactions in the maritime context. Arguably, neither the LFC nor the VOICE would be able to provide an accurate insight into ELF in maritime communication. This is because the LFC was constructed based on data which was collected from speakers from a wide range of L1s in classroom contexts and social settings. Similarly, the data compiled in the VOICE is inclusive of instances of the use of ELF by speakers who represent a variety of first language backgrounds, in a range of settings and domains. Therefore, it could be argued that both the LFC and the VOICE cannot be considered as being reflective of the features of ELF in the shipping industry. Attention has to be paid specifically to ELF used in the maritime domain, where the vocabulary, for instance, would be very different from that used in a classroom setting.

Neither the data analyzed in order to construct the LFC nor the data of ELF compiled in the VOICE seem to include native speakers engaged in ELF communication. Indeed, since ELF interactions take place between non-native speakers of English, it could be argued that research into ELF need not focus on native speakers of English. But, the majority of ELF researchers believe that native speakers too should be included in ELF research since they too participate in intercultural communication [2]. This is true of the maritime industry too since the seafaring community is comprised of both native and non-native speakers of English. Therefore, arguably, domain-specific research conducted into maritime ELF scenarios should include native speakers of English as well, if knowledge of ELF is to be successfully incorporated into the ME teaching-learning process.

VI. Conclusion

In the maritime industry, due to ship's crews and offshore personnel hailing from various linguistic and cultural backgrounds, more than one variety of English is used. Among these speakers of many Englishes, English is being used as a link language/ lingua franca. Research conducted into ELF interactions of seafarers point to the fact that the use of ELF in this context is coloured by features of the several varieties of English being used as well as borrowings from the native languages of the speakers engaged in ELF. Although the pedagogy of English should take into consideration WEs and ELF theory and research findings, this is not the case at present, since the descriptions of the basic entry levels and some of the advice given to ME

instructors in the Instructor Manual of the Maritime English Model Course seem to be trapped in the 'native/non-native' speaker dichotomy. The incorporation of both WEs and ELF knowledge into the pedagogy of ME is crucial.

This is not to further a notion that proposals have not been made and research has not been conducted so far into the ELF interactions between seafarers. Research has found out that ELF interactions in the maritime domain is similar to a pidgin language. This language makes communication a possibility between speakers who use various Englishes. In addition, seafarers' ELF interactions can be colored with translations from the native languages of the interlocutors. If so, exploration into ELF in maritime contexts cannot be based solely on the LFC or the VOICE or any such ELF research studies which have been conducted with no specific focus on the maritime domain. Therefore, it can be argued that future research conducted into maritime ELF scenarios should be domain-specific, thus highlighting the features peculiar to the use of English as a lingua franca in the maritime industry.

Furthermore, although most ELF researches discount the native speaker, research conducted into ME as ELF should involve native speakers of English. This is because the maritime community comprises both native and non-native speakers of English. It could be argued that if the former group is left out, the entirety of the seafarers' population will not be represented in research conducted into maritime English as a Lingua Franca.

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Reading Samuel Beckett's Portrayal of the Self from a Buddhist Perspective

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***Abstract*— Samuel Beckett's evocation of the self through the discussion of the intertwined themes of language, relativity/dependency, memory, time and change invites diverse perspectives from which the self could be read. Beckett, through the delineation of the self as constantly revising itself in relation to its memories and the larger social exterior, portrays the self as fragmented and impermanent. The delineation of the self in the plays *Waiting for Godot* (1956), *Endgame* (1958) and *Krapp's Last Tape* (1958) as disintegrated, dependent and lacking in certitude, resonates with the Buddhist's consideration of the self as a mental formulation.**

***Keywords*— Theatre of the Absurd, Existentialism, the self, Buddhism**

I. Beckett, Existentialism and Buddhism

> "Life is habit. Or rather life is a succession of habits, since the individual is a succession of individuals. Habit then is the generic term for the countless treaties concluded between the countless subjects that constitute the individual and their countless correlative objects. The periods of transition that separate consecutive adaptations … represent the perilous zones in life of the individual … when for a moment the boredom of living is replaced by the suffering of being" [1, p. 59]

The above is a quotation from Samuel Beckett's *Proust*. It reflects Beckett's perception of the self as a series of habits. This interpretation of the self in particular, and a search for the self in general, characterize Beckett's plays which belong to the Absurd theatre convention or the Theatre of the Absurd.

In the term 'Theatre of the Absurd,' the word 'absurd' has not been used in the same sense as 'ridiculous.' It has been defined by Albert Camus as that "which is devoid of purpose." Absurd refers to the situation where a human being's "actions become senseless, absurd, useless" when s/he is "cut off from his religious, metaphysical, and transcendental roots" [1, p.23]. In other words, the disconnection between the human and the framework that once explained the world to her/him results in a lack of purpose which is termed Absurdity. Theatrical work which reflects this condition is called Absurd theatre.

Beckett's exploration into the "problem of being" and the "identity of the self" [1, p.29] has led to the association of the playwright with Existentialism, a philosophy which holds that "human beings simply exist in a universe that does not have an overarching moral order or meaning" [2, p. xiii]. The Existentialist philosophy concerns the plight of the individual in an environment which was made alien to her due to the deconstruction of mechanisms that once explained the world around her. Although Beckett has been associated with Existentialism, connections have been made between Beckett and Buddhism too. Davies [3] goes to the extent of stating that Beckett's "correspondence with the Buddhist account is exact" and that "his constant stress on indices on name, age, gender and station" is ever so often "misappreciated as absurdist aesthetics" [p.119], emphasizing the possibility of reading Beckett's texts from a Buddhist perspective.

Beckett's preoccupation with the self and his deconstruction/fragmentation of the notion of the self is conveyed to the audience through his exploration of the overlapping themes of memory, time, change, language, dependency, and relativity, all of which are factors discussed in relation to the self. This is also reflected in his placing of his characters in a vacuum or a 'nothingness', divorced from the larger social exterior. In his plays, the idea of language being a medium of self-expression, and a meaning-making device, is challenged. Any connection between memory and the construction of the self is subverted. The notion of individuality, or the freedom of the self, is problematized through the portrayal of the self as existing in relation to and dependent on factors, both internal and external to the self. If the self is moulded into shape by the combined machinations of time and change, and has to be defined in relation to the Other, it lacks certitude and independence and therefore cannot be termed a fixed entity that one brings along into the world when one is born. The idea of the self or "I" being a mental creation, in a constant state of flux, and therefore beyond our control, negates the consistency of the self and as a result borders on the concept of the 'non-self' or the Buddhist Doctrine of No-Soul or *Anatta*, which considers the self to be an "imaginary, false belief which has no corresponding reality" and "den[ies] the existence of …a soul, Self, or *Atman*" [4, p.51].

In this paper, the plays *Waiting for Godot* (1956), *Endgame* (1958) and *Krapp's Last Tape* (1958) will be analyzed with regard to how Beckett deconstructs and fragments the self via his treatment of the themes of language, memory, time, change, dependency and relativity. This research will be based on (and limited to) textual analysis of these three plays, which will be henceforth referred to as *WFG*, *E* and *KLT* respectively. Therefore, the evocation of the self through performance would not be looked at. The choice of these plays was influenced by their consistent engagement with the themes mentioned above.

In the first section of the paper, Beckett's devaluation of language as a meaning-making device and the simultaneous creative employment of language are discussed in relation Beckett's portrayal of the self as fragmented. The delineation of the self as being dependent on both the interiority of the self and the larger social exterior for its definition is focused on in the second section. Lastly, the treatment of the interconnected themes of time, memory and change and the resulting deconstruction and fragmentation of the self is discussed.

II. Language, the 'Accusative I' and the Unsayable

In Beckett's plays, the idea of language being a form of self-expression and a meaning-making device through which an individual connects to her/his surrounding, is challenged. To have a sense of self, or to be an individual, one must be able to speak for oneself in the "first person: every language offers that possibility, in its own grammar" [5, p.56]. In addition to aiding self-expression, language is considered to be the "appropriate site of political understanding" [6, p.309]. In the Theatre of the Absurd, which is characterized by a "devaluation and disintegration of language" [1, p. 406] and "a turning away from language as an instrument for the expression of the deepest levels of meaning" [p.328], language is neither a medium of self-expression nor a tool of political understanding or action. It ceases to function as the mediator between the self and the environment and is made to assume the position of an object with its meaning-making abilities put to test.

Beckett makes language one of his many theatrical devices as well as one of the subjects/ themes of his plays. His use of language "probes the limitation of language both as a means of communication and as a vehicle for the expression of valid statements, an instrument of thought" [1, p.85]. Through this objectification of language, Beckett equates language and content with one of the realities of his time, the postmodernist notion which states that

> if language itself lacked stable referentiality [...] and was fundamentally arbitrary in its relationship to the objects and concepts it described, then all kinds of intellectual theories and processes of cultural enquiry [...] could have no claim to reflect reality or posit objective truths [7, p.179].

The dramatist's focus was on the plight of the human being in a society in which every social system, including that of language, had crumbled. Arguably, through using language creatively, Beckett strives to express the difficulties and consequent inability of the self to express itself using a device which has become dysfunctional.

The act of conversing, from a linguistic perspective, is a "ritualized process which allows the participants to construct and project desirable versions of their identities in a succession of performances targeted at specific audiences" [8, p.415]. Contrary to this view, Beckett's use of dialogue does not reflect the character's identity or sense of self. In *WFG*, the more Vladimir and Estragon talk, the more their selves seem fragmented since their everflowing conversation itself is incoherent and keeps on negating any impression the audience might have created of the characters at the beginning of the play. Therefore, Vladimir and Estragon never project desirable versions of their identities. Instead, their sense of self is a series of impressions; one emerging after the other in quick succession, with the newer 'self' serving to negate the older one. This portrayal of the self is also similar to the description of the post-structualist self which is that an individual has many selves which are propagated by the diverse contexts the individual is made to situate her/himself in [8]. Contrary to this poststructuralist view however, although Vladimir, Estragon, Hamm, Clov, Nagg and Nell, and Krapp are mentally transferred into the past via memories and have many conversations and monologues in the plays, they still remain disintegrated selves deprived of individuality.

From a sociological perspective, mastery of language is crucial in a person's efforts to distinguish herself as a social object. Therefore, the act of "learning one's own name is one of the earliest and most important steps in acquiring a self" [9, p. 82]. Interestingly, never do the protagonists in the three plays dealt with in this paper identify themselves using their names. In the plays, language is deprived of its status as a contributor to identity formation. The dramatis personae of *WFG* include Vladimir and Estragon, but in the course of the drama these characters call each other Didi and Gogo and never Vladimir and Estragon. At the conclusions of both Acts, Vladimir responds when the Boy calls him Mr. Albert-

> Vladimir: Approach, my child.
> [Enter BOY timidly. He halts]
> Boy: Mr. Albert?
> Vladimir: Yes... [10, p.42].

Vladimir's response, in turn, makes the audience wonder whether Vladimir's name is Vladimir or Albert, adding to the sense of uncertainty. Similarly, in another instance, Pozzo responds when Vladimir and Estragon call him both Abel and Cain, causing Estragon to exclaim "He's all humanity"–

> Vladimir: I tell you his name is Pozzo
> Estragon: We'll soon see. [He reflects]. Abel! Abel!
> Pozzo: Help!.....
> Estragon: Perhaps the other is called Cain. Cain! Cain!
> Pozzo: Help! (p. 76).

Beckett's use of language could be read in the light of Derridean deconstruction which builds on the principles of poststructuralist theory and suggests that the linguistic system, or the relationship between the signifier/word and the signified/referent, is one of *differance*. The word "differance" is described as "sameness which is not identical" [11, p.278], which, when applied to language and meaning making, would suggest the gap or delay between a word and the object it refers to. In this play, Estragon wonders what day it is and this leaves Vladimir "looking wildly about him, as though the date was inscribed in the landscape" [10, p.7], bringing out the idea that the name of the day of the week is merely a construct and has no corresponding object in the real world. Elsewhere in the play, the stage directions read "Estragon gesture[s] towards

the universe" and "Vladimir uses his intelligence" [10, p.8]. The use of the words 'universe' and 'intelligence' as though they refer to tangible objects, as opposed to abstract concepts, evokes the arbitrary relationship and the gap or slippage that exists between the signifier and the signified.

In a world where change is wrought due to the passage of time, language cannot remain fixed and rigorous. It is this inconsistency of language that Beckett explores in his plays. Dialogue between Hamm and Clov, in *E*, points to how words are rendered meaningless when deprived of a meaningful context, or when the context is wrought with changes according to which language has not been updated. In reply to Hamm's exclamation "Yesterday! What does yesterday mean? Yesterday!", Clov says –

That means that bloody awful day, long ago, before this bloody awful day. I use the words you taught me... [12, p.33].

Seemingly, Hamm himself has forgotten the words he taught Clov and, in this particular instance, the word 'yesterday' has no meaning in a context where the concept of time, as Hamm puts it, "[...] was never and [...] is over" [62]. Thus, the signifier remains while the signified no longer exists.

In *KLT*, Krapp's disembodied voice from the past lacks the context in which they were originally spoken and this evokes the contingency of language on a particular context in order to be meaningful. On hearing his own recorded voice use the word 'viduity', Krapp looks it up in the dictionary, having forgotten its meaning. He reads the dictionary definition of the term and concludes that the younger Krapp used the term with reference to "the vidua-bird" as opposed to the "state or condition of being or remaining a widow or widower" [13, p.18] when, in fact, young Krapp uses the word to convey the latter meaning. This too challenges the concept of fixed meaning. The dictionary definition of the term 'viduity' elicits the fact that this word has two meanings. It is only through its placement in a meaningful context that any sense could be given to the word 'viduity', in particular, and to all words, in general.

However, Beckett does engage himself in creative use of language. Katz [14] argues that Beckett 'grammaticalizes' the self, offering it a "middle-space," a location in between the nominative/subjective case and the accusative/ objective case. In other words, Beckett allocates the self a position which is neither 'I' (the subject) nor 'me' (the object). This "middle-space" is named "accusative I" and hints at an "accusative existence." Beckett's "accusative I" is described as "one of the most significant of Beckett's stylistic inventions" [14, p.187]. Therefore, the "accusative I" becomes an example of Beckett's experimentary and creative use of language. Katz [14] highlights an accusative existence which pervades much of Beckett's novels, meaning that 'I' in the novels are never given a nominative or accusative position. The 'I,' in one of Beckett's novels titled *Texts for Nothing,* is bestowed a liminal position via the use of language, as is highlighted in the following excerpt –

> Where would I go, if I would go, who would I be, if I could be, what would I say, if I had a voice, who says this, saying it's me? Answer simply, someone answer simply. It's the same old stranger as ever, for whom alone accusative I exist, in the pit of my inexistence, of his, of ours, there's a simple answer [14, p.184].

The 'I' in this passage exists in the accusative/ as the object; it exists for "the same old stranger". Therefore, the stranger, the 'I' and 'him' become one. The "accusative I" functions to blur the distinction between the nominative/subject and accusative/object cases. Therefore, what Beckett portrays as the body or the self occupies a liminal position, in between the two cases, belonging to neither. This particular portrayal of the self highlights the limited possibilities of expression that language offers.

Beckett's use of the "accusative I" is not limited to his novels. In *KLT*, the recorded Krapp himself hints at an accusative existence in the following excerpt –

...With all the darkness around me I feel less alone [...] In a way [...] I love to get up and move about in it, then back here to ... *(hesitates)* ... me. [...] Krapp. [13, p.14-15]

In this passage too, the 'I' and 'me' are the same person, Krapp. Like Pozzo and Lucky in *WFG*, 'me' seems to hold 'I' on a leash. 'I' returns to 'me' similar to how Vladimir and Estragon unite at the beginning of the two Acts in *WFG.* Therefore, Krapp is positioned in this liminal space, in between the 'I' and 'me', the nominative and the accusative.

The in-between space Beckett allocates for the body/self through the use of the "accusative I" is in line with what is called the "unsayable" or the "unheeded neither"[3]. Davies [3] writes that neither self-expression nor its absence is a pre-requisite for being human. This is because language is "error-prone." The truth or the "real refuge" for both Beckett and the Buddhist is the unsayable, the "openness of question," as opposed to the "fabrication of answer," since self-expression is only "a chimerical apparition" [p.120-5] or a fantasy where no self subsists. If so, the accusative I and the unsayable, both of which are middle-spaces, can be considered as being equivalent to the non-self, or the Doctrine of No-Soul.

III. Dependent Existence and Relative 'Selves'

The theme of relativity/dependency is evoked via Beckett's characterization of the dramatis personae in *WFG*, *E* and *KLT* as being dependent on each other or defining themselves in relation to the other. In *WFG*, Vladimir and Estragon are delineated as friends who cannot do without each other. The relationship between Pozzo and Lucky is a master-slave relationship which is reversed to a certain extent in the course of the play. In *E*, Hamm and Clov, and Nagg and Nell are two pairs of characters who depend on each other. In *KLT*, the older Krapp finds his 'other half' in his younger self to whom he listens via his audio archive. Esslin [1] describes these relationships as being characterized by "mutual interdependence" [p.67]. This very interdependence invites into the analysis of Beckett's plays the Buddhist "theory of relativity" according to which "everything is conditioned, relative and interdependent" [4,

p.53], thereby highlighting how Beckett's portrayal of the self resonates with the Buddhist perception of the self.

In *WFG,* Vladimir and Estragon define themselves as friends while for most of the play Pozzo and Lucky are slave driver and slave respectively but the hierachical relationship which characterizes the latter pair is not allowed to last for the entire length of the play. When Pozzo and Lucky reappear in the second act, not only are they "cruelly deformed by the action of time" [1,p.52] physically, this transformation has also resulted in severing the master-slave relationship with the master depending on his slave's sight. Thus, the action of time has changed circumstances, rendering the blind Pozzo dependent on Lucky for sight, with the latter seemingly having gained a certain degree of superiority despite still being dependent on his master. Conversely, Hamm and Clov are equally interdependent, with Hamm needing Clov to serve him and Clov needing the combination to Hamm's cupboard. But both Hamm and Clov deny their dependence on each other at the beginning of the play –

> Hamm: We aren't beginning to... to... mean something?
> Clov: Mean something! You and me, mean something!
> *(Brief laugh)*
> Ah, that's a good one! [12, p.40]

Nevertheless at the end of the play both acknowledge that they have been of help to each other –

> Hamm: I'm obliged to you, Clov. For your services
> Clov *(turning sharply)* : Ah pardon, it's I am obliged to you.
> Hamm: It's we are obliged to each other. [p. 90]

Therefore, the characters of *WFG* and *E* are portrayed as dependent on other characters for the definition of their selves.

The pairs of characters who find each other indispensable have been referred to as "pseudocouples" [15, p.464]. There is a multitude of interpretations given to this term. For instance, Hamm and Clov are considered "vice-existers" with "the former symbolizing the instinctual and tyrannical side of the mind and the latter the intellect" while other such couples were regarded as representing the relationship between "body and mind". They are also read as "halves of a singular personality", halves that constitute a "single figure" which could be viewed from different perspectives, with the contrasting nature of the "two interlocking profiles" suggesting "the contrasting nature of the self and its other." Most of these pairs remain intact throughout the plays not due to their "harmonious friendships but out of fear, guilt and [...] the need to be witnessed," a reading which emphasizes the dependency of these characters on each other for recognition and acknowledgement.

The theme of relativity/ dependency is arguably best embodied in *KLT* where Krapp's present self is predicated upon and is a reaction to and a revision of one of the previous 'selves' he listens to. In fact, Krapp has been engaged in this process of definition and redefinition of himself throughout his entire life as is made obvious when Krapp's recorded voice claims that he had "[j]ust been listening to an old year, passages at random" which makes him exclaim that it is "[h]ard to believe I was ever that young whelp" [13, p.15-16]. At the end of the play, the older Krapp denounces the younger self he listened to on the tapes. The two Krapps we simultaneously hear share "an ability to laugh at the aspirations of an even younger Krapp" [16, p. 90]. This ability represents moments where the older Krapp observes his younger self commenting on yet another younger self – the "young whelp". This image is aptly described as being akin to seeing "a face being endlessly reflected between two mirrors", a face which "can hardly recognize its own reflection" [p.90]. Quite unlike a reflection in the mirror however, this series of Krapps is projected onto different time spaces; the older Krapp transports himself into the past while Beckett, via stage directions, projects the old Krapp, along with the audience, into a "late evening in the future" [13, p.9]. Nevertheless, the metaphor of the mirror serves to appropriately describe the image created via this play. The image is that of a self rooted in and growing out of a former self, thereby creating an endless string of selves. These selves interact with former self/selves for their definition and validation.

The dependence of the self on a larger exteriority is evoked in *WFG* via the nameless character of the "Boy". Despite there being only one "Boy" listed in the dramatis personae, both Vladimir and Estragon along with the audience, at the end of the second Act, are under the impression that the Boy who appears in the second Act is not the same as the Boy who appears in the first Act. Even the Boy exists 'in the accusative'; each boy exists in relation to his brother, therefore dependent not on the interiority of the self but on external circumstances. The Boy in the first Act is not the Boy in the second Act because he is the minder of the goats and not the minder of the sheep, for instance. Therefore, although the Boy, like Krapp, appears in isolation and not as a "half" of a pseudocouple, Beckett makes the other characters in the play and the audience define the Boy in the first Act in relation to the Boy in Act Two and vice versa, thereby highlighting relativity and dependency as indispensable to the process of self-formation. This is in keeping with psychoanalytic theory which identifies the inability to recognize difference as a problem of the formation of selfhood [17, p.35]. This suggests that in order to posit a sense of self, one should inevitably recognize the difference between oneself and the other or see oneself in relation to another.

IV. Memory, Time, and Change

In *WFG*, *E* and *KLT*, the cultural concept of time is problematized while the traditional link between memory and the process of self-formation is disrupted. Jelin [18], in an explanation of the significant role memory plays in the construction of the self, states that it is "the possibility of activating the past in the present that defines personal identity and the continuity of the self over time." When memory is viewed in relation to time, memory cannot be chronologically arranged since "the present contains and constructs past experience and future expectations" [p.4]. In

Beckett's plays however, the flow of time makes one face the fact that the self is in constant flux [1]. Davies [3] presents another argument from the Buddhist perspective, suggesting that Beckett does not engage in the deconstruction of "the values associated with time and the passing of time." Instead, it is suggested that Beckett's portrayal of time is an "effective recognition that in reality there is nothing to desconstruct" since there was "nothing in the first place" [120-1]. In Beckett's plays, the passage of time causes some of his characters to forget and this in turn causes changes in the personalities of these individuals. This severs any connection between the power to recall and self-formation. Therefore, Beckett, once again, thematically fragments the self, depriving it of a sense of fixity.

The concept of time in the plays *WFG, KLT* and *E,* is problematized to different degrees. For Vladimir, "time has stopped" [10, p. 29]. For Hamm, "time was never and time is over" [12, p. 92]. Moreover, the 'language of time' is no more – "That means that bloody awful day, long ago, before this bloody awful day. I use the words you taught me. If they don't mean anything anymore, teach me others..." [p. 51] – meaning that no meaningful discourse on time could ever take place again. In a context in which both the frameworks of time and language have crumbled, memory cannot be expressed in relation to time. It is impossible to anchor memory in time, to make "reference to the 'space of experience' in the present" or to read memory in relation to the "'horizon of expectations'" which "introduces a reference to a future temporality" [18, p.4]. Therefore, many of the characters in *WFG* and *E* have deficient memories. Pozzo claims his memory is "defective" [10, p.31] and Estragon either "forget[s] immediately" or "never forgets" [p.52].

Conversely, in *KLT,* Krapp is equipped with the ability to record memories and have them played back to him in different time spaces. In other words, Krapp is able to revisit his past repeatedly, this recollection and repetition assisting him to have a clear memory and also a stronger sense of self. However, in *WFG,* Vladimir, Estragon, Pozzo and Boy are all deprived of the capacity to recollect, to remember and therefore have almost no memories. Thereby, an uncertainty is attached to, and in turn results in a fragmentation, of their sense of self. If the "singularity of memories and the possibility of activating the past in the present" is what "defines personal identity and the continuity of the self over time" [18, p.4], it would logically follow that a person's inability to recollect or to remember would deprive her/him of a sense of self. Through depriving his characters of both the power of recollection and a sense of self or identity, Beckett arguably highlights the self's dependence on something as transient as memory, which robs the former of any fixity. This particular reading of the self resonates with the Buddhist negation of the existence of an "abiding, immortal substance in man or outside" [4, p.55].

Interestingly, Krapp seems not to revisit his past randomly. The processes of recollection and repetition he engages in are preceded by careful selection. He does not listen to any tape that he lays his hands on. Instead he selects "box...three...spool...five" [13, p.12]. This process of selection resonates with the statement that the "subject selectively takes certain signposts, certain memories that place him or her in relation to 'others'" [18, p.14]. These selected memories assist a person to sustain her/his identity and sense of self. Apart from Krapp, Pozzo too selects memories in order to restructure his self. Pozzo, after an emotional outburst says –

> Gentlemen, I don't know what came over me. Forgive me. Forget all I said. [*More and more his old self*] I don't remember exactly what it was, but you may be sure there wasn't a word of truth in it….. [10, p.27].

In this instance, Pozzo forgets, or pretends to have forgotten what he just said, and by doing so he returns to being his "old self". There seems to be a manipulation of memory on Pozzo's part; he denies the memory of his repentant self and asks the others to do so too, in order to be his former authoritative self. This is suggestive of two ideas. Firstly, it points to the notion of memory being selective. Secondly, it insinuates that the self is dependent on forgetting as much as it is contingent on recollecting.

Beckett's characters refer to or embody the theme of habit, or habitual memory. Jelin [18] describes daily life as comprising patterns of behaviour that are habitual, non-reflective, learned and repeated. "The past of the learning process and the present of its memory turn into habit and tradition" [p.15]. This perception of existence is clearly reflected in *KLT* where Krapp is addicted to revisiting his past selves and formulating a fresher sense of self. For Vladimir, "hours are long, under these conditions, and constrain us to beguile them with proceedings which... may at first seem reasonable, until they become a habit" [10, p.72]. The void Beckett portrays seems to be full of such 'habits'. *E* elicits this idea of memory-turned-habits, which can be considered to be intrinsic to one's sense of self and identity. Clov constantly questions the part of his consciousness that constitutes habitual memory - "Do this, do that, and I do it. I never refuse. Why?" [p. 50] Later on in the play, Clov, in what seems to be a rather philosophical utterance, brings forth the idea of how habit has shaped his sense of being and, in order to be who he wants to be, or another self, he would have to let go of his habits. But, Clov feels "too old…to form new habits" and therefore his life of servitude will "never end" and Clov would "never go" [p.50], leaving Hamm behind. For Beckett, "habit is the ballast that chains the dog to his vomit... Life is habit. Or rather life is a succession of habits, since the individual is a succession of individuals" [1, p.59]. Therefore, life, in Beckett's plays, is portrayed as a habit, a composite of repeated memories, a farce. Nell questions "Why this farce, day after day?" [10, p.40]. Later on in the play, Clov echoes her and Hamm replies "Routine. One never knows" [p.40].

Unlike the characters in *WFG*, those in *E* and *KLT* are bestowed with the ability to recollect or to remember. Krapp's capacity to select, frame and repeat memories until they become part of a routine, however, does not give back the self any validity which Estragon's inability to recall had deprived the self of. Instead, the very fact that memories undergo mental processes of selection, framing and repetition makes the self similar to what in Buddhism is called a "mental projection" [4, p.55]. If the self comprises

memories which are constructions, then the self too becomes a creation.

WFG is described as exploring a "static situation" [1, p.46]. The play is stationary in terms of plot since *WFG* has no story line and the two Acts are almost identical in terms of the incidents that take place. In *E,* "time is the same as usual" [12, p.10] and this refers to either a static situation or the monotony of repetition which makes one think that today's "time" is the same as yesterday and the day before. Although Clov claims that time is the same as usual and that "Nature has forgotten [them]", Hamm maintains that this cannot be the case – "But we breathe, we change! We lose our hair, our teeth! Our bloom! Our ideals!" [p. 18]. Hamm recognizes the passage of time and the change it has brought, and continues to bring about. Therefore, via these plays, Beckett explores the minute changes time wreaks on the characters and the environment. For instance, the machinations of time are evident in the drastic changes Pozzo and Lucky have undergone by the time the audience encounters them in Act II [10]. Also, Estragon's seeming loss of memory makes evident the change wrought in his conscience through the passage of time. Thus, *WFG* does not explore a static situation. Neither is nature portrayed as fixed. Instead, it could be contended that this play, along with *E,* highlights the idea that change takes place even in what seems to be a stagnant state of affairs. As Estragon puts it, "[time] would [pass] in any case" [10, p.41], changing matters as it takes its course.

V. Fragmented Selves and the Doctrine of No-Soul

Beckett's evocation of the self through the discussion of the intertwined themes of language, relativity, dependency, memory, time, and change invites diverse perspectives from which the self could be read. These perspectives include the Buddhist point of view. Beckett goes beyond the mere portrayal of the self and its tribulations in a disintegrated, absurd world. In *WFG, KLT* and *E* he proceeds with a process of deconstructing the self. It is this very disintegration of 'selves' that invites a Buddhist perspective into the analysis.

In the three plays discussed above, language functions neither as a medium of self expression nor as a means through which the characters in the play could connect with the ever-changing environment. In other words, Beckett deprives language of its status as a naming system and a means through which the speaker can project her/his identity and connect with the surrounding s/he is in. Alongside this disintegration of language, Beckett engages in the creative use of it too. Through the invention of the "accusative I" for instance, Beckett allocates a liminal space for the self, which belongs neither to the nominative nor the accusative. This middle-space allocated to the self can be equated to the concept of the unsayable which refers to that which cannot be expressed. The notion of the unsayable suggests that that there is nothing sayable in a world where no self subsists. Therefore, Beckett's deconstruction of language results in the fragmentation of the self and, when read in the light of the notion of the unsayable, Beckett's portrayal of the self as fragmented borders on the Buddhist doctrine of No-Soul.

In Beckett's plays, the self is portrayed as being dependent on the interiority of the self, other characters and the larger social exterior for its definition and validation. Beckett, through his portrayal of accusative existence through the use of "accusative I" and the pseudocouples, suggests the idea of the self being defined in relation to and dependent on both the interiority of the self and external factors. This aspect of the formation of the self is in keeping with the Buddhist theory of relativity according to which everything is relative and interdependent.

The playwright's treatment of the themes of memory, time and change within seemingly static situations, serve to portray the self as perpetually subject to change which is brought about by the passage of time. In addition, in the plays, the traditional link between memory and self-formulation is subverted. The disintegration of the 'language of time' or the concept of time in the plays makes it impossible for the characters to anchor their memories in time or to express their recollections in relation to time. Also, the inability to recollect, which is displayed by most characters in the plays, highlights the degree to which the self is dependent on something as short-lived as memory for its existence. Thereby, a transient quality is attributed to the self, robbing the latter of any sense of permanence. This portrayal of the self resonates with the Buddhist perception of the self. The evocation of the 'impermanent self' is similar to the Buddhist perception of the sense of self which is that, in an individual, there is no everlasting and absolute entity, named the self. Where the characters do have the power to recollect, select, frame and repeat memories, the self becomes, what is from a Buddhist lens, a mental projection. For instance, in *KLT,* where the self is delineated as always predicated upon the memory of a previous self, the self is reduced to a momentary, mental formulation.

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The Scope of Colonial Writing in Enhancing Sri Lankan Cultural Diplomacy

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***Abstract*— Culture is a necessary ingredient in the definition of a nation. Cultural diplomacy is the use of cultural values and norms by nations in the processes of strengthening, revising, or redefining their national identities both within the country and externally. Works of literature are among the many tools of cultural diplomacy. As a source of soft power widely used by countries in their relationships with foreign nations, cultural diplomacy has been criticized from a postcolonial perspective for contributing to the homogenization of cultures and nations. This paper argues that, where Sri Lankan cultural diplomacy is concerned, certain literary representations of Sri Lanka as was seen through the colonizer's gaze could be used in order to construct national culture, strengthen national identity and portray a more holistic picture of Sri Lanka to the world.**

***Keywords*— Culture, cultural diplomacy, postcolonial criticism, national literature**

I. Introduction

Erstwhile colonized peoples have always had to battle with misrepresentations made of their ways of life and disseminated to the world by colonizers. In 1561, an English merchant named John Locke, who sailed to west Africa, chose to represent African people as "beasts who have no houses" and "people without heads, having their mouth and eyes in their breasts" [1]. In *Heart of Darkness,* Joseph Conrad "projects the image of Africa as the 'other world', the antithesis of Europe and therefore of civilization, a place where man's vaunted intelligence and refinement are finally mocked by triumphant bestiality" [2,p.3]. It is this homogenized, distorted image of Africa as Europe's 'Other' that African authors deconstructed through the postcolonial enterprise of writing back to the Empire in defense of their cultures. Writers like Frantz Fanon and Chinua Achebe wanted such generalizations of African cultures dispelled via the emergence of African national literatures which conveyed more detailed portrayals of the experiences of the peoples of the former colonies [3], [4].

Since postcolonial writers focus on resisting distorted and homogenized versions of themselves through the reconstruction and revival of their national cultures through literature, it could be argued that such literary works can be used as agents of cultural diplomacy. Cultural diplomacy is the use of culture for diplomatic purposes. It includes "promotion of a culture … ideas, history, art, a system of values and tradition" with the aim of "fostering mutual understanding between nations" [5, p.9] This form of diplomacy is the use of culture to 'promote' a nation and also to ensure harmonious negotiations and reciprocated understanding between state and non-state actors at an international level.

Arguably, it is with intentions similar to postcolonial African writers that Ven. Dharmapala reminds the "young men of Ceylon" that they belong to a "superior race, whose ancestors had achieved the highest possible social progress" and that it is their duty to revive and restore Ceylon's "lost individuality" to what it was before [6, p.514-15]. The youth of Ceylon are urged to act as patriots should for the preservation of the nation, its literature, its land and "most glorious religion" [p.501]. On the contrary, Thomas Anderson, Ceylon's "soldier poet," in "A Wanderer in Ceylon: A Poem in Three Cantos," delineates the Ceylonese people as a "savage foe" who were overawed by the "superior science" of the colonizers who constructed "majestic walls" to strengthen the "slippery footing" they had on the "infant empire" [7].

But, contrary to how Anderson perceived Sri Lanka, formerly known as Ceylon, back in the day and in keeping with Ven. Dharmapala's description of the nation's history, literature and religion, Sir James Tennent writes that

> [t]here is no island in the world, Great Britain not excepted, that has attracted the attention of authors in so many different ages and so many different countries as Ceylon. There is no nation in ancient or modern times, possessed of a language and literature, the writers of which have not at some time had made it their theme. Its aspect, its religion, its antiquities and productions have been described as well by the classic Greeks, as by those of the Lower Empire; by the Romans; by the writers of China, Burma, India and Kashmir; by the geographers of Arabia and Persia; by the medieval voyagers of Italy and France; by the annalists of Portugal and Spain; by the merchant adventurers of Holland and by the travelers and topographers of Great Britain [8, p. xxiv]

This statement provides evidence of the fact that ancient Ceylon was closely studied and archived in the form of literature by foreign nationals from all over the world who stepped on the island as way back as when the Greek and Roman empires flourished. These perspectives provide knowledge of lifestyle and traditions of the people of the island in the past; knowledge that could be used to mould the cultural identity of contemporary Sri Lanka, both internationally and within the country. Therefore, unlike what seems to be the case with the colonizers' take on Africa, some descriptions of Sri Lanka as was seen through the imperialists' gaze seem to be in Sri Lanka's favour. This paper argues for the use of this perspective in Sri Lankan cultural diplomacy.

The first section of this paper engages in defining cultural diplomacy, its nature and functions and the role it plays in the definition of a nation both within a country and without. Some examples of Sri Lankan cultural diplomacy are then focused on. In the second section, criticisms levelled against cultural diplomacy from a postcolonial perspective are highlighted along with the perceived potential of cultural diplomacy in the preservation of the individuality of cultures that exist worldwide. The use of literary works as cultural diplomacy and the challenges that could be met with are highlighted subsequently. Lastly, excerpts from texts written from the colonizers' perspective that can be used in Sri Lankan cultural diplomacy are analysed.

II. On Cultures, Nations and Cultural Diplomacy

Diplomacy is "the conduct of relationships, using peaceful means, by and among international actors, at least one of whom is usually governmental" [9, p.2]. It is a concept that belongs to the study of International Relations. In this definition, the term 'international actors' encapsulates states and the greater part of diplomacy involves relations between states directly, or between states, international organizations, and other international actors. If so, cultural diplomacy is a branch of diplomacy that makes use of culture to 'promote' a nation and also to ensure harmonious negotiations and reciprocated understanding between state and non-state actors at an international level.

According to the Mexico City Declaration on Cultural Policy, "every culture represents a unique and irreplaceable body of values since each people's traditions and forms of expression are its most effective means of demonstrating its presence in the world" [10, p.1]. A culture could therefore be described as a collection or an archive of values, norms and taboos upheld by a particular community, an assortment of practices, both past and present which can represent that specific community to the rest of the world.

Culture has always played a significant role in the delineation of a nation. The nation is considered to have three ingredients – will (which ranges from "voluntary adherence, determination and loyalty" to "fear, coercion and compulsion"), culture, and political units [11, p.53]. The Western nation state is also described as "an obscure and ubiquitous form of living the locality of culture" [12, p.199]. Therefore, culture is a necessary ingredient in the description of a nation.

Cultural diplomacy does not, however, constitute the innocent dissemination of the culture of one's country in the international forum. On the contrary, it is the deploying of cultural values and norms worldwide in order to manipulate the impression others have of one's nation. Cultural diplomacy is linked to the concept of soft power. Soft power "rests on the ability to shape the preferences of others." It "co-opts people rather than coerces them." This power to co-opt "can rest on the attractiveness of one's culture and values or the ability to manipulate the agenda of political choices in a manner that makes others fail to express some preferences because they seem to be unrealistic." A country's soft power is comprised of three factors which are "its culture (in places where it is attractive to others), its political values (when it lives up to them at home and abroad) and its foreign policies (when they are seen as legitimate and having moral authority)" [13, pp.5-11]. If culture and soft power co-constitute each other, so do cultural diplomacy and soft power.

Cultural diplomacy is not restricted to interactions that take place between or among international actors alone. It can be made use of within the nation-state itself. Cultural diplomacy is "not only a case of promoting a country's image to foreigners but also to its own citizens." In other words, cultural diplomacy "begins at home" [5, p.13]. Both Japan and China have used cultural diplomacy to promote their nations among their own citizens. Japan used it to "change [its] own perceptions of itself" with the belief that "Japanese people should foster a keen awareness of Japan's involvement in international activities" [14, p.48] In the 1980s, the development of contemporary Chinese art was connected to the restructuring of Chinese identity within the state itself. Later, in the 1990s, contemporary Chinese art was used by China to project a positive image of the nation to the world [15]. Therefore, it could be said that cultural diplomacy can be employed by nations to construct their national identity both within the state and across its borders.

The concept of cultural diplomacy is a novel and a unique concept. But where Sri Lankan cultural diplomacy is concerned, cultural exchanges between Sri Lanka and other nations, especially countries like Germany, existed long before the coinage of the term 'cultural diplomacy' [16].

Organized by the Ministry of Foreign Affairs, the Sri Lanka Tourist Board and the Sri Lankan High Commission in the United Kingdom, a ten-day cultural event, named "Refreshingly Sri Lanka" was held at the Trafalgar Square in June 2006. It made use of Sri Lankan cultural elements such as traditional and modern music, dance, drums, food, astrology, Ayurvedic medicine and clothing in order to promote Sri Lanka as a tourist destination in the UK. The event was decorated using 2000 blue water lilies and also included the "Serendib" Trade Exhibition along with a Sri Lankan Book Festival and a Film Festival [17]. This is an example of Sri Lankan cultural diplomacy beyond the Indian Ocean.

