1. INTRODUCTION

Sri Lanka Railways (SLR) established in 1858 as Ceylon Government Railways (CGR) under the British government. It is one of the pioneer transport providers which carry passengers and goods in the land. It is a monopolistic organization since no any other railroad transportation supplying organizations in Sri Lanka. Annually large amount of scrap in the form of ferrous and nonferrous is removed. Railway scrap also consists of condemned rolling stock such as wagons, coaches, locomotives, boilers, waste material from manufacturing and repair processes such as turnings and borings, sweepings, foundry dross, off cuts of metals, waste paper, weeded out records, used tickets, wooden pieces and saw dust. Since it is a very aged service there are many carriages, wagons and tanks which are very old and in unserviceable condition. But there are only very few studies carried on scrap management in the SLR.

1.1 Railway transportation

Railway transportation consists of rolling stock such as DMUs (Diesel Multiple Units), EMUs (Electrical Multiple Units), locomotives, carriages, wagons, rail buses, tanks, container flats etc. As well as there is heavy machinery use for maintenance purpose such as overhead cranes, traverses, lathe machines, milling machines, forging machines etc. There are rail sleepers, signal posts, rail tracks, bridges, vehicles used for rail track maintenance etc. All these rolling stocks, machineries and their spare parts are subjected to deteriorate with the time. The aim of this study is to develop a tool to support the decision taking mechanism to condemn rolling stock andevaluate the condemn value of rolling stock and other related equipment in the SLR. But it is a vast area to consider all the rolling stock and other machineries in railway. This research study has focused only one type of wagons called Bogie covered Good Steel (BCGS) which has been used to transport goods for years.

The good wagons or freight wagons are unpowered railway vehicles that are used to transport cargo. A variety of wagon types are in use to handle different types of

goods, but all goods have standardized couplers and other fittings, such as hoses for air brakes, allowing different wagon types to be assembled into trains.

1.2 Disposing the scrap by railways

After passing the usable lifetime of a rolling stock it becomes scrap. The lifetime of a vehicle basically depends on fatigue failure [1] and corrosion [2]. The average life of a car was about 10-12 years in 1990. The corrosion of the most popular vehicle is a major concern to all of us which affect the vehicle lifetime [3]. Fatigue failures of rail load axis due to cyclic load wereidentified [1]. The fatigue life of a vehicle depends on driving mileage or age of the vehicle.

This study would lead to developing a decision supporting mechanism to condemn and value train wagons in the SLR. Scrap consists of recyclable materials left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. Unlike waste, scrap has monetary value, especially recovered metals, and non-metallic materials are also recovered for recycling. These train wagons consist tons of ferrous as well as non-ferrous materials.

So, there is very high monetary value hidden in the scrap form in railways. Efficient scrap management adds more financial benefits to the railway department.In this case, it should focus on the valuation of scrap. Through this study, it focuses on properly identifying and classifying the removing material as scrap ensuring minimum delay and deterioration. Disposal of scrap is done at the earliest in a transparent manner ensuringthat the best possible price is fetched, accountable of scrap generated is done properly and theft and pilferage is avoided by maintaining proper custody of scrap.

1.3 Impact of incorrect condemning decisions

The incorrect decision to condemning rolling stock causes for the loss of assets. In that case, suitable depreciation method should be selected. Depreciation is the amount of value that an asset loses from the original price that it was purchased

[4].Depreciation method is a key element for determining a firm's net income, the net value of its assets, and for the measured rate of return on a firm's investment [5]. The well maintained rolling stock may good as when originally built and if accounting their lifetime based on straight line depreciation it will be a loss [6].

1.4Bogie Covered Good Steel (BCGS)

BCGS is a covered rail vehicle which is used to transport goods such as furniture, cement, sugar, coconut, etc. Any kind of these goods can transport safely through BCGS without exposure to the external environmental factors such as rain, wind, snow and sunlight.

Figure 1.1: A BCGS

As per the records in SLR there are different subcategories of BCGS as below. This categorization has done by the SLR for identification and it has done based on country of origin.

BCGS Chinese

BCGS Indian

BCGS Korean

BCGS German

BCGS Pakistan

The structure of a BCGS is attached in appendix 01.

1.5 Aim and Objectives

- To study the existing procedures for valuation and condemning process of BCGS in SLR
- To develop a decision support mechanism to condemn BCGS and analyze the scrap value in a transparent manner
- To evaluate the mechanism.

1.6 Methodology

Existing procedure for valuation and condemning process of BCGS in SLR was studied first. Data gathering regarding on that is planned to be done inthe CME sub department of SLR. Primary data were collected through questionnaires, FGDs, and surveys from the relevant employees at the CME and available details of BCGS were collected from the planning department, technical department of CME sub department.

Since there were considerable drawbacks in current system, a decision support tool to condemn BCGS and analyze the scrap value was developed. Collected data on current valuation and condemning the process of BCGS in SLR were used as the base in this aspect. The new tool will be developed in MS excel. Transparent and consistency of result is expected for any user in a newly developed method.

Tool evaluation was carried out based on validation of the tool. Some decayed BCGS will be selected and evaluation will be done based on current method and newly developed method. Two or more evaluations will be conducted for each BCGS from two or more examiners. Then the result will be comparedto the consistency, as well as transparency.

1.7 Chapter breakdown

Chapter 2- Presents the literature review and in this chapter, it discusses existing rolling stock condemn methods, depreciation models, depreciation models suitable for trains, practices of depreciation models in the world, scrap valuation methods and scrap valuation method in the SLR.

Chapter 3 presents the data collection, Analysis of the data and result obtained from that data.

Chapter 4 presents the development of the decision support mechanism and the tool development base on Microsoft Excel

Chapter 5 discusseshow the tool was validated and the obtained results through that.

Chapter 6 presents the discussion and conclusion. Further,this chapter covered limitation and future work.

2 LITERATURE REVIEW

2.1 Rail freight transport

Cargos which are transported through the railroads are known as rail freight transport. When considering the rail freight transport, group of good trains hauled by one or more locomotives. The energy consumption in terms of tonne kilometers hauled per unit is more efficient in rail transportation considered for other types of transportation methods [7]. When the railway era wasestablished, most goods wagons were four-wheeled vehicles of simple construction and those types were small covered wagons, open wagons with sideboards, and flat wagons with or without stakes. Wagon construction was developed with the time. Specially featured wagons such as tank wagons and numerous refrigerated vans were introduced around 1850 by private companies [8].

Transportation of good can be divided into two parts as solid goods and liquid. Wagons are used for transporting solid goods such as coal for power plants, sand and cement for constructions, sleepers and metal for rail track development and passenger goods. Liquid transportation such as diesel, petrol, aviation oil, kerosene oil and water is done with tanks in SRL. It is the most profitable income for SLR.