III. Cultural Diplomacy and Postcolonialism

Over the years, postcolonial literature has been used in the processes of challenging power structures which are in favour of European imperialism, resisting homogenizing representations of the colonized peoples, and the assertion and recuperation of cultures of the former colonies. Post-colonial criticism is described as a "more or less distinct set of reading practices…preoccupied principally with analysis of cultural forms which mediate, challenge or reflect upon … *relations of domination or subordination*" [my emphasis]. Postcolonialism therefore focuses on and challenges power structures which "have their roots in the history of modern European colonialism and imperialism" and "continue to be apparent in the present era of neocolonialism" [18, p.1]. Despite the world having moved beyond the post-colonial era, homogenization continues today, albeit differently, in a neo-colonial world. It is this tendency of the 21st century Western world to homogenize Africa that the Nigerian author Chimamanda Ngozi Adichie challenges in her short story titled "The Time Story" which she wrote in 2006.

Cultural diplomacy has been challenged from the perspective of postcolonial criticism. Chinese cultural diplomacy has been criticized for representing a *singular* culture of China to the world, a practice which would

eventually result in the international community being unaware of the cultural diversity that exists within a nation, in general, and China, in particular. In addition, there exists a disconnection between the singular cultural identity China attempts to project of itself to the world and the actual circumstances that surround, influence and shape China today [15]. Therefore, cultural diplomacy, if not used mindfully, can unwittingly cause the homogenization of the nation-state by which it is used.

Although cultural diplomacy has been criticized for its homogenizing effects, the potential of cultural diplomacy to preserve cultural diversity all over the world has not gone unnoticed. Japanese cultural diplomacy, which has always "aimed to dispel negative images of Japan" or has attempted "to 'correct' misconceptions regarding Japan in foreign countries," should, in present times be used with the intention of sharing Japan's time-honoured cultural traditions with the world. But this should take place not with the intention of enhancing Japan's image abroad but "as a contribution to the enrichment of human society and the maintenance of global peace and cultural diversity" [14, p.53]. Unlike how Chinese cultural diplomacy is criticized for the promotion of a singular culture, Japanese cultural diplomatic activities are considered to have potential to contribute to the preservation of the individuality of cultures that exist the world over.

IV. Literary Works as Cultural Diplomacy

One of the many agents of cultural diplomacy is literature, which is a medium through which people from one country can encounter, understand and familiarize themselves with foreign traditions and customs.

In order to make one culture more accessible to the other, translations have been advocated and made use of by various nation-states. Translated literature was among the many possible sources of U.S cultural diplomacy recommended by the Advisory Committee on Cultural Diplomacy in their report to the U.S Department of State. The former suggested to the US Government that it "set aside funds for translation projects, into and out of English, of the most important literary, intellectual, philosophical, political and spiritual works from this and other countries" [21]. Translated literary works are believed to be at the heart of any diplomatic initiative; some misunderstandings between peoples maybe resolved through engagement with each other's literary and intellectual tradition; the poverty of insight displayed by American policy makers and pundits in their view of other lands may in some cases be mediated by contact, in translation, with thinkers from abroad [21].

This quotation highlights that, through translated literary works, what is considered as American policy makers' lack of sufficient knowledge about the cultures of foreign nations could be addressed. In addition, translated literature could be used to prevent misunderstandings between people of diverse cultural backgrounds. In other words, literature can be used for political purposes as well as to foster mutual understanding.

The Foreign Languages Press of China is committed towards making use of translated works for the same reasons that are mentioned above. Translations of Chinese "ancient books and records, literary works and important documents relating to literature, politics, economy, and laws", play "important roles in introducing Chinese culture, politics and economy to the outside world in an all-round and accurate way." In addition to assisting in cultural diplomatic activities outside the country, these translations are considered to be useful for "domestic English learners and translators" [22]. Therefore, translations are useful both for internal and external cultural diplomacy.

These observations regarding the employment of literature as a tool of cultural diplomacy points at the possibility of using literature in Sri Lankan cultural diplomacy, with the view of promoting a positive image of the country within the local population as well as abroad.

V. The Dangers of Restrictive Frameworks

That literature has to overcome obstacles in order to function successfully as a tool of cultural diplomacy has been acknowledged by authors in the last century as well as in the recent past. Postcolonial literature is considered to be caught within a "headless triangle" which consists of the "native writer, foreign publisher and foreign audience" [23]. Such institutional structures, though "a good three decades old," have resulted in a mounting resentment among many of the first generation of post-independence African writers that their political views were being *inconsistently diluted*, or *simply ignored*, even as their economic interests were, on the whole, adequately served [my emphasis] [23, p.108].

During the time these observations were made, "a workable infrastructure for publishing" [p. 108] did not exist in Africa. Therefore, African writers found out that getting their work published from within a structure that was not in their favour, made them incapable of making political statements through their writing.

Similar concerns regarding issues presently faced when using literary works as agents of cultural diplomacy were expressed recently. The process of reading is neither free nor democratic and this is because institutions, authors, publishers and reviewers "try to interfere in our constitution of subjective meaning." The necessity at schools and universities to grade literary works as "good" or "bad" "allows only a limited freedom of subjective meaning generation when reading a book." In addition, the "language and tone" of book reviews are of finality and "not one begins with the humble admittance to stating an opinion on the novel." Similar to how the reviews shape the reader's interpretation of the book, blurbs and summaries on the back cover of a book are "tools of guidance for the reading public." These institutional structures have consequences for cultural diplomacy. [23, p.6-7]. Therefore, an individual reads and interprets a book from within the frame that is created by book reviews, summaries and blurbs, a framework that moulds the reader's interpretation beforehand or restricts it to that particular frame.

Sip's [24] observations about the negative consequences blurbs, book summaries and reviews have on the success of literature as cultural diplomatic tools is true of Sri Lankan English literature as well. The summaries typed on the cover pages (front and back) of novels like Roma Tearne's *Mosquito* (2007) and Romesh Gunasekera's *Heaven's Edge* (2002), collectively contribute to creating a single story of Sri Lanka. Gunasekera's protagonist by the name Marc travels to "an island once said to be near the edge of heaven, but now ravaged and despoiled by war" [25]. One of the main

characters of *Mosquito,* Theo Samarajeewa, "returns to his native Sri Lanka after his wife's death" and he "hopes to escape his loss amidst the lush landscape of his increasingly war-torn country", his "beautiful, tortured land" [26]. It could be argued that these opinions which appear in the cover pages of these books would leave a foreign audience with a single story of Sri Lanka; that Sri Lanka is a pitiful, war-torn paradise, a potential Garden of Eden whose resources are unacknowledged and unrealized.

In both *Heaven's Edge* and *Mosquito,* the island is portrayed as an erstwhile haven, a place to be avoided. Marc, the protagonist of Gunasekera's novel, is neither a tourist nor a native. He is "a man in search of a father, or perhaps of himself" [25, p. 14] But Uva, a native girl of the island, explains to Marc that citizens of the island "live in a state of terror" and "abuse [their] minds as [they] do [their] bodies when [they] have to control pain" [p.27]. Similarly, in *Mosquito,* Theo Samarajeewa, "an established writer, with a comfortable life in London, his own flat, his work," could barely understand his urgency to come to Sri Lanka when everyone else was "escaping" it [26, p.4]. However, at the end of the novel, Tearne delineates a nation-state in the process of healing itself. She describes the island as one that had begun "to rescue itself, hoping to whitewash its bloody past" The tourism industry was being promoted in the island and "international cuisine was all that was needed" and "paradise was the new currency" in the island [pp. 265-66]. These descriptions of Sri Lanka, in the early 2000s, create a singular story of Sri Lanka. It was an island which was to be fled, a country that could only define itself through the promotion of its paradisiacal qualities to foreigners.

None of these descriptions of the country, however, is unacceptable. These literary works have, beyond doubt, been influenced by recent political tensions and violence that the country experienced. But, such delineations of the country, along with the summaries on the back of the cover pages, constitute a singular narrative of the island of Sri Lanka. From the perspective of a Sri Lankan who was born into a war-torn island and had to reside in Sri Lanka and did not 'escape' the violence, it could be said that this particular framework dismisses much of what Sri Lanka still possesses that could be celebrated.

VI. Ceylon through the Foreign Gaze

Quite contrary to the colonizers' portrayals of the African continent as the opposite of European civilization, the accounts given by some British authors about ancient Ceylon are in appreciation of the traditions practiced by the inhabitants of the island. This does not mean, however, that the foreign perspective on Ceylon can be completely positive. Yet accounts given by John Still in *Jungle Tide* (1930), Rev. W. S. Senior in his poetry and Major Forbes in his book *Eleven Years in Ceylon* (1841) are in Sri Lanka's favour. These perspectives, through which the island was seen, interpreted, understood and documented, are such that they could be thoroughly studied and used in Sri Lankan cultural diplomacy.

Literature written by "Britishers who were in the service of the Empire" or others who received the opportunity to serve in Ceylon as missionaries is "an integral part of Sri Lankan literary tradition." Ironically, it was the poetic works of Rev. W. S. Senior, who was a British national, that gave "an impetus to the latent cultural nationalism of the Kandy Lake poets who wrote in the mid- 1930s and early 1940s" [27, pp. 137-8].

Penned down in Senior's poems is the love he had for the island and its people and history. The poem "Goodbye" probably relates his own feelings at the time he had to depart Sri Lanka and leave for England. Senior begins the poem by portraying Ceylon as a place with "wayside squatters", "food that does not feed you" and "the lawless platform lawyer all out to scratch your face." Then he writes that when the "English climate's chilly and the English clouds are grey…/ You will see Anuradhapura, and the old king's bathing pool" and remember the

> ……faces, the Aryan face (your own)
>
> With its brown and olive beauty, the youths and maids you've known
>
> And the tender pearl of India in the black and brilliant eye
>
> My soul, you will break with longing – it can never be Goodbye [28].

Quite similar to Frantz Fanon, who wanted native intellectuals to initiate the revival of the cultures of colonized people, Senior, in his poem "The Call of Lanka" urges the "Child of Lanka" to rise and answer its mother's call –

> Hark! Bard of the fateful Future,
>
> Hark! Bard of the bright To-Be,
>
> A Voice on the verdant mountains,
>
> A Voice on the golden sea;
>
> Rise, Child of Lanka, and answer!
>
> Thy Mother hath called to Thee! [29]

These perspectives and descriptions of the island, unfortunately, are not well-known in the island. Many Sri Lankans would probably not know who Senior is or that he lived in Sri Lanka from 1905 to 1928, a period which he considered the best years of his life. Senior loved Sri Lanka to the extent that "on retirement to England he expressed a wish that his ashes be brought to Ceylon and buried in the churchyard at Haputale" [30]. His wish was fulfilled.

Unlike Senior, John Still reflects and comments on Ceylonese traditional practices and also on the unity which he witnessed between people of different religions and ethnicities in Ceylon. In *Jungle Tide,* he dedicates an entire chapter, titled "A Holy Mountain," to Adam's Peak. He states that "Hindus and Buddhists, Mahomedans and Eastern Christians alike revere the mountain as a holy place" [31, p. 10]. For Still, Adam's Peak was a mountain which brought people of different religions together in harmony, and this unity in diversity was probably a factor which received his appreciation and respect. He mentions that;

> [a]mong the pilgrims I have seen people of half a dozen races, with as many languages, and at least four distinct religions beside many sects, and I can testify to their reverence; *for the East understands religion, where we of the West have made it a form of warfare*. There is no policeman here, and no one in authority at all, so far as I could learn; *but the place was holy ground, and the tolerance of the pilgrims seemed a thing that might well have been studied by Western ecclesiastics with honour and amazement*, *perhaps even in shame*. I mentioned this tolerance once to a bishop, and *was told it was a sign of weakness of faith; persecution, I suppose, is a sign of strength* [my emphasis] [pp. 11-12].

Elsewhere in the book, Still appreciates the religious harmony among the people in the island when he describes the Madu Church. He writes that

> [i]ts jungles are rich in ruins and shrines once holy, both Buddhist and Hindu, but curiously enough its most holy places where active worship still persists belongs to neither of these creeds, though it is approached by the followers of both. The old temples are forgotten, and Islam has never had a foothold there. … But in the very middle of the forest, hidden farther from cities than any other church in Ceylon, there is an old Roman Catholic mission, so catholic indeed that men and women of all creeds flock there on pilgrimage, and I have even known a strict Mahomedan to go there from Anuradhapura, carrying with him his sick baby son in full faith that he would be healed there. As on the summit of Adam's Peak, where all religions meet without rancour, so at Madu in the Wanni do men and women of many creeds find some common denominator which reduces their divergent faiths to hopes possessed by all… [31, p. 115].

Contrary to how the Europeans perceived and represented Africa as a foil that set off the pride of European civilization, Still delineates the East, in general, and Ceylon in particular as being more civilized and harmonious than the West.

Apart from Still, Major Forbes makes reference to Adam's Peak. Forbes describes Adam's Peak as a mountain that brings together most religions practiced in the island. He witnesses "a cheerful party of respectably dresses Mohammedan pilgrims of both sexes" and two men "in the dress of Hindus," [32, p.169] all climbing the mountain to worship their respectful deities.

These descriptions of practices centered round Adam's Peak could be used for cultural diplomatic purposes within the country with the intention of fostering religious harmony within Sri Lanka as well as the world over.

VII. CONCLUSION

Literature has been used over the years for the purposes of cultural diplomacy. Nowhere is this more apparent than in the postcolonial literary canon. African authors of the last century as well as from the recent past have made use of literature to attempt at reviving their cultural roots which were nearly obliterated during the colonial era. Apart from cultural revival, African authors attempt to challenge the ongoing process of homogenization Africa is subjected to at the hands of the Western dominated modes of representation.

Alongside the deliberate use of literature in order to respond to the Empire, writers have also identified the fact that disrupting Western modes of perception and interpretation from within a Western framework itself is challenging. In other words, African writers from the 20th century have identified that attempts at making political statements on behalf of their nation are not supported by a democratic institutional framework. Countries and cultures are still viewed and made meaning of only through a few frameworks. This eventually leads to the homogenization of those cultures. These observations about the institutional structures from within which literature has to function have consequences for cultural diplomacy too. If literature is to function successfully as cultural diplomacy, a democratic framework should be available, a framework where there will be no strict selection processes of what is to be published and what is to be censored.

Where the use of literature as a tool of Sri Lankan cultural diplomacy is concerned, the ways in which the island has been perceived and portrayed by foreigners during the colonial era are significant. Unlike where African is concerned, Ceylon has been, to a certain extent, portrayed in a favourable light. Descriptions made of the island from a foreign perspective may function better in the international arena than literary works that are published by Sri Lankans. These portrayals, especially the ones made by authors like John Still about the religious harmony in the island, are images of Sri Lanka that can function as national identity shapers both within Sri Lankan and across the seas. These delineations, coupled with the literature written from the Sri Lankan point of view would serve to project to the world a more balanced portrayal of Sri Lanka.

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The Role of the Postcolonial Indian Writer in Promoting Hinduism with Reference to Mysticism

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***Abstract*— Postcolonial Indian writing is heavily influenced by the religion of the colonizers and socio-cultural practices of the Westerners. Many studies are conducted to understand how postcolonial literature attempts to counteract alienation by asserting the richness and validity of native cultures in an effort to restore pride in indigenous practices and traditions. However, little research has been conducted to understand the role of the postcolonial Indian writers in glorifying their native cultures and religions which led to identify their works with mysticism. This paper explores the cultural hybridity of the postcolonial Indian writers and their effort to highlight the importance of Indian identity, culture and Hinduism which result the outside readers to identify their works with a touch of mysticism. Though the term "mysticism" is also associated with Christianity, this paper will look in to mysticism associated with post colonialism, Hindu religious practices and beliefs, Hindu gods and myths.**

The methodology of this study selects two instruments. Referring to the postcolonial texts: *The Serpent and the Rope* by Raja Rao and *Midnight's Children* by Salman Rushdie, this paper builds an understanding about mysticism associated with Hinduism. It also explores the effort of the postcolonial writers to situate and promote Hinduism among the world religions which assigned connotations of mysticism and superstition in their writing.

***Keywords*— Post colonialism, Postcolonial Indian writers, Hinduism, Myth, Mysticism**

I. Introduction

With the process of colonization, the notion of "mystic East" began to expand and it became a popular topic addressed by many scholars within the realm of postcolonial studies. Western imperialism and colonialism interpret the process of colonization both as a giant endeavour aimed at taking care of those regions and societies in the world that otherwise would not develop at all. "It is against this background that Western scientific concepts were introduced and aimed at replacing anything that, according to these concepts, was unscientific, irrational, obscure, and therefore impedimental to progress" [1, p. 18]. The medieval Western scholars quite rarely acknowledged the quality of Indian intellectuality and scientific merits, language, religion and culture. The culturally symbolic, 'mystic East' before the eyes of the Westerners was viewed to be irrational, odd and mystic. The binary of "self" and the "other", the "native" and "colonizer" and "rational" and "mystic" are terms quite often highlighted in scholarly approaches of postcolonial theories. The topic of 'the Mystic East' is a prevalent theme in the Western context and mysticism associated with Hinduism is often explored in relation to power, Christian theology and enlightenment.

This paper endeavours to define 'mysticism' associated with Hinduism within the scope of postcolonial studies and the effort of the postcolonial Indian writer to situate and promote their religion among the world religions which assigned implications of mysticism.

The first section of this paper engages in a discussion on mysticism within the postcolonial context, associated with Hinduism. The second section discusses about the role of the postcolonial Indian writer in promoting Hinduism with reference to mysticism, bringing examples from the two postcolonial Indian texts; *The Serpent and the Rope* by Raja Rao and *Midnight's Children* by Salman Rushdie.

II. Background

The imaginative construction of a 'mystical' tradition within Western context seems to have gained increasing credence in the seventeenth and eighteenth centuries. "With a greater awareness of the plurality of religious perspectives throughout the world furnished by colonial encounters, it became inevitable that oriental religions comparisons to take place with Christianity" [2, p. 98]. The collision between European imperialism and third world nationalism problematizes the construction of Europe at the centre of history. The project of dismantling 'Europe' as the focal point, results in a clash between Europe and the third world. Being in the centre, the Westerners looked down upon the oriental cultures and considered them to be primitive and irrational.

Today, there are perhaps two powerful images in contemporary Western characterizations of Eastern religions. "One is the continually enduring notion of the 'mystical East', a powerful image precisely because for some it represents what is most disturbing and outdated about Eastern culture, while for others it represents the magic, the mystery and the sense of the spiritual that they perceive to be lacking in modern Western culture" [3, p. 01]. The backwardness of the Orient therefore appears to sit side by side with its blossoming spirituality and cultural richness in the East deriving from the European imagination and its fascination with the Orient.

The second powerful image in contemporary Western characterizations of Eastern religions is the 'militant fanatic' or religious fundamentalism. Religious fundamentalism refers to the belief of an individual or a group of individuals in the absolute authority of a sacred religious text or teachings of a particular religious leader, prophet, or God. They believe that their religion is beyond any form of criticism, and should therefore also be forced upon others.

Logical explanations and scientific evidences have no place in these belief systems. Such a characterization also has a considerable effect on the contemporary manifestation of the colonial myths about Oriental despotism and the irrationality of the colonial subject.

The argument does not entail that the modern concept of 'Hinduism' is merely a product of Western thought but also a perception promoted by the colonized population. This paper endeavours to look at this effort of the postcolonial Indian writers to promote Hinduism, which ultimately attracted implications of mysticism in to their writing.

III. What is Mysticism

The term "mysticism" has Ancient Greek origins with various historically determined meanings. Derived from the Greek word (μυω), meaning "to conceal", mysticism is referred to the biblical liturgical, spiritual, and contemplative dimensions of early and medieval Christianity. During the early modern period, the definition of mysticism grew to include a broad range of beliefs and ideologies related to "extraordinary experiences and states of mind"[3, p. 18]. In modern times, mysticism has acquired a limited definition. Margaret Smith describes mysticism as 'the most vital element in all true religions, rising up in revolt against cold formality and religious torpor. The aim of the mystics, she says, 'is to establish a conscious relation with the Absolute, in which they find the personal object of love" [4, p. 20].

As the study of mysticism has developed along the lines of the comparative study of religion, theistic definitions have become increasingly problematic. Having examined the construction of 'Hinduism' within Western culture and the association of India with the cultural symbolic of the 'mystic East', it is worth while exploring the ways in which Indian religions, as Asian representatives of 'the global phenomenon of mysticism', have been interpreted and located within the modern approaches to study mysticism. "Combined with this contemporary lauding of the 'postcolonial era', the 1990s have brought forth a number of works heralding the move 'beyond Orientalism" [5, p. 59]. The era of British colonial expansion and the subjugation of foreign lands and people, the colonial project assigned new connotations to the term "mysticism".

It has become common place in the modern era to consider mystics, their writings and the phenomenon of mysticism in general as being in some sense antithetical to rationality. Specifically, the characterization of Indian religions such as Hinduism as mystical has also tended to support the exclusion of Hindus from the realm of rationality.

In exorcizing the 'mystical' aspects of Western culture, post-Enlightenment thought has also tended to project these same characteristics onto the 'mystic East', which has played a significant role in defining the Western cultural identity and thought.

It is interesting to note in this context that the association of religions such as Hinduism with mysticism and the stereotype of mystic has come to function as one of the most prevailing cultural representations of Indian religions and culture in the last few centuries. The idea of mysticism was associated with the religious practices, gods, legends, myths and the teachings which were different to Western religions. Such novel practices and believes appeared superficial and exotic in the eyes of the colonizers. Hence the Oriental religions were often seen as mystic and superstitious which lacked reason and logic.

IV. The East-West Encounter of Religious Traditions and Culture in *The Serpent and the Rope* by Raja Rao

Raja Rao's *The Serpent and The Rope* is rightly acclaimed as a landmark in the Indian fiction in English. Rao has been hailed as a cultural ambassador of India to the Western literary world and most of his work is grounded in the Indian religious tradition. In the novel, *The Serpent and The Rope*, the East-West encounter in relation to culture and religion, role of marriage as envisaged within the Indian ethos and its religious traditions are explored.

Raja Rao employs various Hindu myths to sanctify and extol the institution of marriage in India. Through these myths the novelist re-establishes and demonstrates the meaning of love and marriage in the Indian context with customs and mythical truths embodied, through the ages, which sustained the Indian society. Northrop Frye, one of the most influential myth critics, gives a simple definition of myth. He states, "A myth, in its simplest and most normal significance, is a certain kind of story, generally about a god or other divine being" [6, p. 27]. M.H. Abrams, "A myth is a system of hereditary stories which were once believed to be true by a particular cultural group, and which served to explain the rationale for social customs and observances and the sanctions for the rules by which men conduct their lives" [7, p. 102].

The novel *The Serpent and the Rope* portrays one crucial moment in the life history of its chief protagonist, K. S. Ramaswamy, a Brahmin from south India. He is referred to as Rama in the novel. He is a student of history and goes to France to do research on the Catharist heresy of the Albigensians. His attempt is to trace back its Eastern, or if possible, Indian origin. After his father's death, he takes his Little Mother (i.e. step-mother) and her infant son, Sridhara, to Benares to perform the obsequies of his deceased father strictly in accordance with the Hindu tradition. This visit to India and Benares in particular brings a thorough change in his attitude towards India. Moreover, he is introduced to Savithri, a daughter of Raja Raghubir Singh of Surajpur. They develop a close friendship and often visit each other. When Madeline gives birth to a still born child for the second time, she renounces the world for Buddhism and considers her body as a composition of astadasa dhatu (the eighteen aggregates of the human body) and decides to break her marital bond with Rama. After a deep anguish filled introspection nearly for three days he is suddenly spiritually enlightened to realize that he needs a Guru or spiritual teacher, not God. His spiritual quest comes to an end when he decides to seek his Guru's blessings at Travencore in India for self- realization.

The impossibility of a unification of West and East due to religious and cultural indifferences is highlighted through Rama and his wife's broken marriage. Rama fails to reconcile himself to Madeleine's indifference to Hindu gods. Her disapproval of the many superstitions that are intertwined with Hinduism upsets Rama who is a devout Hindu. Madeleine "burst out laughing" when Rama says, "Parvathi is singing to Shiva" as if "her unbelief itself was

the proof of my truth" [8, p. 56]. He realizes that his marriage to Madeliene has necessitated in accepting her beliefs. With passage of time, Rama's love for his wife deteriorates to the state of being abstract and impersonal. Rama painfully realizes that Madeleine couldn't lend herself to the sacrifices entailed in this transcendental approach, for she "smelt the things of the earth, as though, sound, form, touch, taste, smell, were such realities that you could not go beyond them even if you tried" ([8, p. 18]. Madeline bares a logical attitude towards life and struggles to compromise with the Hindu beliefs and teachings; which leads to a failed marriage.

The myth of Savithri used in the novel to highlight the relationship between Rama and Savithri has many structural parallels. Savithri is the most sacred verse of the Rig-Veda. It is also known as Gayatri Mantra. Savithri is a name derived from the Sanskrit root 'su' which means 'stimulate.' Every dutiful Brahmin even today repeats it mentally in his morning and evening prayers addressed to the Vedic solar deity who stands for the vitalizing power of the sun." [9, p. 111]. The implication of this myth is very clear in the history of Rama, for the myth is used as another important structural strand in the novel. At the hotel where Rama Sojourns in London, Savithri imagines Rama to be Krishna and herself to be Radha and accordingly worships Rama. She says, "This Cambridge undergraduate, who smokes like a chimney and dances to barbarian jazz, she says unto you, I've known my Lord for a thousand times, from 'janam' to 'janam' have I known my Krishna" [8, p. 212]. To this, Rama readily responds, for he too shares her transcendental mythical experience willingly: "And the Lord knows himself because Radha is, else he would have gone into penance and sat on Himalaya…" [8, p. 212]. He places his mother's toe-rings on Savithri's second toes, for they represent the continuing tradition of his family.

The Rama and Sita myth from the Ramayana epic also finds place in the novel. This myth also hints at the failure of the marriage of Rama and Madeleine. The Ramaswamy's name is after Rama, the hero of the Ramayana. If mythical Rama kills Ravana the demon king and the demons of Lanka, the fictional Rama kills his ego and realizes the self within. Moreover, Rama of the novel is a great admirer of Bhavabhuti's Uttararamacharita (8th century A.D.). When Rama recites some Sanskrit verses from it to Madeleine as if he had the premonition of the failure of their marriage, the significance of this myth becomes evident. These verses reflect the mythical Rama's grief over his separation from his wife Sita when he visits, one, Panchavati, a hermitage where once Rama and Sita lived happily. It may be noted here that Rama is the fictional parallel to the mythical Rama. But it must be admitted that Madeleine is no Sita, he sees Sita in Savithri.

To an Indian, the relationship between Radha and Krishna is nothing but the relationship between the seeker and the sought. According to Indian tradition, marriage is a means to attain salvation or 'moksha' from the eternal cob-web of life and death. For this, husband and wife are complementary to each other. Each must perform his or her own duty or 'dharma', which alone enables them to attain salvation which Madeleine fails to fulfil.

Through the novel Rao attempts to explain the Vendantic tradition and the Hindu marriage rituals as leading religious practices which are hostile to the Westerners. His project of associating the Hindu myth of Rama and Seetha with marriage gives a superficial mystical association to the general practice of marriage. Though the intention of the writer is to place the sacred position of marriage in Hinduism, a foreign reader could interpret these practices in mystic terms romanticizing the Eastern cultural norms.

V. Colonial Hybridity and Hindu Mysticism in *Midnight's Children* by Salman Rushdie

Midnight's Children (1981) by Salman Rushdie is a loose allegory for events in India both before and, primarily, after the independence and partition of India in 1947. The narrative framework of *Midnight's Children* consists of the tale which Saleem Sinai recounts orally to his wife-to-be Padma. This self-referential narrative recalls indigenous Indian culture and religious practices in India

Saleem Sinai, the narrator of *Midnight's Children*, opens the novel by explaining that he was born at midnight on 15th August 1947, at the exact moment India gained its independence from British rule. He imagines that his miraculously timed birth ties him to the fate of the country. He later discovers that all children born in India between 12.00 a.m and 1.00 a.m on 15th August 1947 are gifted with special powers. Saleem thus attempts to use these powers to convene the eponymous children. He acts as a telepathic conduit, bringing hundreds of geographically disparate children into contact while also attempting to discover the meaning of their gifts. In particular, those children who are born closest to the stroke of midnight possess more powerful gifts than the others.

Salman Rushdie's *Midnight's Children* deals with religious mythological references to the abundant diversity of Hindu mythology. The Parvati-Shiva traditional myth textuaslized in the novel and is altered by the dynamic shifting of identities of the primary characters. For example, Shiva-of-the-knees and Saleem, whose fates have been intertwined since they were switched at birth, dually portray the traditional Hindu Shiva in that they alternatively share the consort Parvati the witch. Yet, simultaneously, the fictional relationship between these two struggling opponents, Saleem and his 'alter ego' Shiva-of-the-knees also resembles the mythic traditional opposition between Hindu gods Vishnu, the preserver, and Shiva, the Destroyer.

Several myths and legends are invoked as Saleem's fable like story unfolds. Characters and legends from the Hindu epics like Brahma, Vishnu, Shiva, Rama, Arjuna, Bhima and the battle of Kuruksetra are referred in the novel. There are multiple references to the Musa or Moses, Quran and Muhammad, especially in Ahmed Sinai's preoccupations with reordering the Quran. Saleem identifies himself with "the elephant-headed Lord Ganesh" because of his nose and his love for writing [10, p. 123].

In Rushdie's fiction, the argument of "cultural diversity" runs as a thread through all the chapters. In the book *Salman Rushdie; Contemporary World Writers*, Catherine Cundy underscores the hybridity of Rushdie's background, the paradox of his being "too English for the Indian" and "too Indian for the English" [11, p. 25]. In her analysis on *Midnight's Children* she projects the novel as an amalgamation of eastern content and western form to achieve the near ideal of a "hybrid post-colonial text".

Cundy highlights the technical brilliance of *Midnight's Children*. Different narrative techniques are effectively debated in the text mythic, filmic, real, and fantastic pre-occupations jostle one another with amazing ease even as realism is subverted with genius strokes. The real and the fantastic in relation to characters have parallels to mythical archetypes in the Hindu gods. Saleem, like Rushdie, knows Hindu stories and the textual Shiva is Saleem's alter ego. Rushdie infuses the supernatural into everyday experiences. "Literary traditions are combined with techniques like non-linear progression of events, lengthy digressions, and recursive inconsistent narration adopted from Indian epic literature and oral forms of storytelling" [12, p. 89].

In a country that founded four major religions, Rushdie's extensive use of religious motifs is a necessity in acknowledging India's inherent spirituality. Rushdie uses this religious saturation to provide a narrative and thematic framework with which to familiarize the reader to the story. Incidentally, as Wendy Faris suggests, it is quite conceivable that *Midnight's Children's* characters could actually be incarnations of Hindu gods. Faris writes, In India, of course, beliefs regarding reincarnation make metamorphoses through time particularly ubiquitous, and many of the characters in *Midnight's Children* duplicate a deity, Saleem's much mentioned nose (to city only one instance) corresponding to Ganesh the elephant-headed god's trunk. Parvati acts especially as a stabilizing force thus restoring order. She is the one who helps Saleem return to Delhi by using her magic basket, making him invisible. She tempers even the most overwhelming of Shiva's sexual urges, a task that none other had managed before. She is a positive accomplished feminine figure [13].

Homy Bhabha states that "the master discourse is appropriated by the native whose agency reflects cultural resistance in the form of the mimicry and parody of colonial authority" [14, p. 144]. In *Midnight's Children*, the resistance to colonial shadows is presented through a discussion with the flavour of Hindu mythology. The mystic portrayal of Hinduism by Rushdie is a form of resistance where the occident reader relates with superstition and mysticism.

Rushdie's manipulation of roles regarding the anti-self, marks his fundamental divergence from the rest of magical realism. While transculturation is evident and continuing throughout the novel, it is never truly implemented and completed. A prominent aspect of Farris's extensive discussion of transculturation focuses on the idea that the process in "magical realism is a two-way cultural bridge", which enables "a cultural conversation that heals" [13, p. 155-57]. This healing occurs through the convergence, and ultimate merging, of the colonizer's empirical reality with the native culture's ancient spiritualism, creating a collective national identity. In this novel, Rushdie leverages many of the techniques typical of transculturation in an effort to show the similarities of differing cultures. Shiva is Saleem's anti-self, the person from whom he realizes and gains power, suggests it is not only the colonizer that India must overcome to achieve unification, but also its own discursive cultural identities.

VI. Conclusion

The study helps to gain a vivid understanding about the role played by the Indian postcolonial writers to project Hinduism in mystic lenses. While defining mysticism through Hindu religious practices, gods, legends and myths, I have made an attempt to understand the reasons which lead the outside readers to identify the works of the postcolonial Indian writers with a touch of mysticism. This study allows the reader to understand the socio- political and cultural events which lead the postcolonial writers to propagate Hinduism in association with mysticism and exoticism and their marginalized colonized mentality which forced them to place their culture among the other governing, more popular western ideologies of the time. Moreover, the study provides space to recapture the notion of myth and irrationality (social: class division, emotional: beliefs) in Hindu philosophy and also the importance and values in the Indian culture. This study proves the culture collision and post-colonial hybridity, the fear of losing belonging, ambivalence, otherness, and alienation result the postcolonial Indian writers to glorify their cultural aspects and place Hinduism among the realm of other world religions.

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Maritime English at CINEC: A Needs Analysis

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Abstract **The goal of this study is to investigate the needs of Sri Lankan students at Colombo International Nautical and Engineering College (CINEC) in learning and using English in maritime contexts. Derived from concepts of Task-based Needs Analysis this study compiled data on academic and professional contexts along with self-assessed receptive and productive skills in English of the respondents. The methodology consisted of a questionnaire and random interviews with 115 respondents across three strata: entry level Cadets and Ratings who are the target population; Experienced (M=15 years) seafarers who construct a contrastive population. All respondents were bilingual in Sinhala/Tamil and a variety of Sri Lankan English. The data analysis of self-assessed proficiency in English language skills specifies that the Cadets (M=4.2) outranked the experienced seafarers (M=3.0) and the Ratings (M=2.8). The findings across all three strata indicate that all seafarers consider all four language skills *Very important* for success in their field. Identifying the need for correct grammar the experienced seafarers with an *Acceptable* self-estimated level of grammar (M=3.07) stated that it is *Usually* required. It is interesting to note that Ratings who self-assessed their level of grammar as *Poor* (M=2.50) assumed that correct grammar was *Never* (M=1.47) required in their profession. All respondents unanimously considered Speaking; and Listening to users of other Englishes of the World as *Very Important*. This study offers further insights into making the teaching/learning process of Maritime English at CINEC beneficial for all stakeholders.**

Keywords**- Maritime English, four English language skills, grammar**

I. INTRODUCTION

The International Maritime Organization (IMO) formally indorses English as the language of the sea. Thus, the teaching of Maritime English is a requisite at present as statistics indicate that many seafarers have studied English as a second language and the English they have learnt could be a variety of English amongst the Englishes of the World. The main objective of Maritime English is to eliminate communication failures between multinational seafarers speaking diverse Englishes and develop the corpus of Standard Marine Communication Phrases for ensuring safety on board. Thus, the burden of Maritime English courses is to provide classroom materials for the set syllabi across at least three levels, each level with a population of students with diverse proficiency in English, compile classroom materials and utilize current techniques in order to facilitate learners to adequately master maritime requirements of English.

The Overall Goal of the IMO is to ensure that "Safe, secure and efficient shipping on clean oceans" is viable. Of the standards set down by the IMO the aim of Maritime English (MarE) is to produce a seafarer who can 'communicate in English with multilingual, multicultural crew' and possess an 'across-the-board ability to use English to communicate key points in all day to day activities and in emergencies'. MarE is obligatory to seafarers across three levels: senior officers (deck and engine), officers (deck and engine), cadets, and ratings.

According to Vangehuchten et al. (2010: 122) [1],

> Insufficient knowledge of vocabulary and/or grammar in general, insufficient knowledge of technical vocabulary, poor pronunciation and weak oral skills, listening problems, poor reading skills and writing problems influence the quality of work in the maritime sector.

Following observation and interviewing techniques in data collection Kahveci, et al. (2001) [2] conducted a research on social dynamics of multinational crewing aboard fourteen merchant cargo ships. Their research methodology consisted of observation and recorded interviews. The population included 242 seafarers. Main research findings uncovered that 'approximately 65% of the world merchant fleet have adopted multinational crewing strategies. Just over ten percent of the fleet is staffed with crews composed of five or more different nationalities'. (p. i)

Reconnecting with the focus of discussion of this paper; Maritime English, they state that 'on many of the vessels included in the research, the stated common working language (English) was a second language for everyone on board'. Tabulating the 'native' speakers of English on board the case study vessels they provide the following analysis.

TABLE I
NATIVE SPEAKERS ON BOARD CASE STUDY VESSELS (KAHVECI ET AL., 2001: 14) [2]

Native speakers on board case study vessels		
Ship	**Number of nationalities**	**Number of English 'native' speakers**
1	3	0
2	4	7/36
3	2	0
4	3	14/27
5	3	1/7
6	4	14/29
7	3	0
8	3	0
9	6	4/25
10	5	2/34
11	4	0
12	6	1/7
13	14	0
14	5	0

As projected in the above tabulation of the 14 vessels 7 had no 'native' speakers of English. Of the others 43/158 or only 27.2% were 'native' speakers of English making the majority (72.8%) of the users of English not 'native'.

They further state that 'language was found to be a critical issue for multinational crews'. Inability to use the working language of the ship generated frustration, hampered social interaction and integration. The findings state that the 'use of first languages rather than a common language fostered suspicion amongst multilingual crews'. Thus, the

recommendations of the study include 'ensuring high levels of fluency in the working language of the ship amongst both officers and ratings' (ibid: p. iv)

The mandatory five key English skills for all classes of seafarers are: reading, writing, listening, speaking and grammar/ Standard Marine Communication Phrases (SMCP). The Syllabus as set down by the Model Course 3.17 for MarE (2015 Edition: 24) [3] states that it is 'based on the principles of the Communicative Method and other methods to language teaching which instructors are encouraged to adapt for their trainees' needs. It further states that the course developers can design appropriate materials to bridge any gap between the trainees' existing knowledge and the course content set down for MarE.

As the Model Course 3.17 promulgates and grants acquiescence to MarE course developers to adhere to 'the principles of the Communicative Method and other methods to language teaching' an opportunity is open to move away from prescriptive methodology to the post-method era (Brown, 2000[4], 2002[5]; Kumaravadivelu, 2001[6]; Richards and Rodgers, 2001[7]). The post-method era uses a controlled eclectic method of teaching and is a judicious combination of numerous methods suited to the target population. Controlled eclectic method is developed to overcome the inadequacies in existing methods and reap the benefits of the combination of approaches or methods that work best in the target teaching/learning context.

Brown (2000)[4] argues that "virtually all language teaching methods make the oversimplified assumption that what language teachers 'do' in the classroom can be conventionalized into a set of procedures that fits all contexts" (p. 170).

According to Kumaravadivelu (2001)[6], method has mesmerized and "has had a magical hold on us" (p. 557) while Brown (2000) [4] celebrates the demise of "recently interred methods" (p. 14), by holding a "requiem" (p. 17)

Brown (2000) [4] commenting further on the pragmatism in principled eclectism states,

> The profession has at last reached the level of maturity where we recognize the complexity of language learners in multiple worldwide contexts demands an eclectic blend of tasks, each tailored for a particular group of learners studying for particular purposes in a given amount of time. (p. 172)

Thus, the IMO granting permission to the use of the 'Communicative Method and other methods to language teaching' or in the Applied Linguistic terminology 'principled eclectism' in methodology, provision of aims and objectives and a set time frame to fulfil them make the MarE courses feasible. But the course intake limitations (Model Course 3.17 Maritime English: P. 25)[3] sets down the ideal student population requirement. 'Class size should be limited to not more than twenty-four to allow the instructor to give adequate attention to individual trainees. Larger numbers are to be admitted if additional instructors and tutorial periods are provided to support trainees on an individual basis'. This ideal situation if relaxed might make the trainers face difficulties in achieving the objectives of the courses.

II. Review of Literature

According to Kizlik (2017) [8] a needs assessment is,

> A systematic process for determining and addressing needs, or "gaps" between current conditions and desired conditions or "wants". The discrepancy between the current condition and wanted condition must be measured to appropriately identify the need.