2.2 Railways rolling stock condemning methods

Very less literature can be found in rolling stock condemning method in railways. Most of the railways condemn their rolling stock based on the lifetime. Carriers in European railway were decommissioned their rolling stock based on their own in-company regulations created based on many years of experience and legal environmental inclinations [9]. Developed countries consider only about depreciation rates and useful life period of vehicles. As per New Zealand government announced in 2015, the estimated useful life period of rail wagon is 25 years and straight line depreciation rate is 6 percent [10].The Indian government announced in 2013, as the estimated useful life period of rolling stock is 15 years [11].

Rolling stock condemning method includes the elements as, reporting of rolling stock for decommissioning, collective inspection of the reported rolling stock, decision on ending the vehicle's life, forwarding railcars for treatment, dismantling for recycling and financial settlement of the disposal [9]. The decisionto dispose may be made because of the rolling stock damage, repeated malfunctions, high repair costs, excessively high maintenance costs compared to the new models available in the market as well as product obsolescence [9].

2.3 Depreciation

Depreciation means the drop-in value of an asset over time. It describes the amount of value that an asset loses from the original price [4]. The asset's value changes because of depreciation and revaluation. Depreciation is the value loss take place in asset due to the aging of an asset [12].

Based on basis over its useful life, the depreciable amount of an item of property, plant and equipment should be allocated and the method of depreciation applied to property, plant and equipment should be reviewed periodically. If there isanimportantvariation in the projected pattern of economic benefits from those assets, the method should be changed to reflect the changed pattern. The useful life of an item, property, plant and equipment should be reviewed at times and, if expectations are significantly different from previous estimates, the depreciation charge for the current and future periods should be adjusted [13].

2.3.1 Depreciation models

There are many depreciation modelsand for any application, the appropriate method can be selected. Some of those methods are can be described as below.

Straight line method is the simplestand, most commonly used method which considers the cost of the fixed asset evenly over its useful life and declining balance method is an accelerated method which results in higher depreciation expense inthe early years of ownership.The sum of the years' method is another method which computes depreciation expense by adding all years of the fixed asset's expected

useful life and factoring in which year you are currently in, as compared to the total number of years.Units of the production method the total estimated number of units the fixed asset will produce over its expected useful life, as compared to the number of units produced in the current accounting period, is used to calculate depreciation expense Double declining balance methodsimply doubles the straight-line depreciation amount that is taken in the first year, and then that same percentage is applied to the un-depreciated amount in subsequent years. Time based methods are declining-balance, straight-line and the sum of the years' digits and units of production is based on actual physical usage of the fixed asset [14] [15].

Hours of service depreciation is another depreciation model. The two most common accelerated depreciation methods are the sum of year method and double declining balance method and companies write off their assets faster in the early years based on accelerated depreciation methods while straight-line depreciation method uses to write off a small amount in the later year [15].

2.3.2 Depreciation models suitable for trains

Most accountants have generally used the straight-line method and the accelerated method of depreciation of automobile, but for the automobile, the depreciation function is somewhere between the straight line and the declining balance method [16]. Depreciation models same as the automobile can be applied to the rolling stock. The lifetime of the rollingstock is based on the maintenance [6].

2.3.3 Practices of depreciation models in the world

When it compares depreciation rates of developing countries and developed countries, it is significantly lower in developing countries than they are in the developed world [12]. As per the USA records, there are two basic factors which decide the useful life of a vehicle as age and mileage. The average car lasts about 15 years and the value of any car generally depreciates over time and if it is considered in mileage, cars can be driven about 241500 km before major repairs should be made. As a vehicle is driven, mechanicalparts of the car slowly wear out [17].

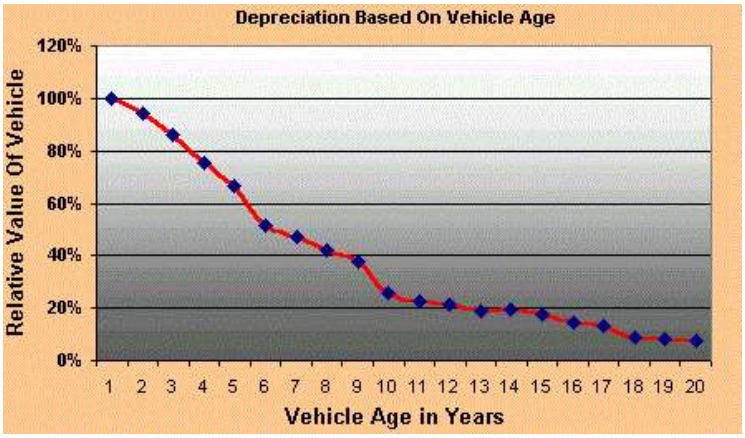

Figure 2.1: Depreciation value based on vehicle age [17]

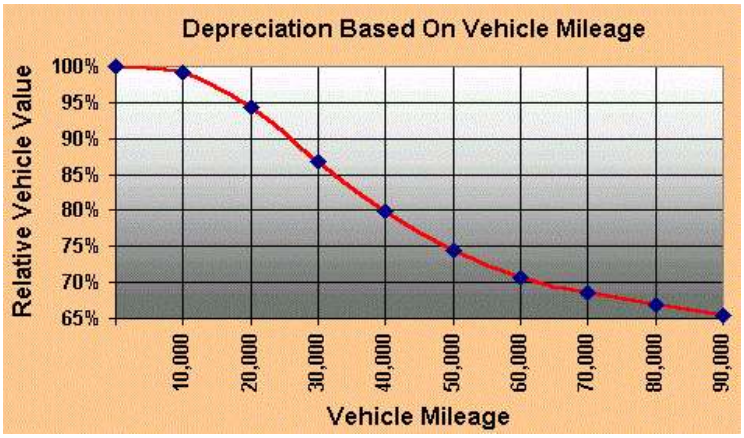

Figure 2.2: Depreciation value based on vehicle mileage [17]

As per the New Zealand government general depreciation rates, which were published by Inland Revenue in 2015 it described, estimated lifetime, the depreciation rate of vehicles based on diminishing value and straight line as follows [10].

Table 2.1: Estimated useful life and depreciation rates

Vehicle	Estimated Useful life (years)	Diminishing value depreciation rate (%)	Straight line depreciation rate(%)
Freight cars (rail) (wagons)	25	8	6
Locomotives (diesel)	25	8	6
Locomotives (electric)	25	8	6
Locomotives (steam)	25	8	6
Tanks and vats (steel, galvanized)	20	10	7
Motor vehicles - (for transporting heavy goods) gross vehicle mass over 12 tonnes	10	20	13.5

The Indian government announced in 2013, as the estimated useful life period of rolling stock is 15 years [11].