Kourieos (2015)[9] conducting a needs analysis on Maritime students' academic and professional language skills based in Cyprus identifying three stakeholders: students, subject specialists and Human resource managers and records the following findings. A need commonly reported by participants relates to the development and enhancement of their spoken language. Common among the majority of students (N: 27) was also the need for a more practical, interactive lesson which would provide them with ample opportunities to use the language in meaningful, work-oriented learning situations rather than passively learn about the language. (p. 27)

The t-test conducted to identify Proficient vs. Non-proficient students' perceptions on Academic language skills produced mean scores to indicate that proficient students valued the improvement of language skills more than their non-proficient counterparts. Identifying a possible reason for these results Kourieos (2015: 18)[9] states that during classroom tasks which require verbal peer interactions, non-proficient students may feel vulnerable and frightened.

The findings further state that the subject specialists' ratings are in conflict with the students' ratings of the same skills in selected areas as tabulated below.

TABLE II: Selected Data (Kourieos, 2015) [9]

The mean average ratings of selected skills		
Skill category	Mean	
	Subject specialists (p. 13)	Students (p. 16)
Understanding printed course materials (lecturers' notes, course books)	4.40	3.88
Writing assignments and reports	3.90	3.70
Interacting with peers to complete a task	3.00	3.76

The results indicate that the students find writing assignments and reports; understanding printed course materials less attractive while the weight placed on them by the subject specialists has a larger mean. She further revealed that though students placed a higher mean upon interacting with peers to complete a task there is a discrepancy in the mean scores of proficient (3.94) and non-proficient (3.56) students. She attributes this to the fact that 'peer interactions, while useful, they require a certain level of language proficiency, in which case, non-proficient students may be threatened or intimidated by such classroom tasks'(p.18).

Mercado et al (u. d.: p. 8) [10] analysing needs of the learners in terms of Maritime English Communication Skills identify and prioritize the following:

TABLE III: SELECTED DATA (MERCADO ET AL., U. D.: P. 8)[10]

Maritime English Communication Skills	Prioritized rank	Percentage
Speaking	1. Relaying messages using standard marine vocabulary	85.88%
	2. Reporting emergency situations on board	81.85%
Listening	1. To orders in routine operations	76.61%
	2. To native speakers of English	76.20%
Reading	1. Reports	78.02%
	2. Articles, abstracts, etc.	69.35%
Writing	1. Reports	79.63%
	2. Memos/messages	70.56%

The findings above depict that while Speaking emerges as the most important need, in the skill of Listening priority is for maritime communication.

The genre of grammar is incorporated in the Maritime English Model Course 3.17 (2015: 112)[3] under the common competencies to cover. It is further stated that,

> Traditional approaches to teaching attached great importance to the learning and application of grammar rules. Students were required to memorize structures by drilling and had to translate complex structures into their first language. Grammar is still considered important in contemporary teaching and some of these techniques are still used. However, the focus has changed from 'knowing about grammar' to understanding the meaning as well as the form of grammar items, in order to be able to use the structure in communication. In this way, students develop a 'global' sense of context along with the ability to manipulate the structure in detail. (2015: 124)

Dengiz (1995: 56) [11] conducting research in the Maritime Faculty of Istanbul Technical University records that '28% of the teachers believed that a low level of proficiency in grammar while speaking would be enough. Sixty percent of prep students and 50% of graduates thought that an intermediate level of proficiency in grammar was required'.

III. METHODOLOGY

The main question addressed in this study is:

> What are the English language needs, at linguistic and pragmatic levels, of the students who follow MarE courses at CINEC?

Based on concepts of Task-based Needs Analysis (Long, 2005) [12], this study conducted a needs analysis randomly interspersed with interviews. A stratified random sampling procedure was used along with a Likert scale with legends varying along Very Good (4.21-5.00), Good (3.41-4.20), Acceptable (2.61-3.40), Poor (1.81-2.60) to Very Poor (1.00-1.80). Identification of difficulty in skills Often (1), Sometimes (2), Never (3) were utilized.

The participants (N=115) were stratified into 3 groups 50 Cadets with a mean age 21 years, 50 Ratings with a mean age 22.5 years. Both groups had 0 years of experience at sea. 15 seafarers with an average of 20 years of experience at sea, mean age 38.5 years consisted of 4th Engineers and below; Electrical Officers and Cooks. The Cadets and Ratings, the main target population of this study, are at the entry level. While Ratings follow Core Section 1: Elementary level of General Maritime English Course, Cadets are at Intermediate/ Upper Intermediate level.

The Experienced seafarers are used in this study as a contrastive population for assessment purposes. The Ratings were given the questionnaire prior to their course in MarE while the Cadets completed the questionnaire during the second day of the course. Thus, what the findings denoted are the English skills and abilities in a non-maritime context.

The instrument was a questionnaire with semi-structured interviews conducted when required. 10 questions were the principal components for factor analysis. Difficult lexis in the questionnaire was verbally translated into Sinhala when requested by respondents especially the Ratings. The instrument used a factor structure of self-ratings of English skills and abilities, self-reported language use and guesstimated professional requirements of English in the field of seafaring. Analysis was conducted using SPSS.

IV. RESULTS AND ANALYSIS

A. *Proficiency in English*

According to the data on Proficiency in English, based on the results obtained at two national exams in Sri Lanka (G. C. E. Ordinary Level and Advanced Level), in the three populations differ. The Cadets on average had the highest proficiency in English. The contrast is clearly visible between the Cadets and the Ratings who have zero experience at sea and with an approximately equal mean age.

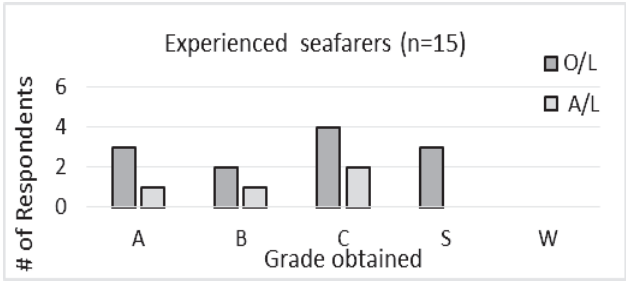

Fig. 1 *Proficiency in English: Experienced Seafarers*

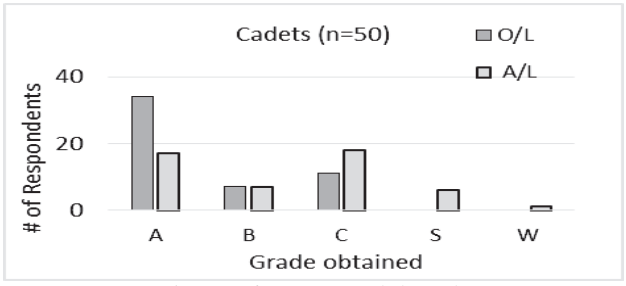

Fig. 2 *Proficiency in English: Cadets*

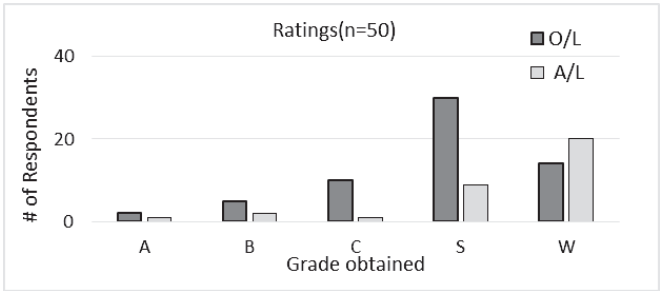

Fig. 3 *Proficiency in English: Ratings*

B. Use of English in Social Domains

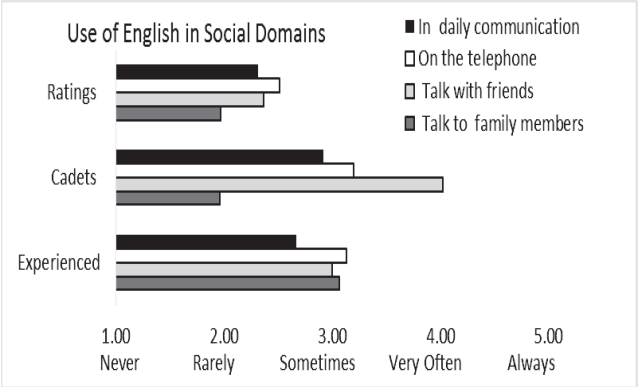

Fig. 4 *Frequency of Use of English in Social Domains*

The higher mean values of the frequency of self-reported use of English in selected social domains is an indication of exposure to and engagement in English across social domains and are vital predictors of high levels of proficiency. This study notes that use of English in the respondents in public domains (e.g. speech with friends, on the telephone and daily communication) is more frequent than in domestic domains (talk with family members) other than in the experienced seafarers who self-reported that they interacted very often in English within domestic domains.

On the other hand, the Cadets had a high frequency of usage of English when interacting with friends while the low frequency in the Ratings indicate that the low proficiency in English hinder its use in domestic as well as public domains.

C. Self-Evaluation of Skills in English: Overall

According to Brown & Harris (2013)[13] self-assessment, also known as self-evaluation, is defined as a process in which students are asked to estimate their own knowledge, skills, and performance. Using such self-evaluation modes this study provides further evidence for the discrepancy in Proficiency in English levels in the participant populations.

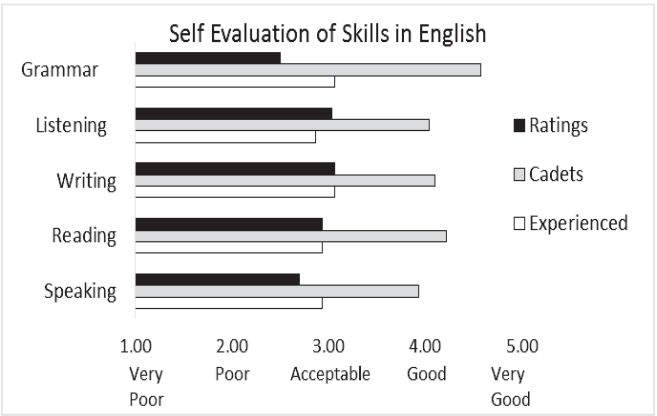

Fig.5 *Self Evaluated Skills in English: Overall*

The analysis above bears evidence that the Cadets on average had the highest mean in self-evaluated 4 skills in English and in grammar. Additionally the self-evaluation of the proficiency of skills too provides further confirmation that the Ratings possess the weakest proficiency levels.

Though the four skills are strongly correlated many researchers (Powers, 2010[14]; Stevens, 2005[15] and others) suggest that they have to be measured separately. Thus this study estimated the four skills in isolation when used in conjunction with a measure of a target ability.

D. Self-Evaluation of the Four Skills in Isolation Based on Target Ability Areas

According to Powers (2010)[14] estimates of language skills in conjunction with a measure of a target ability 'add nuance/depth and accuracy to the measurement of the target ability'. Thus this study utilizes a range of target abilities to gauge English language skills in isolation.

1) Speaking: Intelligibility or comprehensibility is a primary requirement during speech (Ladefoged, 2005: 2[16]; Munro, 2008: 196-197[17]). Munro (ibid: 194) questions the need for users of English as a second language, the category the respondents of this study belong, to speak in a so-called perfect accent and argues that a foreign-accent-free pronunciation is not necessary in communicating in English. Many studies (Altenberg, 2005[18]; Edwards & Zampini, 2008[19]) have revealed that a foreign accent is due to the transfer of L1 sounds to L2 speech. There is agreement among linguists (Garrett, 2010[20]; Modiano, 2009[21]; Scheuer, 2005[22]) that paying excess attention to train an English as a second language learner to a targeted native speaker accent may harm the process of speech production itself, creating pressure and anxiety, since changing accents is a very difficult process. The difficulty scores in the target ability areas given below highlight that a facilitator of Maritime English has to face a daunting task when addressing the needs, especially of the Ratings, in the productive skill: Speaking.

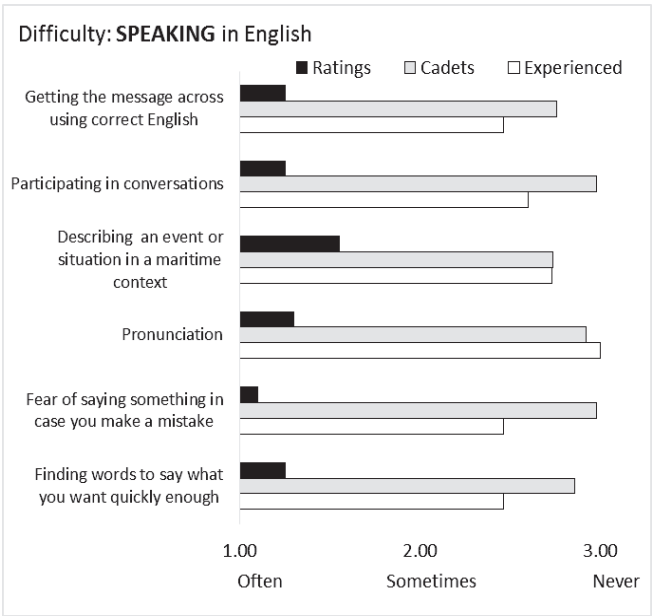

Fig.6 *Self Estimated Difficulty: Speaking in English*

In all target ability areas within the genre of Speaking evaluated above the Ratings self-declare that they often face difficulties. They confess that they are often reluctant to speak due to the 'Fear of saying something in case they make mistakes' (M= 1.1). This often inhibits them thus preventing them from

'Participating in conversations' (M= 1.25). The Cadets declare a confident high score in all the target abilities with the Experienced seafarers achieving a very close mean value to the Cadets. Inviting attention to the fact that these are self-declared estimates it is interesting to note that the Experienced seafarers profess that they have no difficulty (M= 3.00) in the area of pronunciation.

2) *Reading:* General Maritime Communication, Core Section 1: Elementary level requirements include reading checklists regarding safety procedures on board (Model Course, 2015 3.17, Maritime English: 28)[3]. Intermediate level reading skills include skimming and scanning for information, comprehending email communications, operational manuals, formal reports and documentation.

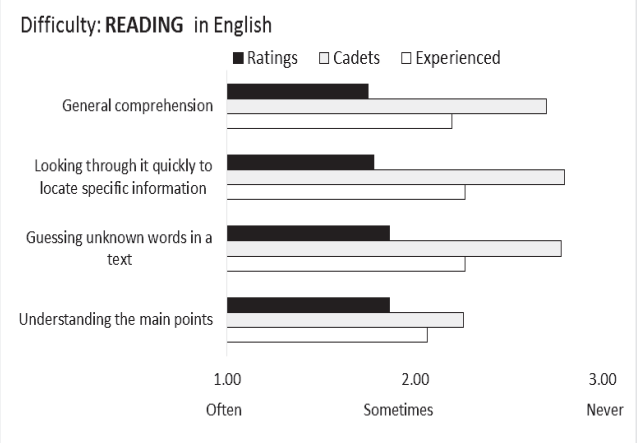

Fig.7 *Self Estimated Difficulty: Reading in English*

The analysis of the results above indicates that general comprehension and locating specific information from a text scored the least mean amongst the Ratings. Yet again in this skill too Cadets Self estimated difficulty*: Reading in English* resulted in a Mean = 2.6 within close approximation of the highest score 3 given to *Never*. The Ratings with a Mean = 1.82 *Often/Sometimes* had difficulty in all the target ability areas within the genre of *Reading in English.*

3) *Listening:* Analyzing the Self estimated difficulty*: Listening in English* it is noticed that the Ratings often had difficulty in *Understanding speakers from other countries* (Mean = 1.05) as denoted in the graphical representation below. Yet again the Ratings self estimated that they had difficulty in General listening comprehension (Mean = 1.25) too.

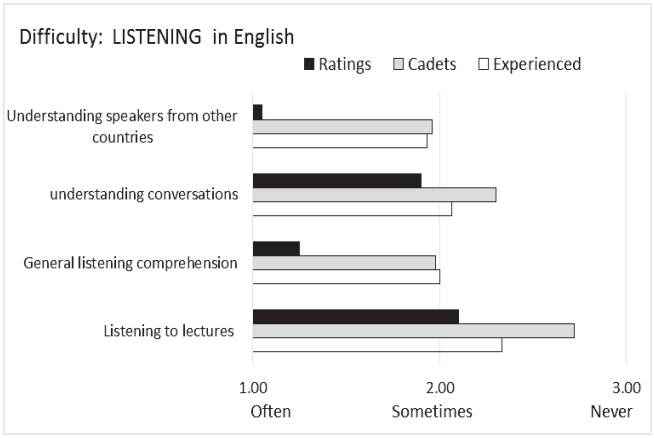

Fig.8 *Self Estimated Difficulty: Listening in English*

4) *Writing*

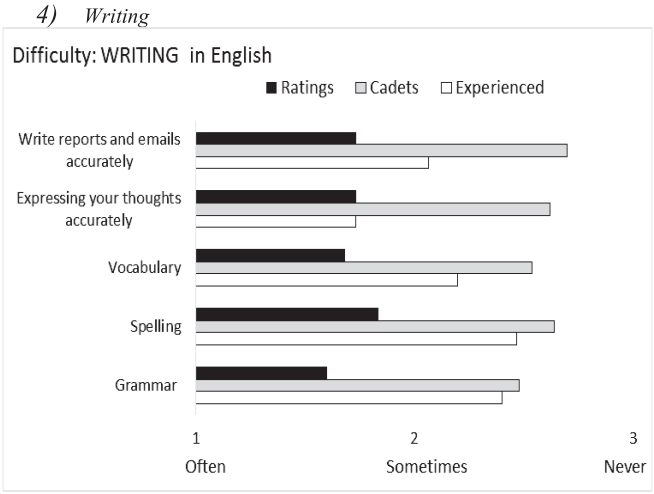

Fig.9 *Self Estimated Difficulty: Writing in English*

Vocabulary and grammar as indicated by the statistics above are sensitive areas within the skill of *Writing in English.* Setting a trend the Ratings yet again were weak in all target abilities measured. The weakest are vocabulary and grammar.

Thus, this study identifies a trend in the Self estimated difficulty declared by the respondents in the four skills examined. The Cadets enter the course with a fairly advanced overall proficiency in all skill areas in English and the intermediate level course outline would further their abilities to use the skills in a Maritime context.

But the greatest need for skill development exists in the Ratings. Thus the lesson planning while been guided by the example set down in the Model Course 3.17, Maritime English (2015: 199)[3] should be implemented strategically to suit the student population while motivating them to enhance their proficiency in English. This is imperative as the analysis below indicates that all respondents unanimously recognize the importance of English language skills and abilities for success in the maritime field.

E. Importance of Skills in English to a Career in Seafaring

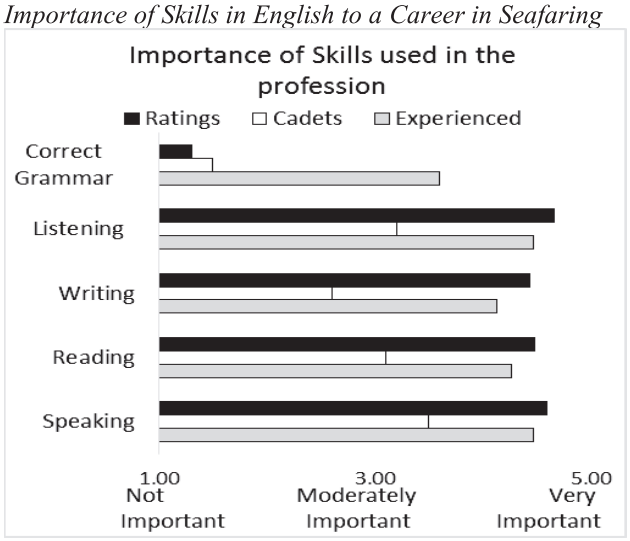

Fig.10 Importance of *Skills Used in the Profession*

The ability to use *Correct Grammar* in a seafaring career is deemed to be approximately *Not Important* to Cadets and Ratings while the Experienced seafarers caution about neglecting grammar giving it a Mean = 3.60 which places it in the *Important* category. This contrast shatters the illusion in the new entrants that *Correct Grammar* is not a primary requisite to the communicative functions of a seafarer.

F. Importance of Language Abilities for Success in the Maritime Field

This study along with the analysis *Self estimated difficulty* in target abilities juxtaposes statistics on the importance the respondents place upon selected language abilities for success in the maritime field.

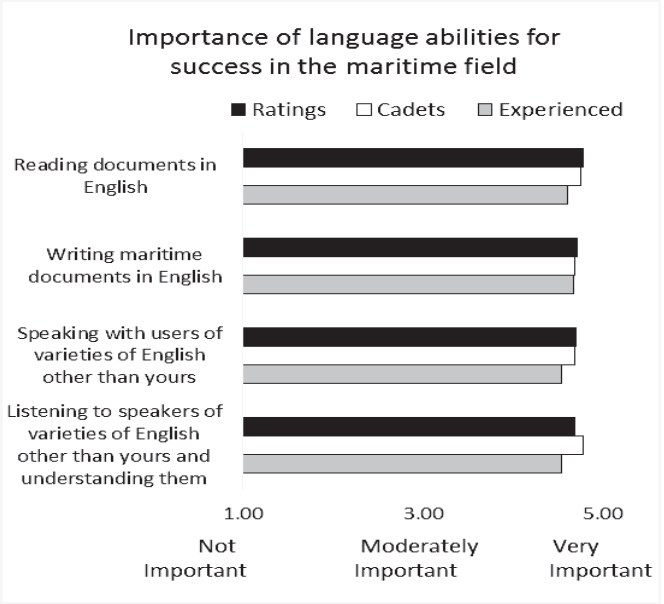

Fig. 11 *Importance of Language Abilities for Success in the Maritime Field*

What is noted is that the Ratings have the self-realization that they are consistently weak in all skills in English. Moreover, they recognize the importance of these skills in their chosen career. This will generate a stimulus motivating them and is an advantage to the MrE facilitator.

G. Reasons for Becoming Seafarers

As reasons for becoming seafarers this study selected five categories for evaluation. Most respondents, especially the Cadets and the Ratings, are consistent in identifying the importance of the targeted reasons. All respondents consider *Free boarding and lodging* the least important reason for choosing seafaring as a career. One Cadet in the *any other reason/s* category noted *Freedom* as an important reason.

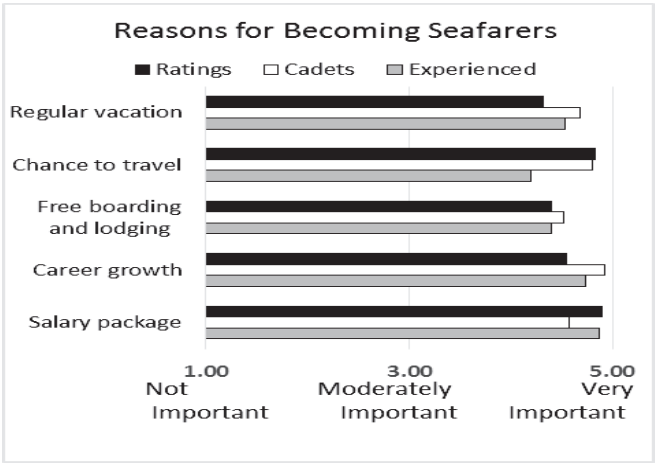

Fig. 12 *Reasons for Becoming Seafarers*

The Experienced seafarers provide the contrast for the analyses in this study. One respondent from the above category, very fluent in English, had side notes to inform the researcher of the irony in the above choices. Commenting on *Chance to travel* he states,

> If you want to travel get a ticket and travel the world. It is a lie that we get to see everything when we go to port.

This makes the *Chance to travel* highly rated as a reason for becoming seafarers among the Cadets and the Ratings (Mean = 4.80 and 4.83 respectively) become a myth.

He had the following to say on *Regular vacation.*

> We get surprisingly big vacations as there are no jobs. Time intervals without ships are massive.

This respondent seems to project the reality in the Sri Lankan context to the new entrants who embark on a career of seafaring.

H. Self Declared Identity of Variety of English in Usage

As a linguist this researcher had the opportunity to keenly observe the pronunciation of the respondents in communication and during loud reading. The observation was that other than 2 Experienced seafarers, who at supra segmental level had slight nuances of a native variety of English, the rest of the respondents were bilingual in Sinhala/Tamil and a variety of Sri Lankan English. The intelligibilty of the pronunciation was high in the Cadets while satisfactory in the Ratings. The findings are graphically represented below.

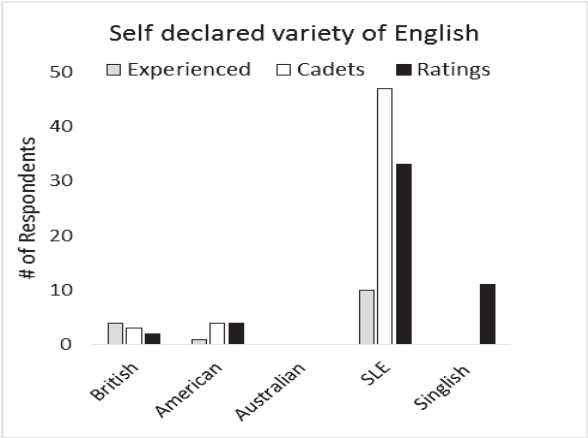

Fig. 13 *Self Declared Variety of English*

The results of *Self declared variety of English* as seen above consist of a few claims that they were using British or American English. Thus the *self declared variety of English* gives rise to further discussion.

This researcher conducting informal interviews with the respondents who claimed that they spoke British English (BE) discovered that they believe that they use the donor colonial BE pronunciation. It is true that the donor variety during the colonial linguistic contact was BE. But BE pronunciation has undergone a long period of evolution within the linguistic ecology of Sri Lanka.

At this juncture the researcher seeks to digress momentarily as awareness on the linguistic atmosphere in Sri Lanka is deemed necessary. The first exposure of the monolingual Sinhala/Tamil speech communities to English would have occurred as far back as in 1796 when the British East India Company annexed the maritime provinces of Ceylon. Thus as Gunesekera (2005)[23] states 'from the close of the 18th century (1796) English has been used in Sri Lanka'.

This signifies that the evolution of English within Sri Lanka has taken place over a period of more than 200 years and has created a new nativized, acculturated, endonormative variety, Sri Lankan English (SLE) and two major speech communities Sinhala/SLE and Tamil/SLE bilinguals. SLE has a standard variety Standard Sri Lankan English (SSLE) with a codified phonological, morphological, syntactic identity; defined standard usage. The phonology of SSLE reflects a strong influence from the vernaculars of Sri Lanka: Sinhala and Tamil. This results in identified deviations from the donor colonial Standard British English pronunciation. Furthermore, there is variation within the variety. Users of Other Varieties of SLE (OVSLE) differ from SSLE mainly in the area of pronunciation (Refer to Widyalankara, 2014b[24] for further details).

Relinking with the findings under *Self declared variety of English* observation of auditory production skills and experience in identifying pronunciation variation makes the researcher hesitant to categorize the respondents who self declared that they were users of BE under native speaker category. Albeit, recognition is granted to the slight nuances of BE pronunciation which were evidenced.

Two Experienced seafarers who claimed that they use American English (AE) stated that they had worked for short durations with native speakers of AE. Other than a few identified segmental areas where they adhered to AE pronunciation they bear no linguistic claim to classify themselves as users of AE.

Into this labyrinth enter the highly proficient Cadets. The majority of them claim that they are users of SLE. This researcher identifies them as users of SSLE. Against this population are the self-declared users of *Singlish*[1]. Attention is requested to the fact that the analysis in Fig. 13 demonstrates that it is only Ratings (n= 11) who declare that they use *Singlish*. *Singlish* in the sense the respondents intend, as explained at informal interviews, is a mixture of English and Sinhala. They claim that the vocabulary of *Singlish* consists of words originating from Sinhala occurring at a high frequency with lexis from English.

In linguistic terms when speaking *Singlish* English is the lexifier language and is dominant in the utterances. But it can be considered a form of Code-switching, the practice of moving back and forth between two languages in a bilingual. Linguists (Gudykunst, 2004[25]; Muysken, 2000[26]; Winford, 2003)[27] concur that this practice can perform several functions. One function of code-switching is to hide the lack of fluency or memory problems when they cannot access an equivalent word in the second language from their mental lexicon. But Linguists caution that this form of code switches accounts for about only 10 percent of speakers who are weak in the second language. The Ratings during interviews declared that they switch codes as they are weak in their second language which is English in this instance. Thus they use *Singlish* or code-switch between English and Sinhala when they cannot access the English word for Sinhala concepts from their mental lexicon.

V. Conclusion

The framework for this research employed a questionnaire cum interview methodology to gauge self declared English proficiency and collected self-reports of patterns of use of English. Based on the findings this research presents a detailed picture of the needs in English among two targeted main populations: Cadets and Ratings at CINEC, Sri Lanka.

Findings include the following.

- The Ratings are identified as a very weak population in all skill areas in English. In the area of speaking they fear of saying something in English in case they make mistakes and as they have difficulty in getting the message across using correct English.
- First language interference in this population is high in speech the as they often cannot find words to say what you want quickly enough. This makes 20% of the Ratings identify themselves as users of *Singlish.* This requires extensive vocabulary enhancement.
- The important point here is that *Singlish* cannot be used as a functional language on board. In addition, it stands to reason that along with a low corpus of English words comes intelligibility concerns in pronunciation.

Model Course 3.17, Maritime English (2015: 147)[3] states the following on World Englishes.

[1] This variety should not be confused with Colloquial Singaporean English.

> Today, so many varieties of English are spoken world-wide that there is no single model of pronunciation and it is certainly not necessary to aspire to speak 'the Queen's English'. There are more people now speaking English as their second language than are native speakers. We also have to remember that there are a range of 'Englishes' i. e. accepted variations of English with particular accents and linguistic styles, e. g. Indian English, Sri Lankan English, Malaysian English, Australian English.

But it further claims,

> An accent forms part of the speaker's identity and is acceptable so long as it does not prevent the speaker being understood'. Furthermore teachers will need to select the areas that are of most importance to the nationality of the group in order to minimise first language interference with English. (ibid)

Thus it is pertinent that lesson planning in MrE should address these skill deficits of the Ratings.

- The Cadets are entry level officers requiring intermediate level exposure to all aspects of MrE. Adhering to the guidelines provided by Model Course 3.17, Maritime English (2015)[3] and bringing in technology to the classroom as suggested in the Model Course will fulfil the objective of further enhancing the language skills of these proficient users of SSLE.

Limitations of the study include the following.

The population selection targeted the Cadets and Ratings in the sampling procedures at CINEC Sri Lanka. Thus there is a population restriction which needs caution when extending inferences to a population of students in a different country.

The experienced seafarers were a restricted contrastive population. A larger population was infeasible and it is recommended that a larger population would result in a better contrast in future studies.

Self-reports of skills and abilities are rough indicators and a collated formal evaluation of proficiency would give an even richer and more valuable picture of skills and ability levels of the populations.

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Factors to be Considered when Purchasing, Using, Maintaining and Monitoring the Condition of Plant and Equipment for Promoting Sustainable Development

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***Abstract*- It has been found that a vast majority of organizations in this country do not have proper guidance about monitoring their plant and equipment in order to enhance productivity. First of all there should be a guide line for the selection and purchase of plant & equipment. There after we should know how to use them correctly, and also how to maintain and monitor their condition periodically. Without introducing such arrangements, most organizations suffer in their business activities and incur heavy losses. Only a few organizations have any clear idea of the factors that have to be taken into consideration when purchasing plant and equipment and other related issues. As we all know the need of the current era is sustainable development which means the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Accordingly, we have to consider the three factors namely the economy, environment and society when we purchase plant and equipment for our organizations.**

***Keywords*-** Sustainable development, Selection of plant and equipment, Overall equipment effectiveness.

I. INTRODUCTION

This paper is a result of my long experience as an Engineer, Manager and Consultant, involved in improving the performance of industrial organizations with respect to the quality and productivity. The paper introduces specially the guidelines indicating factors for the selection of plant and equipment for industrial organizations.

The Brundtland Commission in 1987 in "Our Common Future" [1] defined Sustainable development as follows.

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

In the present context the concept has evolved and according to Shaker (2015) [2].

> The term 'sustainability' should be viewed as humanity's target goal of human-ecosystem equilibrium (homeostasis), while 'sustainable development' refers to the holistic approach and temporal processes that lead us to the end point of sustainability. (p. 305)

Singh et al., 2009 [3] incorporates three main processes contributing to sustainable development.

> In terms of sustainability, it must address an integral approach that encompasses suitable measures that reflect economic, environment and social aspects.

The figure below projects this through a Venn diagram.

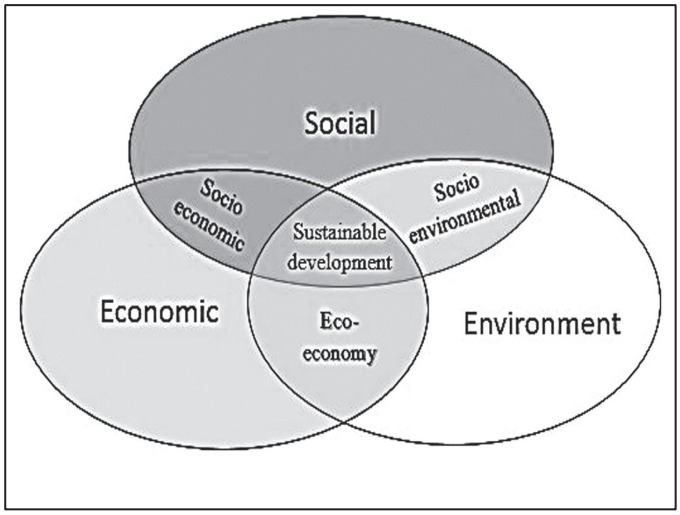

Fig. 1 Sustainable Development [4]

In Figure 1 above *Social* denotes Respecting individuals, Equal opportunities and Human rights. *Environment* stands for conserving the environment. *Economic* represents consistent economic growth. *Socioeconomic* stands for Sponsorships, employment, Training and Development while *Socio- Environmental* encompasses the criteria Climate Change, Responsibilities for environmental changes, Health and Safety. *Eco-economy* represents Renewable resources and energy efficiency.

II. METHODOLOGY

The following eight factors should be considered when selecting plant and equipment for any industrial organization.

A. *Fitness for the Purpose*

This is the most crucial factor. There is no point in going for equipment of high quality, high efficiency or low cost if the equipment cannot fulfill the desired purpose.

B. *Cost*

The cost of equipment includes several factors as outlined below.

1) Purchase Cost – The selling price of the equipment.

2) Transportation Cost – The cost incurred to get them down from the place where they are available for sale (CIF value)

3) Installation & Commissioning Cost – The expenses incurred to install the equipment in the required location and commence operations.

4) Training Cost – The cost incurred to train the operators in order to operate and maintain the equipment.

5) Operational Cost –The cost of operation which includes the cost of electricity, fuel or gases which are necessary for its operation.

6) Maintenance Cost – Special skills may be necessary to maintain the equipment and also the cost of materials required for maintenance and repairs.

7) Disposal Cost – The cost incurred to dispose the salvage item. This has now become a legal requirement. After using the salvage also has to be disposed in an environment friendly manner which has now become a legal requirement

C. *Durability*

This relates to the depreciation of the equipment which means the loss in value due to wear and tear.

If the equipment can be used only for a short time, the loss in value due to wear and tear would be very high.

D. *Guarantee and Warranty*

Guarantee means the assured period of fitness for the equipment to function without failing prematurely. If it fails before the guaranteed period due to manufacturing faults, the supplier is bound to compensate the customer for the loss incurred.

Warranty means mandatory maintenances which should be done by the supplier free of charge. However, it is an obligation of the customer to get such services done as recommended by the manufacturers as stated in their service instructions. If an equipment fails for not complying with this requirement the customers will not be compensated for any losses suffered.

E. *Risk of Obsolescence*

This denotes the risk of becoming outdated. Although equipment could be used for several more years, the new equipment that are introduced to the market could be much more productive and could give better quality products or services at a lesser cost. If our competitors use them, they can offer much better products or services at a lessor cost with better quality and efficiency than us and they could become a threat to our business.

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F. *Ergonomic Factors (Human Factors)*

As defined by Dohrman Consulting (2014)[5], Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and the profession that applies theory, principles, data and methods to design in order to optimize human wellbeing and overall system performance.

Such factors would enable us to operate and maintain the equipment easily, efficiently and economically which is known as a “user friendly” approach.

G. *Environmental Factors*

According to the Central Environmental Authority (2017) [6], the equipment should be environmental friendly. This means that there should be less emissions such as dust, fumes, gases, smoke, noise, vibration and waste. The cost of energy such as electricity, fuel or gases should also be minimized. After the usage the salvage should be easily disposable without causing any environmental pollution.

Environmental Management System is a set of processes and practices that enable an organization to reduce its environmental hazards and energy cost. This is an important factor that has to be considered in the modern industry.

H. *Occupational Health & Safety Focus*

International labor standards on occupational health &safety specify that all equipment used in the industrial sector should be safe & less hazardous in order to protect the occupational health and safety of employees. Such requirements have to be looked into during the design stages. A systematic approach for managing safety has to be taken into consideration when purchasing equipment.

It is also essential to consider the following two factors when purchasing plant and equipment which are also categorized under safety requirements.

I. No Load Protection

The power supply to the equipment should not turn on without a load which is part of its protection. Any devices connected to it should also satisfy the load requirements.

J. Over Load Protection

Every electrical circuit in the equipment must be protected against overloads.

III. Overall Equipment Effectiveness (OEE)

Quality rate indicated as OEE measurement is made up of three elements, each one expressed as a percentage and accounting for a different kind of waste in the manufacturing process. The three elements are Availability, Performance & Quality Rate (Paul (2013)[7]; Vorne Industries, 2016 [8].

OEE = Availability x Performance x Quality Rate

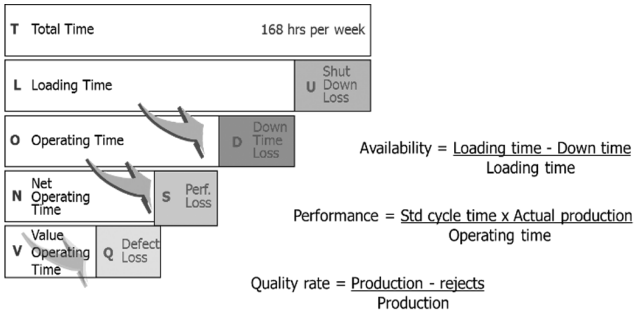

Fig. 2 – OEE Calculation

A. **Availability:** Is a measure of the time the plant was actually available for production compared to the manufacturing requirements. Any losses in this area would be due to major breakdowns or extended set up time.

$$\text{Availability} = \frac{(\text{Running Time} - \text{Stoppage Loss Time})}{\text{Running Time}} \times 100$$

B. **Performance:** It is the rate that actual units are produced compared to the designed output. Losses in this area would be due to slow speed, minor stoppages or adjustments.

$$\text{Performance} = \frac{\text{Theoretical Cycle Time} \times \text{Processed Amount}}{\text{Productive Working Time}} \times 100$$

C. $$\text{Quality Rate} = \frac{\text{Items Acceptable}}{\text{Total Output}} \times 100$$

If the exact values are not available, the assessed values could be used instead to determine the OEE.

IV. Conclusions

All industrial organizations should use guidelines by emphasizing the above factors which must be considered when purchasing plant and equipment. They should use manufacturers guidance for the correct use, maintenance and monitoring of plant and equipment.

All related staff should be educated about the use of the above guidelines. Such an approach would be essential to promote sustainability which includes the promotion of economy of the organization and also to comply with the related statutory and regulatory requirements. After purchasing the equipment, they have to be maintained as per the guidance laid down by the manufacturers in their service catalogues and other related literature. Beside that it would be necessary to monitor the condition of the equipment periodically.

By implementing the requirements mentioned in the proposed guidelines, industrial organizations would be able to perform their technical operations efficiently, effectively and economically.

The measure of the Overall Effectiveness of the Equipment (OEE) should be monitored annually and their values should be displayed on the equipment. Such information should be included in the annual fixed asset verification reports and discussed at the management meetings accordingly.

Further the Product Life Cycle (PLC) is the cycle through which every product goes through from introduction to withdrawal or eventual demise. PLC analysis, if done properly, can alert a company as to the health of the product in relation to the market it serves.

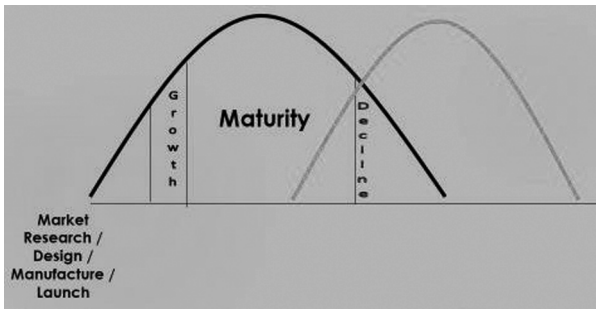

Fig. 3 – Product Life Cycle

A product in this instance, can be a physical item or a course in an educational discipline. According to ISO terminology a product is a result of a process. In a production, first a market research has to be conducted to determine the demand. The next stage is designing the product/ course. Then the manufacturing of the physical item or launching the course takes place. Initially there will be a growth which will peak at maturity and then the demand will decrease. Before the demand is completely eliminated the next cycle begins.

Thus when a company orders a physical item or launches a course the life span of the equipment or the demand for the course should be estimated depending on the requirement of the company. If such plans are not made huge losses could be incurred.

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Factors Associated with the Use of E-learning Systems in Selected State Universities of Colombo District.

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***Abstract*-The swift development of internet technology had made a remarkable impact on learning. Technology has been used as a tool to support thE-learning. Electronic learning (E- learning) is considered as the main component of this techno oriented learning infrastructure. The purpose of E- learning programs is to facilitate and assess the learning with the support of communication technology. Compared to the last decade, students are now using E-learning for their studies. Though E-learning is highly used in higher education, some drawbacks can be seen in implementing and maintaining of E- learning programs. Those drawbacks are reducing the productivity of learning. Therefore, it is essential to identify the factors which are associated with E-learning and then to implement E-learning systems. The aim of this article is to identify the factors associated with the use of E-learning.**

Keywords: Electronic learning, deficiencies, factors

I. INTRODUCTION AND LITERATURE STUDY

With the advancement of ICT, E-learning is becoming the most significant recent development in the field of education. Most universities nowadays develop and are planning to develop E-learning programs in order to fulfill the large amount of distance learning requirements. E-Learning also supports the access to learning resources, communication facilities, assessment facilities, administrative and student support. Therefore most of the Sri Lankan universities especially State universities are now very much interested on E-learning projects. The Government of Sri lanka has allocated funds in order to fulfill this requirement.

Several educators have considered E-learning as the newest development of distance education. E-learning provides more active and synchronous learning by using interactive technology (Choi et *al.*,2008). According to Harman, & Kulkarni (2007), E-learning is having the ability to improve the quality of learning, improve access to education, reduce the cost of education and improve the cost effectiveness of education. E-learning can be considered as the most popular learning tool in modern education. Therefore, it is highly used in universities, as students finds it more reliable to work with. Electronic learning provides several benefits to modern education. It provides unique opportunities to students, who have limited access to training and education. E-learning associates with new and creative methods to guide and provide unique access to information resources.

Several researchers have conducted various studies to identify the success factors associated with the Use of E-learning. Govindasamy (as cited in Selim,2007) is one of the researchers, who discussed the learning quality.

Most of Sri Lankan students are now enrolling in government or foreign universities to gain a degree after school education. E-learning is highly used in Sri Lankan higher education nowadays due to its interactivity and effectiveness. As a part of E-learning, distant learning is now also becoming a popular learning method. The Quality Assurance and Accreditation Council also known as QAAC(as cited in Suraweera,2011) had recommended that it should ""take necessary Phases to commence e-learning courses for both internal and external students ("Subject Review Report: Department of Library and Information Science," 2008). The QAAC, is a part of UGC Sri Lanka, which serves to enhance the quality of Information education.

TABLE I

BATTERFIE'S MODEL

Type of Dimension	Associated factor
Learner Dimension	Learner attitudes towards computers
	Learner computer anxiety
	Learner Internet self-efficiency.
Instructor Dimension	Instructor attitudes
	Instructor responses timeline
Course dimension	E-Learning course flexibility
	E-Learning course quality
Technology dimension	Technology quality
	Internet quality.
Design dimension	Perceived usefulness
	Perceived ease

QAAC named quality benchmarks such as good institutional support, proper course structure, traditional classroom learning methods such as face to face learnings, written exams, tutorials, laboratory practices.

Volery and Lord (as cited in Selim,2007) identified three factors associated with the use of E-learning. Researchers had randomly selected about 200 university students for the survey and identified most related aspects for Online education. Finally, Volery and Lord had identified several factors. Those were technology (including ease of access, interface design and level of interaction), Instructor (attitudes towards students, instructor technical competence and classroom interaction), and previous experience of using technology.

The Study used deductive approach, as it is based on a proved theory and narrows down to a more specific hypothesis to test. The existing theory plays a major role, as it encourages to develop research hypothesis and variables.

Theory ⟶ Hypothesis ⟶ Observation

B. Quantitative Approach

Quantitative approach has been used for the study. Characteristics of the sample were analyzed numerically. Each variable was assigned a weighted value and then appropriate statistical methods were used to identify the significant association between independent variables and dependent variable. Finally, results were generalized to the population. The size of the population was 859. The population consisted with internal undergraduate

Bhattacherjee(2001) had done a study on success of E-learning. He had used randomly selected sample and conducted the study using both qualitative and quantitative approaches. Based on the results, expectation and confirmation model was derived. The model describes the learners 'satisfaction with E-learning by discussing six dimensions. Those dimensions are student dimension, instructor dimension, course dimension, technology dimension, design dimension, and environment dimension. Under those six dimensions, thirteen factors are identified listed in Table 1.

II. METHODOLOGY

A. General Objective

This paper uses data from undergraduate students from selected state universities in Colombo district. The general objective of this paper is to find out the factors which are associated with the use of E-learning in selected state universities. The general objective is categorized to following specific objectives;

B. Specific Objectives

To identify Personal factors associated with the use of E-learning

To identify Academic factors associated with the use of E-learning

To identify Technical factors associated with the use of E-learning

To identify Social factors associated with the use of E-learning

III. RESEARCH APPROACH

A. Research questions

1. What are the personal factors associated with the use of E-learning?

2. What are the social factors associated with the use of E-learning?

3. What are the academic factors associated with the use of E-learning?

4. What are the technical factors associated with the use of E-learning

Researcher assumed that several factors are associated with the use of E-learning. Researcher made hypothesis based on those assumptions. The study was then carried out to check hypothesis which rejects the null value.

students of selected state universities of Colombo district.

C. Data Description

Several independent variables were detected under each factor. Use of E-learning is considered as the dependent variable for the study.

D. Data Collection.

Collection of data was done using a questionnaire.

E. Sampling procedure

The purposive sampling method was used as the sampling technique. The researcher had found departments of each universities which uses E-learning systems in their studies. From each department total number of students were identified.

F. Data Sources

The Data source for the research was all the participants of the sample. Also, books, e books, e journals, web sites, reports, subject experts‟ knowledge has been used to find information to the research. verbal statements were also used in order to verify the gathered data.

TABLE II

RESULTS OF BINARY LOGISTICS REGRESSION

Variable	S.E.	Wald	Sig.
Gender	0.353	0.260	0.610
Age	0.257	0.249	0.618
Mother tongue	0.335	0.828	0.363
University	0.128	4.354	0.037
Faculty	0.135	0.063	0.802
Academic year	0.189	0.587	0.443
IT Background	0.268	8.019	0.005
Often of connection	0.099	0.763	0.229
System Availability	0.190	6.000	0.024
Constant	2744.190	0.000	0.996

IV. DATA ANALYSIS

A. *Questionnaire and fact finding*

Data for the study was gathered using a questionnaire. The questionnaire consisted with twenty-two main questions. Among the twenty-two questions, fourteen questions have single answers. Two open ended questions were also added to the questionnaire. questionnaire also consisted of four multiple choice questions. Last two questions were Likert scaled questions.

A pilot survey was conducted, before starting the actual data gathering. It was done to identify the success of the questionnaire. The pilot questionnaire was distributed among eighteen students of the sample. (Student selection for the pilot survey was random). Few changes were made on the questionnaire based on the response rate of the pilot survey. Finalized questionnaire was distributed among the sample.

Data collection process has been taken at selected departments. Collected data was analyzed using SPSS 21. It was noticed that 377 students have submitted their responded questionnaires. Missing values has been detected in submitted questionnaires. Missing values were recoded to the same corresponding variable before starting the data analyzing process. Therefore, missing values are also utilized to the study.

Descriptive analysis was also done on data in order to Analyze the sample. Figure 1 presents the results obtained for Gender.

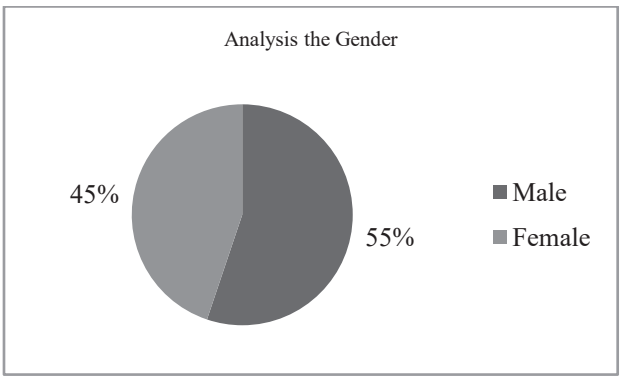

Fig1.Analysis of the Gender variable

According to the Figure 4.2, most of participants were Male students, by giving 55.00% responding rate from the total participants. Responding rate of Female participants are 45.00%. No missing values for this question. It was clearly noticed that all participants have responded to this question.

Selection of students for the study was random. Each student was given an equal opportunity for answer

questions. No favor or no potency given for any students at the time of study.

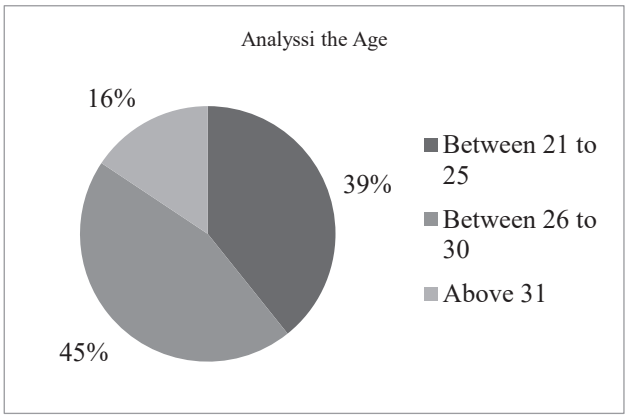

Fig 2 Analysis of the Age

According to results, highest number responses were obtained from 26 to 30 age categories.

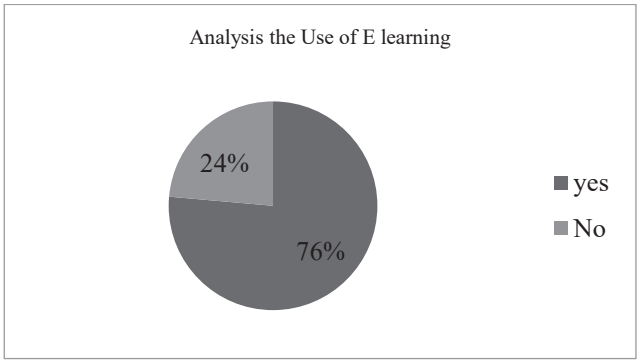

Fig 4 Analysis of the Use of E-learning

According to the Figure 4, 76% of the sample is using E-learning systems.

Cross tabulation was used to identify the association between independent and the dependent variable.

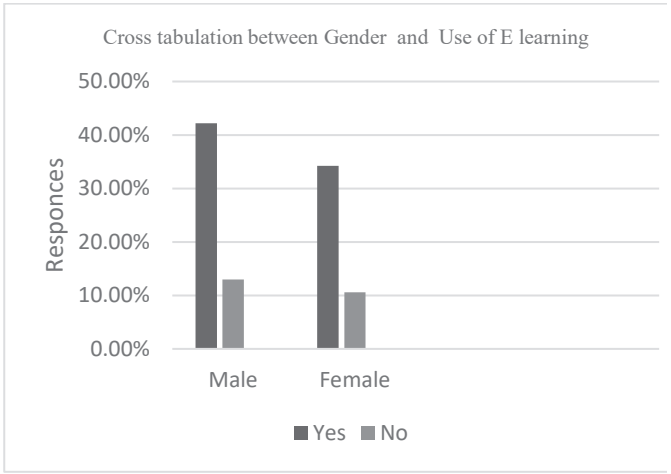

Fig 6 Cross tabulation between Gender and Use of E-learning

According to results, Male students are more interested on using E-learning systems.

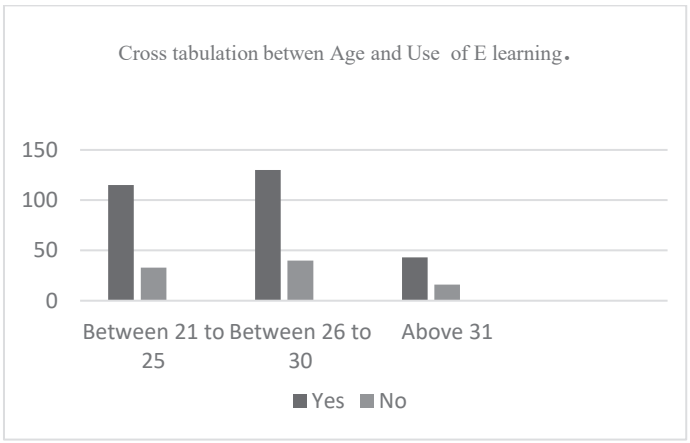

Fig 3. Cross tabulation between Age and use of E-learning.

According to figure 3, students who are in age between 26-30, use E-learning systems than others.

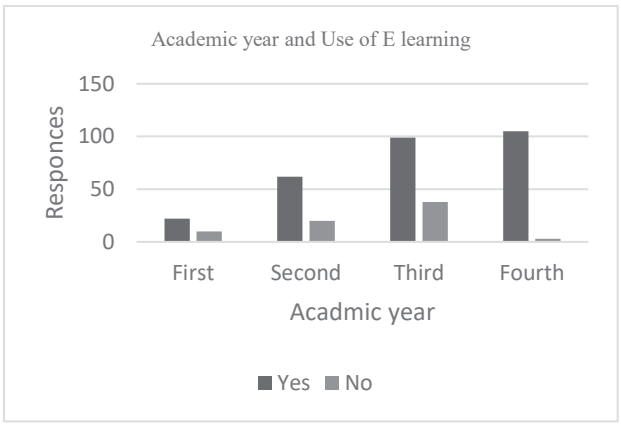

Fig 5. Cross tabulation between Academic year and use of E-learning.

According to the figure 5, fourth year students use E-learning systems than others.

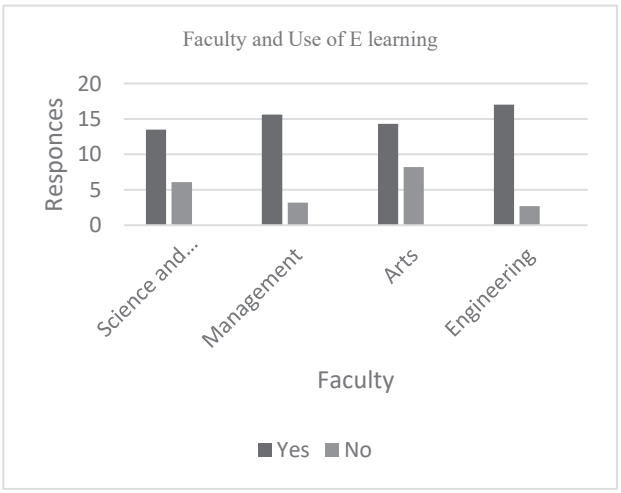

Fig 7. Cross tabulation between Academic year and use of E-learning.

According to the results, Engineering students are highly using E-learning systems.

B. Binary Logistics Regression

Binary logistic regression analysis was used in the research, as the Dependent variable (use of E-learning) is dichotomous. weighted values were assigned to use of eLearning as follows.

If yes for use of E-learning – 1

Not using E-learning - 0

Each independent variable is tested with the dependent variable to discover a statistical correlation. Results were Tabulated below.

C. Hypothesis Testing.

Correlation Analysis was performed to examine each hypothesis. For each hypothesis, null hypothesis and alternative hypothesis are derived.
Null hypothesis: H0
Alternative hypothesis: H1

Hypothesis 1: Use of E-learning is depending on Academic factors

Hypothesis 2: Use of E-learning is depending on Social Factors.

Hypothesis 3: Use of E-learning is depending on Technical Factors

Hypothesis 4: Use of E-learning is depending on Personal factors.

Hypothesis tested during the analysis. Correlation and Binary Logistic Regression analysis was used to discover factors. If a significant value was obtained below 0.05, the null hypothesis was rejected and decided that there is an association available between independent and dependent variables. Following independent variable were identified as having significant association with the Use of E-learning. Those are,

- University- significant value was 0.037
- IT Background- significant value was 0.005
- System Availability- significant value was 0.024.

Identified independent variables can be categorized to following factors.

University- Academic

Table 2 shows the results of Standard error, Wald statistic values, and significance value of each independent

variable. The table shows the contribution of each independent variable to the model and statistical significance. The Wald statistic was used to determine the statistical significance of each independent variable to the dependent variable. Significance value was used to determine statistical significance between tested variables. Significance value of University, IT Background and System Availability are less than the 0.05. The Wald statistic value of University, IT Background and System Availability is also more than 1.000. Therefore, University, IT Background and System Availability has a significant correlation to the Use of E-learning.

V. CONCLUSION

A. Conclusion of Binary Logistics Regression.

According to Binary logistics regression, following factors were selected as having a statistical correlation with the use of E-learning.

- University - Significant value obtained was 0.037, which is smaller than 0.05.
- IT background- Significant value obtained was 0.037, which is smaller than 0.05.
- System availability- Significant value obtained was 0.024, which is smaller than 0.05.

Therefore University, IT background and System availability has the significant impact on E-learning systems.

IT Background, System Availability- Technical

B. Conclusion of the Study

The development of new information technologies in the 21st is rapidly introducing new opportunities in education. It is also creating conditions for the formation of a global informational, educational and cultural space. From this research, the researcher had tried to identify the factors associated with the use of E-learning. ICT seems to have an extreme impact on the process of learning. ICT offers new possibilities for learners and educators. Therefore, ICT directly make an impact on student's performance.

Academic Factor and Technical factors are having significant association with the Use of E-learning. Results of the study shows that use of E-learning systems is highly dependent on

university and technology. Researcher believes it is worth to identify those factors to enhance the quality of education.

Acknowledgement

The research was supported and monitored by the University of Colombo, Sri Lanka. The author wishes to credit all selected State universities of Colombo district, for their tremendous support nurtured throughout this study.

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Effect of Latency for a Reputation Based Trust Model of Peer-to-Peer Content Distribution Networks

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***Abstract* — Over the last few decades, pioneering tools and techniques for successful communication have been invented with the remarkable evolution of attention in information sharing and knowledge. As a result, sophisticated communication environments are invented in order to have a better communication and information delivery. Internet has become the most outstanding discovery among extensive communication technologies with gigantic volumes of information. Content Delivery Networks (CDNs) have been introduced for rich and rapid data delivery over the Internet. Hence the capability enhancements of CDN nodes have been improved the reputation and the scope. Various challenges appeared on those open and autonomous network architectures in order to achieve confidentiality, authenticity and availability security dimensions. This paper resolves trust issues between content delivery nodes on Peer to Peer (P2P) network infrastructures by an enhancing trust algorithm of my previous research "de-centralized reputation based trust model for peer to peer content delivery networks" (Shanika Ekanayake, 2014). Moreover, performance comparison between previous trust algorithm and the enhanced trust algorithm is evaluated through the ns-2 simulator.**

Keywords— Peer-to-Peer Content delivery; Reputation based trust; Content Delivery Networks; ns-2

I. INTRODUCTION

Traditional Content Delivery Networks (CDNs) have evolved to overcome the in-built limitations of the Internet in terms of user perceived Quality of Service (QoS) when accessing web content. CDN architecture or the client/server model replicates content from the origin server to cache servers, which are scattered over the globe in order to distribute content to the end-users in a reliable and timely manner from nearby optimal surrogates. Therefore, the latency can be significantly reduced. CDN combines development of high-end computing technologies with high performance networking infrastructure and distributed replica management techniques. Various technology enhancements support CDN nodes to frequently deploy over multiple backbones and Internet Service Providers (ISPs) as well as over multiple point-of-presences (POPs) within different ISPs. With this rapid growth of server deployments, CDN companies aggressively promote themselves as video distribution companies. Content distribution companies provide reliable delivery and cost-effective scaling via a shared distribution infrastructure. There are about twenty-eight commercial CDNs (Pakkala and Latvakoski, 2005) and a number of non-commercial networks exist around the globe. Hence, brutal competition has been originated among them for the profitable video distribution market.

Traditional content delivery network environments can be categorized into two different types of basic designs. First category of the design types deploys content distribution servers inside ISP POPs in order to increase user perceived performance in delay as well as in throughput. That will result in a content delivery network which contains a large number of distributed server clusters and this massively scattered design type creates various maintaining and managing difficulties. This design type requires advanced algorithms to shuffle data among the servers across the internet. For instance, Akamai network can be specified as one of the major commercial CDNs, which follows the previously described design.

The other design category builds a small number of large content distribution centers with private high-speed connections as main centers of the network. Each of those distribution centers are generally placed in a location that is near POPs for multiple large ISPs without getting into the POPs of the ISPs. This design type is associated with lower maintenance and management overhead than the first type. However, according to the perspective of the user it may involve higher delays. Limelight network is an example CDN that comes under this design category.

On the other hand, P2P networks are designed for the direct sharing of computer resources rather than requiring any intermediate or central authority. Those networks, categorized as information retrieval networks, are designed by ad-hoc aggregation of resources to create a fully or partially decentralized system. Each peer of Peer-to-peer systems is autonomous and relies on other peers for resources, information and forwarding requests. There is no central point of control involved with P2P networks. As a result, the entities of such systems work together to achieve tasks such as locating or caching content, searching for other nodes, encrypting, decrypting, routing requests, retrieving, and verifying content. P2P systems are not involved with any single point of failures. Thus, such systems are more scalable and fault-tolerant than the centralized systems. Entities of a P2P network can join or leave anytime.

Many differences have been identified between CDN and P2P architectures as specified below. Main considerations of P2P networks are to generate effective strategies to locate certain files within a group of peers and to provide reliable transfers of such files in highly unpredictable situations and heavy traffic situations caused by the demand for very popular files. Compare to P2P systems, the main goal of CDN systems consider the performance requirements of clients than efficiently finding a nearby peer with the desired content. Furthermore, the number of nodes joining and leaving the network per unit time is negligible in CDNs whereas the rate is important in P2P networks.

The flow of P2P networks has spread all over the world recently. Various P2P commercial products and free software packages are available for different purposes and P2P communication has engaged a great amount of Internet traffic. Distributed network architecture of CDNs, improves efficiency of content delivery and the end user experience. On the other hand, high availability and

high performance P2P networks enhance resource sharing competently. However, in order to obtain complementary advantages of CDNs and P2P systems the next stage of CDNs or P2P CDNs have recently evolved. The architecture of hybrid content distribution networks can be further abstracted to a two-level hierarchical hybrid model. Two levels of that model are termed as CDN-level and P2P-level.

1. CDN-level: CDN system is established over backbone network and the content is strategically distributed on surrogate servers. The surrogate server is a logical entity and may consist of multiple physical servers or clusters.

2. P2P-level: All most all P2P levels of HCDN systems are based on centralized P2P systems which are organized over the access network and the peer nodes can exchange content between each other. This P2P system architecture is described as an indexing model. This system contains user nodes as well as an index server. The content is exchanged between user nodes and the index server is only responsible for maintaining the indices. Communication between user nodes and the index server is only used to obtain and update indices. Therefore, the burden of the index server is reduced, and the scalability and robustness are improved. Totally decentralized P2P approach can also be used at this level. Such systems do not contain any centralized control. Peer nodes communicate with each other to share resources over decentralized approach.

With the use of the levels described, above users will be able to concurrently get content from both surrogate servers and other peer nodes. Hence, the combination of CDN and P2P architecture with trust models provide a refined content delivery experience. In P2P CDN architecture, end users can obtain contents from the nearest CDN edge server and they share those contents with other end users or their peers. This content distribution type becomes a popular alternative to traditional CDNs and handles the increasing demand of the end users efficiently. Content distribution is an important peer-to-peer application on the Internet that has received considerable research attention. As an instance, a P2P-based video start-up in China called PPLive revealed that it is possible to use 10 Mbps server distribution bandwidth to serve 1.48 million users concurrently at a total consumption rate of 592 Gbps (Huang, 2007). Practical combination of CDN and P2P environment initiates through hybrid CDNs.

Decentralized and autonomous nature of hybrid P2P CDN networks lead to several reliability issues as mentioned in the following section. Some end users are trustworthy and provide the exact content obtained from the edge server and some of the others might be unreliable and do not provide accurate content to their peers. And also, intruders who are working as end users might provide malicious and false or harmful content. Thus, no assumptions can be made as regards the end user behavior. P2P nodes of CDNs may halt their operation without the knowledge of the Content Service Provider (CSP). Fully dynamic P2P CDN environments experience rapidly joining and leaving end user terminals over moderately slow network connections and performance become lesser with respect to the legacy CDN systems. Trust based approaches try to overcome previously discussed issues over content distribution. This paper evaluates the effect of latency and number of successful packets to my previously build trust algorithm for decentralized CDN environment via simulation results (Shanika Ekanayake, 2014).

The rest of the paper is organized as follows. Section II explains existing trust based approaches over P2P CDNs and section III states enhancements and procedure of the enhanced trust model. Then the simulation process, experiment and test results are described in section IV. Finally, section V concludes the paper by outlining potential future works.

II. Existing Trust models over Peer-to-Peer CDNs

In this particular context, various models have been accomplished and several reviews and surveys established on those models as stated below. Cryptographic based trust models assure trust by providing authenticity of an entity and non-cryptographic models are responsible to confirm fair and secure content delivery while interacting with peers. Among those reviews and surveys a broad analysis on trust in Peer-to-Peer systems is provided [Zhu., Jajodia and Kankanhalli,2006; Arts and Gil,2007]. The review classifies the entire literature on trust in P2P systems into two major sub categories as reputation-based trust and trade based trust. It also provides information on potential attacks in the P2P systems. Reputation of a peer in reputation based trust schemes is decided through the recommendations of the other peers. In trade based trust schemes peers contributing to other peers are remunerated directly or indirectly. Since the proposed trust model is based on the reputation based trust scheme the rest of the survey of existing similar researches focuses on the literature related to this trust scheme only.

Three major challenges have been identified in the reputation-based trust schemes

1. The method to combine essential information to guarantee the accuracy of the reputation
2. The method to detect or prevent different attacks of malicious peers
3. The method to confirm efficiency with the system scales up (Ayyasamy and Sivanandam,2010)

Almost all initial trust models worked as centralized systems and later trust models gradually focus towards the decentralized trust systems. Those decentralized systems evolved in order to work on ad-hoc based unstructured P2P networks.

Boolean relations or fuzzy logic has been inserted in to several earliest trust models. That method tends to generate techniques to analyze unfair behavior; model based on Eigen trust algorithms and trust propagation schemes (Zhu, Jajodia and Kankanhalli., 2006). Chen et al., have proposed a unique poisoning-resistant security framework based on the idea that the only trusted sources to verify the integrity of the requested content would be the content provider. A content provider publishes the information of his shared contents to a group of content maintainers self-organized in a security overlay, to present the mechanisms of availability and scalability. Hence, a content requestor can confirm the integrity of the requested content from the associated content maintainers. They have devised a scalable probabilistic verification scheme, to further enhance the system performance (Chen et al, 2008). Abdul-Rahman and Hailes introduced a decentralized trust model, which contains trust generalisation plus recommendation together. Various research papers used that model as the fundamental concept of those researches later (Abdul-Rahman and Hailes, 1997). B. Mortazavi et al., have first provided a survey of related Peer-to-Peer systems. They then have focused on content distribution networks that have honest but sensibly selfish users. Their focus is to expand a novel reputation framework, in which the absence of misrepresentation of the reputation values can reveal the tendency to cooperate of the peers. Based on their framework, a game is designed in which users play to maximize the files received from the system by adjusting their cooperation level and gaining a better reputation as a result (Cornelli and Damiani ,2002). Repantis and Kalogeraki, have proposed a decentralized trust management middleware, based on reputation for unstructured, ad-hoc, peer-to-peer networks. In their middleware to requests for data or services, the reputation information of each peer is stored in its neighbours and piggy-backed on its replies. In self-organizing networks, the lack of structure and the dynamic nature of the network are usually regarded as barriers in managing trust information. Their approach utilizes these characteristics to build a self-organizing, non-intrusive trust management infrastructure resistant to tampering and collusions (Repantis and Kalogeraki, 2006).

Khambatti et al., have proposed an approach for trust management in P2P systems. They have established an optimistic role-based model for trust amongst peers and prove that it is scalable, dynamic, revocable, secure and transitive. Their proposed

solution allows asymmetric trust relationships that can be verified by any peer in the system through a simple, low-cost algorithm. The authors have introduced a metric known as iComplex, which combines a peer's trust value for each of its roles into a single, relative, probabilistic guarantee of trust. Finally, they have also discussed the no repudiation of peer relations and how their trust model allows peers to revoke relationships with malicious peers (Khambatti et al., 2004). Nguyen et al., have proposed a probabilistic model to handle trust in a P2P setting. It supports a local computation and a simple form of propagation of the trust of peers into classes of other peers. They have claimed that it is well suitable to the dynamics of P2P networks and to the choice of each peer within the network to have different perspectives towards the peers with which it interacts (Nguyen et al., 2008).

Most of the existing systems built on performance parameters of network nodes. Trust calculation of this research combines performance and security parameters both. In this research effect of the successful packets parameter and latency parameter to trust calculation of my previous research have been evaluated. Furthermore, modified trust model combines with a rating system to obtain an improved result.

III. EFFECT LATENCY FOR DECENTRALIZED PEER-TO-PEER TRUST MODEL

Previously designed simple reputation based trust model version utilized non-cryptographic concepts as its underlying architecture. This trust model evaluates trust with reputation-based analysis as well as Mean Short Distance (MSD) method. MSD is used to recognize peer CDN server, which contains the least hop count or the least distance from lower level tier, is selected as the contact server for that particular tier. The algorithm and trust index of that trust model utilizes successful secure content hits ratio, amount of drop packets and search time non-functional attributes of CDN nodes to generate precise information flows. However, this research tries to analyze the effect of latency and successful packet ratio trust parameters for reliability on CDN networks. At the end of each transaction CDN nodes update trust index values according to the previous algorithm. Moreover, in this modified version CDN nodes prioritize each other according to their trust values. Then the calculated trust values are stored inside trust tables to evaluate in content delivery process. Network Simulator 2 (ns-2) simulation environment illustrates the trustworthiness of P2P CDN nodes by comparing the result of previous trust index and modified trust index to analyze the effect of this non-functional parameters.

A. Trust Index Parameters

Generally, reputation based P2P trust systems depend on following performance parameters to evaluate reliability over time.

- Latency: User perceived response time. Low latency specifies lower bandwidth usage of an origin server.
- Cache hit ratio: Ratio between the number of cached documents and total requested documents.
- Reserved bandwidth: Bandwidth utilization of the origin server.
- Reliability: High reliability values leads to lower packet losses.
- Surrogate server utilization: Busy time periods of surrogate servers (Buyya et al, 2007).

This enhanced algorithm adds latency as an additional parameter and modifies drop packets parameter of previous trust index to successful packet ratio in order to make an improved trust index. Latency of the origin server specifies whether the server takes much time to respond to a request or a quicker responder. The following equation calculates latency of trust indices,

Latency = Receiving time of content – Sending time of content request

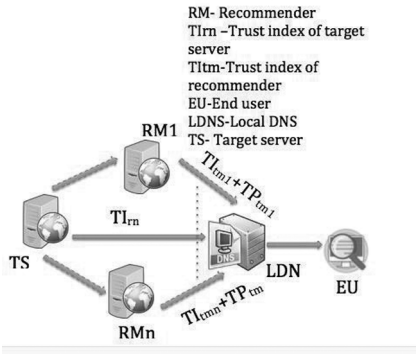

Fig. 1. Trust evaluation.

Successful packet ratio or packet delivery ratio support to detect concerns that might lead to poor throughput or information sending rate of a CDN network. Thus, this research is totally based on these two parameters to analyze the effect of those to the reliability of CDN nodes.

A. Calculating the own trust index of a CDN node

Own trust of a CDN node (***n***) for a request $\boldsymbol{TI_{rn}}$ is calculated with following parameters using equation (1),

Successful secured content delivery ratio - $\boldsymbol{SR_{rn}}$
Successful packet ratio - $\mathbf{SPR_{rn}}$
Latency - $\boldsymbol{L}_{\mathrm{rn}}$
Search time - $\boldsymbol{ST_{rn}}$

$$\mathrm{TI}rn = \frac{\mathrm{SR}rn * \mathbf{SPR}rn}{\mathrm{ST}rn * \mathrm{Lrn}} \quad (1)$$

$\boldsymbol{SR_{rn}}$ specifies secure successful connection hits ($\boldsymbol{SH_{rn}}$) to total successful connection hits ($\boldsymbol{TH_{rn}}$) ratio according to the following equation (2).

$$\mathrm{SR}rn = \frac{\mathrm{SH}rn}{\mathrm{TH}rn} \quad (2)$$

Similarly, $\mathbf{SPR_{rn}}$ provides number of successful packets ($\boldsymbol{SP_{rn}}$) to total number of packets ($\boldsymbol{TP_{rn}}$) ratio according to the following equation (3).

$$\mathrm{SPR}rn = \frac{\mathrm{SP}rn}{\mathrm{TP}rn} \quad (3)$$

B. Calculating trust index for a recommender CDN node

Similar to $\boldsymbol{TI_{rn}}$, peer node (***m***) calculates recommender trust ($\boldsymbol{TI_{tm}}$) of a CDN node (*t*) with the following parameters as illustrated in equation (4),

Successful secured content delivery rate - $\boldsymbol{SR_{tm}}$
Number of successful packets ratio - $\boldsymbol{SPR_{tm}}$
Latency – $\boldsymbol{L_{tm}}$
Search time - ($\boldsymbol{ST_{tm}}$)

$$\mathrm{TI}tm = \frac{\mathrm{SR}tm * SPRtm}{\mathrm{ST}tm * \mathrm{L}tm} \quad (4)$$

$\boldsymbol{SR_{tm}}$ specifies secure successful connection hits ($\boldsymbol{SH_{tm}}$) to total successful connection hits ($\boldsymbol{TH_{tm}}$) ratio that is calculated by a recommender node according to the following equation (5).

$$SRtm = \frac{\boldsymbol{SHtm}}{\boldsymbol{THtm}} \quad (5)$$

As specified above $\boldsymbol{SPR_{tm}}$ provides number of successful packets ($\boldsymbol{SP_{tm}}$) to total number of packets ($\boldsymbol{TP_{tm}}$) ratio that is calculated by a recommender node according to the following equation (6).

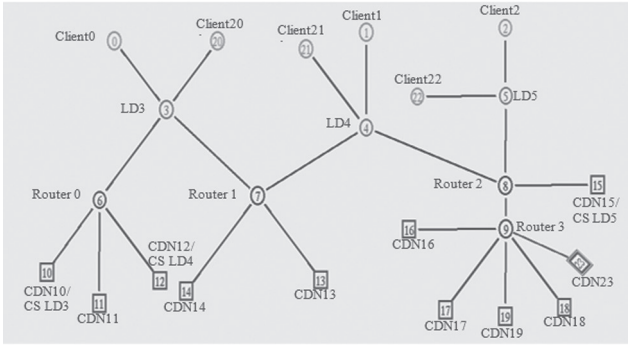

Fig. 2. Simulation topology.

$$\mathrm{SPR}tm = \frac{\mathrm{SPtm}}{\mathrm{TPtm}} \quad (6)$$

Recommenders assign priorities for their peers by checking their trust index values. Priority range starts from 1 and going up to 9.'1'is considered as the highest priority and '9' is considered as the lowest priority. Higher trust index values get higher priorities from (1-5) and lower trust index values get lower priorities (5-9).

C. Trust evaluation process

Trust evaluation process enables on demand and should perform before obtaining contents from a specific target as illustrated on Fig.1. Each trust request for a specific target evaluate correlated trust indices as well as trust priority.

i). Trust index evaluation

There is no difference in trust index evaluation process with the previous algorithm. Trust index of the target (TI_{rn}) and recommender trust index value (TI_{tm}) of the target compares at local DNS. If there is a significant difference between two values ($TI_{rn} \neq TI_{tm}$), that target is classified as an unreliable. If the difference is less than the threshold value ($|(TI_{rn} - TI_{tm})|<0.00001$), then the target is reliable.

ii). Trust priority evaluation

Trust priorities of recommenders are evaluated as follows,

- If only one recommender exists – $TP_{tm}<5$ is considered as trusted target
- If only n recommenders exist – Calculate average priority and those who have Average $TP_{tm}<5$ is considered as trusted target

iii). Final Trust evaluation

Targets where ($|(TI_{rn} - TI_{tm})|<0.00001$) & $TP_{tm}<5$ are considered as reliable and contents will be deliver to the client. Contents from other targets will be rejected. Trust indices calculation use the same trust algorithm of my previous research and the algorithm revise with the above trust priority evaluation method and trust index calculations.

D. Trust Priority evaluation

Calculate trust index value
    Check available trust index values on trust index table.
    Find out the nearest lower priority value among available indices.
    Assign next priority value for the new trust index.
    Change the other priority values with respect to this new priority.
    Store priority value on the table.
Send priority values on demand to local DNS servers.
Check priority at local DNS server
    If $TP_{tm}<5$
        Reliable
    Else
        Unreliable

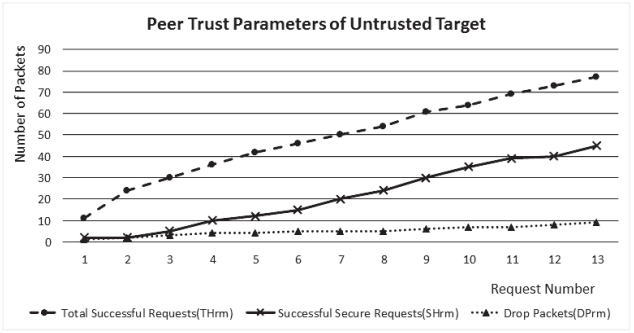

Fig. 3. Peer trust parameter variations of an untrusted target (Previous Version)

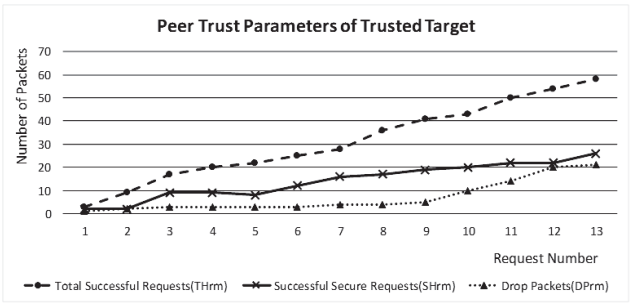

Fig. 4. Peer trust parameter variations of trusted target (Previous version)

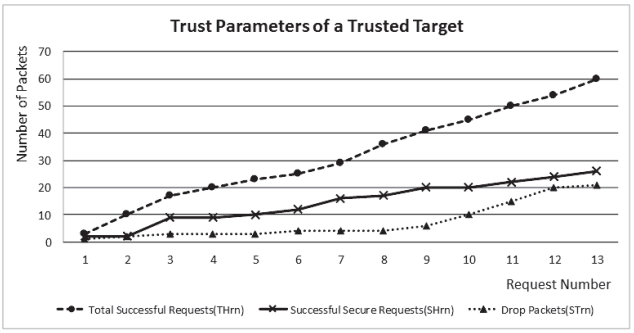

Fig. 5. Trust parameter variations of trusted target (Previous version)

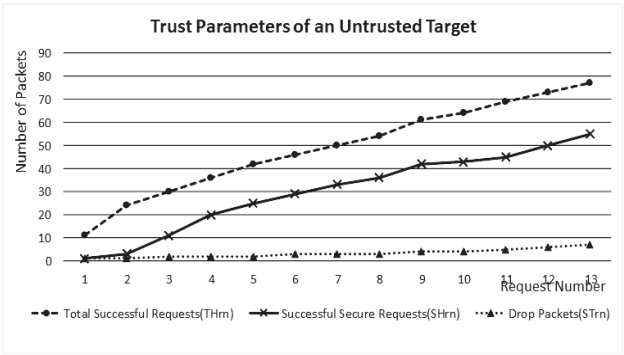

Fig. 6. Trust parameter variations of untrusted target (Previous version)

IV. SIMULATION EXPERIMENT AND TEST RESULTS

Trust model is simulated on an Intel Core2Duo 2.2GHz CPU, 8 GB RAM, 512 GB hard disk computer with a CentOS 6.5 64-bit operating system. Modified algorithm generates and evaluates on open source Ns-2 simulation environment over P2P CDN network structure. Simulation utilizes a basic topology with fixed P2P CDN nodes on Fig. 2. Various existing protocols supported by Ns2 simulator and it promotes user extensions to implement new algorithms and protocols. This enhanced version of trust model also

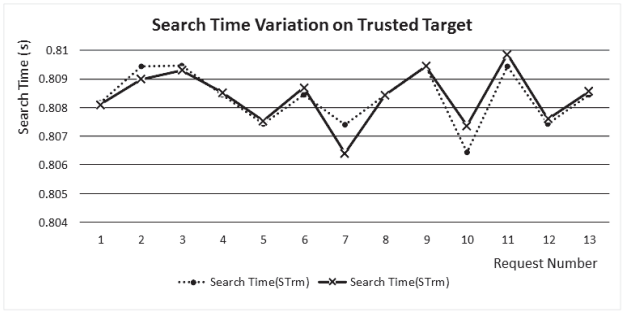

Fig. 7. Trust parameter variations on target node and peer node for trusted target (Previous version).