2.3.4 Depreciation could be covered by maintenance

Since the depreciation means the loss of value in a car or an engine due to wear and tear, it could be covered by proper maintenance. Maintenance of rolling stock can be divided into two phases as running repairs and general repairs. "Running repairs," are meant the repairs necessary to keep equipment in safe running condition, and "general repairs," are meant the repairs needed to restore the equipment to its original condition. Through the proper maintenance, lifetime of rolling stock can be increased [6]

2.4Scrap valuation models

Scrap can be defined as the material, which is no longer useful to the railways for the purpose for which it was originally purchased or obtained. One of the major scrap arising ways of the railway is condemned rolling stock such as wagons, coaches, tanks, locomotives and boilers. The 2 main reasons for arising of scrap are various components are worn out to such a condition that they can't be reconditioned economically or are beyond repair and in a manufacturing process some wastages are unavoidable and therefore some quantity of scrap material is generally generated. Ferrous as well as nonferrous scrap exists and as per records maintained in the office

of Controller of Stores of Indian Railways, the year wise realization from the sale of scrap is given below [18].

Table 2.2: The year-wise realization from the sale of scrap

Year	Year Money value of scrap sold (USD million)		
	Path Way scrap	**Rolling stock**	**Total**
2002-03	73.77	18.13	91.90
2003-04	73.01	21.75	94.77
2004-05	55.29	31.11	86.40
2005-06	50.92	24.45	75.38
2006-07	99.20	30.07	129.28
Total	352.21	125.54	477.75

Approximately one million tonnes of metallic scrap valued at USD 224 million are sold by Indian Railways every year [18]. As per the Indian railways, scrap disposal has been identified as one of the high priority areas in the recent years for generating internal resources for supplementing the Railway finances. Engineering and Mechanical departments are the major sources of scrap and various scrap materials like melting scrap, released track material including rails, condemned Rolling stock, released materials from redundant sidings etc., generated on the Railways are collected at convenient locations and disposed of through auction/tender sales [18].

2.5SLR scrap valuation method

A discussion was held withmechanical Engineer carriages and wagon Mr. Krishantha and discovered the current scrap valuation method in the SLR. Scrap valuation is done based on the weight of the disposed rolling stock and the current steel scrap value. The whole mass of the condemned rolling stock considered as steel. At the condemn board stage the rolling stock is visually inspected and assigned an approximate scrap value for the relevant rolling stock by the members of the condemn board. As an example, approximate weight and scrap value are shown in condemning board report. See appendix 02.

3.STUDY ON CURRENT METHOD

3.1 Introduction

Developing a tool to make a decisionto condemn train wagons ensuring transparency is the aim of this study. To achieve this goal, there were three objectives set. The first objective is to study the existing procedure for valuation and condemning the train wagons in an SLR, then a decision supportive tool to condemn train wagon in a transparent manner will be developed. At the end of the study,the tool will be evaluating comparing current method and the proposed method.Studying of the existing procedure for valuation and condemning the train wagons in SLR will be covered in this chapter. Statistics on the current system should be gathered to accomplish this aim. Since the examination and inspection of the old wagon and recommendation to the condemning done at the CME sub department of the SLR, the data gathering was planned to carry out at the CME sub department Rathmalana. Collecting information was planned to do through questionnaires, FGDs and surveys. Engineers, supervisory managers, examiners, and workers are getting participate in these surveys.

3.2 Data collection

3.2.1 Sample

Statistics on the current system should be gathered to accomplish this aim. Since the examination and inspection of the old wagon and recommendation to the condemning done at the CME sub department of the SLR, the data gathering was planned to carry out at the CME sub department Rathmalana. Collecting information was planned to do through questionnaires, FGDs and surveys. Engineers, supervisory managers, examiners, and workers are getting participate in these surveys.

Rolling stockconsists with many types of locomotives, carriages, wagons and other vehicles used in railway.Details of rolling stock were received from the technical department of the CME sub department, and based on those data this rolling stock further categorized into many subcategories. In that case, it is a vast area to consider whole rolling stock condemning. So, wagons were considered as the sample for this

study.When it considers the wagons, there are many sub categories. As per the fixed asset register, 2802 numbers of the wagon were purchased to SLR so far which are belonging to 53 types of wagons. Those wagons have bought to SLR from 1884 to 2001. Studying all these 53 types were difficult. So, out of 53 types, only one type was selected for this study. The BCGS wagon type was selected for this study.

3.2.2 Current condemning procedure

Since SLR is a very aged service there are many rolling stocks which cannot use anymore. And these old carriages, wagons and tanks gather all over the sheds, workshops, stations and rail tracks. It disturbs other services in SLR as well as creating an unpleasant view. There is high monetary value gathered in these scraps which diminish with time. At present SLR practices a condemn procedure as below discusses.