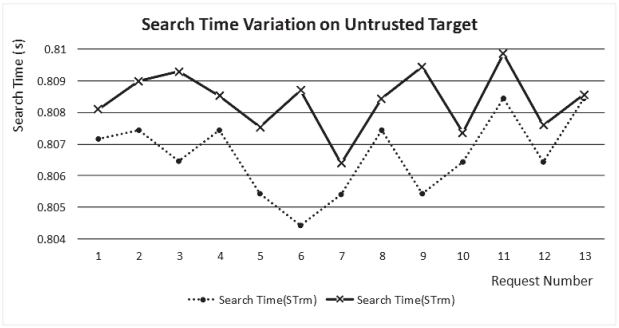

Fig. 8. Trust parameter variations on target node and peer node for untrusted target (Previous version).

evaluated on the same P2P CDN environment of my previous research (Shanika Ekanayake, 2014). Simulation code produces content requests and inserts a modified packet header structure to those data packets.

A. Packet structure and agents

Three types of simulation agents called trust agent, DNS agent and PC agent generate P2P CDN network topology as illustrated in Fig. 2 to illustrate the trust model. The trust agents switch between client and server roles on the P2P environment with respect to the situation. The modified packet structure of the trust agent inserts latency and number of successful packets parameters to its packet header and direct user defined traffic to correct recipients. Twenty-Three P2P simulation nodes of the CDN network structure are arranged in to three tiers. Tier2, Tier1 and Top-level tier comprise six nodes, four nodes and the origin server node respectively.

P2P network topologies are considered as highly dynamic network environments where various nodes are able to connect and disconnect regularly. Some nodes in the system may be selfish and unwilling to upload data to others. Some nodes might carry out some abnormal actions such as frequent rebooting, launching attacks, cheating their neighbors and those can harmfully affect their neighbor nodes. Those dishonest nodes continually attempt to raise their own trust values by modifying trust index parameters. As a result, recommender trust index of those unreliable nodes frequently deviated from their own trust values. In order to analyze the behavior of dishonest nodes simulation topology combines with an unreliable node.

At the end of each secure content request target nodes, update their trust indices with SR_{rn}, SPR_{rn} ST_{rn} and L_{rn} parameters. As soon as contents downloaded from the target node recommender nodes update related recommender trust values with the SR_{tm}, SPR_{tm}, ST_{tm} and L_{tm} parameters.

B. Evaluation

Tier 2 includes a dishonest node (node ***CDN 14***) to simulate the fraudulent behavior of an unreliable node and other nodes are reliable. Client 0 and client 2 sent 100 content requests from each to retrieve required content. Fig. 6, Fig. 10 illustrates trust parameter variations of that unreliable node which detected at the local DNS server (***LD 3***).

Trust parameters of target nodes change with respect to the content requests and the request number increases with the simulation time. The unreliable node attempts to increase number of successful packets and number of successful secure content delivery requests while reducing search time and latency parameter values to raise trust index values on earlier trust model Fig.6, Fig.8 and modified trust model Fig.10, Fig. 14. Trusted targets not attempt to modify their actual trust values on previous version Fig.5, Fig.7 and improved version Fig.9, Fig.13. Hence, on trusted targets the minor differences available between target parameter values and peer parameter values. On the other hand, considerable amount of variations presented between parameter values on unreliable nodes and that fact supports to prove fraudulent behavior of a particular node.

According to the modified version trust value is inversely proportional to the latency and search time and the successful secure hits ratio and number of successful packets parameter is directly proportional to the trust value. Therefore, trust index of the node increases with successful secured content delivery attempts plus number of successful packets and it decreases with the rise of the search time and the latency.

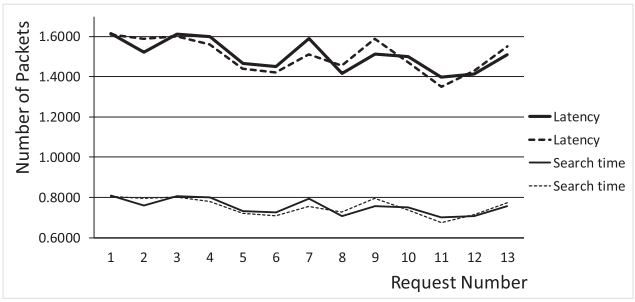

Fig. 13. Trust parameter variations on target node and peer node for trusted target

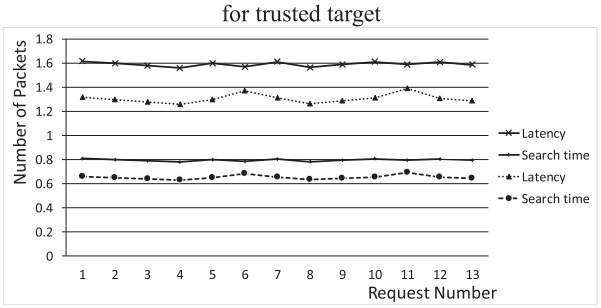

Fig. 14. Trust parameter variations on target node and peer node for untrusted target

Comparison of the graphs of previous trust index version in Fig.3 to Fig.8 and modified version in Fig.9 to Fig.14 indicates the parameters of a trusted target in previous version has higher deviation from its peer trust parameters than the parameters of modified version.

The graph of Fig.15 indicates the trust indices for a trusted target in previous version has averagely about ±1.331*10-5 deviation from its peer trust indices on Fig.3 to Fig.8. However, in Fig.16 parameters of modified trust indices display averagely about ±6.302*10-6 deviation or a lesser deviation from its peer trust indices.

Therefore, the evaluation of above graphs provides an evidence to say that the modified trust index provides a sophisticated result than the earlier index in order to precisely detect a reliable target over unreliable target in P2P CDN networks on ns-2 simulation environment.

V. CONCLUSION

Recently, various significant improvements have been enforced towards the security models of P2P networks. This paper evaluates effect of a number of successful packets and latency parameters to my previously produced trust model for P2P CDN networks and improve efficiency by attaching it with a priority value. Moreover, paper describes glitches of P2P CDN network environments and specifies that the trust issues of those of P2P overlay networks increase exponentially. Additionally, the paper mainly considered the effect of new parameters to trust establishment technique and procedure to addresses those drawbacks. The modified version of the trust model revealed that this fundamental security enforcement method could be utilized as a base to enforce some higher-level security mechanisms. Trust model can be implemented as a centralized trust system with a centralized trust index server.

Trust model simulation effectively modified the ns-2 extension for P2P network of earlier research and introduced new fields for packet header to accommodate additional details. In order to obtain more sophisticated results this model can be simulated on the Network Simulator3 (ns-3) and on real world servers in future. In addition, all the limitations identified on early trust models affect this modified version. However, trust indices are clearer than the previous results and better variations appeared on trust values.

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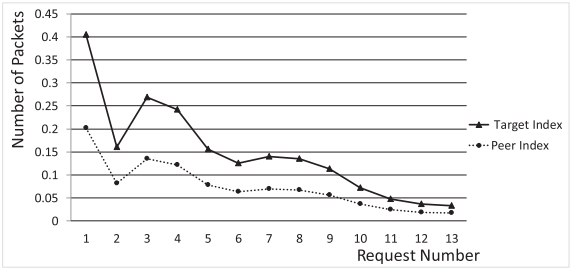

Fig. 15. Trust index variation (Previous version).

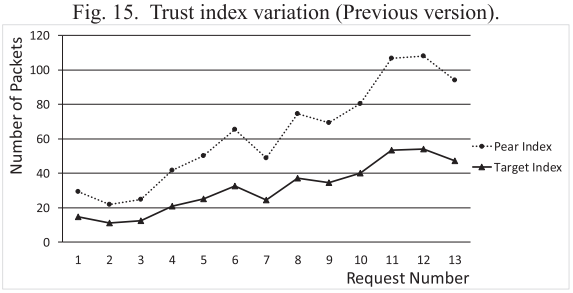

Fig. 16. Trust index variation (Modified version).

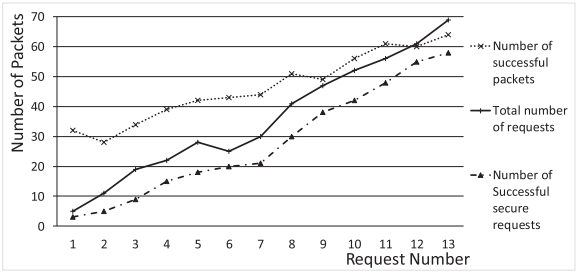

Fig. 9. Trust parameter variations of a trusted target (Modified version).

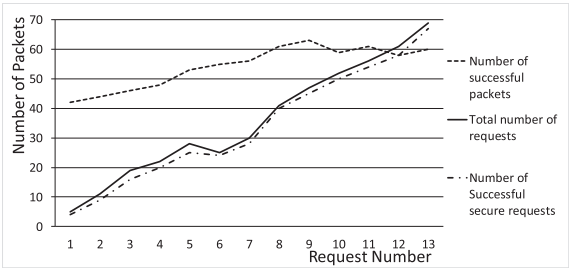

Fig. 10. Trust parameter variations of an untrusted target (Modified version).

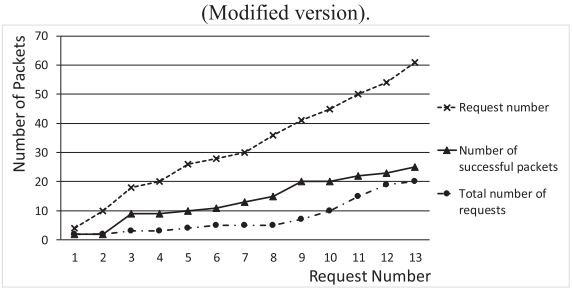

Fig. 11. Peer trust parameter variations of trusted target (Modified version).

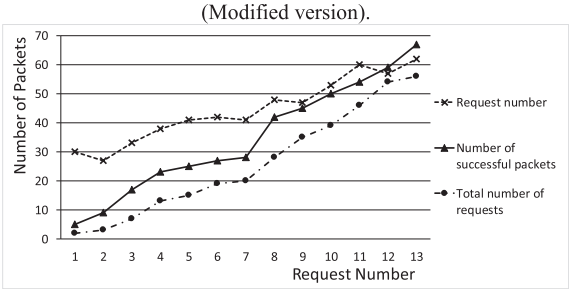

Fig. 12. Peer trust parameter variations of untrusted target (Modified version).

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A Contemporary Appraisal of the Employers' Perceptions Regarding Values and Skills of Graduate Employees in Logistics and Transport Sector in Sri Lanka: A Case Study

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***Abstract* — The transport and logistics industry is considered a fast-growing industry in the word because of the rapid development of the international trade. However, competent professionals in this field is scarce. Therefore, educational institutions are engaged in developing more professionals in the industry. This study mainly focuses on three objectives namely, to identify the sectors in which logisticians are demanded, to identify the level of employers' satisfaction in the industry, and finally to differentiate the performances between various categories. The study has used descriptive analysis and One-Way ANOVA in the analysis. According to the findings it could be concluded that graduate logisticians are engaged in varied industry sectors and their employers are satisfied with the quality standards and the skill levels of the graduate students. Also, the study reveals a performance gap in the gender analysis. It was noted that there were three types of performance gaps between industries.**

***Keywords* – Transport and Logistics Company, Undergraduates, performance gap**

I. INTRODUCTION

Transportation and logistics companies are lagging behind other sectors in terms of recruiting and hiring. In developing economies, transportation and logistics as a sector is growing rapidly – but workforce development is not yet keeping pace. [1]. Maritime education and training institutes need a careful evaluation about the factors that influence students' selection of higher education institutes [1]. In this process logistics chains are assumed to be in the centre as the core part of production processes. Then availability of required professionals in the field is essential. The quality and skills of the employees should be upgraded. Containerization which changed everything was the brainchild of Malcom McLean, an American trucking magnate [1]. McLean understood that reducing the cost of shipping goods required not just a metal box but an entire new way of handling freight [2]. The recent project that Sri Lanka extended its fullest support addresses one of the key issues in maritime logistics namely, competent work force in ports. Candemir and Celebi (2016) have identified that the world economy (and society) has been transformed and is being transformed fundamentally and yet more to come. The Logistics environment is primarily influenced by the international trading patterns [4].

It is the burning need of many countries in the region to improve productivity and competitiveness of their workforce in domestic and international labour market. shipping today is highly specialised, competition for the right candidate for the right ship is intense. Higher levels of skill are needed for specialty vessels of today [3]. The Employers survey forms part of a broader project to obtain insight into the issues being faced by employers and their perceptions regarding the employability of recent graduates of one of the leading private educational institutions in Sri Lanka. In educational institutions private university education system, the respective institute needs a critical evaluation of the feelings of three important stakeholders namely, the student (consumer), parents or family members (customers who pay the course fee), and the ultimate employer of the graduate. Edirisinghe, Jayakody, Ranwala, & Shen, [4] suggest that 45% of students' selection depend on the recommendation of their parents. While the student and parents have the regular contacts with the education institute for a limited period of 3-5 years during the course delivery, the ultimate employers will be compelled to deal for their rest of lifetime. This reality suggests that the employers' comments about the students have a significant importance to the respective education institute. This research has considered the comments of the present employers of the undergraduates in Logistics and Transport degree program conducted by the CINEC Maritime Campus in Sri Lanka.

Logistics and Transport undergraduates are usually in demand by the organizations involved in fast moving consumer goods (FMCG), Apparel & Garments, Shipping and Logistics, Port Operations, Pharmaceutical, Airline, Freight Forwarding, Automobile, Supply Chain consolidators, Warehousing and Printing, Manufacturing and Sales, Cement, Banks, Audit firms, education, Sugar Confectionery, hospitals, and hotel industries. It is significantly seen in the society today that two words namely, logistics and transport are becoming buzz words very fast. Unlike in the past, firms pay serious attention to manage their supply chains more economically. This

requires highly competent professionals in logistics and transport. An undergraduate in logistics and transport management could give a great contribution to all the sectors mentioned earlier. Therefore, many firms strategically absorb a substantial number of interns (those who complete 3 years as an undergraduate and ready to work 6 months full time basis) and test the capabilities prior to offer them permanent employment. It is made to understand that the outstanding performers will be invited to continue their employment even prior to their formal graduation which usually takes place after 4 years. The firms offer very flexible terms to the good performers until they complete the degree program and this is a highly win-win situation for both students and the firms.

The survey wishes to establish the employers' perceptions about the values, competencies and skills of undergraduates CINEC Campus, Sri Lanka. This would provide a reasonable assessment about the match between the skills acquired by graduates at university and the skills needed in the labour market. Accordingly, the objectives of the Report could be defined as follows.

- To understand the industries in which the students are presently engaged for their job or training
- To undrstand the satisfaction level of the end users.
- To understand the performance gap between diference groups.

II. METHODOLOGY

The researchers administered both qualitative and quantitative methods. Initially 5 employers were interviewed to ascertain the key factors that are usually considered by the employers with respect to evaluate the suitability of a graduate to be employed in the organization. The questionnaire was designed accordingly and employers of 34 students who had graduated from the institute were approached to collect data. Descriptive statistics and ANOVA have been used for the analysis purposes.

A. Chi-Square Tests

A chi - square (X^2) statistic is used to examine whether distributions of definite variables differ from one another. Basically, definite variables yield data in the groups and numerical variables yield data in numerical form. The Chi Square statistic associates the totals or counts of categorical answers among 2 (or more) independent groups.

H_0: There is no relationship between X and Y
H_1: There is a relationship between X and Y
Or
H_0: $O_i \neq Ei$ ……*(1)*
H_1: $O_i = Ei$……*(2)*

The null hypothesis is the one which the chi square test. That is, if there is no relationship between the two variables, or if X and Y are independent of each other. As equation (1) shows E*i* is calculated assuming two variables are independent.
The following equation is the statistic used to conduct this test,

$$x^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

X^2 = chi – square
O_i = Observed value
E_i = Expected value

B. One-way ANOVA

It is tested that Ho: μ1 = μ2 =μ3 .... μJ
H1 : the means are not equal.
The individual score can be explained as follows;

Yij = μ+ τj +εij, where Yij is the score of the i^{th} observation j=1,2,3....in group i (i=1,2,3...) μ is the grand mean of the combined population. A treatment effect τj associated with the population from which the observation is taken in other words it is the deviation of the group mean from the overall mean. The random error term εij reflect variability within each population.
Estimation of treatment effect,
Tj = $\bar{Y}_J - \bar{y}$

C. The F test in Anova

$\Sigma i\Sigma j(Yij - \bar{Y})^2 = \Sigma i\Sigma j(\bar{Y}i - \bar{Y})^2 + \Sigma i\Sigma j(Yij - \bar{Y}j)^2$
SST=SSB+SSW
SST =Total variability of dependent variable.
SSB = The variability between ach group relative to each grand mean.
SSW= The variability within each group relative to the group mean.
SSB is explainable by the effect of the manipulated factor and SSW is attributed to chance.
F statistics,

$$F = \frac{MSB}{MSW} \sim F(j-1, N-j)$$

III. Data Analysis

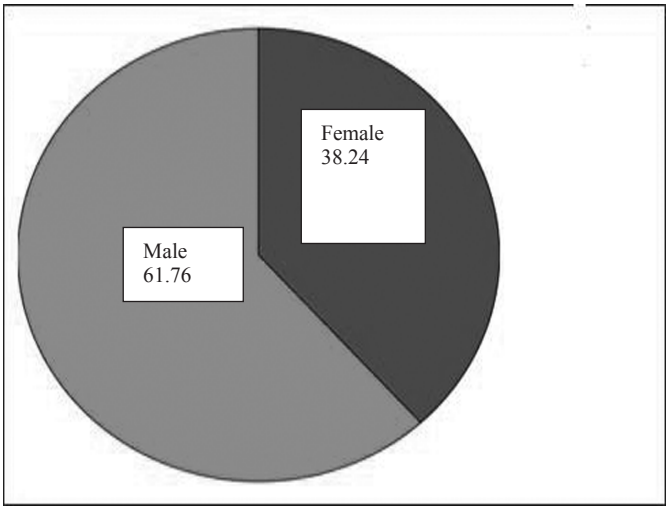

Fig. 1 Gender distribution of students of batch.

The study considered 34 students for the analysis. Among the sample 38.24 percent were female while 61.76 % were male students.

D. Type of Industry/ Specialization Area

The students are working in several industry sectors and different job functions. The percentage share of each industry is given in table 1.

TABLE I.
THE INDUSTRY SECTORS THAT THE STUDENTS ARE ENGAGED IN THEIR CURRENT JOB/INTERNSHIP

Industry type	Frequency	Percent	Cumulative Percent
FMCG	5	14.7	14.7
Apparel & Garments	9	26.5	41.2
Shipping and Logistics	2	5.9	47.1
Port Operations	1	2.9	50.0
Pharmaceutical	3	8.8	58.8
Airline	2	5.9	64.7
Freight Forwarding	4	11.8	76.5
Automobile	1	2.9	79.4
Supply Chain consoling	1	2.9	82.4
Warehousing and Printing	1	2.9	85.3
Manufacturing and Sales	3	8.8	94.1
Cement	1	2.9	97.1
Sugar Confectionery	1	2.9	100.0
Total	34	100.0	

According to the analysis students are doing several types of transport and logistics related tasks (import, exports, supplier arrangements, shipping documentations, demand planning, warehouse management, procurement etc..) in diverse types of industries. It can be seen applications of transport and logistics functions is vital since it cover the most of industries in the economy.

E. Responses for Evaluation Criteria

The study evaluates the trainee performance and 13 criteria were used. The following table 2 represents the results of the study.

TABLE II. RESULTS OF EVALUATION

	Evaluation Criteria – Percentage Values			
	1.Not Adequate	2.Adequate	3.Good	4.Excellent
Theoretical knowledge	0	5.9	58.8	35.3
The skills to perform action when required	0	0	47.1	52.9
Improvement on quality works	0	5.9	50.0	44.1
Improvement on health and safety concerns & practices	0	11.8	55.9	32.4
Improvement on communication ability/ language skill	0	8.8	47.1	44.1
Improvement of interpersonal relationship with co-workers	0	5.9	20.6	73.5
Personality and self confidence	0	5.9	44.1	50.0
Risk based thinking	0	32.4	58.8	8.8
Creativity	0	20.6	58.8	20.6
Proactive	0	8.8	64.7	26.5
Innovative	0	26.5	50.0	23.5
Team work	0	2.9	20.6	76.5
Improvement of concern for environment protection	0	11.8	58.8	29.4

According to the analysis, the criteria of skills to perform an action when required, interpersonal relationship with co - workers, the personality and self-confidence and term works have recorded highest percentage for the excellent performance while all others have recorded highest percentage for the superior performance.

IV. Gender Vs Industry Type.

Logistics firms that were prioritizing on male workers in the logistics and transport sector have gradually realized the advantages of employing female professionals [8].
Furthermore, it analysed whether there is a difference is in the selection of industry is depending on gender.

Ho: industry type is not independent from the gender type
H1: Industry type is depending on gender type.

TABLE III. CHI-SQUARE TESTS

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.321[a]	12	.081
Likelihood Ratio	24.954	12	.015
Linear-by-Linear Association	.012	1	.914
N of Valid Cases	34		
a. 25 cells (96.2%) have expected count less than 5. The minimum expected count is .38.			

According to the statistics it can be seen that the industry type is not dependent on the gender type under the 5 % significant level since p-value is greater than the significant level. Nevertheless, null hypothesis can be rejected under the 10% confidence level($p=0.08<0.1$).

F. Difference Between Groups

It can be further stated that there is a performance gap between male and female as well as between different industries. For this objective One -Way Analysis of variance has used. the hypothesis testing as follow,

H0: all means are equal.

H1: at least two samples are difference.

1. Gender wise variation

To identify whether there was performance gap between males and females, the following hypothesis is investigated for validity.

H0: the average performance of a male is not different from the average performance of a female.

H1: the average performance of a male is different from the average performance of a female

TABLE IV. ANALYSIS OF VARIANCE: INNOVATION

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.630	1	1.630	3.400	.074
Within Groups	15.341	32	.479		
Total	16.971	33			

According to the above statistics it can be seen that there is no significant performance difference between male and female since the P- value for each criterion was more than the confidence level of 0.05.

It can be seen that different performances in innovative ideas between males and females under the 10% confidence interval. According to the descriptive analysis it can be seen that males have more performance than females in innovation.

TABLE V. DESCRIPTIVE ANALYSIS FOR INNOVATION CRITERIA.

Gender	Mean	N	Std. Deviation
Female	2.6923	13	.63043
male	3.1429	21	.72703
Total	2.9706	34	.71712

2. Industry wise variation

To identify whether there was a students' performance gap between industries, the following hypothese have been checked.

H_0: the average performance of students is not different between industries

H_1: the average performance of students is different between industries

TABLE VI: ANOVA -DIFFERENCES IN PERFORMANCE BETWEEN INDUSTRIES.

Evaluation Criteria		Sum of Squares	df	Mean Square	F	Sig.
The skills to perform action when required	Between Groups	3.583	8	.448	2.400	.048
	Within Groups	4.292	23	.187		
	Total	7.875	31			
Improvement on quality works	Between Groups	7.458	8	.932	5.305	.001
	Within Groups	4.042	23	.176		
	Total	11.500	31			
Personality and self confidence	Between Groups	5.927	8	.741	2.820	.025
	Within Groups	6.042	23	.263		
	Total	11.969	31			

Among 13 evaluation criteria, there is difference between industry with three criteria.

1. The skills to perform action when required
2. Improvement on quality works
3. Personality and self confidence

Nevertheless, according Turkey to HSD statistics represent significant differences in second and third criteria is at 5% significant level. It is shown in table below.

TABLE VII. TURKEY HSD

Dependent Variable	(I) Type of Industry	(J) Type of industry	Mean Difference (I-J)	Std. Error	Sig.
Improvement on quality works	FMCG	Pharmaceutical	1.33	0.30613	0.0048
		Freight forwarding	1.25	0.2812	0.0038
	Apparel & Garments	Pharmaceutical	0.95	0.2837	0.0447
		Freight forwarding	0.875	0.2567	0.0417
	Supply Chain	Pharmaceutical	1.33	0.3826	0.0354
		Freight forwarding	1.25	0.3630	0.0387
Personality and self confidence	FMCG	Freight forwarding	1.25	0.3438	0.0253

According to table 6 it can be identified that valuation given by supervisor for the activities done by students to improve quality work is different in FMCG compared to pharmaceutical and freight forwarding industry. That is excellent in FMCG but averagely good in other two industries.

Also, personality and self-confidence is statistically difference between FMCG industry and freight forwarding industry. That is excellent in FMCG and moderately good in freight forwarding industry.

V. CONCLUSION

The transport and logistics industry has been identified as a fast-growing industry in the world. professionals in this field is limited in the pass few years. Therefore, educational institutions were engaged in developing the professionals for the industry. This study mainly focuses three objectives. They are to identify the types of industry where logisticians are required, to identify the satisfaction level of industry and to identify performance difference between different groups. According to descriptive analysis 50% of students are working in FMCG and Apparel and garment industry. It can be concluded that transport and logistics activities more available in those industries. At 10% significant level it can be seen that selection for jobs depended on the gender type. To identify performance gap between difference groups One Way ANOVA has been used for analysis. According to the findings it can be identified that logisticians are engaging in variance type of industry in the economy and the industries were satisfied the quality and the skill of the students. Further it can be identified the one performance gap between gender type while three types of performance gap between industries. It is recommended to identify the reasons for the gap and find solutions for the overcome the difference. Nevertheless, it is recommended to expand the study with collaboration of undergraduates who were passing out from the government institutions. It is recommended to identify the reasons for the gap and find solutions to overcome the difference. It is recommended to extend the study to cover undergraduates from few other universities including government institutions.

It is commendable to note the international cooperation to effectively overcome the forecasted skills shortage in the logistics and transport industry. The IORA is one good example in the region. The acronym IORA recognizes the Indian-Ocean Rim Association. IORA is a dynamic organisation of 21 Member States and 7 Dialogue Partners, with an ever-growing momentum for mutually beneficial regional cooperation. The Project aims to address skills development in agreed port occupations under two key sectors. Firstly, it refers to develop/enhance capacity of IORA countries to engage with industry in technical vocational education and training (TVET) system development. Secondly it intends develop common occupational standards (transnational skills standards) in three occupations (initially) to underpin effective TVET programmes to meet local industry skills needs and support industry, trade and skilled labor mobility across the IORA region [7].

In conclusion, the industry perception about the graduates of CINEC Maritime Campus is seen very positive. Despite the input of about 400 graduates in this field from other higher education CINEC graduates have managed to create an edge that has consistent improvement for the last decade.

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Strategic Marketing Approach in Container Shipping: Application of Ten S Model

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Abstract— **The application of strategic marketing theories is rather difficult due to the complexities in demand and supply factors in the shipping industry. Shipping is a derived demand of international trade. The supply of shipping also has its exclusiveness leading to very complicated outcomes. Given the fact that shipping has more services characteristics than that of a product the key fundamentals such as perishability, intangibility, non-separability, and heterogeneity make it further complicated. This paper attempts to systematically apply the Ten S marketing model because it is expected that the model could be applied in highly complicated marketing environments.**

Keywords— **Include container shipping, Ten S Model, strategic marketing**

I. INTRODUCTION

A. Container shipping

Shipping has proved its potential as an increasingly efficient and swift method of transport. Containerization has made a notable change globally in the system of freight transport. Containers are capable of transporting efficiently over long distances, and facilitate multimodal transport without intermediate reloading at any mid points. It is generally accepted that more than 90 per cent of global trade is carried by sea. Containers are an asset that maritime shipping companies make available to service their customers. Providing containers help increase the utilization rate of containerships [1]. Container ships and containers are supplementary to each other thus Container Shipping Lines (CSL) cannot transport cargo if containers are not available. Shipping is highly sensitive with respect to timely delivery of cargo thus availability of containers is vital as much as availability of ships. Edirisinghe, Jin, & Wijeratne, [2] (In press) investigates, the strategies that are currently used by shipping lines to manage their container inventories efficiently and effectively

One of the most striking developments in the global economy since World War II has been the tremendous growth in international trade [1]. The total sum spent on repositioning of an empty container (MTY) is a complex calculation because the cost parameters are numerous and varied [3]. Shipping is a business that grew up with the world economy, exploring and exploiting the ebb and flow of trade [2]. The CIM decisions are usually influenced by many factors [4].From 1981 to 2009, global transport of containerized cargo increased approximately 3.3 times faster than the world's GDP [3]. World's very first all-container ship "Gateway city" was found in 1950 [4] and containerization was commercially implemented in the US in the mid-1950s [1] and is the driver of the twentieth century economic globalization and world container port throughput increased by an estimated 3.8 per cent to 601.8 million 20-foot equivalent units (TEUs) in 2012 [5]. Containerization was not just about ships but a new way of organizing transport [2] which has made a significant change globally in the system of freight transport. However, container fleet size and the complexity of the container shipping network [6] have increased dramatically bringing more challenges to the operation of the container shipping system. Cross-border transportation is an engine to promote the foreign trade [7]. The system, that proved its potential as an increasingly efficient and swift method of transport, led to greatly reduced transport costs, and supported a vast increase in international trade. 'Container' means, an article of transport equipment of a permanent character and accordingly strong enough to be suitable for repeated use [8] or any type of container, transportable tank or flat, swap body, or any similar unit load used to consolidate goods, and any equipment ancillary to such unit load [9]. Container ships and containers are supplementary to each other thus Container Shipping Lines (CSL) cannot transport cargo if containers are not available. Containers are capable of transporting efficiently over long distances, and facilitate multimodal transport without intermediate reloading at any mid points. The total existing fully cellular fleet as at 14th November 2016 (all sizes / all positions) stands at 6.038 fully cellular ships for 20,713,884 [10]. Containers are built to standardized dimensions, and can be loaded and unloaded, stacked, capable of being transported efficiently over long distances, and transferred from one mode of transport to another without intermediate reloading at any mid points. The terminal related variable fees connected to different segments and services (e.g., fee per handled container, trailer, swap-body, storage of load units, etc.) [11].

Although bigger Container Ships (CS) were built to derive benefits of economies of scale carriers found it does not work always given the derived demand factor inherent in the shipping industry. To obtain the economies of scale advantage CSL used to form consortia and share the ship space. Accordingly, CSL presently share ships' space with competitors. In addition to Vessel sharing these alliances gradually extended the collaboration to other areas such as, service rationalization, operating expense sharing, equipment interchange, and joint service contracts.

B. Ten S Model

Many textbooks attempt to explain how to market a product successfully. The marketing concept having its origin in many already complicated disciplines such as Economics, psychology, and Sociology created a platform for many professionals and ideologist to construct various models or matrix to help analyse and debate firms marketing approaches. Out of various models and tools available to help develop a strategic marketing plan, the Ten-S model created by the late Professor Uditha Liyanage is exclusive and something unique for its simplicity while keeping the comprehensiveness and visibility of the entire marketing process.

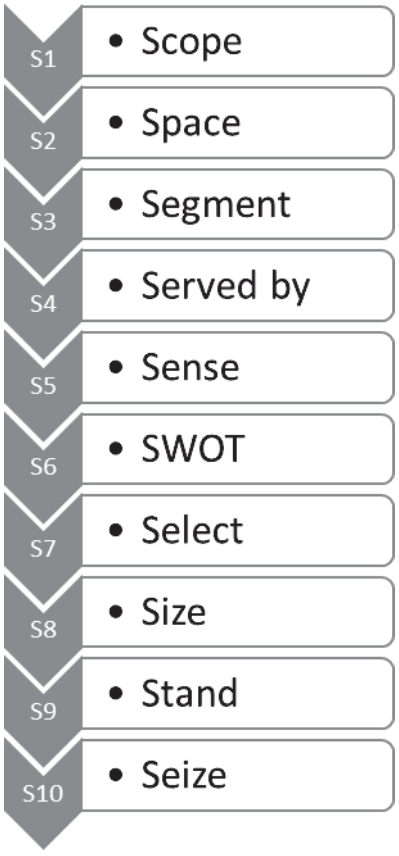

Fig. 1 The Ten-S Model

Firstly, the framework originates from the Business scope that eliminates the possibilities of being myopic defining what business they are in [2]. Secondly it prompts the firm to clearly define the market space that they will associate followed by identifying market segments, competitors who serve the segments through a detailed study such as analysing key purchase determinants. This helps the firm to sense the market opportunities that will be evaluated through a SWOT analysis in the stage six. The target market segment(s) will be selected and quantifiable objectives will be determined in next two stages. The last but not the least the operationalization of the plan using marketing mix will be done in the tenth stage. This framework is produced in Fig.1as a process flow diagram for easy reference.

Marketing is on one hand defined as a business philosophy which shapes and directs the organizational processes. This confirms the necessity of every person's contribution in the firm through top management's commitment while on the other hand marketing functions sense, design and deliver customer value that should necessarily be handled by professionals. Therefore, in such a complicated process the Ten-S model thus provides the visibility across the firm to stakeholders about purpose of their existence and facilitates smooth functioning of true marketing approach.

C. Case study approach

The researcher has selected to apply the Ten S model to one of the leading shipping lines in the world but the name of the carrier is kept anonymous due to commercial reasons. However, it would be necessary to enlighten the reader about the commercial status of the carrier as the model will be explained as an application to the respective carrier. The selected carrier ranks at top level with a fleet of approximately 3 million TEUs and claiming a double-digit market share of container trade. The marketing of shipping industry involves many complicated disciplines in addition to consumer marketing such as Services, Organizational buying which make this exercise very interesting though. A service is an economic activity that creates value and provides benefits for customers at specific times and places by bringing about a desired change in, or on behalf of, the recipient of the service [3]. Organizational buying is the decision-making process by which formal organizations establishes the need for purchased products and services then identifies, evaluate, and choose among alternative brands and suppliers. [4]

This paper consists of three main sections and the section II illustrates the stages of the Ten-S framework and its application in the container shipping environment.

II. The Application of Ten 'S'

This chapter consists 10 sub topics that that elaborate the application process of the components in the Ten 'S' model. Since the model is generalized to suit to any firm irrespective of the intended organization deals with product or service, the application of each component can be customized to shipping lines that offer services. Accordingly, the ten components namely, Business scope; Market space; Segmentation; Served by; Sensing; SWOT; Select; Size; Stand; and Seize will be explained below.

A. Scope (Business Scope-BS) A. Scope

Defining the right business scope (BS) of a firm is crucial and challenging because it is the starting point of the Ten-S matrix. If the beginning itself is myopic the firm cannot expect a successful outcome at the end of the process. The literature reveals that IBM lost sight of its customers. IBM failed to deliver the 'change' demanded by customers. Because, the firm believed that they were in "selling computer hardware and software" business. In contrast companies such as Nike and Wal-Mart manage to stand for market oriented definitions by understanding what business they are in. Nike help people experience the emotion of competition, winning, and crushing competitors, while Wal-Mart delivers low prices every day. The results would have been the same like IBM if Nike thought they sell shoes and if Wal-Mart ran discount stores. In order to determine the BS it is vital to understand the concept of Terminal Customer Value of an industry or a firm.

- Terminal Customer Value (TCV) in shipping

Identifying the service or benefit the customer is really buying is the key to success for any product or service; a hotel guest is buying "rest and sleep"; the purchaser of a drill is buying "holes". Therefore, the shipping company must see themselves as benefit providers to engage in successful marketing. Ohmae, [5](1988) explained how the manufacture of a coffee percolator may identify the features that should reflect in the successful design of a percolator [5]. The first and foremost is to understand why do people drink coffee and what are they looking for when they do? The answer was "Good Taste". In order to provide this the firm should know what influences the taste of a cup of coffee. The beans, the temperature, the water was identified as key factors among many such causes thus the product was designed to cater to such TCV making the product most successful. The similar question was raised to the consumers in shipping. Why do they use shipping lines? The answer came, 'hire space in ships'. Why? ; To move their cargo. And what are they looking for when they do? A "Good Service" so what influences a good service ? State of the art ships, fixed arrival/departures, and convenient shore based service.

Defining the TCV correctly help marketers to understand the strategic business scope. Using the archetype of railroads, Levitt (1975) urged organizations to define their industries broadly to take advantage of growth opportunities. (Break Bulk ships-one major ocean freight category failed considerably in the rail road due to evolution of sea freight containers which will be discussed under FSS in water transport.)

Encyclopædia Britannica defines transportation, as "the movement of goods and persons from place to place and the various means by which such movement is accomplished." The most dominant modes of transport are aviation, rail transport, road transport and water transport. However, the transportation is possible through pipelines, cable transport, space transport and off-road transport. The container shipping business therefore has its origins in water transport. Therefore, as long as the container shipping consumer looks at a TCV of "movement of cargo" it derives a conclusion that the Container shipping lines (CSL) are in the transportation business.

B. Space

Space in this model refers to the market space. If a firm that manufactures toothpaste defines its BS as toothpaste they become myopic and will not visualize real competition until it is too late. The toothpaste is just the form of the firm's offer but the TCV is a broader factor such as oral care. Therefore, the BS could consider oral care to be nonmyopic. Consequently, the Market Space (MS) of the firm may be defining as toothpaste. According a CSL should closely look at its FSS (stated above) before defining its MS. Having considered the inherent limitations, pros and cons etc. of each FSS the MS for CSL can be concluded as container shipping market.

One can argue that when the toothpaste firm restricts to just one form (i.e. toothpaste) isn't it itself being myopic. Well, the answer is Yes and No. How can one conclude that an oral caring "chewing gum", medicated tablet or a mouth wash that provides precisely the similar benefit like the oral "paste" (existing toothpaste to be specific) would not create a deadly competition from nowhere? (From the Sri Lankan context, the brand "Danttha Muktha" came in powder form and lost its foot due to messy application and compatibility issues with use of tooth brushes together with heavy advertising by MNCs). Therefore, the possible justification in favour of MS-toothpaste is a logical assumption that the "paste" form continue to be the trend in the foreseeable future thus the firm should not be unnecessarily expanding its watchful boundary.

2) Forms Substitution Set (FSS)

The firm must define the business domain in terms of value and not as means of the competitor brands. Apart from barely escaped Hollywood there are other industries and firms that are faced with severe repercussions due to the emergence of Television. Therefore, the firm should analyse other forms of offers that can substitute the firms' existing offer. The rightly define a Business scope and TCV is a prerequisite in the Ten-S process. The FSS can originate from a totally different industry thus what really matters is that to see if such a form can offer the same or higher value to the consumers and compete.