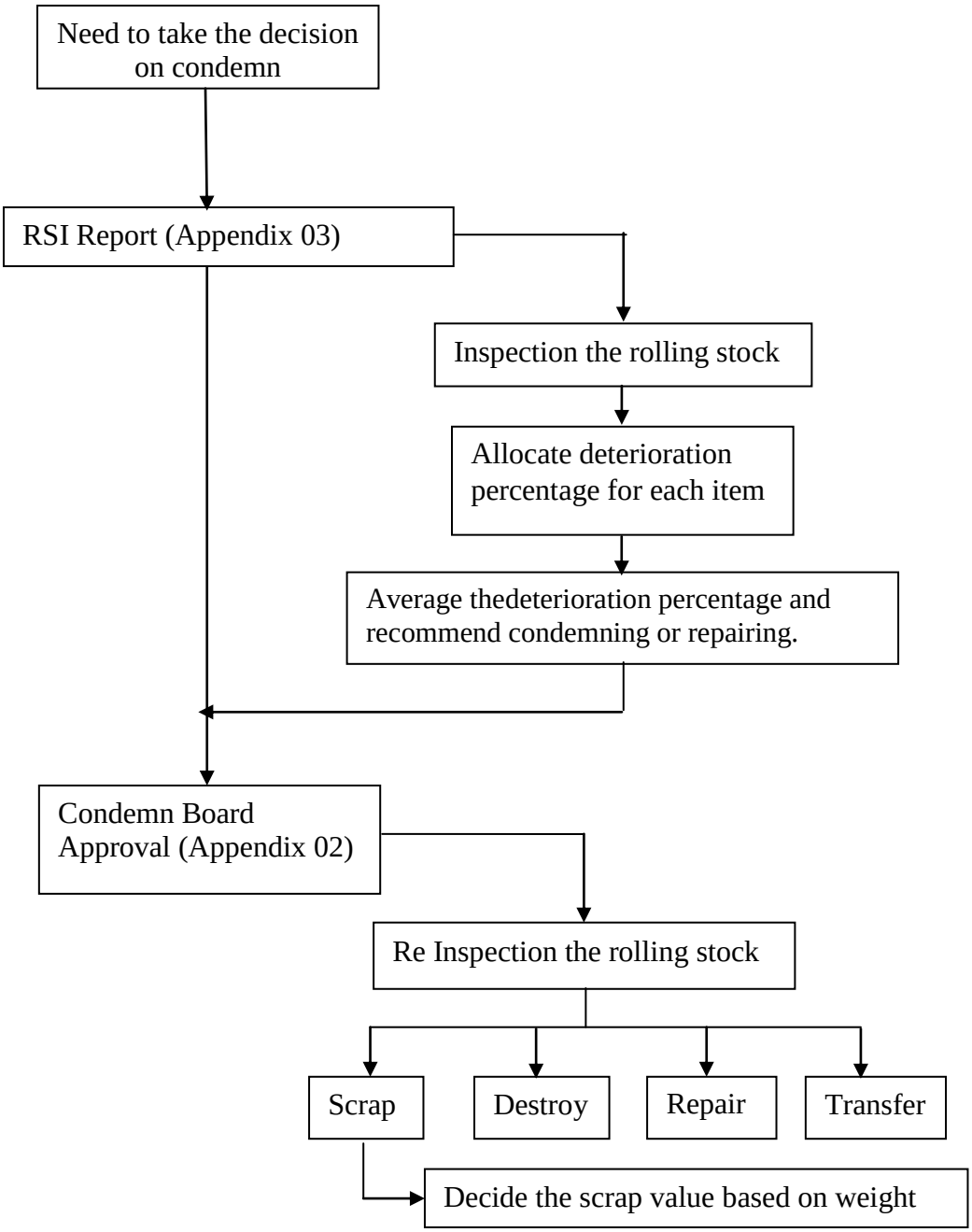

Figure 3.1: Current rolling stock condemning process

As per above chart discusses first it chooses rolling stocks which are in condemn stage and then call Rolling Stock Inspection (RSI) report.

- **Current RSI report (Appendix 03)**

The rolling stock is examined and prepare the RSI (Rolling Stock Inspection) report and submit by examiners. It is contained with three stages as described in above figure. RSI report is consisting of a list of all the parts of rolling stock and examiner should fill the condition of each part. RSI report calls from Srilanka Railway, Chief Mechanical Engineer's sub department. So, it displays at the top of the report. As well as this report coded as W 59. The report has titled as Engine and Carriage Inspection Report. The report consists of the number, type, Date put to the traffic, Age(years), Last heavy repaired date and the condition of each part. These facts are described below.

Number: Each rolling stock has their own number which was assigned from the SLR. This number consistsof some letters and number where the letters refer toa type of rolling stock, whether it is a tank, type of carriage, type of wagon, engine or etc. (Ex: BCGS 9560).

Type: Type refers the country of origin as per the SLR. If it considers BCGS it consists of types as Pakistan, Indian, Chinese, Korean and German

Date put to the traffic: This topic refers to the date of this engine/ tank/carriage/wagon began to use.

Age (years): Based on date put to the traffic it can calculate the age of the relevant rolling stock.

Last heavy repaired date: This refers as HR (Heavy Repaired) date in the SLR. HR is the scheduled repair of an any rolling stock. In every 5 years' time, each carriage, tank or wagon hasa scheduled repair. And the date is marked on the body of rolling stock.

The condition of parts: Condition of the parts comes in a table which has three columns. The first column is with parts of rolling stock. There are 13 parts as roof,

body, inside panelling and ceiling, seat and parcel racks, doors, window frames and shutters, water tank and pipe fittings, wiring, floor, underframe, buffer and auto coupling, brake pipe and brake cylinders, bogie and wheels. The second column is to mark the condition of each part. Each part inspects by the examiner and given the decayed percentage of the part in this column. The third column is for remarks. If there is any special case, it noted in this column. After assigning the decayed percentage for every part take the average percentage of it to the 14th row named total maintenance. Lacking parts are recorded in the next row. The last row is to state the recommendation.

At the bottom of the RSI report, it is recommended by SMW 15 and forwarded to CME for his comments. If the average decayed percentage is greater than 60% CME order to form a condemn board.

- **Report of the condemned items (General 47) (Appendix02)**

Condemn board approval is done in two stages and recommendations are submitted through the form General 47. At first rolling stock to be condemned is re-inspected by members who assigned to the condemn board. Then decide whether to sell for scrap, destroy, repair or transfer to the port engineering department for sale on open tender. If it is taken as scrap, scrap value is taken regarding the approximate weight of the item.

This form General 47 is used to report condemn items of the government sector. At the top of the sheet it shows the year and then it displays that this report is printed at the government press. The code of this document is General 47. Then the heading of the document comes as the report of the condemned items. Since this document is prepared as per financial regulation 877 there is a paragraph saying that "this report is to send for the government treasury or department head or government agent without any covering letter". Then the name of the department is to be written in next blank. There are four columns in the table which appears below. The first column is for goods and the second for the number and the third column is to mention whether to sell for scrap, destroy, repair or transfer into another place for reuse it. The letter

“S” refers that the goods are cannot be used, so recommended to sell for scrap. The letter “D” refers that the goods are not in usable condition and recommended to destroy it. The letter “R” is referred that the goods are in repairable condition and recommended to repair and keep. The letter “T” is referred that the goods are not in usable condition and recommended to transfer to the port engineering department to sell on open tender. Fourth column is for remarks. Used time of the good should be mentioned in this column.

3.2.3 Stakeholder views on condemning procedure

Stakeholders' views on condemning procedure need to find out to develop the new method to condemn the rolling stock. In this case, the required statistics were gathered from SLR through three ways.Those three methods are questionnaires, FGDs and access of available data sources.

Questionnaires

1. QuestionnaireI on current condemning procedure and further improvements (Appendix 05 I)
2. Questionnaire II on current condemning procedure and further improvements (Appendix 05 II)
3. Questionnaires onMaintainability of BCGS (Appendix 07 a)

FGD

1. FGD on availability of each part of BCGS (Appendix 08 a)
2. FGD on replaciability of Main parts of BCGS(Appendix09 a)
3. Interchangeable partial list of BCGS sub categories (Appendix 11a)

Available data sources

1. Data of all the BCGS which were purchased to SLR (Appendix 04)
2. Price list of each item of BCGS (Appendix 10)

- **Questionnaire I on current condemning procedure and further improvements (Appendix 5 I)**

Two questionnaires were conducted in two phases. Part 1 is conducted at the beginning of the study and the part 2 was conducted in the middle of the study. Questionnaire part 1 was contained with 11 questions that 9 of them were to select the answer from given answers and 2 of them are to write down the answers. A sample questionnaire is attached as appendix 05I. These questions are based on current RSI report submission and current condemn procedure. The selected sample size is 5 and the questionnaire was distributed among 5 respondents and it was translated to Sinhalese for the better understanding of respondents.

The first question is about the experience of the respondent on the inspection and examining the rolling stock and RSI report filing. The given answers were a breakdown of 4 phases as 1 year to 5 years, 6 years to 10 years, 11 years to 20 years and more than 21 years.

The second question was designed to capture how they allocate decayed percentage of the rolling stock in the current system. So, the second question is "How do you allocate percentages to RSI report?" and three answers were given as below.

i. By practice
ii. Using a standard method following by everyone at SLR
iii. Other methods

Third and fourth questions designed to find out whether it considers all the sub parts individually when allocating the decayed percentage in the current system and what factors should consider in decayed percentage allocation. The third question is "What are the factors that consider when allocating the decayed percentage in the present system?" Here it questions about the factors that are considered in the current process to define the decayed percentage of whole wagon or carriage. And the fourth question is "What are the factors should consider when allocatingthe decayed percentage?" This question seems similar to the third question but this focus on the future improvement of the current system. Here in the fourth question, it considers

the factors to be consideredindefining decayed percentages. Answerers given in the questionnaire for these two questions are same. These are as follows.

i. Decayed level of each *main part
ii. Decayed level of each *main part and importance of that *main part
iii. Decayed level of each *sub part
iv. Decayed level of each *sub part and importance of that part
v. None of above

Main parts and subparts of the train wagon which were collected from the technical department of the CME office is listed at the end of the questionnaire.

The fifth question was based on the answer which was given to the fourth question. The fifth question is “If you think that it should consider the importance of parts when consider for condemning, do number the below given factors and if importance should not consider leave it blank. (State the other important factors to be considered and number them)”.

i. Maintainability of parts
ii. Price of the decayed parts
iii. Availability of those parts in the market
iv. Ability of replacing main part
v. Other factors……

Maintainability of parts refers that how easy or difficult to repair those parts. It may depend on the material, access to the relevant place, labour skill etc. Price of the decayed parts discusses the price that SLR should afford replace a new part instead of decayed part. As an example, if the part is roof sheet, the price of roof sheets that need cover the whole roof. It should check whether the whole part or the materials to repair the part is available in the market. This aspect refers from the availability of those parts in the market. The ability to replace main part defines that does it can replace the whole main part as a unit instead of replacing sub parts. As example wheel set is a main part and it can replace easily, butthe roof is also a main part which cannot replace as a unit. There are some blanks to write down any other

factors that they consider valuing each part. No one stated any other factors which do not specify in the questionnaire.

Sixth, seventh and eighth questions were designed to discover the consistency of the current system. The sixth question of the questionnaire is “Do those allocated percentages of the RSI report for each part will differ from person to person?”. It is a closed ended question which has only “Yes” or “No” answer. The answer to this question leads to find out whether the current system is subjective or not. The seventh question is “Does it may change the Examiners decision in RSI report at the condemn board stage?” and it has three answers as “Yes”, “No” and “May be”. The eighth question is “How about train a new person in this process?” and answers were “Easy”, “Normal” and “Difficult”. These three questions lead to find out whether there is a logic behind the current system which gives the consistency decision without varying the decision from person to person. The requirement of a new system is can be revealed through these questions.

The next question is to find out whether the respondents are fed up with the current system and the requirement of a new system. The question is a closed ended question which asks whether they are happy or not about thecurrent system. Question number 10 is designed to find out at which stage the condemning decision is taken in the current system. This is not a question with choices of answers. The question is “At what decayed percentage does it recommended to condemn?” As usual, the last question is for their suggestions for the improvements of the current method.

- **Questionnaire II on current condemning procedure and further improvements (Appendix 5 II)**

Part II of the questionnaire was conducted in the middle of the study. It was designed to gather some data which were required at the developmental stage of the tool. The same five respondents who participated in part I have participated this questionnaire part II. This questionnaire consists of two questions. Both questions were required to write down answers.The sample questionnaire is attached in Appendix 05 II.

The first question is about the conditions of the sub parts that find out at the RSI stage. At this question,the respondent was asked to write down those conditions and allocate marks out of 100 for their importance. The question states as “When the wagon is inspected at the RSI stage, sub parts may at several conditions as cannot use, can use etc... What are the conditions that identified by yourself? State those conditions and allocate marks out of 100 based on their importance”.

The second question is based on reusing the parts. The question is “what are the factors that consider removing a sub part from condemned rolling stock for use in any other rolling stock?” Due to the high price and less availability some parts are removed from condemned rolling stock by SLR and in this question, asks what are the factors considered in that case.

- **Questionnaire on Maintainability of BCGS (Appendix 07 a)**

When the data gathered from the questionnaire I on “current condemning procedure and further improvements” was analyzed it gives that the importance of parts should consider for condemning. As per analysis maintainability is a factor that ranked in second place which should consider getting the importance of a part. In that case, this questionnaire was designed to identify the maintainability of each part in BCGS.

This questionnaire was designed based on Likert type scale. It is a five point Likert scale. Likert items are used to measure respondents’ attitudes to a question or statement [25]. This questionnaire is on maintainability of Chinese BCGS. The sample questionnaire is in appendix 07 a. At the top of the sheet, it displays 4 categories as an Engineer, Supervisory manager, Examiner and Worker where respondent should tick according to his position. The entire main and sub parts are listed in the below table with the five scale Likert in front of each.

Likert scale is as follows.

1=Very easy 4= Difficult

2= Easy 5=Very Difficult

3=Normal

The respondent should circle the correct numeric response to each question which matches the maintainability of the BCGS. It means based on their experience if they feel like that part is very easy to maintain circle number one. As sub parts are given in the sheet, respondents should pay their attention to each sub part.

- **FGD on Availability of each part of BCGS (Appendix 08a)**

As per the outcome of the questionnaire I on "current condemning procedure and further improvements" the importance of parts should consider for condemning. The factor availability of each part of BCGS is ranked in third place which should consider getting the importance of a part. In that case, this FGD was designed to identify the maintainability of each part in BCGS.

There were three FGDs were carried out in this study and first FGD was conducted to find out the availability of parts in BCGS. The sample group was selected among the CME sub department staff. Five participants joined to this FGD and they were one Engineer, one supervisory manager and three examiners.

Availability refers that, at the maintenance stage whether the parts are highly available, normally available or difficult to find. Since the wagons are very old, some parts are not manufactured now. At this FGD a survey sheet was handed over to the group and asked them to discuss and fill. A list of all sub parts accordance with the main parts was given in that sheet. There were 46 sub parts are coming under 9 main parts. In front of each sub part scale of 1 to 3 displayed and the group was asked to circle the appropriate response according to the survey scale.

Survey scale is

1- Highly available in local market

2- Available in the local market, but difficult to find

3-Cannot find in the local market and should import

- **FGD on Replaceability of Main parts of BCGS (Appendix 09a)**

As per the outcome of the questionnaire I on "current condemning procedure and further improvements" the importance of parts should consider for condemning. The replaceability of main parts of BCGS is a factor which should consider getting the importance of a part. It is the most prioritized factor to consider the importance of a part. In that case, this second FGD was designed to identify the replaceability of main part in BCGS.