The Time Magazine was very popular few decades ago but not anymore. The reason is not only other firms who publish magazines but the firm not realizing the TCV and defining the broader BS that allows the firm to be cautious on the real competition apart from mere existing brands of same product. People enjoyed the action pictures in the Time Magazine and the firm was doing it well but the Television could satisfy such customers comprehensively and it was very late when the Time magazine realized that there was no gap for them to supply in the demand/supply equation anymore.

As far is shipping industry is concerned what are the other forms that would possibly satisfy the TCV of its consumers? There are three primary means of transportation; Land, water and air. Land will be isolated to a great degree because land transportation cannot always substitute water or air transportation. (The concept of multimodal transport has its own complications and in-depth analysis of it therefore intentionally left out in this discussion). Air can be an equally or better substitution to provide customers a faster service but in the foreseeable future the cost factor and other technical reasons would not allow "Air" to substitute "Water" in a comprehensive capacity. (However, it should be remembered the fact that shippers3 found air as a "situational" substitute between certain port pairs for few distinctive commodities such as garments or live plants but the world trade volumes that should essentially go by sea is very big).

However, the industry complexity does not end there. The water transportation itself consists of many sub forms.

3) FSS in Water Transport

There are eight types of water transport vessels classified in the reports compiled by UNCTAD, however only four main categories will be considered here primarily to assess the importance of focusing on a broader market space and business scope. The four main categories include Break bulk ships, Dry bulk ships, Container ships, and Tanker ships. Break bulk (BB) was the most ordinary form of cargo for most of the history of shipping. The competition for BB did not come within BB vessel operators but from other substitutable forms called Dry Bulk ships (DB) and Tankers (TS) and Container ships (CS). The substitution DB and TS did away with the transport of liquids in barrels and cargoes such as grain in sacks. Consequently, a decline of BB was inevitable

with the advent of containerships and even tankers and bulk carriers about some commodities in which the consumers realized more value due to faster turnarounds with fewer personnel.

Since the late 1960s CS made an enormous impact on the volume of break bulk cargo because moving cargo on and off ship in containers is much more efficient, allowing ships to spend less time in port. The outcome was more value to consumers. However not all cargo can be substitutable due to obvious practical reasons but the above scenario sets living examples of FSS in the industry in which the CSL need to remember. This is a very good example to prove that the competition toa container carrier may not necessarily come from another container carrier but from a totally different category of carrier such as DB. It is noted that historically commodities such as grain in sacks in the BB market had been converted to DB ships. Therefore, competition had come from another FSS and not among other BB carriers. Tanker ships (TS) in fact initially were built to carry liquids such as oil but are now making a substantial threat on BB and DB carriers for some commodities such as grain. With the improvement of technology these ships consist of high power pumping systems that can easily handle loading and discharging of cargo comprising of relatively small solid in addition to liquids (of course with limitations). Therefore, the true competition comes from another FSS.

C. Segment

For example, the segments in toothpaste market represent socio economic, Demographic (Large families, Teens. Children/parents, Male/Female) and psychographic groups as it is considered to be Business to Consumer (B2C) market. Shipping, predominantly being a Business to Business (B2B) market calls for a different approach in segmentation.

Once the potential groups of consumers are identified, a test to be carried out to validate the existence to such segment. The answers for "what do they buy?" and why do they buy?" make the fundamental validation of a segment. If a product (what) can satisfy two who's (two proposed segments) then actually no two segments exist in such situation. This may require further validation of SADAM test which evaluates each segment whether the selected segment is sizable, accessible, distinctive, actionable, and measurable to exist and sustain.

While the conceptual reality is the same, there is practical variance in application in shipping than that of toothpaste or any Fast-Moving Goods (FMG) for that matter. It is useful to understand the customer value hierarchy prior to attempting the segmentation and Liyanage value pyramid illustrated in figure 2 gives a logical direction.

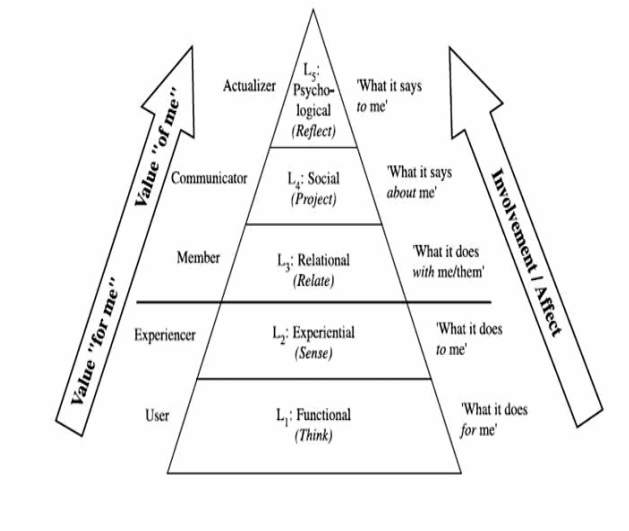

Fig. 2 Liyanage Value pyramid [6]

The Business markets havea greater tendency towards rational decisions based on economic discipline than the emotional impact that is usually found in consumer markets. But it is still possible to analyse the value hierarchy in the shipping market. However, it is easier to understand the concept using an example from the consumer market. A consumer buying a CROSS pen primarily gets a functional value of smooth ink flow, then get a low weight as an experiential value. When the consumer realizes that his/her admiring friends too use similar pens it gives a relational value of being associated. Thereafter consumer "wears" the pen as an ornament trying to communicate to others about himself. Thereafter he gets a psychological value by self-actualizing.

Similarly, the shipping consumer primarily gets the value of smooth delivery of goods as a functional value. Then he experiences the service features such as the network communication, container tracking etc. The shipping line considered in the research being a prestigious carrier feels proud to be associated with other leading exporters in the country thus getting a relational value. This association gives value to a communicator about the consumer that he would not have got otherwise. At the end, the consumer will have a psychological value by being proud about using their service.

1) Major Segmentation Variables for Business Markets

Previous researches suggests seventeen segmentation variables for business markets out of which five appropriate variables were considered for this study. For the given MS, therefore the segmentation variables of Industry, Company size, Location, Urgency and Size of order are vital. For the convenience of reference the author has assigned four identities namely, Galivers, Consevaties, Destinies,and Liliputs.

TABLE I
SEGMENTING THE CSL MARKET

	Segment Name	Galivers	Consevaties
Who buys?	Industry	Garments, Tea	Fibre, Spices
	Company size	Above 5000 TEUs/year	1000-5000 TEUs/year
	Location	Many	Moderate specific
	Urgency	High	Moderate
	Size of order	Big	Moderate
What is bought?	% of the market	35%	30%
	Type	Service contract	Spot volumes
	Purchase frequency	Weekly	2-3 times a month
Why?		Fast Transit	Availability
Potential for growth		Medium	Moderate

	Destinies	Liliputs
Who buys?	Various	Specific
	Less than 1000TEUs/year	Less than 1000TEUs/year
	Specific	Occasional
	Mixed	Mixed
	Small	Very small
What is bought?	15%	20%
	Ad-hoc volumes	Isolated
	Monthly	Monthly and less
Why?	Regularity	Flexibility
Potential for growth	Moderate	Moderate

Each segment qualified the SADAM Acid test and also holds different answers when the question "Why do you buy the X line (the name of the line anonymous) service?" is being raised. Galivers buy for availability of any quantity of clean containers and slots while Liliputs needs prompt response to inquiries. Consevaties need extended container demurrage free time and freight adjustments. Destinies focus on the customer service criteria at ports that they have regular movements.

D. Served (by whom?)

Container shipping business is presently served under various brand names including Non-Vessel Operating Common Carriers-NVOCC in Sri Lanka as per recent un-official statistics. However, there are only thirty-one key players who own/operate ships and carry more than 1000 TEUs of export container cargo ex Colombo per year. More details about top three players will be discussed under "Sensing"

E. Sense (Market Opportunities)

To sense market opportunities a clear understanding on the Key Purchase Determinants KPD is a must. The degree of importance of each KPDs may vary thus the marketer should essentially assess this criterion too and assign a weight to each KPD if at all to derive a logical marketing information through the data set. This approach facilitates a comparison among competitor offerings and the own offering.

It has been revealed from a previous researches that container shipping consumers are very concerned about the Flexibility in documentation, availability of clean and seaworthy containers, Fast transit times, Fixed vessel schedules, Competitive freight rates and maintaining weekly Frequency of ships. The impact on freight rate (Price) play a more complex role unlike in contrast to a consumer market primarily due to shipping being a derived demand of world trade and for its B2B front end.

Figure 3 illustrates the response of 50 customers for six KPDs in the likert scale. (SA-Strongly agree, A-Agree, N-Neutral, D-Disagree, SD-Strongly disagree)

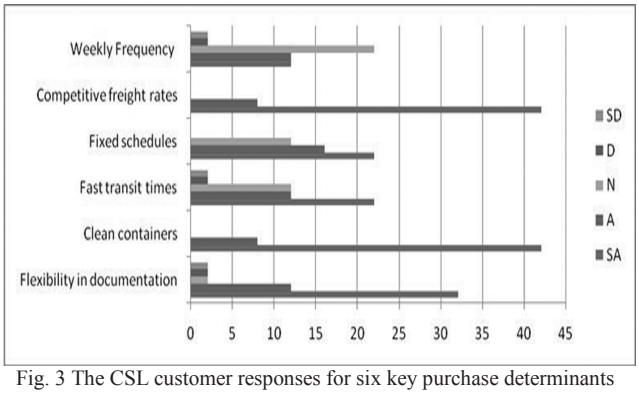

Fig. 3 The CSL customer responses for six key purchase determinants

Based on the response a specific weight was allocated to represent more realistic value under each criterion. This was done based on the following assumptions.

1. Customers who responded N has no impact to the weight.
2. SA and SD have 100% strength in each response while A and D have less strength on their stand of the response (Hypothetically taken as 75% for each count of response under A and D. In other words, the term Strong gives 100% impact).
3. SA and A have positive value while SD and D are negative)

TABLE II
ASSIGNING WEIGHT FOR EACH KPD

	1	2	3	4	5	6
KPD	SA	A	75% of A	N	D	75% of D
Flexibility in documentation	32	12	9	2	2	1.5
Clean containers	42	8	6	0	0	0
Fast transit times	22	12	9	12	2	1.5
Fixed schedules	22	16	12	12	0	0
Competitive freight rates	42	8	6	0	0	0
Effective Weekly Frequency	12	12	9	22	2	1.5

Continued….

	7	8	10	11
KPD	SD	1+3-5-7	Percentage	Weight 1-10
Flexibility in documentation	2	37	74	7
Clean containers	0	48	96	10
Fast transit times	2	27	54	5
Fixed schedules	0	34	68	7
Competitive freight rates	0	48	96	10
Effective Weekly Frequency	2	17	34	3

This information is then tabulated together with competitor details of three major CSL (2009 Exports from Sri Lanka- Top three CSL-X 27055TEUS, APL 23624 TEUS, MSC 18057TEUS - Unofficial data)

TABLE III
THE EXPECT AND GET COMPARISON OF KPDS

KPD	Weigh t 1-10	X Line	Key Competitors	
			APL	MSC
Flexibility in documentation	7	3	6	9
Clean containers	10	9	9	8
Fast transit times	5	6	5	3
Fixed schedules	7	9	7	3
Competitive freight rates	10	7	8	9
Effective Weekly Frequency	3	8	5	1
Price (Freight Rate/TEU- Hypothetical -average of many trade lanes were considered)		1500	1300	900

The outcome of the systematic sensing exercise is usually a meaningful and effective Market Opportunity Statement (MOS). The concept of competitive value proposition should be considered at this level where greater satisfaction to the customer (V>P) and greater profit to the firm (P>V) realized in each Context thus both parties are better off.

1) Formulating a MOS for a Shipping Line

This statement usually includes what factors are to be raised, reduced, eliminated, create or maintained by a firm to capture market opportunities. The prime objective of forming the MOS is to either manage the organization's performance to suit customer expectations or to manage the customers' expectation itself. The latter can be achieved through effective marketing communication.

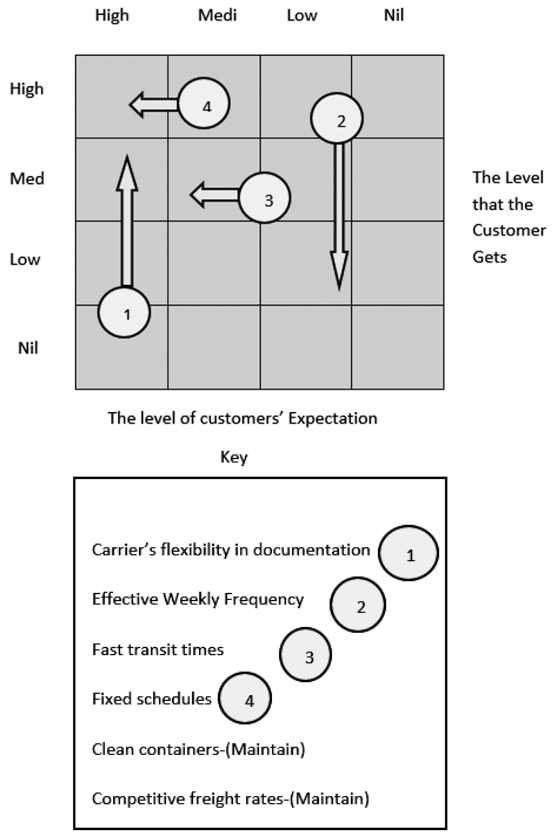

Fig.4 The Expect –Get Matrix

The Expect-Get matrix was used to map the X line's exiting status under each KPD to determine what factors should be raised, reduced, eliminated, created or maintained with due consideration to those of completion. KPD label 1 needs to increase while 2 reduces to match the customer expectation. About label 3 and 4 the firm will change the customer expectation level through marketing communication.

2) Proposed MOS for X Line

We will increase flexibility in documentation, and will reduce cost presently spent maintaining weekly frequency of ships. We will effectively communicate to the customers the competitive advantage offered by X in "Fast Transit", and "Fixed schedules" thus enhance the customer expectation levels under these factors. The company will make every effort to make available clean containers and competitive freight rates.

F. SWOT

Though the existing Gaps that need to be bridged have been identified in the sensing stage it is equally important to assess the internal strengths and weaknesses as well as external opportunities and threats in doing so.

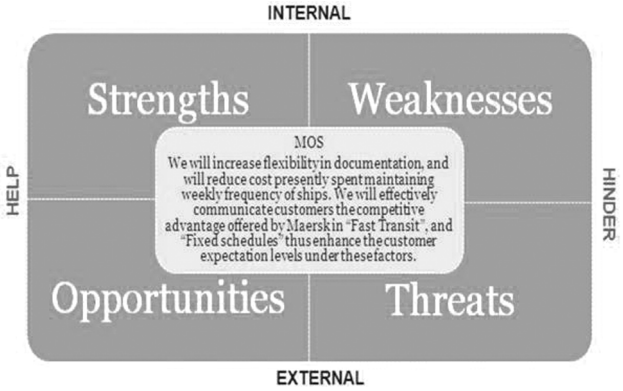

Fig.5 Assessing the internal and external impact

(Note: The Opportunities in the SWOT should not be misunderstood as the factors covered in MOS. These are essentially the external factors that help the firm). SWOT can be effectively carried out using two instruments commonly identified as ETOP and OCP. Market environmental analysis is carried out to understand and give a quantitative measure to opportunities and threats that are impelling on the operational space of the company. It is used to assess the business's chance of success in relation to the market opportunity identified.

TABLE IV
ETOP MODEL

KEF-Key environmental factors	Relative importance (1-10)				Impact (-5 <> +5)				Score			
	G	C	D	L	G	C	D	L	G	C	D	L
Legal implications	3	3	3	3	-1	-1	-2	-2	-3	-3	-6	-6
Container Imbalance	5	5	5	5	-2	-2	-1	-1	-10	-10	-5	-5
Demand for world trade	7	7	7	7	6	6	5	5	42	42	35	35
World politics/war	5	5	5	5	-2	-2	-2	-2	-10	-10	-10	-10
									19	19	14	14

Key: G-Galivers, C-Conservatives, D-Destinies, L-Liliputs

After the analysis, the company will know whether the internal competencies of the organization favour the proposed actions.

TABLE V
OCP MODEL

KOF-K2y organizational factor	Relative importance (1-10)	Impact (>-5 > +5)	Score
Sales team capability	7	+4	+28
Dispersed operating culture	5	-3	-15
Advance MIS	5	+3	+15
Customer service high end attitude	6	-4	-24
Cheap financing	2	+2	+4
			+8

It is clear from the results of both OCP and ETOP score that the MOS can be operationalized successfully.

G. Select

The prerequisites of the selecting stage have already been achieved at the Segmentation stage because, to be an effective target a market segment should fulfil "SADAM" criteria explained under segmentation.

Destinies have Specific destination requirements which attracts some constrains to firm's decisions on service rescheduling etc. Its Ad-hoc volumes may create operational issues. After all, they expect regularity of service as the reason to purchase but on the other hand the carrier is not interested due to the firm's culture. Finally, the future potential is moderate while it constitutes only fifteen percent of market. Then the obvious question arises why the Liliputs be chosen? Well, the main reason is that new MOS focus on flexibility which is the purpose of buying claimed by that segment. The volumes are isolated and be operationally manageable. On the other hand, CSL should anyway target both big parcels and small parcels to strike a balance both operationally as well as commercially thus Liliputs are the best option. Especially, about Sri Lanka (SL) the geographic location plays a major role in many strategic decisions of CSLs particularly in the west bound vessels. SL is usually considered the last filling port on west bound vessels to Europe and Mediterranean. In case of previous port i.e. Singapore or Port Kelang has short-filled the ship than forecasted. SL should be able to capture additional volume to bridge the gap. Otherwise the entire voyage becomes a loss as the shipping space is perishable. Therefore, the combination of sufficient number of big parcels and large number of small parcels make sense in the Sri Lankan context provided that can be secured at short notice.

TABLE VI
SEGMENT ATTRACTIVENESS ANALYSIS

Segment	Share of the market	Growth Potential	ETOP score	OCP score	Rank assigned
Galivers	35%	10%	19	8	1
Consevaties	30%	5%	19	8	2
Destinies	15%	5%	14	8	4
Liliputs,	20%	7%	14	8	3

H. Size

The firm should set SMART objectives at this stage prior to implementing the marketing plan.

The forecasted volume should be specified in terms of TEUs from Galivers, Conservatives and Liliputs separately. Shipping is the derived demand of world trade, thus by evaluating past and present total export market, its growth potential and seasonal fluctuation etc. a realistic and achievable figure can be arrived at. Usually annual forecast be published with monthly breakdown considering traditional monthly fluctuations. (i.e. April and December low volumes).

TABLE VII
SEGMENT ATTRACTIVENESS ANALYSIS

	Market Volume in TEUS	Present X share	Forecasted X share
Galivers	75030	20%	25%
Conservatives	64310	18%	22%
Liliputs	42870	3%	10%

I. Stand

The Greatest Marketing Principal (GMP) is to own a word in the consumers' mind and be lodged there. Getting in to the consumers' Mental Filing System (MFS) and storing the

brand physically and chemically needs a systematic approach. There are two fundamental questions to be answered as a prerequisite in the process of complying with GMP: Now the competitive frame of reference for positioning has been fixed by defining the customer target market and nature of competition. Obviously, there are other CSL brands that offer similar benefits thus those attributes may not be the reason to buy X service. But such attributes cannot be neglected because, if the customer does not find those attribute in his/her MFS under X the brand will never come to customers mind in the first place.

This approach is called Points-of-Parity (POPs) – Associations that are not necessarily unique to the brand but may be shared by other brands i.e. where you can at least match the competitors claimed benefits. While POPs may usually not be the reason to choose a brand, their absence can certainly be a reason to drop a brand.

Once the marketer is clear about where to position the next logical question to answer is "what is to position?" It should be something that strongly associate with a brand, and customer should positively evaluate, and believe that they could not find those attributes or benefits to the same extent with a competitive brand. This approach is called Points of difference (POD) in which consumer finds strong, favourable and unique brand associations such as FedEx which call them as "guaranteed overnight delivery", and Nike's "performance".

In a comparable manner X may define the appropriate points-of-difference and points-of- parity associations. Having evaluated the container shipping consumers' needs attributes such as Reliability, Fastness, Punctuality and Flexibility may be called the POP. Fixed schedule (Reliable) and Fast transit times (Fast) perform better as confirmed in the table 2 can be considered the POD of the carrier.

J. Seize

Seizing the market opportunity through the MOS or Product Positioning Statement (PPS) is the final yet complicated stage in the Ten - S model. Because all the strategic decisions that were made in previous stages now to be operationalized using the appropriate marketing Mix. Even with regard to a similar product a completely different approach should be adopted by two brands therefore. To capture the distinctive nature of service performances, we will be modifying the terminology and extending the mix by adding three elements associated with service delivery: physical environment, process and people [3].

TABLE VIII
OPERATIONALIZATION OF MOS

Proposed Marketing Mix for X	
Product/Service	Fixed Schedule
	Maintain Fast Transit
	Add Flexibility to Documentation
Place	Maintain / facilitate more online booking
Price	Maintain /adjust to capture new share
Promotion	Communicate customer, in financial terms, about "outcome" values of fixed schedules. Compare competitor freight rates keeping reservations for losses due to late deliveries etc.
Physical Environment (PE)	Customers have accepted the existing physical evidences (i.e. as confirmed under clean containers one of key PE). thus, maintain existing approach
Process	Serious consideration needed as required under flexibility in documentation
People	Perceptual reality is not a lesser reality. It is the reality. According to previous research many customers do not perceive X as a convenient shipping solution primarily due to negative attitude of people factor. Therefore, need an "outside- in" approach that will be only possible through change in people or their attitude. An outside-in perspective means that companies aim to creatively deliver something of value to customers, rather than focus simply on products and sales.

III. CONCLUSION

The Ten-S Framework is an ideal tool that can be used to develop an effective strategic marketing plan of any type of firm. Having applied the model to a complicated service like CSL it has been proved without any reasonable doubt that this is an excellent tool that can be used by the marketers to develop very comprehensive yet simply understandable strategic marketing plan. In many occasions firms fail their marketing efforts not because the plan is bad but the lack of compatibility at operationalization stage or simply being myopic in defining what business they are actually in. The Ten-S model provides sufficient opportunities to the marketer to deeply look at the realistic scenario through a bigger picture. In other words, this is a kind of a check list to the firm to carefully assess the market opportunities in a sensible manner. This facilitates the firm to be "looking out of the window" rather than "Looking into the mirror".

Every possible effort has been made to apply the real data such as trade volumes and competition in the process of the Ten-S model to make the study more useful in a real-life scenario than a mere academic exercise. However, in order to eliminate certain ambiguity some hypothetical data were also used. The previous research data that were used to derive the KPDs have their own limitation because the respondents are not necessarily the customers of CSL. Although CSL engages in multimodal transport only the water transport mode has been considered for this study due to its inherent complications.

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Smart Container Inventory Management: A Conceptual Approach

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***Abstract*— Containerization has provided a substantial contribution to the global supply chain. However, it is quite a paradox to note that carriers do not practice or pursue a standard container inventory management system. Each individual carrier develops an inventory management mechanism that suits to their vision, mission, and objectives. These practices are hardly shared between carriers and most of them believe that container inventory management is purely the tacit knowledge of their container controllers and nothing to argue on their decisions. This attitude impedes the industry gaining the experience curve advantage and learning by mistakes. Therefore, the same mistake tends to take place quite often which is highly absurd. The paper challenges this reality and recommends a realistic approach to manage the container inventories of carriers that help reduce global container inventory imbalance. The conceptual model comprises Multidimensional carrier index and country index; 3F Container Inventory Management conceptual model; 6R container supply model; and Virtual container pool.**

***Keywords*— container shipping, Virtual container pool, carrier, container supply**

I. INTRODUCTION

One of the most striking developments in the global economy since World War II has been the tremendous growth in international trade [1]. Shipping is a business that grew up with the world economy, exploring and exploiting the ebb and flow of trade [2]. From 1981 to 2009, global transport of containerized cargo increased approximately 3.3 times faster than the world's GDP [3]. World's very first all-container ship "Gateway city" was found in 1950 [4] and containerization was commercially implemented in the US in the mid-1950s [1] and is the driver of the twentieth century economic globalization and world container port throughput increased by an estimated 3.8 per cent to 601.8 million 20-foot equivalent units (TEUs) in 2012 [5]. Containerization was not just about ships but a new way of organizing transport [2] which has made a momentous change globally in the system of freight transport. However, container fleet size and the complexity of the container shipping network [6] have increased dramatically bringing more challenges to the operation of the container shipping system. Shipping is a derived demand of international trade in economic terms [7]. The system, that proved its potential as an increasingly efficient and swift method of transport, led to greatly reduced transport costs, and supported a vast increase in international trade. Cross-border transportation is an engine to promote the foreign trade [8].

However, as in most cases containerization brings the world a serious burden due to Container Inventory Imbalance (CII). Ninety six percent of carriers consider CII as a significant issue but only 58% have a standard CIM policy [9]. This provides a sufficient insight as to why a conceptual approach is required to mitigate its alarming negative impacts.

'Container' means, an article of transport equipment of a permanent character and accordingly strong enough to be suitable for repeated use [10] or any type of container, transportable tank or flat, swap body, or any similar unit load used to consolidate goods, and any equipment ancillary to such unit load [11]. Container ships and containers are supplementary to each other thus Container Shipping Lines (CSL) cannot transport cargo if containers are not available [12]. Containers are capable of transporting efficiently over long distances, and facilitate multimodal transport without intermediate reloading at any mid points. The total existing fully cellular[1] fleet as at 14th November 2016 (all sizes / all positions) stands at 6.038 fully cellular ships for 20,713,884 [13]. Containers are built to standardized dimensions, and can be loaded and unloaded, stacked, capable of being transported efficiently over long distances, and transferred from one mode of transport to another without intermediate reloading at any mid points. The terminal related variable fees connected to different segments and services (e.g., fee per handled container, trailer, swap-body, storage of load units, etc.) [14].

A considerable amount of investments has been made in purchasing containers and vessels and building port infrastructures [6]. The maximum 'utilisation' of containers can be achieved if they are on consistent move with freighted cargo [15]. Container ports provide the primary interface where physical exchange between buyers and sellers of containerized shipping capacity can be consolidated and realized [16]. Containers are usually supplied to exporters for stuffing of cargo at respective ports by the agents of carriers (Some exporters have their own container fleet for private use and this study does not consider their practices). The containers have a useful life of about 12 to 15 years [17] and the standard twenty-foot container costs about $2,000 to manufacture while forty-footer costs about $3,000. Therefore, a twenty-foot container costs $1.71 per cubic feet to manufacture while a forty-foot container costs $0.80, which

[1] Cellular fleet – the fleet of Container vessels

underlines the preference for larger volumes as a more effective usage of assets [17]. However, according to Alderton, [18] the life expectancy of a container depends on many factors, but it is approximately 8 years and it frequently needs repairs and maintenance. Technically, containers are governed by the ISO (the International Standards Organization) and the CSC (the Container Safety Convention). In 1968, the ISO defined a container as an 'article of transport equipment' [18].

Controlling logistics costs allows companies to maintain a competitive edge and countries to experience trade growth, since lower logistics costs translate into competitive export and import [19].While for light commodities the load unit is secondary, for ponderous commodities the twenty-foot container is the most suitable. This is a principal factor behind the fact that the twenty-foot container still accounts for more than 27% of the world container fleet. About 20% of total container flows at sea around the world are empty, and the costs of repositioning are about USD 400 per container [20]. For hinterland transportation, the availability of containers can be an issue as maritime shipping companies own most of the global container assets and prefer these containers to be within the maritime system where they generate income for the carriers as opposed to hinterland where they generate income for truck, rail and barge companies [17]. Apart from the empty container reposition (MTY Repo) there are two other sources to container supply namely, leasing and purchasing. These sources provide a kind of reactive solution to CII. A considerable amount of investments have been made in purchasing containers and vessels and building port infrastructures [6].

II. Conceptualizing the CII

The present CIM solutions are relative rather than proactive [21]. Key problems to be solved are to find a mechanism to decrease the container imbalance and thus better utilization of resources. This need to answer what is the current situation, what are the factors that determine the degree of willingness with respect to container sharing (interchange), how to organize those factors in a hierarchical system in order to understand as to what extent each of them influence the container fleet imbalance, how to improve those critical factors, and what benefits are expected through collaboration.

During the exploratory study, it was noted that stakeholders of the shipping industry have the following perceptions.

1. The collaboration of Container Shipping Lines may improve utilization of empty container inventories and therefore, the cost of transportation may influence the container exchange mechanism
2. Container sharing may affect the expected payoff of shipping lines
3. Business culture of carriers and organizational Policies of carriers effect the decision of container exchange
4. Marketing rationale of carriers with respect to collaborating with competitors may affect container exchange
5. Legal Implications pertaining to containers effect the decision of container exchange
6. Complexity of container inventory control of carriers effects the decision of container exchange
7. Legal procedures and the degree of tolerance to potential legal implications of collaboration effect container exchange
8. Level of presence of international politics affect container sharing as a CIM strategy
9. Availability of container tracking systems affect container sharing
10. Level of consideration to environment pollution due to excessive movements of empty containers effects container exchange
11. Degree of collaboration may depend on the organizational Policies, vision and mission effects container exchange
12. Decision making level of the organization (whether upper or middle) affects container exchange
13. Level of freedom to take decisions independently by agents' affects container exchange
14. Level of consideration on losses due to holding of empty container stocks effect container exchange
15. Total container fleet of the organization affects container exchange
16. Ability of incorporating empty reposition cost in establishing freight rates affects container exchange
17. Degree to which the business culture and commercial practices of carriers facilitate collaboration affects container exchange
18. Degree of resilience to the expected complexity container Inventory Control that may cause due to collaboration affects container exchange
19. Degree of organization's sensitivity towards stakeholders' interests may affect container exchange

Therefore, it was identified that the outcome of the research may have a bearing to these views and should answer the related issues.

Container exchange, irrespective of its very visible advantages, may generate some complications particularly in terms of legal parameters. Usually a carrier has three sources of empty containers that are used for their export bookings. They are, (i) the carrier owned containers (COC), (ii) on-hired or leased containers, and (iii) shipper owned containers (SOC). Therefore, at a given time carriers may have containers of all these categories dispersed globally, in sailing ships, in the hands of exporters, importers, container yards, port terminals, customs warehouses, on the roads, on trucks, on rails or simply abandoned with a third-party due to some issues. Therefore, monitoring the container inventory is a serious activity of a carrier. With the introduction of alliances between carriers and commencement of slot sharing activities this was further complicated. Now the containers are commonly in the alliance vessels. This has created a situation that carriers must handle their competitors' containers in addition to their own. Similarly, carriers should release their containers in to the hands of competitors according to the alliance agreements. Initially, this created many marketing disadvantages to carriers as their highly sensitive customer data get lost its security. But given the economies of scale advantage that supersedes these barriers had paved the way for successful collaboration among carriers for slot exchange. The possible legal implication that will aggravate container exchange should be explained with this background. After successful implementation of CE system there can be a possibility of an export cargo belonging to an exporter e, stuffed into a container belong to carrier **c**,

freight handled by forwarder **f**, loaded on board a ship owned/chartered by carrier s, stacked in a slot owned by carrier **a**. Therefore, in an event of a legal implication the number of parties that will be involved is getting higher and higher. However, one can also argue that this complication is already in existence even now. If the c is replaced by a leasing company which is in existence does not make any difference. Therefore, the critical factor that needs to be considered here is that a similar or even stronger legal documentation should be in place for effective implementation of the CE model. The statistical significance ($p<0.050$) reflects that there is a relationship between Benefits and Complying with the legal procedures which will be an additional burden to exchange containers.

1. The study reveals that container exchange has a potential in solving the container imbalance issue. However, the industry does not show a unanimous agreement to the concept. The comments received during the interviews reveal that the carriers are not highly influenced by the concept mainly because of branding issues. And the industry has no literature that gives a scientific analysis of the solution. In other words, the industry hypothetically believes that if a country has a trade imbalance (i.e. the variation between imports and exports) the container imbalance in something inevitable. When this is true, it applies to any shipping line serving in that country or port. This makes sense as there should be two parties namely, deficit and excessed if at all to originate an 'exchange'. This myopic view of the industry is in fact discouraging the carriers to explore the possibilities in finding a solution through container exchange. Therefore, it should be proved to the industry with the use of real industry data with respect to opportunities available. In other words, the number of carriers that need empty containers (offeree) and those who can provide containers to them (offeror) at a given time at a given location should be highlighted. This factor has some relevance to the queuing theory as well. The mathematics underlying queuing theory is quite like those underlying seemingly unrelated subjects as inventories, dams, and insurance [1].

2. For example, the industry gauges the seriousness of the container imbalance simply calculating the stock levels in the beginning of the year and the end of the year. However, there are more activities taking place during the year when considering the monthly or weekly imbalances. Therefore, a case study to investigate the realistic movement on monthly basis (or weekly basis provided the data accessibility) by each carrier should be recommended. This may need a theoretical Modelling of Collaboration among Shipping Lines with respect to Container Sharing and proposing a unit of measurement to quantify the outcome of container exchange.
3. It would be necessary to identify and evaluate the existing solutions to mitigate Container Inventory Imbalance Problem prior finding a new solution. It is then obviously require identifying the factors that influence the existing practices. As the outcome of such a study it would be worthwhile to develop an operating model that incorporates existing CIM strategies and practices of CSL. In terms of generalising the results with other countries it may be important to explore a mechanism that could evaluate a country's competence in CIM. If the competence is low the respective country needs more efforts in rectifying their short comings to improve their index. Accordingly, development of a Global CIM competence Index would be useful
4. Once the groundwork for an effective CIM mechanism is constructed the study may require exploring the container exchange possibilities based on real data. It may also explore any other potential solutions to container inventory imbalance problem in contrast to container exchange mechanism. After such unbiased evaluation, the study may further explore the efforts of minimizing the Container Inventory Imbalance through Collaboration among Carriers.
5. The most significant factor in the whole study is that the container exchange has not been effective even though carriers on principle agree the concept. It may be due to some peculiarity on the organizational behaviour of carriers. Therefore, further discussion on container exchange between CSL would be vital to understand the behavioural aspects of CSL that lead to the absence of collaboration. This should be followed by development of Container Exchange Simulation Model and introduction of Virtual Container Pool.
6. To attract carriers to the container exchange concept, evaluating the potential benefits and pitfalls of container exchange between CSL should be required. This may be done as a case study in Sri Lanka. Further research may be required with respect to optimization of container utilization through minimizing empty container repositioning and evaluate the degree of opinion on the collaboration among shipping lines to view the industry point of view. The container exchange simulation model may be validated using the views of industry experts in view of further research and development of On-line software application to facilitate implementation and the sustainability of the new concept is recommended

The conceptual approach of the research should be constructed on 2 fundamental objectives of CIM namely, maximization of customer satisfaction and minimization of container idle duration and empty container reposition. It is presumed that the introduction of an innovative container inventory management system fuelled by collaboration between carriers may help minimize container imbalance. This proposed container exchange is derived from the collaboration between carriers and provides an extension to the existing slot exchange mechanism between consortium partners. Figure 1 illustrates the basic "operationalization" of the main research.

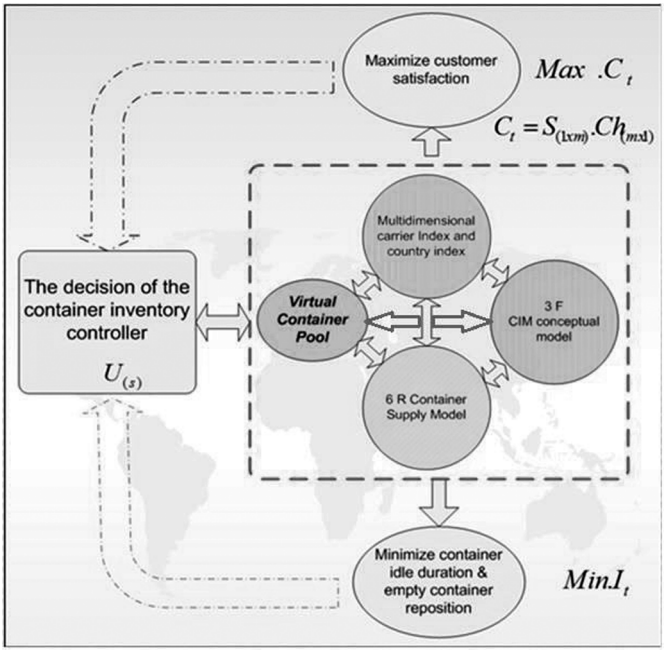

Fig.1 Conceptual Framework of Smart CIM

The effective and efficient CIM means striking the right balance between customer satisfaction and cost of container imbalance (i.e. $Max.C_t$ and $Min.I_t$ at the time *t*). The cost of container imbalance is defined as container idle duration and empty container reposition for this research. The decision of the container inventory controller $U_{(s)}$ is to make both ends satisfied. The customer satisfaction is given by

$$C_t = S_{(1\times m)}.Ch_{(m\times 1)},$$

Where, *S* is a raw vector consisting of the perceived utility scores of *m* service factors, *Ch* is a column vector consisting (0 ,1) where the corresponding element 1, represent the desired level of the given service factor, 0 represent the absence of the desired level. To achieve the optimum level of satisfaction all the elements of the column vector should be unity.

Each objective of the main research is covered by different material and methods of each sub researches. However, the research location, respondents, literature, and container data are common to all sub researches as they were conducted in Sri Lanka with the intention of generalizing its outcome in the global context. Sri Lanka attracts the majority of mega carriers to its main ports primarily due to strategic geographic location. Seventeen out of the top twenty container carriers in the world operate regular services in the busiest commercial port in the country, Colombo. Approximately 75 percent of the global container capacity is operated [1] by those top carriers. Accordingly, the sample is expected to be relatively reflective of the general views of the global shipping industry. Therefore, it is presumed that the results can be generalized for the benefit of the global shipping community. There are two formal organizations that represent CSL in Sri Lanka namely, Ceylon Association of Shipping Agents which is composed of 135 licensed ships' agents, and Sri Lanka. The other association, Sri Lanka Association of Vessel Operators comprises 14 members. The views of exporters also obtained wherever applicable and there are approximately thousand exporting companies (including non-regular) in Sri Lanka according to unpublished data.

The core issue that prevails in the industry is to find a mechanism to decrease the cost incurred on container inventory imbalance thus better utilization of resources. In most cases, an imbalance occurs because of inaccurate forecasts [22]. It is understood from the exploratory study that there is no collaboration among shipping lines with respect to container interchange. Chapter three explains that the effectiveness container exchange mechanism has a relationship with the level of Complexity of Inventory Control; empty reposition surcharge; and Capacity of container inventory. Also, carriers are likely to exchange containers if there is a mechanism to evaluate the overall benefit in financial terms and it has relationship with the level of Complexity of Inventory Control; empty reposition surcharge; Capacity of container inventory; additional burden on legal procedures; Organizational Level Support; and the Decision-making level of the organization. The container carriers those who experience excess inventory at a port at a particular time may offer containers to carriers those who suffer shortages. As a result, both carriers may reach balanced inventories in an ideal situation.

The common agony of the carriers who hold excess inventory is the substantial cost associated in empty repositioning out from that port and idle inventory that lead to ground rent, monitoring, loss of return on investment, extra maintenance (against rust and other natural/environmental phenomena) at CFS. On the other hand, the line with deficit inventory tend to experience regular cargo booking cancellation thus always at a risk of losing customers on the long run. Cargo booking cancellation is a significant issue as it not only affects the revenue to the line but negatively impacts on the long-term forecast and budgets. Liners usually consider exports from one port to another port in the respective port rotation as the prime source of empty containers to the latter. Therefore, cancellation of booking will have a continuous negative impact throughout the supply chain for all ports connected the liner service. To avoid this chain of effect, lines tend to import empty containers or on-hire boxes. Both these options add cost to the line. The sharing may reduce the need for empty reposition.