The second FGD was done to find out the replace ability of the main parts in BCGS. From the fifth question of the questionnaire on current condemning procedure and further improvements part I the replaceability is the first factor considered when the wagon is considered for condemning. The same team, which was participated at FGD on the availability of each part of BCGS have participated in this FGD.
Replaceability refers to whether the main part can be fixedas a set in the maintaining stage. At this FGD a survey sheet was handed over to the group and asked them to discuss and fill. A list of the main parts was given in that sheet and in front of each main part scale of 1 to 2 displayed and the group was asked to circle the appropriate response per the survey scale.

Survey scale is
1-Whole main part can be replaced
2-Main part cannot be replaced

- **FGD on interchangeable parts in BCGS sub categories(Appendix11a)**

The third FGD was conducted to find out interchangeable parts among BCGS sub categories. The questionnaire II on "current condemning procedure and further improvements" is used to find out the factors to be considered when the sub parts interchange. If the BCGS is to be condemned, the developed tool will be proposed the sub parts which can remove for reuse. This collection of data is used for that purpose.

Each type wagon can further categorize into sub categories and this categorization has done based on country of origin. BCGS is divided into 5 categories. Some parts of these subcategories are interchangeable. So, a survey was conducted with the technical team to find out interchangeable parts and common comments on each category.

This survey was conducted in two workshops in because maintenance of the body of BCGS is done by one group in workshop 24 and another group in workshop 22 is carried out the maintenance of all bogies. Survey sheet distributed among these two technical teams and they filled it as a team and submitted.

Table 3.1: Categories of the BCGS

BCGS	Chinese
	Indian
	Korean
	German
	Pakistan

Due to design factors or material selection, some of wagons or tanks are with easily damaged or corroded parts and most of these parts have been identified by the maintenance team. Five sheets distributed among the team for the five sub categories of the BCGS. The first column is to write down the main part and the second column is the subpart of the BCGS. Then there are five columns where each column represents a category of a BCGS. The respondent should tick the cell selecting which sub category that subpart can changeable.

- **Data of all the BCGS purchased to SLR**

Details of all BCGS which were purchased to SLR were gathered from accessing available data sources in the CME office planning department. Fixed Asset Register of wagons states all these facts. Tanks are also considered as wagons.

There are eight columns in the fixed asset register. The first column is the wagon type and it states BCGS. Second column states for the wagon number. It is a unique number which is assigned to each wagon for identification purpose.

In the third column,it mentions the gauge of the track. There are narrow and broad gauge rail tracks. Next column states the status of the BCGS. There are two statusesdescribedunder this column and those statuses are “in service” and “not in service”. Sub category of the BCGS states in the fifth column. There are 5 types of sub categories as Chinese, Indian, Korean, German and Pakistan. Service date comes under the sixth column. It expresses when the wagon puts into traffic. In the seventh column,it mentions the capacity of the wagon. The capacity of the BCGS which transport solid goods has indicated in metric tonnes (MT). The last column conveys the cost of each wagon.

- **Price list of each item of Chinese BCGS(Appendix10)**

When the data gathered from the questionnaire I on “current condemning procedure and further improvements” was analyzed it gives that the importance of parts should consider for condemning. As per analysis price of each item is a factor that ranked in fourth place which should consider getting the importance of a part. In that case, this price list of each item of Chinese BCGS was accessed.

Price list of each sub parts was collected from purchasing department and all the figures lower than Rs.100000.00 was rounded up to the nearest thousand and figures higher than Rs.100000.00 was rounded up to the nearest ten thousand. As well as the values, more than one million have rounded up to nearest hundred thousand.

3.3 Data analysis and Result

3.3.1 Sample

Data gathering was done at the CME sub department Rathmalana. Sample respondents were selected from CME department employees to answer the questionnaires, FGDs and discussions. There were Engineers, Supervisory managers, examiners and skilled labours.

The questionnaire I and II were conducted with 5 respondents. All of them were examiners. Questionnaire on maintainability was conducted with 9 participants. Those are one Engineer, one supervisory manager, four examiners and 3 workers.

Two FGDs on replaceability and availability was conducted with 5 members and those were one Engineer, one supervisory manager and three examiners.

When considering the rolling stock it consists with locomotives, carriages, wagons, rail buses, tanks, container flats and other rail vehicles. BCGS wagons were selected as the sample in this study because it is a vast area to consider the whole rolling stock.

Details of all wagons and tanks which were purchased to SLR were gathered from the planning department of CME office. Fixed Asset Register of wagons states all these facts. Details of BCGS were filtered from the fixed asset register. Records from1884 to 2001 states there.There are details of 322 BCGS. A unique number has assigned to each wagon for identification purpose. 45 MTis the highest carrying capacity of wagons and tanks respectively. By analyzing in service date, the oldest wagon was put into traffic on 1930 when Sri Lanka is under the British government. Train transportation was initialized in Sri Lanka by the British government and they have added many wagons to the service in their period.

3.3.2 Current condemning procedure

Collection of data about the current condemning procedure was done through questionnaires. The questionnaire I on current condemning procedure and further improvements give an idea about the current condemning procedure. The result of the questionnaire I and II are given in appendix 06.

Out of five respondents who face this questionnaire three had 6 to 10 years of experience, only one had 16to 20 years of experience and another one had 1 year to 5 years of experience.

The second question is “How do you allocate percentages to RSI report?” All the five respondents stated that the decayed percentages of given parts in RSI report are allocated by the practice. So, the current method is subjective and there is no any rational logic behind the condemning the train carriage and wagons.

The third question is “What are the factors that consider when allocating the decayed percentage in the present system?” Here it questions about the factors that are considered in the current process to define the decayed percentage of whole wagon or carriage. For the question three, the entire respondent has chosen the same answer as the decayed level of each item. It means that when it decided the decayed percentage of each part only visually inspects the main part and percentage is given. It conveys that in the current process it does not refer any subparts or importance of each part.

The sixth question of the questionnaire is “Do those allocated percentages of the RSI report for each part will differ from person to person?”. All the participants have given “yes” as the answer. So, it conveys that the current system is subjective, which decision varies from person to person. In that case, in this study, it focuses on developing a system which is not subjective.

“Does it may change the Examiners decision in RSI report at the condemn board stage?” is the seventh question in the questionnaire. Out of five respondents, four of them replied as “may be” and only one participant stated as “yes”. In the current process after inspected and RSI report is submitted the condemn board is called and re-inspect the rolling stock and recommend to condemn or not. As the inspection method is not defined clearly and as it is subjective the decision of RSI report may change at condemn board stage. But there is no any logic behind the procedure.