III. Appraisal of the Conceptual Model

The model underpins a strategic approach of CIM and comprises 4 key tools namely, Multidimensional carrier index and country index; 3F CIM conceptual model; 6R container supply model; and Virtual container pool.

A. Multidimensional carrier index and country index

Multidimensional country index refers to the CIM competence level of a country. It is vital to have an appraisal of the country's competency level regarding the container inventory management because each country will have container inventory imbalance levels, seasonal fluctuation that are exclusive to them, slot cost variations and port handling costs for empty container reposition. The multidimensional CIM index of Sri Lanka is calculated at 0.586 [23]. Multidimensional carrier index provides the level of CIM competence of an individual carrier. This helps the

management of the respective carrier to enhance the knowledge and skills of their container control staff. Sometimes, it may remind them to review the strategies used in CIM because usually there are no standard practices on how carriers should manage their container inventories. It is expected that carriers may assess their individual competence (CCI) while the country's CIM index (MCI) provides the overall competence level of the shipping industry with respect to CIM in each country [23].

B. The 3F CIM conceptual model

The CIM mix, provides an independent opinion about the key dimensions that should be the focus of a carrier's attention when managing its container inventories [22]. It is comprised of 3 key aspects in CIM. Under each of these three dimensions, six strategies are elaborated that facilitate effective and efficient CIM. This approach provides an objective, "proactive" solution rather than the more common, ad hoc "reaction" to market conditions related to empty container repositioning. This mechanism enables carriers to act more effectively and efficiently as they regularly evaluate their decision through an indicator that consists of criteria validated by the industry experts.

C. 6R container supply model

Shipping supply is a very complicated phenomenon. Unlike a common consumer good that the demand forecast is dependent of rather strength forward consumer centred factors, shipping supply has its own indirect characteristics. For example, the supply can increase by adding more ships, increasing the size of ships, increasing the speed of ships, increasing productivity of ports and reduced port stay, change of shipping route and many other strategic approaches and may not be necessarily related to ship size and number of ships. The 6 R's in this model refer to, right quantity of containers, right types (such as standard; open top, reefer etc), right size (20', 40',45' etc), right quality containers to be supplied by the carrier at the right time and at the right location. These requirements are initiated by the exporters.

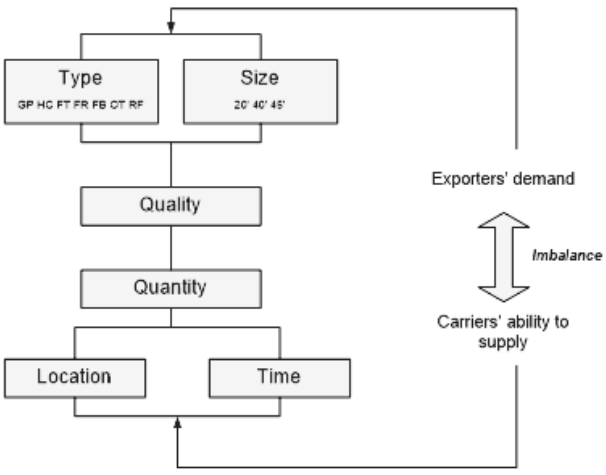

Fig.2 The components that create an imbalance in container operations

Accordingly, carriers need careful assessment of these factors to strike the right balance between the demand and supply.

D. Virtual container pool

The concept of Virtual Container Pool (VCP) is based on the container exchange between carriers on a global platform. Each carrier has the full control of their containers with respect to release or hold for their own use. Shao et al., [24] formulate this problem as maximum matching in a large general graph, and propose a distributed matching algorithm to solve this problem. We also propose several optimization techniques to improve the efficiency of our algorithm. The fundamental prerequisite in a container exchange is that there should be a carrier who is in shortage and another carrier in excess. In the chapter eight, as per the case study in Sri Lanka, it is evidenced that the prerequisite is met. Therefore, it is worthwhile investigating this concept further. Lines may exchange containers provided it enhances value of the supply chain to all participants. The basic requirements that demands this action is that one carrier should be experiencing a deficit of containers (either the size or the type in demand) while another carrier has surplus on the identical size and the type of containers at the same time horizon and in the same location. The offeror however primarily needs to make sure that they have ongoing services (and agents to undertake handling) at the intended destination. Secondly, there should be a demand for empty containers by the offeror at the time that the respective containers are scheduled to reach. This demand should be either greater or equal to the number of containers they offer to the other carrier (offeree). The fundamental prerequisite to exercise CE is the variability of inventories that one or more carriers with excess containers while others with deficit at a given location and at a given time [25]. Leading CSL already has provisions in their contracts to interchange containers. However, the general perception among CSL is that, there could be CI monitoring issues associated with respect to interchanging of containers [26].

In addition to vessel sharing these alliances gradually extended the collaboration to other areas such as, service rationalization, operating expense sharing, equipment interchange, and joint service contracts. Therefore, nothing should prevent regional corporation in maritime logistics per present developments. However, it is easier said than done and more complicated by nature [27]. The carriers have unanimously agreed that VCP could be considered an effective CIM solution although they do not exchange containers at present. The ability to synchronize the capacity, complexity, empty reposition surcharge to ascertain the benefits of CE are influential factors on developing a VCP [25]. Therefore, the success of VCP mainly depends on the ability of overcoming this psychological barrier. This can be only done through the awareness, clarity and visibility of the concept [15].

As illustrated in the Fig 1, the key CIM methodologies are usually interrelated and interconnected. One activity can follow the other or all 4 can be activated simultaneously. For example, a carrier can first ascertain its Multidimensional carriers index first and them administer the 3F CIM conceptual model. The same firm could improve its CIM by applying the 6R container supply model followed by entering to the Virtual container pool. However, a carrier joining the virtual container pool should not be the final activity of the effective CIM process. The sustainability of an efficient and effective virtual container pool would highly depend of consistent monitoring and prompt decision making. This process requires combined efforts of all these complimentary tools mentioned above.

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Factors that Affect the Buying Behaviour of the Shippers and Freight Forwarders when Choosing an Ocean Carrier in Sri Lanka

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Abstract **— The shipping sector has become the backbone of international trade and globalization. Therefore, the freight transportation selection is of vital importance for the shippers and International Freight Forwarder (IFF). Accordingly, assessment of requirements and trends of freight forwarding while understanding key factors that rule its efficacious movement is a timely want to provide high quality service to societies. This study aims to determine the factors that affect both shippers and IFF's when selecting an ocean carrier preference to the Sri Lanka. Primary data is collected through Questionnaires and 174 questionnaires have been collected. Descriptive analysis has been carried out to check the association between the response variables and explanatory variables. Due to the availability of collinearity between explanatory variables, factor analysis has been carried out. Hypothesis testing has been carried out for ordinal data using Kruskal Wallis test. The factors which affect the buying behaviour of the shippers and international freight forwarders when selecting an ocean carrier with orientation to Sri Lanka can be mainly categorized into facilities, accuracy, frequency and relationship, capacity, reliability and competence, general reputation, service capabilities. service capabilities are dependent on the organization type, Number of employees, Average volume per month and estimated average income per month. General Reputation is dependent on the organization type, Number of employees, Average volume per month and Frequency. Capacity is dependent on the organization type, Firm age and Average volume per month.**

Keywords **- Shippers, Freight Forwarders, Buying Behaviour**

I. Introduction

Based on the statistics provided by annual report & accounts 2010/2011 of Shippers Council, Sri Lanka, there are over 50,000 merchant ships trading internationally, transporting every kind of cargo. The world fleet has registered over 150 nations, and manned by over a million seafarers of virtually every nationality. Considering the Sri Lankan context, statistics suggest that the country has experienced an increase of 22.4% in imports during the last financial year (2013) compared to that of 2012. The total monetary value of sea exports in 2013 reached USD 10,559 million while the expenditure on sea imports increased by 50.7% and reached USD 20,269 million in value. Simultaneously, Sri Lanka Ports Authority (SLPA) statistics show that Sri Lanka has experienced 8% of economic growth during 2010.

The operating mechanism of ocean carriers vary depending on the types of cargo they transport. Dry bulk carriers, container carriers, roll on roll off (RO-RO) carriers and liquid bulk carriers are the categories of ocean carriers based on cargo type. Among these the container carriers may include self-owned or shipper owned containers as well as self-owned or externally arranged (in other carriers) vessels in order to fulfil the requirements of their customers.

Basic objective is to understand the factors that affect the buying behaviour of both shippers and IFFs when selecting an ocean carrier. The outcome of this study will highlight all important aspects considered by shippers and IFFs, and will in turn directly help the service providers to enhance their service, in terms of both quality and quantity. Study outcome can therefore be used as a direct guideline to improve services provided by ocean carriers at different facets, facilitating their customers with many additional value-added services.

A. Objectives

Identifying the determinants that affect the buying behaviour of the shippers and international freight forwarders when selecting an ocean carrier

Identifying the factors that are considered as critical by each organization type

II. Methodology and Experimental Design

Online questionnaires were sent to the all registered IFF companies (170) in Sri Lanka. Out of them 40 questionnaires were returned and the response rate was 23.52%. 24 questionnaires were filled physically when visiting them and all together 64 questionnaires were collected from the IFFs. Approximately over 200 questionnaires were sent to the container export companies located in Sri Lanka and 75 questionnaires were returned. The response rate is 37.5% and 39 completed questionnaires were collected by physically visiting the exporting companies.

Descriptive analysis has been carried out to check the relationship between the response variable and other explanatory variables. Based on the reliable factors hypothesis testing has been carried out for ordinal data using

Kruskal Wallis test. Factor analysis is the method of data reduction. Correlated variables are grouped together and separated from other variables with low or no correlation Factor analysis could be described as orderly simplification of interrelated measures. Traditionally factor analysis has been used to explore the possible underlying structure of a set of interrelated variables without imposing any preconceived structure on the outcome (Child, 1990). By performing exploratory factor analysis (EFA), the number of constructs and the underlying factor structure are identified. Kruskal Wallis test has been used to k independent samples which is an extension to the Mann Whitney test.

III. Results

A. *Descriptive Analysis*

Out of 174 organizations 19%, are organizations that consist of 20 to 39 employees while lowest percentage of 6% is consist of 60 to 80 numbers of employees. 35% of organizations have a firm age between 10 to 14 years and only 13% of companies are older than 20 years. 45% of organizations (both shippers and IFFs) exporting TEU's "Between 20 to 99". Only 1% of companies export TEU's over 300. 53% of companies' process daily exports of TEU's while 32% of companies export their TEU's weekly and 15% companies export their number of TEU's weekly and monthly. The highest percentage is 28% and it belongs to companies that have a monthly income of between Rs. 5 million to 10 million.

B. *Factor Analysis*

TABLE I. Communalities

Variable	Extraction
On time arrival and departure of an ocean carrier	.415
Delivering the cargo at promised transit time without any damage	.481
Maintenance of equipment and containers in satisfactory condition	.750
Convenience in taking and returning the containers at the yard	.739
Historical operation performance	.713
Reputation of the carrier	.647
Finance stability	.708
Loss and damage record	.516
Issuing competitive & accurate price quotations for inquiries	.665
Negotiation of rates	.540
EDI (Electronic Data Interchange) & tracking facility	.645
Multimodal service	.633
Geographical coverage	.690
Expertise / knowledge of sales representatives	.610
Frequency of sailings	.526
Credit facility for their customers	.680
Free detention period at destination port	.608
Customer relationship	.488
Informing the status of the cargo	.520
Speed of issuing shipping documents	.534
Accuracy of shipping documents & bills	.658
Speed processing of claims	.622
Space availability	.746
Speed operation process	.627
The competency of emergency handling	.718

Table 1 shows how much variance in the variables has been accounted for by the extracted factors. According to the table 1 Over 75% of the variance Maintenance of equipment and containers in satisfactory condition is accounted for while 74.6% of the variance in Space availability is accounted for.

TABLE II. Total Variance Explained

Component	Cumulative %	Total	% of Variance
1	20.568	2.995	11.979
2	30.955	2.610	10.439
3	37.752	1.949	7.794
4	43.663	1.853	7.413
5	48.725	1.831	7.322
6	53.436	1.806	7.224
7	57.865	1.255	5.019
8	61.918	1.182	4.727

As per the Table 2 all 25 variables are explained in eight factors. The percentages of variances are attributable to each factor and the cumulative variance of the respective factor is equal to the sum of percentage of variance of the respective factor and other previous factor. First factor accounts for 20.568% of the variance, second to 10.387%, third to 6.797%, fourth to 5.911%, fifth to 5.062%, sixth to 4.711%, seventh to 4.429% and the eighth to 4.052%. The total variance explained by the factor model is 61.918%.

TABLE III. Interpretation of the Factor Model

FACTOR 1 – Service Capabilities includes	
On Time Arrival and Departure of an Ocean Carrier	.616
Multimodal Service	.452
Free Detention Period at Destination Port	.612
Informing the Status of the Cargo	.620

Speed Processing of Claims	.750
Speed Operation Process	.564
The Competency of Emergency Handling	.659
FACTOR 2- General Reputation includes	
On Time Arrival and Departure of an Ocean Carrier	0.323
Historical Operation Performance	0.723
Reputation of the Carrier	0.780
Finance Stability	0.791
Loss and Damage Record	0.553
FACTOR 3- Container & Equipment includes	
Maintenance of Equipment and Containers in Satisfactory Condition	.814
Convenience in Taking and Returning the Containers at the Yard	.826
FACTOR 4 – Facilities includes	
Geographical Coverage	.734
Credit Facility for Their Customers	.739
FACTOR 5 - Frequency & Relationship includes	
Negotiation of Rates	.641
Frequency of Sailings	.488
Customer Relationship	.618
FACTOR 6 - Reliability & Competence includes	
Delivering the Cargo at Promised Transit Time without Any Damage	.474
Issuing Competitive & Accurate Price Quotations for Inquiries	.479
Expertise / Knowledge of Sales Representatives	.746
Speed of Issuing Shipping Documents	.540
FACTOR 7 - Accuracy includes	
Accuracy of Shipping Documents & Bills	.796
FACTOR 8 - Capacity includes	
Space Availability	.833

C. Hypothesis Testing for Factors

The hypothesis below has been checked by performing the Kruskal Wallis test;

Ho: Factor is independent from the ith variable

H1: Factor is dependent on the ith variable

i^{th} Variable – Organisation type, No. of employees, Firm age, Average volume per month, Frequency, Approximate average income per month

TABLE IV. HYPOTHESIS TESTING TEST RESULTS OF ORGANISATION TYPE

	Asymp. Sig.
Service Capabilities	.000
General Reputation	.031
Container & Equipment	.055
Facilities	.930
Frequency & Relationship	.432
Reliability & Competence	.175
Accuracy	.528
Capacity	.025

There is significant association between Organization Type with the General Reputation and Capacity as significant values are below 5%.

TABLE V. HYPOTHESIS TESTING TEST RESULTS OF NO. OF EMPLOYEES

	Asymp. Sig.
Service Capabilities	.000
General Reputation	.005
Container & Equipment	.076
Facilities	.101
Frequency & Relationship	.768
Reliability & Competence	.080
Accuracy	.694
Capacity	.813

There is significant association between Organization Type with the Service Capabilities and General Reputation as significant values are below 5%.

TABLE VI. HYPOTHESIS TESTING TEST RESULTS OF FIRM AGE

	Asymp. Sig.
Service Capabilities	.120
General Reputation	.724
Container & Equipment	.294
Facilities	.650
Frequency & Relationship	.593
Reliability & Competence	.231
Accuracy	.788
Capacity	.048

There is significant association between Organization Type with the Capacity as significant values are below 5%.

TABLE VII. HYPOTHESIS TESTING TEST RESULTS OF AVERAGE VOLUME PER MONTH

	Asymp. Sig.
Service Capabilities	.001
General Reputation	.043
Container & Equipment	.100
Facilities	.960
Frequency & Relationship	.714
Reliability & Competence	.482
Accuracy	.084
Capacity	.432

There is significant association between Organization Type with the Service Capabilities, General Reputation and Capacity as significant values are below 5%.

TABLE VIII. HYPOTHESIS TESTING TEST RESULTS OF FREQUENCY

	Asymp. Sig.
Service Capabilities	.693
General Reputation	.027
Container & Equipment	.138
Facilities	.291
Frequency & Relationship	.531
Reliability & Competence	.401
Accuracy	.459
Capacity	.250

There is significant association between Organization Type with the General Reputation as significant values are below 5%.

TABLE IX. HYPOTHESIS TESTING TEST RESULTS OF APPROXIMATE AVERAGE INCOME PER MONTH

	Asymp. Sig.
Service Capabilities	.020
General Reputation	.086
Container & Equipment	.089
Facilities	.918
Frequency & Relationship	.752
Reliability & Competence	.798
Accuracy	.416
Capacity	.136

There is significant association between Organization Type with the Service capabilities as significant values are below 5%.

V. CONCLUSION

Factors that affect the carrier selection process (with regards to IFFs and Shippers) were identified as Facilities, Accuracy, Frequency and Relationship, Capacity, Reliability and Competence, Container and Equipments, General Reputation and Service Capabilities. Result generated in hypothesis testing led in arriving at following conclusions:

Identified the followings which shows the association between Organization infrastructure and the carrier selection criteria

1. Service capabilities (factor 1) is dependent on the organization type, Number of employees, Average volume (TEUs) per month and approximate average income per month.
2. General Reputation (factor 2) is dependent on the organization type, Number of employees, Average volume (TEUs) per month and Frequency.
3. Capacity (factor 8) is dependent on the organization type, Firm age and Average volume (TEUs) per month.

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Demand Factors for the Use of Public Transport to Reduce Congestion within the Colombo Region

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***Abstract*— As congestion is a growing issue in Sri Lanka, a quick and efficient solution is required as it is causing many negative issues both economically and socially. This research was therefore carried out to find out the demand factors for public transportation to reduce congestion. The objectives of this research were to find out the demand factors of private transport users to switch over to public transport, and this research also focused on the shortcomings of the current public transport system. After the collection of data through primary and secondary methods, the gathered data were used to model a public transport system that will try to please all markets while generating more business for service providers.**

An online based questionnaire survey was conducted with an instrument of 28 questions. The target sample is both public and private transport users, although the sample size was 500, there were only 423 valid responses. Simple random sampling was used in this study and SPSS was used to analyse the data. A factor analysis was carried out to reduce the number of variables and grouping factors which have the same characteristics. Once this was completed the 28 variables were reduced to 10 variables.

Hypothesis testing was carried out to validate the hypotheses. The research findings explain that the willingness of people to move from private automobiles to modes of public transport depends on the comfort ability and safety, where the comfort ability includes the availability of reserved seating, cushioned seats and air conditioning. Surprisingly the availability of technology on board the bus/train was deemed not so important although the level of service at boarding points was proved to be a crucial factor. Respondents who were already users of public transport, surprisingly created a very good picture of the existing public transport system. The basis of recommendations was to focus on customer service and comfort ability to have an efficient and effective public transport system.

***Keywords*— Public Transport, Customer Service, Automobiles**

INTRODUCTION

Colombo is the economic hub of Sri Lanka; with an area of 37.31 square kilometres, within this relatively small land area, there is a thriving population of 2.375,000 people (Almost 10% of Sri Lanka's population). In a recent study, it was found that on average we have 443,586 private vehicles plying the roads of Colombo daily as opposed to only 29,064 public transport vehicles, which roughly translates to a ratio of 15:1. [1]

The below figure when compared to the area of Colombo city indicates a rather alarming issue, the congestion.

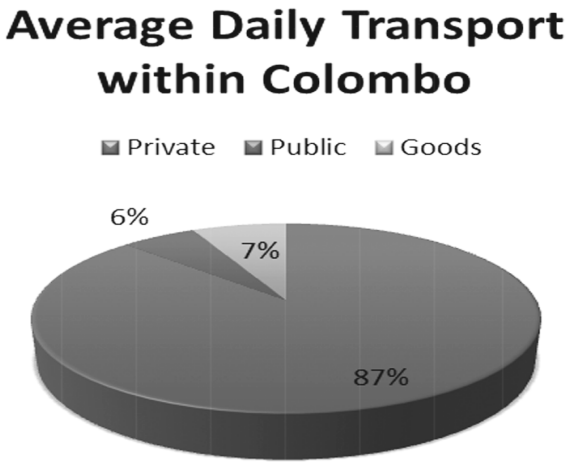

Fig. 1 Average Daily Transport within Colombo; Source Central Bank Report 2014 [2]

Congestion is becoming a huge issue with numerous negative effects on both the economy and society. With congestion, service levels of businesses are falling, as employees are late to work. Delivery companies must spend more time in traffic than completing their deliveries, which results in wastage of time, money and even energy/fuel. Massive amounts of fumes and other dangerous gasses are emitted into the air causing air pollution and this impact on the wellbeing of the country's community.

This major issue of congestion also affects our carbon footprint as a country, which is a huge barrier when foreign investors consider investing in our country, as all developed countries are considering eco-friendly investments.

People use their private vehicles for their daily commute not only because it is easy, but also because it's more comfortable, safer and much more time-saving than using public transport. Thus, the outcome of the research could be used to create a public transport system that will be a good enough substitute to private transport. It will consider all the demand factors that private vehicle users will want in public transport, for them to switch over. By taking into consideration what the potential customers want, a customized public transport system can be created, where the customer's wants are met, and private vehicle users are attracted, thereby reducing the number of vehicles on the road which in turn will reduce the congestion. A customized transport service not only ensures that the customers are kept happy, but also generates new business for public transport providers, as now there is a whole other market to be captured.

This creates a win-win situation for both the users and the service providers.

A. Research Review

According to the Cambridge Dictionary; Public Transport is defined as "a system of vehicles such as buses and trains that operate at regular times on fixed routes and are used by the public" [3]. An efficient and effective public transportation system is an absolute necessity for a country to develop and it creates many positive effects to both the economy and the society. According to Association, American Public Transport (2007) [4] , public transport helps not only to create and maintain jobs but also takes people to and from their job which indicates how important public transport is to an economy of a country.

According to Rodrigue (2017) [4] congestion occurs when transport demand exceeds transport supply at a specific point in time and in a specific section of the transport system Sri Lanka is a developing country and with its lack of infrastructure to handle current volumes of traffic, it has brought about congestion that affects the country in numerous ways. According to Edirisinghe (2014) [5] congestion in the Colombo district is not only because of the large volume of vehicles on the road but also because of shortage in parking areas, parking of heavy vehicles on busy highways during working hours and even poor public transportation systems.

Ranawana and Hewage (2015) [6] found out in their research that the main factor is customer satisfaction when people choose to switch from public to private transport. Paulley et al (2004) conducted a research on the factors affecting the demand for transport and found that fares of public transport are elastic to demand, and if fares are increased it has a higher likelihood of people stopping the usage of public transportation. They also found that the customers who want to use public transport system, requires boarding points which are clean, safe and protected from weather, requires a high quality, reliable public transport mode and an efficient complaint handling system

B. Objectives of the Research

The objectives of the study are to identify the inadequacies of public transport to meet the needs of the public and to compile and analyse factors that contributes towards private motor vehicle users adopting public transportation. Use analysed date to formulate a model for public transport service providers to not only satisfy existing customers, but also generate new business by meeting the requirements of potential customers

C. Research Questions

- What are the factors affecting customer satisfaction in public transport?
- Why do private vehicle users prefer using personal methods of transport as opposed to public transport?
- What are the possibilities which can satisfy both current and potential customers?
- How do the solutions to the above questions help to reduce congestion?

D. Significance of the Research

Congestion is an ever-growing issue in the world, and we Sri Lankans have witnessed it first hand in the past 2-3 years. Imports of vehicles for private use is increasing year by year, and traffic jams are getting more and more apparent, all these shows that we just have too many vehicles on the road. Our road infrastructure is not adequate to handle the large volume of traffic that is generated every day and as shown before, there is no more space for expansion to take place.

With congestion on the rise especially during peak hours, Sri Lanka needs a quick, cost effective and high response rate solution. Sri Lanka already has an active public transport system; however, the many drawbacks present in the service such as the lack of a proper scheduling system and no concern for safety of passengers are factors that are making people choose to use their personal vehicles instead of public transportation.

This study considers creating a more attractive public transport system by using factors that potential public transport user wants in public transport for them to switch over from private to public transport. By using this method, we are creating a customized public transport system thus giving the people a reason to reduce the usage of their private vehicles and use more public transport. With more people switching over, naturally there will be a reduction in the number of vehicles on the roads. The goal is to reduce congestion by making people use public transport to reduce congestion.

METHODOLOGY

A. Variables for the Use of Public Transport

Earlier studies related to switching from private to public transport have been initially concerned on the identification of user selection factors using empirical studies. Even globally there have been many researches on similar topics. These exploratory studies with similar perspectives have been taken as a guide to the development of the current research. The literature used for the subject has been categorized as *fares, environment of boarding points, reliability, service quality and complaints handling.*

Paulley et al, (2004) [7]concluded that fares are fundamental to the operator of public transport system as it is their main source of income. They found that fares are elastic, since it was found that when fares increase, the usage falls. However, this effect varies according to factors such as journey and distance, as well as rising incomes and vehicle ownership as well as the quality of public transport.

It was found in the research of Paulley et al, (2004) [7] that customers who wanted to use the public transport system, required boarding points which were clean, safe and protected them from the weather at the very least.

According to them people were very sceptical regarding the reliability of public transport as the general view of public transport were late arrivals of trains and busses as well as long in vehicle waiting times due to traffic.

Ranawana and Hewage, (2015) [6] found out in their research that service quality of public transport was of utmost importance when people were selecting public transport. Another factor that was noted in their research was the fact that people wanted an efficient complaint handling system when using public transport.

B. Population and Sampling

The Colombo district has a population of 2,375,000 people (Department of Census and Statistics 2012-2016) within an area 37.31 square kilometers. The population selected for this research, are public transportation users, to gather

information on the current short-comings of public transportation system. The questionnaire has also been distributed to users of private transport in order to ascertain the factors they would consider important, for them to consider switching over to public transport. The questionnaire was distributed to a sample size of 500 people through an online process and there have been 423 valid responses having a response rate of 84.6%. The sampling method used is simple random sampling, to make sure that an unbiased and fare outcome is obtained.

C. Methods of Data Collection

Data collection methods used in this study was both secondary and primary data collections where a structured questionnaire survey having five parts addressing several segments of the transport demand was carried out online as the primary data collection method, while data collected from articles related to the research, previous studies, and information from government authorities were used as secondary data sources. The questionnaire survey was based on the identified demographic, geographic, physiographic, and demand factors in understanding what factors are considered most important when people consider switching over to public transport.

TABLE I
STRUCTURE OF THE QUESTIONNAIRE

Sections	Objectives	Summary of the Questions
Part A	Demographic Data has been requested here to identify the respondent's details.	1. Gender 2. Age 3. Sector of Employment 4. Gross Monthly Salary
Part B	This part collects all the Geographic data of the respondent.	1. Purpose of the trip 2. Frequency of Travelling 3. Distance Travelled 4. Time Taken to travel 5. Number of Transits 6. Location of Travel
Part C	Here the Physiographic data is collected to ascertain which transport mode the respondent uses, this is vital as it guides the respondent to the next related part of the questionnaire.	1. Private Transportation 2. Public Transportation 3. Or if both modes are used
Part D	This part is answered by private vehicle users in order to ascertain, what factors they demand in order to switch over to Public Transportation Public Transport Users also answer this part to ascertain the current shortcomings of public transport to model a more holistic public transport system for the future	1. Type of Private Vehicle used 2. Type of Public Transport used 3. A rating of how important the given factors are, when the respondent chooses public transport over private transport. Respondent also answer to how strongly they agree to the given shortcomings of the current public transport system

Measurements used for factor evaluations were included in the questionnaire and the Likert Scale System was used.

D. Data Analysis Tools and Methods

The qualitative data gathered from Google Forms were converted to quantitative data, using a weighing system. Statistical Package for Social Science (SPSS) was then used to analyse the numerical data. KMO, Cronbach's and Bartlett's tests were conducted in order to find out the adequacy, reliability and equal variance respectively of this research.

EXPERIMENTAL DESIGN

The design of this research primarily has its base of research objectives and research problems, on which the data collection is carried out. As the research objective is to find out the demand factors for people to use public transport, there are three main independent variables that have been selected; *comfort-ability, fare collection methods* and *facilities offered to passengers.*

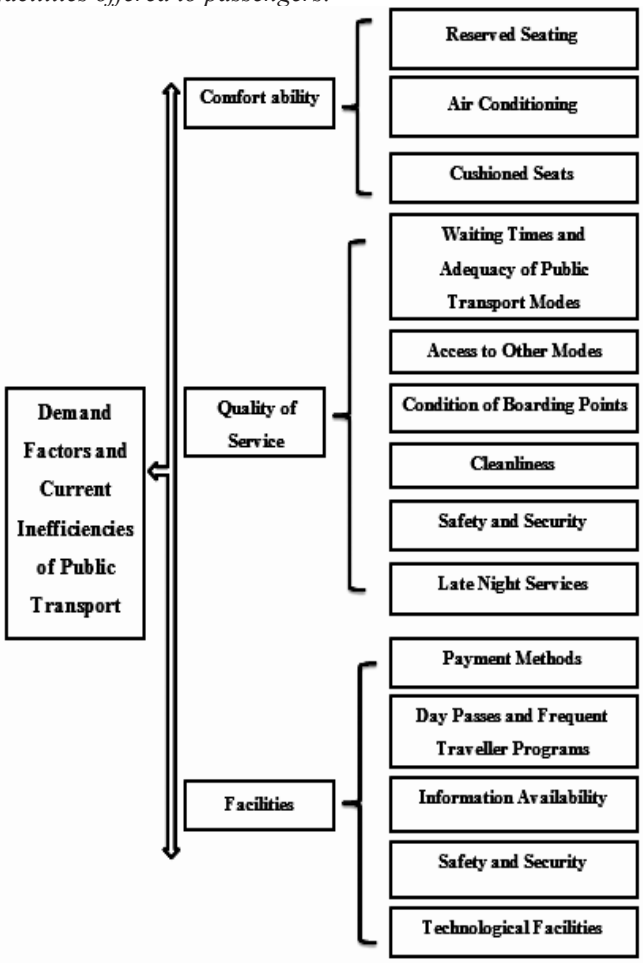

Fig. 2 Conceptual Framework of the Research

These variables have been once again subdivided into various parts, which have been shown in the conceptual framework.

The design concept for this research is a Conclusive Design. By using a conclusive design the relationship between the demand factors and passenger can be easily assessed, and an amicable model could be designed in order to fulfil the ultimate objective of this research. Another reason why a conclusive design is best suited for this research is because of the large sample rate (n =500) and the fact that the primary data is quantitative.

RESULTS

A. *Descriptive Analysis*

According to the descriptive analysis of the research, in terms of Gender the respondents have been equally distributed between Male and Female having 49.2% for Male and 50.8% for Female. This helps in giving an accurate and unbiased opinion, resulting in a more realistic picture.

In terms of the age group, the respondents have been widely distributed through all ages. However, the majority is in the 18-25 age group, this is quite obvious as this is an online questionnaire and it directly relates to the mentioned age group.

In terms of monthly income, 55% of the respondents earn under Rs. 20,000, and this category includes students, unemployed and retired individuals. Hence a sizable percentage is on one particular category.

B. *Factor Analysis*

1) *Reliability Test:* The reliability is identified by Cronbach's Alpha, for the data set to be deemed reliable the value must be greater than 0.70. The calculated Cronbach's alpha is 0.767 which indicates that reliability of the data set for this research is acceptable.

2) *KMO Test:* The Kaiser Meyer Olkin measures the sample adequacy represented in the sample size of the data. The recommended value of the KMO is 0.6. As per the research the KMO value is 0.672, which simply means that sample size is adequate for this research.

3) *The Bartlett's test of Sphericity:* Bartlett's test of Sphericity is used to test if "k" samples are from populations with equal variances. The recommended value is less than 0.05. The Bartlett's test of Sphericity of the study is 0.000, therefore null hypothesis is not accepted. The correlation matrix is not an identity matrix.

   Ho: correlation Matrix is an identity matrix

   H1: correlation Matrix is not an identity matrix

4) *The Scree Plot:* The Scree Plot points out after component number 10 there is a continuous drop with no sharp turns. Therefore, it can be stated that the 10 factors are enough to accommodate all 28 factors. This can be observed more clearly in the variance explained matrix.

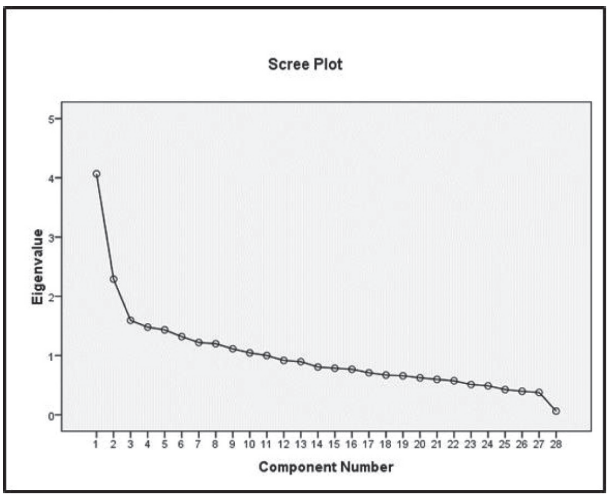

Fig. 3 Scree Plot of the Study

5) *Principal Components Extracted from Factor Analysis:* The rotated component matrix helps in identifying which component belongs to which factor. It can be observed that although there are 28 factors, these factors can be grouped into 10 larger factors. The table below represent the categorized factors according to SPSS.

TABLE II
VARIABLES OF FACTORS IDENTIFIED

Factor # and Name	Included Variables
Factor 1 – Price and Quality	➢ Safety Concern ➢ Price of Fares ➢ Inadequate Storage Space ➢ Overcrowding of Public Transport
Factor 2 – Technology	➢ Availability of Technology ➢ Availability of Trip Planning Services
Factor 3- Inefficiencies of Public Transport	➢ Inefficient Fare Collection Methods ➢ Lack of Season tickets ➢ No Proper Safety Measures ➢ Unclean Busses and Trains
Factor 4 – Service Levels	➢ Inadequate Number of Route Busses/Trains ➢ Level of Service at Boarding Points
Factor 5 – Accessibility	➢ Importance of Travelling ➢ Payment methods ➢ Availability of Day Passes ➢ Lack of Night Time Services
Factor 6 – Route Factors	➢ Access to other modes of Transport ➢ Condition of the Route ➢ Inadequate Seating Space

Factor 7 – Lack of Facilities	➢ Lack of Day Passes ➢ Lack of Connectivity to Secondary Transport Services ➢ Lack of Facilities at Boarding Points ➢ Availability of Air Conditioning and Cushioned Seats
Factor 8 – Weather and Reserved Seating	➢ Weather ➢ Availability of Reserved Seating
Factor 9 – Availability of Frequent Traveller Programs	➢ Availability of Frequent Traveller Programs
Factor 10 – Season Tickets and Delays	➢ Availability of Season Ticket ➢ Long Waiting Time for Connecting Bus/Train

CONCLUSION AND RECOMMENDATIONS

A. Research Findings

This research was conducted to find the demand factors of both potential and current users of public transport to create a more customized and efficient public transport system. Using the demand factors potential users, it was easy to identify what the most demanded factors were in order to make them a priority when creating a customized public transport system. The demographic data helped to identify what each party thought was most important, which is vital when creating a personalized transport system. Also using information regarding how important current public transport users felt about its shortcomings, helped in identifying the status of Sri Lanka's public transport system and it is possible to come up with quick solutions to solve the short comings.

The extracted factors showed that people are willing to move over to public transport, as long as a comfortable, safe service was provided, this included the availability of reserved seating, cushioned seats and air conditioning. A fair share of respondents stated that price of fares will affect their decision in choosing public transport. However, the availability of Day Passes/ Season Tickets and even Frequent Traveller Programs were not so important when choosing Public Transport. Surprisingly the availability of technology on board the bus/train was also deemed not so important. Although the level of service at boarding points was proved to be a principal factor when making the decision of switching over to public transport, respondents who were already users of Public Transport, 43 surprisingly created a very good picture of the existing public transport system. According to responses there are no issues with adequate route busses/trains nor are there any issues regarding seating and storage.

Also, there is good connectivity with the secondary modes. However, issues such as lack of night time services and long waiting times for connecting bus/train had an almost 50-50 agree to disagree rate, this shows that there is conflict of interest in these particular factors.

B. Recommendations

This study was conducted within the main city center of Colombo with only a sample size of 500, in future researches it is recommended to focus the research on a broader scope which involves a larger area preferably up to the outskirts of Colombo city. Also for the future researches it is advised to define factors more clearly to generate a more realistic picture.

C. Limitations

Some of the limitations faced were this research was conducted only within Colombo, if it were to be extended to other regions, perhaps there would have been a different outcome. Also, comparatively the sample size of 500 is too small. Time was also a limitation when conducting this research.

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We would like to show our sincere gratitude to everyone who has supported in this research. We would also like to thank all the respondents, without whom we wouldn't have been able to successfully complete this research. Along with these people we would also like to thank our employer, families and friends for their support in helping us with the completion of this research. Finally, we wish to thank CINEC Maritime Campus for the opportunity they have provided us to study a subject such as Logistics and Transportation, which has helped in our career development thus far.

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Functional Equivalency of Rotterdam Rules

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Abstract – This article critically analyses the 'electronic transport records' (electronic bills of lading) introduced by the Rotterdam Rules against the traditional paper bill of lading to identify the functional equivalency in the carriage of goods by sea.

THE FINDINGS

The electronic transport record and the negotiable electronic transport records which are introduced by the Rotterdam rules are functional equivalent to respective paper bills of ladings and having the same functions of a paper bill of lading. To get the optimum use of electronic transport records and negotiable electronic transport records, the implementation of similar regulations by individual countries is required, if not the objectives of the Rotterdam rules will be lost.

I. INTRODUCTION

The bill of lading is an important document in international trade. It fulfils few functions in the transport of goods by sea internationally, such as;

- It acts as a receipt for the goods received by the carrier,
- It is an evidence of contract of carriage between the shipper and the carrier, and
- It is a document of title

In common law, the parties to a contract of affreightment covered by a bill of lading had complete freedom to negotiate their own terms, but, abuse of the carrier's stronger bargaining position during the nineteenth century, however resulted in the curtailment of this freedom and the formulation of the Hague Rules in 1924. Those were the 1st set of rules which governed the bills of lading. Then, in 1968 Hague Rules were amended due to commercial requirements and it is called as Hague/Visby Rules. In 1992, Hamburg Rules came in to force and this is considered as an updated and more 'cargo owner-friendly' version of Hague and Hague/Visby Rules. Hague and Hague/Visby Rules apply mandatorily only to contracts covered by a "bill of lading or any similar document of title", i.e. basically, to paper bills of lading.

In the present commercial environment, the use of traditional paper bill of lading seems to be very problematic due to the following reasons;

- High administrative costs,
- If the vessel arrives before the bill of lading, the indemnifying of the carrier to release the cargo early, is very inconvenient and also this may create delays (in liner shipping, 15% of all cases no bills of lading are presented, in bulk trade it is about 50% and in oil related trades it is close to 100%),
- Misdelivery of cargo

The Hamburg rules recognises the validity of an electronic signature on the bill of lading, but, still does not address an e-document which can be used to avoid above mentioned difficulties.

The international organizations have taken extensive efforts to eliminate the above problems by the introduction of CMI rules in 1990. The CMI Rules do not have the force of law, and parties must contractually agree to use them in conducting their businesses. The CMI framework is open internationally for any merchant to use. The CMI Rules turned out to be unpopular in the trading world, because, it did not resolve the issues inherent in creating a negotiable electronic bill of lading. The CMI Rules have not attracted wider acceptance from merchants for the following reasons:

- no provision for contractual rights and liabilities to be transferred along with the documentation;
- it is not clear what happens if a holder who has accepted the right of control and transfer defaults;
- no provision for the passing of property in the goods;
- no comprehensive system or body to administer it; and finally,
- it was not secure because the secret code was not encrypted.