The eighth question is “How about train a new person in this process?” Four out of five responded as “Difficult” and the most experienced respondent has answered as “normal”. It seems knowledge transferring about the current system is not easy. Ninth question is asked whether they are happy or not about the current system. Four respondents were unhappy about the current system and the other one was happy about the system. This result leads towards the requirement of a new system. Question number 10 is “At what decayed percentage does it recommended to condemn?” It is not a question with choices of answers. As the answer, all the five participants gave as 60%. It takes the average the decayed percentages of all main

parts and if it is more than 60%, then the train carriage or wagon is recommended to consider for condemning.

3.3.3 Stakeholders' views

Data was gathered on stakeholders' view through questionnaires, FGDs and accessing the available documents. Stakeholders' views can be evaluated by studying those data.

- **Analysis of the questionnaire I and II on current condemning procedure and further improvements(Appendix 06)**

Through the result obtained from the questionnaire, I and II on current condemning procedure and further improvements stakeholders' views can be identified. Received answers were summarized in appendix 06.

The fourth question of the questionnaire is "What are the factors should be considered when allocating decayed percentage?" It considers the factors to be considered indefining decayed percentages. This question focuses on the future improvement of the current system. All the participants have given the same answer as the decayed level of each sub part and importance of that part should be considered to allocate decayed percentages. Based on this answer decision was taken to further categorize the main parts into sub parts and consider the array of their importance in this study. This finding leads to assigning a weighted factor for each sub part in this study.

The fifth question was based on the answer which was given to the fourth question. The fifth question is "If you think that it should consider the importance of parts when consider for condemning, do number the below given factors and if importance should not consider leave it blank". Since all the respondents stated that the importance of each part should consider when the decision is taken to condemning, everyone has numbered given factors.

By studying the result which was obtained, it could rank these four factors. Out of five respondents, three of them have stated that the ability to replace main part can be placed in first place while other two stated as second place. Maintainability of parts was mentioned at second place by three participants, at first place by one participant and at third place by one participant. Out of five participants, three of them stated that availability of parts in the market should take in third place while other two placed it at first and fourth. Price of the decayed part was mentioned in fourth place by four respondents, whileanother one stated it in third place.

Considering the mode value of response get per each factor above factors can be ranked as,

Rank 1: Ability to replace main part

Rank 2: Maintainability of parts

Rank 3: Availability of those parts in the market

Rank 4: Price of the decayed parts

The questionnaire II on current condemning procedure and further improvements were conducted in the middle of the study. It conducted to gather some data which were required at the developing stage of the tool. The first question was asked to write down those conditions and allocate marks out of 100 for their importance. Out of five participants, three respondents have identified 5 conditions of parts while inspecting the rolling stock. Those five conditions are part is missing, part cannot use, part can use with heavy repair, part can use with normal repair and part can use without repair and they allocated 0,0,25,75 and 100 marks respectively. One of the respondents identified 6 conditions of parts while inspecting the rolling stock and those are part is missing, part cannot use, part can use with heavy repair, part can use with normal repair, part can use with minor repair and part can use without repair and allocated 0,0,25,50,75 and 100 marks out of 100 respectively. The other respondent has stated 4 conditions as part is missing, part cannot use, part can use with repair and part can use without repair and allocated 0,0,50 and 100 marks out of 100 respectively.

The second question is based on reusing the parts. The question asked for the factors that consider removing a sub part from condemned rolling stock for use in any other rolling stock. All the respondents stated two factors that consider for part reusing which are the items that can use without repair and items can use with the normal/minor repair. And only two of them were stated that if the item is very difficult to find and the price is high and it can be used with heavy repair, that item will remove for reuse.

- **Analysis of result obtain by questionnaire on Maintainability of BCGS(Appendix 07 b)**

This is a five point Likert scale questionnaire which asks the maintainability of the BCGS. Received responses were summarized based on mode value and the summarized report is in Appendix 07 b. Nine respondents participated in this questionnaire as one engineer, one supervisory manager, four examiners and three workers. Workers only participated in the area that they engaged. They have scored the maintainability of each item as per their experience. Through the study of the data received from the Likert it found out that, out of 46 sub parts Roof beams, End Wall columns and beams, Side Wall columns and beams, Crossbar, Sole bar, longitudes and headstock are the parts with very difficult to maintain. There are no any parts with very easy to maintain.

The data analysed based on mode value and distribution of respondents is displayed in bar charts as below. And the mode value of each sub part was taken to assign a weight to each sub part.