On the other hand, to eliminate the above-mentioned problems involved with the traditional bills of lading, UNECE (United Nations Economic Commission for Europe) recommendation 12 emphasizes to consider the following points when using a bill of lading, among other things:

- Discourage the use of negotiable bills of lading unless it is required. Encourage the use of seaway bills,
- Encourage the use of single original transport documents,
- Facilitate the introduction of EDI (Electronic Data Interchange)

In fact, these recommendations are provided to ship owners, cargo owners, ship operators etc. Therefore, various institutions and organizations have attempted to address and reduce those problems, but, still they exist. The most recent attempt is the drafting of the Rotterdam Rules, which address 'electronic transport records' which can be considered as electronic versions of traditional paper bills of lading.

II. OBJECTIVES OF THE ARTICLE

The receipt function and the evidence of contract function of a paper bill of lading can be easily replicated by an electronic bill of lading. Therefore, the main problem with the electronic bill of lading is the replication of the third function, i.e., document of title function. During this article, we will try to identify whether the electronic bill of lading which is mentioned in the Rotterdam rules is sufficient enough to perform the functions of a paper bill of lading and also whether the electronic bill of lading is capable enough to overcome the above-mentioned problems of the paper bill of lading.

The Rotterdam rules are designed to regulate rights and obligations under a substantially broader spectrum of transport documents than that which is regulated under Hague, Hague/Visby and Hamburg rules, but, only the electronic transport records are discussed in this paper. When discussing about an electronic bills of lading, there are two issues to be addressed. Firstly, the legal aspects and the feasibility of its use in the commercial trade (how effectively it can take the position of the traditional paper bill of lading). Secondly, the computer and software generated problems. Gaskell[10] among other things, identify the following computer and software generated problems in his article on "Bills of lading in an electronic age" as;

- Problems associated with printing bills of lading, especially where the number of attempts to print an original exceeds the number of originals shown on the face of the bill as having been issued,
- The resistance of the major traders and banks to invest on other software solutions (which are related to electronic bills of lading) since they have already invested on their own tailor made or proprietary software solutions to deal with customer relationship and supply chain management,
- Cyber risks

The above-mentioned computer and software generated problems are not addressed in this article since it goes beyond the scope of Rotterdam Rules. Only the problems which are within the scope of Rotterdam Rules such as the legal aspects of electronic bills of lading and the possibility of replacing the traditional paper bills of lading are addressed in this discussion.

III. ANALYSIS

A. Technological Neutrality

It is important to understand that the Rotterdam rules does not use the conventional terminology (bills of lading, seaway bills etc.), but, it uses its own terminology, such as transport document, negotiable transport document etc. Theoretically, this has advantages since different legal systems have different provisions governing the characteristics and use of document of title in the carriage of goods.

The Rotterdam Rules defines "electronic communication" as "information generated, sent, received or stored by electronic, optical, digital or similar means with the result that the information communicated is accessible so as to be usable for subsequent reference" and also it defines "electronic transport record" as "information in one or more messages issued by electronic communication under a contract of carriage by a carrier.....". Both Articles above are medium and technologically neutral, i.e. any of the existing electronic mediums or new mediums in the future can be used as long as the stated requirements are satisfied.

When considering the above points, the negotiable electronic transport record also can be used similar to a paper bill of lading, irrespective of the type of the electronic medium used, provided that it is used with the consent of the carrier and the shipper both.

Same as Hague and Hague/Visby Rules, Articles 6 and 7 of Rotterdam Rules excludes charterparties except the consignee, controlling party or holder that is not an original party to the charterparty.

B. Functional Equivalent – Receipt function of the Bill of Lading

There are two types of electronic transport records under the Rules. One is not negotiable (non-negotiable electronic transport record) which can be considered similar to a paper seaway bill, also may be used as an alternative to the straight bill of lading and the other one is negotiable (negotiable electronic transport record) which is an equivalent of paper negotiable bill of lading.

When looking at the definitions of 'electronic transport record', 'negotiable electronic transport record' and 'non-negotiable transport record', it is clear that whenever the Rules says, 'electronic transport record' it includes both negotiable and non-negotiable transport records.

The Hague and Hague/Visby rules have been criticised for the minimum information required to be on a bill of lading. The Rotterdam Rules specify that an electronic transport record should evidence the carrier's receipt of goods under a contract of carriage and also it gives an extensive list of information that is to be provided on an electronic transport record as follows;

- A description of the goods
- Leading marks for the identification of the goods
- Number of packages or pieces, or the quantity of goods
- Weight of the goods

It should further include the following as well;

- The apparent order and condition of the goods
- Name and address of the carrier
- The date of loading or the date of the issue of the bill of lading
- Number of bills of lading issued if it is negotiable & also more than one original is issued

- Name & address of the consignee, if named by the shipper
- Name of the vessel, if specified in the contract of carriage
- Place of the receipt and, if known to the carrier, the place of delivery
- Port of loading and the port of discharge, if specified in the contract of carriage

To complete the receipt function of the electronic transport record, Article 38 paragraph 2 of the same regulations states that the electronic signature of the carrier or a person acting on its behalf shall be included on the electronic transport record. One can argue that the 'electronic signature' is not separately defined in the rules. As mentioned above, since the Rotterdam rules are medium and technologically neutral, this may include any version of an electronic signature provided it is accepted in the governing country.

Same as Hague and Hague/Visby Rules on traditional bills of lading, Rotterdam Rules also states that an electronic transport record is a prima facie evidence of the carrier's receipt of the goods as described in the contract particulars. Similar to Hague/Visby rules, Rotterdam Rules also specify that proof to the contrary shall not be admissible when the negotiable electronic transport record has been transferred to a third party acting in good faith (this provision is not included in Hague Rules). Therefore, it can be considered that when a negotiable electronic transport record is transferred to a third party acting on good faith, same as a traditional bill of lading, this also becomes conclusive evidence related to the information provided on electronic transport record.

Article 41, paragraph (c) of the Rotterdam Rules further states that proof to the contrary by the carrier shall not be admissible against a consignee that in good faith has acted in reliance on any of the following contract particulars included in a non-negotiable electronic transport record:

- The contract particulars referred to in article 36, paragraph 1, when such contract particulars are furnished by the carrier;
- The number, type and identifying numbers of the containers, but not the identifying numbers of the container seals; and
- The contract particulars referred to in article 36, paragraph 2.

That means a non-negotiable electronic transport record also a prima facie evidence of the carrier's receipt of the goods as stated in contract particulars, except in the above (i), (ii) and (iii). This is more logical because once the above information is provided by the carrier [above (iii) is usually provided by the carrier] it becomes conclusive evidence in the hands of a consignee acting in good faith.

According to the Rules the shipper is entitled to obtain from the carrier, a non-negotiable electronic transport record or a negotiable electronic transport record at the shipper's option. As mentioned before, since the term 'electronic transport record' includes both negotiable and non-negotiable electronic transport records, the receipt function is included in both the types of electronic transport records.

When considering the above factors, it can be concluded that the Rotterdam Rules describe the electronic transport record as a proper functional equivalent of the paper bill of lading in the receipt function.

C. Functional Equivalent - Evidence of the Contract of Carriage of an Electronic Transport Record

According to the rules, the carrier's period of responsibility of the goods starts when the goods are received by the carrier and ends when the goods are delivered. At the same time, this covers liability of the carrier for loss, damage or delay and also additional liabilities of the carrier relating to particular stages of carriage, such as deviation, carriage of deck cargo etc.

Chapter 13 describes about the time for suit which includes period of time for suit, action for indemnity, actions against the person identified as the carrier etc. Chapter 12 governs the limitation of liability by the carrier in the case of a damage or loss of the goods.

According to Article 1, paragraph 18 (b) electronic transport record is an evidence of a contract of carriage. As mentioned before, since the term 'electronic transport record' includes both negotiable and non-negotiable electronic transport records, both these types of 'electronic transport records' perform the function of evidence of contract of carriage.

The above points well establish that an electronic transport record under the Rotterdam Rules fulfils the second function of a paper bill of lading. Further, Goldby[14] says that the electronic transport record governed by the Rules would, at law, be perfectly capable of performing as an evidence of a contract of carriage.

D. Functional Equivalent - Document of Title of an Electronic Transport Record

There are two things to be fulfilled if a bill of lading is to become a document of title. Firstly, it should be able to transfer the rights of possession of cargo. Secondly it should be able to transfer the ownership and the receiver or the buyer should be able to protect and enforce those rights against the carrier. To make a document transferable, rules must inevitably be developed to regulate the rights and obligations that arise under such a transferable document if the document is to facilitate the international trade. As mentioned before, the Rotterdam rules specifically states that electronic transport record is a receipt for the goods received by the carrier and also it evidences or contains a contract of carriage. The rules intentionally drop out the document of title part. That is because the term 'electronic transport record' includes both negotiable and also non-negotiable transport records. This may be because the Rotterdam

rules do not consider the non-negotiable transport records as a document of title. The English law considers straight bills of lading as a document of title since it is at least transferable once, from the shipper to the consignee. But, this may not be the same in other countries.

Article 51, paragraph 4 of the Rotterdam Rules states that, when a negotiable electronic transport record is issued:

- The holder is the controlling party;
- The holder may transfer the right of control to another person by transferring the negotiable electronic transport record;
- In order to exercise the right of control, the holder shall demonstrate, that he is the holder.

The Article 1, paragraph 10(b) defines the word "holder" as;
"The person to which a negotiable electronic transport record has been issued or transferred in accordance with procedures referred to in Article 9, paragraph 1".

This definition specifically applies only to negotiable electronic transport records. This shows that negotiable electronic transport record is capable of transferring constructive possession of the goods, which is important under the 'document of title'.

Rotterdam rules define the word "transfer" as, "transfer of a negotiable electronic transport record means the transfer of exclusive control over the record". Diamond QC[12] argues whether this concept of "exclusive control" is an apt one or will be workable. He further adds that when the conventional bill of lading is being transferred, even though endorsements are added during each transfer, the original paper remains the same. In electronic transport record, every successive version includes a new set of data and also new information (the latest endorsement), but, there is nothing regarding the transfer and survival of the paper document. It is the nature of the electronic documents that even if the information is the same, the presented version would be different from the former one. It may not affect the legality of an electronic document since it is the nature of it. In here, the term "exclusive control" is provided to indicate the new holder has the possession of the cargo, he has the right to transfer the possession of the cargo again and he has the right to take the delivery of the cargo when it is not transferred. In simple terms, what it means is the new holder can do whatever he likes with the cargo.

At the same time he (Diamond QC[12]) argues that "What is important is, not so much that a holder can 'control' the record, as that, at any one time, there is only one holder. An alternative solution would have been to omit the references to 'exclusive control' and to adapt Article 9 so that it requires procedures that provide 'an assurance that at any one time there is only one holder'". Under Rotterdam Rules there will not be any doubts in relation to the number of holders of an electronic transport record, because, Article 1 does not define any words like "Holders" (in plural). It defines the word "holder" (which is a singular) as;

"The person to which a negotiable electronic transport record has been issued or transferred in accordance with the procedures referred to in article 9, paragraph 1".

The above Article talks about a "person", but, not about "persons". It means at any one time there can be only one holder. The Article 9, paragraph 1 states that there must be procedures for the issuance and transfer of that record to an intended holder, the holder should be able to demonstrate that he is the holder and manner of providing confirmation that delivery to the holder has been affected….. This shows that throughout Article 9, the word 'holder' is used instead of 'holders'. Even in Article 47 the singular word (holder) is used throughout. This confirms that under Rotterdam rules there can be only one holder to an electronic transport document at any one time.

Van[16] states that the term 'right of control'(which is used through the chapters 9 to 11) is solely related to the contract of carriage and it gives rights to the party to amend the contract with the carriers consent which may include instructions to return the goods, discontinue the carriage, deliver the goods to another consignee. This confirms the ownership of the goods under a contract of carriage by sea.

The Article 47 states that, generally, the carrier shall deliver the goods at the time and location, upon demonstration by the holder of the negotiable electronic transport record, also it further adds, the carrier shall refuse the delivery if the negotiable electronic transport record is not produced. The paragraph 1, sub-paragraph (c) of the same Article specifies that validity of the negotiable electronic transport record ceases upon the delivery of the goods to the holder of the record. The method of identifying the holder is left for the parties to determine in their contract and allows for future technological developments.

Article 47 specifically deals with only the negotiable electronic transport record, but, not with the non-negotiable electronic transport record. That means, if a non-negotiable transport record is issued at the request of the shipper, the Rules do not specifically say that it should be produced to take the delivery of the cargo and also it does not say whether to refuse or not to refuse the delivery of the cargo, if a non-negotiable electronic transport record is used.

On the other hand, these Rules deal with non-negotiable transport documents which require surrender prior to the delivery of cargo. In Article 46 (a), it says that, the carrier shall deliver the goods to the consignee upon the consignee properly identifying itself on the request of the carrier and surrender of the non-negotiable document. It further adds, the carrier may refuse delivery if the person claiming to be the consignee fails to properly identify on the request of the carrier, and shall refuse delivery if a non-negotiable document is not surrendered. Finally, it says that, if more than one original non-negotiable document has been issued, the surrender of the one original will suffice and the other originals cease to have any effects or validity. Unlike seaway bills, straight bills of lading should be produced to take the delivery of cargo and also it is not negotiable

(except once from the shipper to consignee). Therefore, the mentioned Article is applicable to straight bills of lading.

Article 51, paragraph 2, subparagraph (a) says that shipper may transfer the right of control to the consignee named in the transport document by transferring the document to that person without endorsement. A transport document is a prima facie evidence of the carrier's receipt of the goods and proof to the contrary by the carrier in respect of any contract particulars shall not be admissible, when such contract particulars are included in a non-negotiable transport document which is required to be surrendered when taking the delivery of the cargo, is transferred to a consignee acting in good faith. Diamond QC[12] agrees that the Convention is getting closer to recognizing a "straight" bill of lading as one like a negotiable transport document. That means, the Rotterdam Rules covers straight bills of lading and also it can be considered as a document of title.

After addressing the position of a non-negotiable transport document to be recognized as a document of title, the rules have not addressed the position of non-negotiable electronic transport record as a document of title. As mentioned earlier, electronic transport record (which includes non-negotiable electronic transport record) act as a receipt for the goods received by the carrier and also as an evidence of the contract of carriage. Diamond QC[12] also agrees that there are no indications in the Rotterdam Rules which requires surrender of a non-negotiable electronic transport record to take the delivery of cargo.

Sandiforth and Baatz[19] says "the Convention does not use the phrase 'bill of lading, although at the Colloquium it was said that should the Convention enter into force the phrase would doubtless continue to be used in practice". "If there is fully functional equivalence, then it should not matter much which type of document is used, provided that it falls within the various Article 1 definitions of paper transport 'document' or electronic transport 'record'". Does this mean that the common law theories on straight bills of lading and seaway bills (seaway bills are not required to surrender to take the delivery of cargo) will be applicable on non-negotiable electronic transport records as well? Since English law is objective than subjective, it is very doubtful that English judges will consider non-negotiable electronic records as straight bills of lading or having the third function of a bill of lading, when the Rules define requirements for non-negotiable transport records clearly but not the non-negotiable electronic transport records.

On the other hand, the Rules define "non-negotiable transport document" and also identify issues when a "non-negotiable transport document that requires surrender is issued". This indicates that "non-negotiable transport document" may include seaway bills and straight bills of lading both. According to Article 46, "Non-negotiable transport document that requires surrender" should indicate that it shall be produced to take the delivery of the cargo. Therefore, if such an indication is provided, a non-negotiable transport document may be a straight bill of lading. If it is not indicated that it is required to be produced to take the delivery of the cargo, it may be a seaway bill. If the same theory is used on the non-negotiable electronic transport records, it may include electronic version of seaway bills as well as electronic version of straight bills of lading both. Then why do the Rules not address a "non-negotiable electronic transport record that requires surrender"? There is no argument, that an electronic record cannot be surrendered. But, it should address something like "non-negotiable electronic transport record that requires the proof of the holder".

When considering the above factors, it can be stated that a negotiable electronic transport record can be considered as a document of title but, not a non-negotiable electronic transport record. At the same time, it is not clear whether a non-negotiable electronic transport record includes an electronic version of a seaway bill and an electronic version of straight bill of lading. The Rotterdam rules are silent on this, may be because, it is left open to cover future electronic transport record developments.

Courts might question whether an electronically transmitted document would have the same force as a paper bill of lading, and whether it would offer sufficient security in identifying the merchant as the party who has title to the goods. What makes a paper bill negotiable is not that it is paper but what can be done with it. Therefore, as long as the electronic transport record can perform the customary functions of a paper bill of lading there should not be any confusion at law. Goldby also argues that it is sufficiently clear and simple for national courts to continue to apply previously developed principles, regarding the electronic record as well.

E. Electronic Bills of Lading and the Banks

UPC 600 states that "A document may be signed by handwriting, facsimile signature, perforated signature, stamp, symbol or any other mechanical or electronic method of authentication". This indicates that the banks are ready to accept electronic signatures on bills of lading, but, their position relating to electronic bills of lading is not clear. Therefore, banks may not accept bills of lading in electronic form against letter of credits. In that case, a printed bill of lading may be required at the last leg of this chain. Since the close systems like ESS-Databridge also have banks as representatives, those banks may accept electronic bills of lading against letters of credit.

IV. CONCLUSION

If the consent of the carrier and the shipper is present, the electronic transport record would be deemed equivalent to a paper document for all intents and purposes. Therefore, it is functionally equivalent and also technologically neutral.

The negotiable electronic transport record has all the functions of a negotiable paper bill of lading and

- It is a receipt for the goods received by the carrier,

- It evidences the contract of carriage, and
- It is a document of title

At the same time the negotiable electronic transport record is a functional equivalent of the paper bill of lading, because, the convention states that the issuance, exclusive control, or transfer of an electronic transport record has the same effect of a transport document. On the other hand, chapter 10 of the Rotterdam Rules deals with 'rights of controlling party' by which the Rules become more functional equivalent.

There are advantages and also disadvantages of Rotterdam Rules. Initially, Hague Rules were developed to govern the contracts of carriages of goods by sea. To overcome the problems associated with Hague rules, The Hague/Visby Rules were introduced. Then, to increase the scope of the application, Hamburg Rules were drafted. At this moment, most of the maritime nations have ratified Hague or Hague/Visby Rules. Only few countries have ratified Hamburg Rules. Likewise, questions may arise to the value of the Rotterdam Rules if it fails to command sufficient popularity to be widely adopted, especially by the major maritime nations. Even Peter[20] doubts the implementation of Rotterdam Rules if the countries do not ratify it. This is the biggest disadvantage that the Rotterdam rules have. United Kingdom COGSA 1992 states that the "Secretary of State may by regulations make provision for the application of this Act to cases where a telecommunication system or any other information technology is used .....", but, so far no any changes done to facilitate the electronic transport records. If the Rotterdam rules are not accepted internationally, the electronic transport record need to be converted back to paper transport document. Then the one purpose of the electronic transport record is lost.

On the other hand, it does not clearly state the position of a non-negotiable electronic transport record. Even though The Hague/Visby rules do not include seaway bills and straight bills of lading, the COGSA 1992 includes seaway bills. Therefore, the definition of non-negotiable transport record depends upon individual countries. Which may lead to confusions, same as for a straight bill of lading in different countries.

The electronic transport records will help to reduce the delays involved in physical transfer of paper bills of lading and also it will be a good security against misdelivery of cargo. At the same time, Rotterdam rules have a broad spectrum to include any type of technological means to include carrier operated systems such as APL electronic bills of lading, registry operated systems such as Bolero etc. If it is implemented, the users do not have to worry about the legality as in the case of Bolero with CMI rules.

Even though the computer-generated problems are not covered in this paper, it is worth mentioning that the International Group P & I clubs have started covering risks involved in 'cyber risks'. This is a good step forward regarding electronic transport records. The P & I clubs are shipowner's mutual third-party liability insurance providers. They are providing coverages for Bolero and ESS-Databridge users.

Even though the international regime related to electronic bills of lading is still pending, Laryea [25] says that Australian local regulations have in-cooperated an electronic bill of lading system and it is functioning well. Therefore, the electronic transport document covered in the Rotterdam rules may have a better future.

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Analysis of Customer Satisfaction Factors on Luxury Rail Services from Colombo to Kandy, Sri Lanka

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***Abstract*— The Luxury Rail service has been demonstrating a boost in the transport service sector in the past two decades in Sri Lanka. This study identifies the factors affecting customer satisfaction on the Luxury rail services in Sri Lanka on the Colombo-Kandy route.**

The target population of this research is the total passengers using the luxury rail services available in Sri Lanka and a sample of 250 has been used for data collection based on Stratified random sampling method. Data has been collected using a questionnaire survey on local and foreign rail passengers of selected Railway services, i.e. First Class observation saloon, Expo-Rail and Rajadhani Express, which operates daily from Colombo to Kandy and vice versa. The response rate for the questionnaire has been 86%.

The Descriptive analysis of collected results has shown that majority of the luxury rail travellers are private sector employees and annual travellers. It has proved that the data set has obtained reliability of value as 0.868. The Factor Analysis and Principal Component Analysis of the data have shown that customer satisfaction factors in luxury rail concept have slightly attracted towards the convenience of trip planning and efficiency of service providers. As per the study, most influencing factors in customer satisfaction are comfortability in the accommodation in carriage and station, Technology and Entertainment availability, Information and employee responsiveness, quality of the service, Complain handling mechanism and Package attractiveness.

The progress and the development have always depended on the level of satisfaction of the customers. This Study further suggests that use of customer service marketing concepts and more customized services as providing more carriages with good internet and promotional campaigns with pricing strategies would help the luxury rail service providers to increase the satisfaction level of customers and the future growth of the luxury rail services.

***Keywords*— Luxury rail Service, Facility, Customer satisfaction**

I. INTRODUCTION

Today, rail transportation represents one of the significant modes that transport people and goods. Big cities cannot live without totally functioning underground metro systems that carry millions of people every day.

Rail was introduced to Sri Lanka in 1864 to deliver coffee from plantations in the hill country district of Kandy to the port city of Colombo on its journey to Europe and the world market. Sri Lanka Railways (SLR) has been a government department operating under the Ministry of Transport and Civil Aviation. It has been a major transport service provider and has been the only rail transport operator in our country. SLR has 6.0 % market share for passenger transport and about 0.7 % for cargo transport.

Sri Lanka Railway operates nearly 310 trains which include 45 Long-Distance and 12 Intercity trains and carries about 0.29 Million passengers daily. SLR owns and maintains more than 1400 km of rail tracks, 175 locomotives, 900 carriages and their signalling network. At present, it has a workforce approximately 15,000. SLR operates under the General Manager of Railways [1].

The rise of the tourism industry has opened rail transport as the choice of long-distance travels for both foreign and local. This dissertation identifies the rail transport related crucial factors for passenger demand.

There have been three main luxury rail service providers from Colombo to Kandy as Expo rail, Rajadhani express and First class observation saloon. Expo rail has been a privately own luxury railway service which travels from Colombo to Kandy, Trincomalee and Badulla. The expo rail commenced its operations in the year 2011. Expolanka holding PLC currently owns the expo rail. Rajadhani Express has been a luxury rail service which has been in operation through a partnership with Sri Lanka Railways Department and the Blue Line Company. First Class observation saloon is a luxury train carriage which has been in operation through Sri Lanka Railways Department. It has 45 comfortable seats in a First Class observation saloon of a train compartment with a prominent seating arrangement. The front face of the compartment fully covered with glass windows and the side panels are also glass [2].

The factors considered by passengers when selecting a luxury rail service have been translated into the research question as follows;

What are the factors considered by passengers when selecting a luxury rail service to travel from Colombo to Kandy?

The railway sector has been a highly subsidized most used transport method in Sri Lanka. Therefore, unfortunately, there were only a few studies that had been conducted to measure the customer satisfaction. This

research has been very much focused Irfan et al [3]on understanding the impact of selected factors in the rail sector to increase passenger demand and the findings are important to influence the policy makers to develop the luxury rail service in order to attract more customers, increase the country's GDP by increasing income from tourist and luxury class customers, Improve the country transportation quality by addressing customer demands and expanding the capacity of accessibility in order to achieve the maximum customer demand.

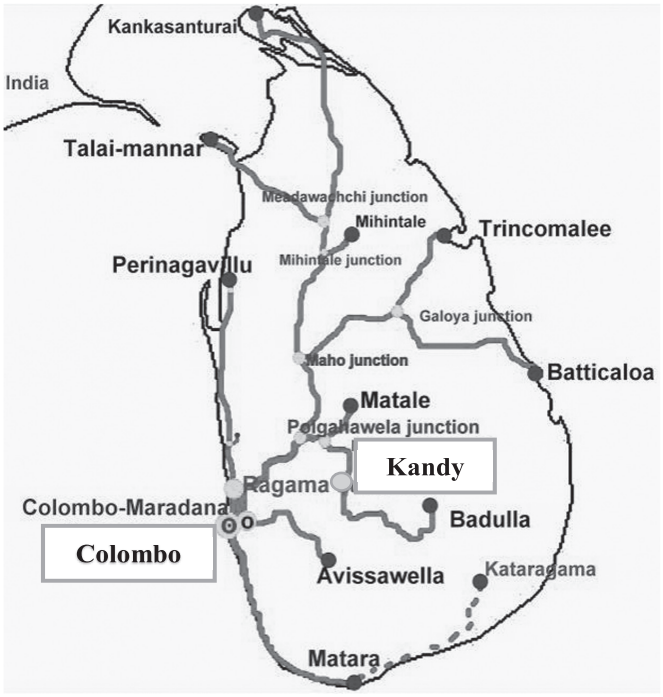

Fig. 1 - The existing rail network in Sri Lanka

The scope of the study is limited to Sri Lankan luxury railway services from Colombo to Kandy route using only three main luxury railway operators. The survey was done by selecting a sample luxury rail passengers. This study has not interviewed the total population who are engaged in railway transportation or other rail line routes. In future studies surveys done with other class categories and other railway routes may give a comprehensive result of customer satisfaction on Sri Lankan Rail passenger transportation.

II. Methodology and Experimental Design

A. Variables of customer satisfaction

Empirical surveys on factors affecting customer satisfaction have been initially concerned on factors such as tangibles, empathy, safety, information, food, assurance, timeliness, responsiveness, financial, customer requirement, reliability, comfort, cleanness and facilities. These factors have been used as variables in this study.

The research conducted by Irfan et al [3]has concluded that tangible service has been a prominent factor in selecting a luxury rail service. Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include tangibility. Vanniarajan and Stephen (2008) [5] identified tangibility as an attribute that passengers use to evaluate the service quality.

Rahaman et al [6] have identified 20 useful factors and select 8 most crucial factors for customer satisfaction. It has the factors that state element of empathy. Maruvada and Bellamkonda [7] have stated five dimensions that affect to rail service quality, including empathy as a dimension. Pakdil and Kurtulmusoglu [8] have mentioned empathy as an important factor to measure service quality.

Safety on board and safety at the station as calculated parameters under the general parameter of safety. Rahaman et al [6] have identified 20 useful factors and select 8 most important factors for customer satisfaction. It has some factors that state element of safety. Xu et al [9] mention safety as a technological and economic characteristic. Mahudin (2012) [10], use 32 key performance indicators for measure the performance of these metro railway services through six categories, it is including safety as the main category.

Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include information as a requirement. Panagiota et al [11] had stated that information before travelling and information at a station and during a trip as a calculated parameter under the general parameter of Information. Irfan et al [3]consider information as a factor to build hypothesis in his research.

Irfan et al consider food as a factor to build hypothesis in his research. Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include food as a requirement. Rahaman et al [6] have identified 20 useful factors and select 8 most important factors for customer satisfaction. It has some factors that state element of food. V. Rajeswari, K. Santa kumari [12]too have developed a hypothesis and identified the factors affecting to service qualities including food as a factor.

Vanniarajan and Stephen (2008) [5] identified assurance as an attribute that passengers use to evaluate the service quality. Irfan et al [3] consider assurance as a factor to build hypothesis in his research. Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include assurance as a requirement. Kurtulmusoglu [8] mentioned assurance as dimensions to measure service quality.

Panagiota et al [11] had stated that timetable punctuality as a calculated parameter under the general parameter of timetable punctuality. Irfan et al [3] consider timeliness as a factor to build hypothesis in their research. Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include timeliness as a requirement.

Irfan et al consider responsiveness as a factor to build hypothesis in their research. Vanniarajan and Stephen (2008) [5] identified responsiveness as an attribute that passengers use to evaluate the service quality. Parasuraman et al 1988; Kurtulmusoglu [8] mentioned responsiveness as dimensions to measure service quality. Maruvada and Bellamkonda [7] have stated five dimensions that affect to rail service quality, including responsiveness as a dimension.

Sharma and Manimala (2007) [13] remark that there was external, as well as an internal reason for the declining performance of Indian Railways and they mentioned financial situation must manage to compete with other

transport modes. Irfan et al [3]emphasis fare (Financial) as a factor to build hypothesis in their research.

Gangwar (2007) [14] remark that Indian Railway needs to respond to the specific needs of industry by interacting with them and they must give a significant focus, based on the customer specific requirements. Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include customer requirement as a requirement.

Parasuraman et al [4] identified ten requirements useful for evaluation of the quality of services which include reliability as a requirement. Vanniarajan and Stephen (2008) [5] identified reliability as an attribute that passengers use to evaluate the service quality. Mahudin (2012) [10], use 32 key performance indicators for measure the performance of these metro railway services through six categories, it is including reliability as the main category.

Irfan et al et al **[1]** consider comfort as a factor to build hypothesis in their research. Panagiota et al [11] had stated that temperature, accommodation comfort, wagon comfort as a calculated parameter under the general parameter of comfort.

Rahaman et al [6] have identified 20 useful factors and select 8 most important factors for customer satisfaction. It has some factors that state element of cleanness Irfan et al [3]highlighted cleanness as a factor to build hypothesis in their research.

Pakdil and Kurtulmusoglu [8] have mentioned facilities of rail industry as an important factor to measure service quality. It has some factors that state element of facilities of the rail industry. Anderson et al [15] mention facilities of rail industry as a Service Quality Indicator. -

B. Population and Sampling

The target population of the study has been considered as the total passengers who have been using the luxury rail services available in Sri Lanka. Luxury rail services in Sri Lanka are Expo rail, Rajadhani Express, First-Class observation saloon (Sri Lanka Railways, n.d.). The Sample has been quantified by selecting the number of passengers from each rail service. There have been 215 valid responses from the sample size of 250 total numbers of respondents.

C. Sampling Method

The "Stratified random sampling method" has used. This method will reduce sampling error. (Kluwer, 2009)

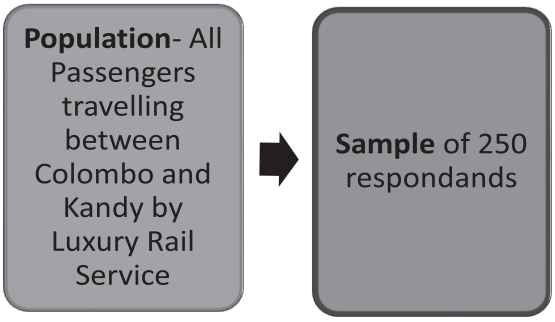

Fig. 2 - Target population and Sample

D. Methods of Data Collection

The primary data had gathered through a structured questionnaire survey. The questionnaire has handed via personally and online to luxury rail passengers in Colombo – Kandy route. The questionnaire consisted of several parts as part A, part B and part C. The part A consists of demographical factors. Part B consists of the trip detail of the passengers and part C consists of variables of the survey. There have been only 215 valid responses with a response rate of 86%. All variables had measured based on five-point Likert scale, ranging from (1) "strongly disagree" to (5) "strongly agree".

E. Data Analysis Tools and Methods

The statistical software package for Social Sciences SPSS, has used to analyses of the data. The dataset has been finalized with the aid of the Cronbach Alpha test, Bartlett's test and KMO's test. Factor analysis has been used to create new factors to reflect the common idea of the cluster of variables used in the research.

III. RESULTS

A. Descriptive Analysis

According to the descriptive analysis of the research, most of the luxury rail users are Asians (93.5%). Other nationalities have been insignificant within the selected sample as African (1.9%), Europeans (0.9%), American (0.9%) and Oceania 2.8%.

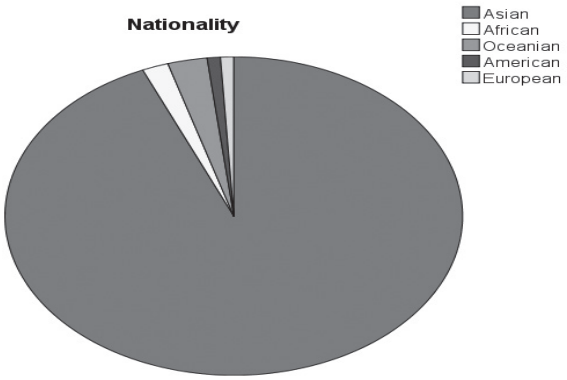

Fig. 3 – Respondents Nationality

According to the analysis, majority of luxury rail users are Males which amount to 74% of the total population. Females only count for 26% of the total users. According to the sample data, private sector employees (39.5%) mostly use luxury rail services than public sector employees (26%) students and retired indicate a proportion of 20% and 12.6% respectively.

The sample data indicate the trip purpose of the luxury rail users has been Personal Tours, Pilgrimage and Official trips. From the descriptive analysis, the most users are yearly users representing 35.3%, monthly users on 25%, weekly users consist of 33% and the least number of users are daily users who represent only 6%.

According to nominal data many of the luxury rail users lie between Rs 50000- Rs 100000 income level. The next largest amount has been 42% which are more than Rs 500000 income earners. By the sample data, it is evident that the First-Class observation saloon (45.1%) has been the

most used railway service followed by ExpoRail (41.9%) and Rajadhani express (13%).

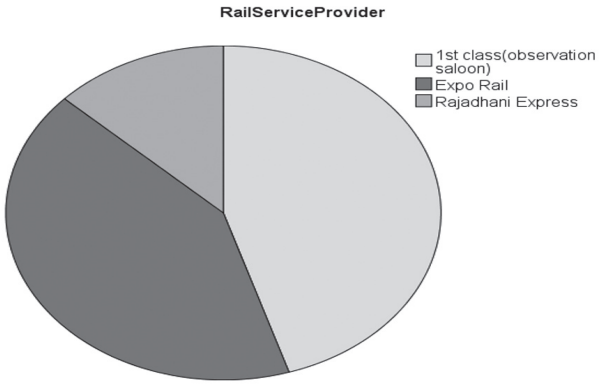

Fig. 4 – Rail Service Provider used by Respondents

B. Factor Analysis

1) Reliability Test: The Cronbach alpha valve has generated 0.868 for all items by verifying that the internal consistency of the data set has been accurate.

2) KMO Test: The Kaiser-Meyer-Olkin" value of the data has appeared .751. This value lay between 0.7 ≤ kmo < 0.8 and has termed as "middling kmo figure".

3) The Bartlett's test of Sphericity: Results have given the significance level as .000 (<.05). This indicates that the variables used in the study have been unrelated. This provides that the variables of the study are unsuitable for structure detection

4) Total Variance Explained Using PCA: This Eigenvalues table indicate that the study has 12 principal components with an Eigenvalues (total variance) greater than one (>1). The Cumulative percentage of variance has accounted 74.485 for the first 12 components of the study. The first factor accounts for 22.653% of the variance, the second 8.709%, the third 6.535%, fourth 5.841%, 4.984%, 4.626%, 4.168%, 3.967%, 3.662%, 3.252%, 3.143%, and 2.946% respectively. There has been only 25.5 present (25.5%) loss in the total set.

5) The Scree Plot: The analysis has plotted all the principal components. The Scree Plot has pointed out all the 36 components of the study. It displays that 12 of those components clarify most of the variability because the line starts to slightly straighten after component 10.

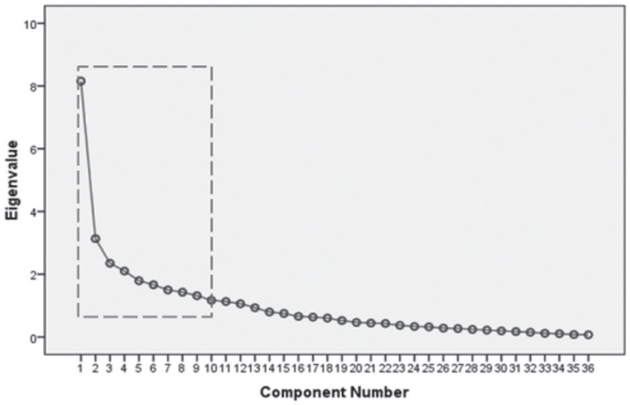

Fig. 5 – Scree Plot of the study

6) Principal Components Extracted from Factor Analysis: The rotation component matrix has minimized the 36 variables underneath the investigation into identifiable 12 factors. These results have used to formulate equations with Component Score Coefficient Matrix values to express the relationship between observed variables and the generated components. The model has been as follows;

Here the

$$Fi = f\{2 * \text{appurtenant variable of the component i}\}$$

F = Function of the customer satisfaction factor

i value has been, (i = 1,2,3,4,5,6,7,8,9,10,11,12)

"2" value has been the Component Score Coefficient Matrix of each variable.

TABLE I
VARIABLES OF FACTORS IDENTIFIED

Factors # and Name	Included Variables
1 Service Effectiveness	• Cost of meals on board the train • Seating arrangement • Quality of washroom • Car parking facility at the station • Performance of services as promised • Attractiveness of locations • Connections with other modes
2 Convenience	• Easy to plan journey • Seating capacity • Length of time taken for the journey
3 Facilities Quality	• Comfort of seating • Free Wi-Fi facilities on board the train • Safety of journey • Punctuality of trains • Complaint handling mechanism
4 Information and Customer service	• Provision of information on board trains • Ventilation in railway carriage Air conditioning • Availability of staff on board trains • Employees responsiveness
5 User perception	• Individual attention to passengers • Understanding of the needs of the passengers
6 Advert	• Quality of meals on board trains • Availability of electricity for phones and laptops • Entertainment facilities available
7 Infomercial	• Ease of reservation • Provision of information about train schedules • Your overall satisfaction about the luxury rail service
8 Empathy	• Employees willingness to help
9 Quality and Ticketing	• Ease of buying tickets • Quality of meals on board the train • Quality of station facility

10 Cost and Hygiene	• Cost of a ticket Package • Cleanliness and maintenance of railway carriages
11 Perspective and Lighting	• Information about packages available • Lighting in railway carriage
12 Luggage Handling	• Luggage handling facility

IV. CONCLUSION

A. Conclusions and Recommendations

The Convenience of Service, Facilities on board Train, Customer service level, Passenger comfortability: and Responsiveness, Recreational facilities, User perception, Reliability and passenger care, Empathy, Quality of Services and Facilities, Cost of Services, visibility Aids have been identified as significant factors.

The luxury rail passengers in Sri Lanka have identified the need for "more efficiency and a reliable service" and "updating the latest facilities according to the world recognized luxury rails". More accessibility in connecting with various other transport modes (Intermodal connectivity) has been an emerging concept in Sri Lankan Luxury Rail operations model. The strategic importance of Sri Lanka's position in international trade has brought Sri Lanka as one of the main tourist attracted destinations and this has been creating a rapid growth in country's economy as a commercial hub.

Railway policy-makers should draw their attention to "Developing luxury Rail Service to cater to the Demand" than regulatory measures. The concept of developing luxury rail services has been a fair strategy to manoeuvres the tourist demand from other regional tourist destinations like Maldives, Indian and from other East Asian countries. Furthermore Developing the current luxury rail to cater more local demand such as Business personnel, Local travellers, and Daily long-distance travellers will increase the rail revenue.

Introduction of the modern railway locomotives was also a noticeable comment that was stated in the customer responses. Considering the global scenario, the Luxury Rail services in other countries have developed far more ahead than ours. The introduction of modern locomotive would reap many benefits to operating authorities such as fuel efficiency, latest features, high comfortability and safer.

Sri Lanka has been in a development up thrust the business and leisure demand for a quality transport has been a need. Developing the luxury rail will give a qualitative transportation service and will provide an optimal solution for the long-distance travel demand in the Country.

B. Limitations of the Study

The scope of the study was limited to customer satisfaction in luxury rail services in Sri Lanka and has not interviewed the preferences of the entire population who are engaged in rail transport such as rail operators, investors and policymakers. In future, surveying a reasonable population with various- respondents from the luxury rail users in Sri Lanka will help to overcome the deficiency of the sample.

ACKNOWLEDGMENT

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