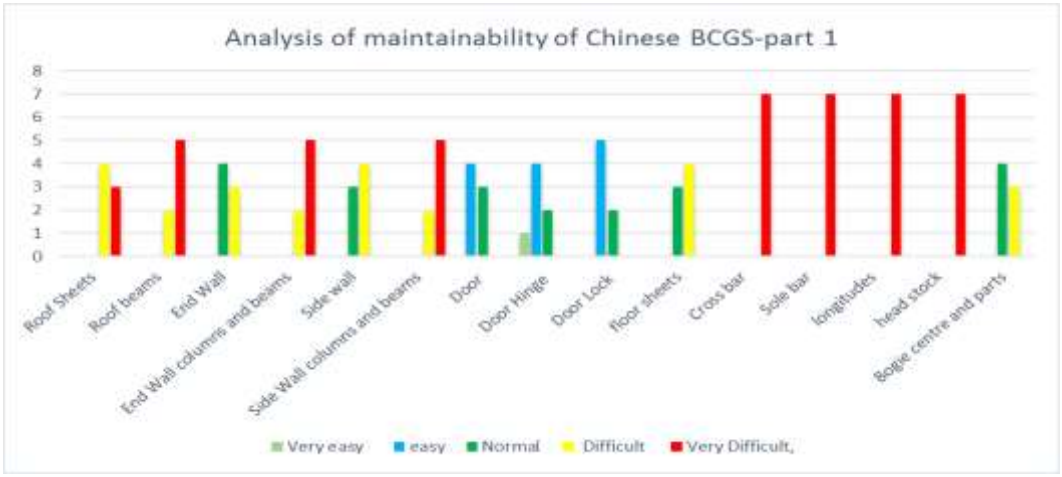

Figure 3.2a: Analysis of maintainability of BCGS part I

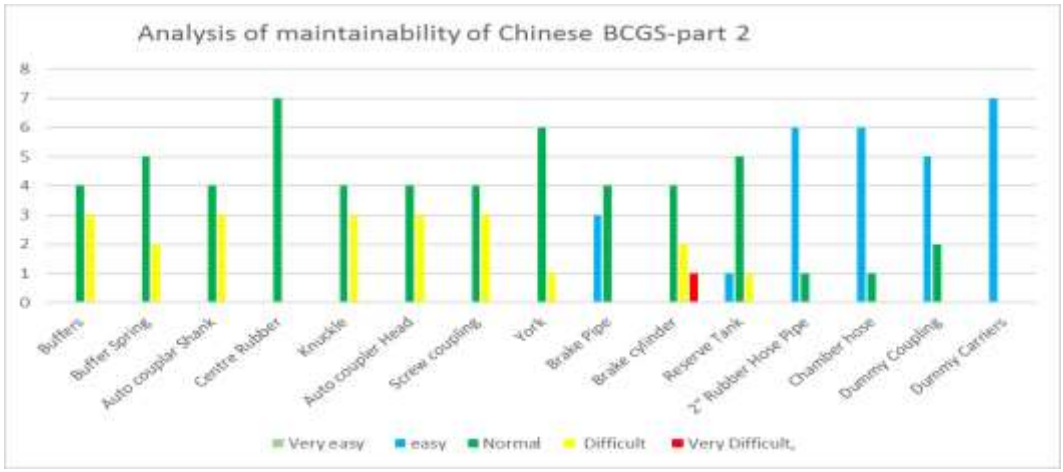

Figure 3.2b: Analysis of maintainability of BCGS part II

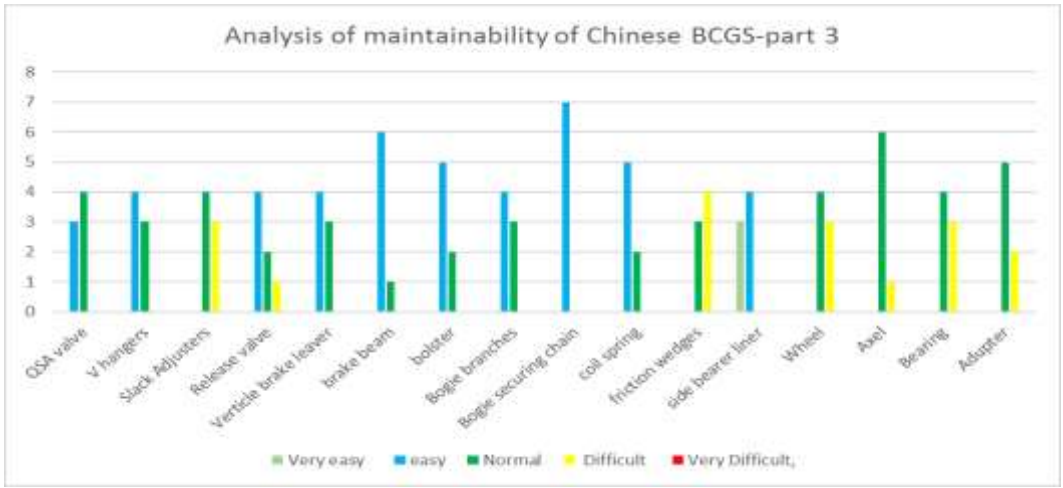

Figure 03.2c: Analysis of maintainability of BCGS part III

- **Analysis of result obtains by FGD on availability of each part of the BCGS(Appendix 08 b)**

An FGD was done to find out the availability of parts in Chinese BCGS. The result is given in Appendix 08 band as per the result that obtains through this, out of 46 subparts 08 sub parts were identified as highly available in the local market and 18 sub parts were identified as available in the local market but difficult to find. And 20 items are not available in the local market and those items are to be imported. The process of importing an item has taken much time as well as it is costly.

- **Analysis of the result obtained by FGD onthe replaceability of Main parts of the BCGS(Appendix 09 b)**

An FGD was done to find out the replaceability of the main parts in BCGS. As per the questionnaire on current condemning procedure and further improvements, replaceability is the first factor considered for the importance of the subpart. Replaceability refers to whether the main part can be fixed as a set in the maintaining stage.

The result obtained for this FGD is displayed in Appendix 09b. There are 09 main parts in a wagon as, Roof, Body, Door, Floor, Underframe, Buffer and auto coupling, Brake pipe and cylinders, Bogie and wheel set. Out of those 09 main parts, 05 parts can be replaced as a whole set and another 04 set cannot be replaced as a set. Door, Buffer and auto coupling, Brake pipe and cylinders, Bogie and wheel set are the replaceable 5 main parts and Roof, Body, Floor and Underframe are the non-replaceable parts.

- **Analysis of the price list of each item of BCGS(Appendix 10)**

The rough price list was collected from purchasing department and found out that out of 46 items price of 18 items were below than Rs10,000.00 and 17 items are in the range of Rs. 10,001.00 to Rs. 100,000.00. Price of the 11 items is higher than Rs. 100,000.00

- **Analysis of the result obtained by FGD on interchangeable parts in BCGS sub categories (Appendix11b)**

An FGD was done to find out the interchangeability of parts in BCGS. The questionnaire II on "current condemning procedure and further improvements" is used to find out the factors to be considered when the sub parts interchange.This data is used to propose the sub parts which can remove for reuse when the BCGS is condemned. There are 5 categories of BCGS as Chinese, Indian, Korean, German and Pakistan.Some important facts can be found when the received data was studied. One fact is that some parts can be find out which can use for any BCGS. Those parts are Buffer springs, Knuckle, Auto coupler head, Screw coupling, Brake cylinder, Reserve tank, Dummy coupling, Dummy carriers, QSA valve, V hangers, Slack adjusters, Release valve and Vertical brake leavers. Some minor modification may be used when interchange some parts. The other fact is the Chinese BCGS has their own unique design. Because of that door parts and wheel set parts in Chinese BCGS cannot interchange with other BCGS while these parts can interchange among Indian, Korean, German and Pakistan BCGS it selves. Those parts are Door, Door hinge, Door lock, Wheel, Axel, Bearing and Adapter. Side bearer liner is the only item which cannot interchange with any other type of BCGS.

4. DEVELOPMENT OF DECISION SUPPORT MECHANISM

4.1 Decision support mechanism

4.1.1Wagons

Though the fixed asset register of wagons is contained 2802 numbers of wagons which belong to 53 types of wagons in this study, we focus only BCGS. There are 322 BCGS has purchased to SLR so far. BCGS can be sub categorized into 5 categories and those are Chinese, Indian, Korean, German and Pakistan. The developed decision support mechanism is applicable to these BCGS only.

4.1.2 Stakeholder views

Requirement of a new method

The data received from the questionnaire on current condemning procedure and further improvements were analyzed at the first. The questionnaire was conducted in two phases where in part I, primary data was gathered through this questionnaire and out of eleven questions nine of them are a quantitative type of questions and two are a qualitative type of question. In researches most commonly used quantitative survey questions, and respondents will know how to deal with them [19]. The mean response was considered at the analyzing stage. 60% of the respondents were with 6 years to 10 years of experience in inspecting rolling stock and submitting the RSI report.

As per the data received through this questionnaire, it grasped that the decayed percentage of parts of the wagon are allocated in the RSI report by the practice. As well as 100% of the respondent answered, as this allocation of decayed percentage is different from person to person. The teaching the current method to a novice is difficult. Analyzing these three aspects it can realize that current method of condemn is subjective, which is not any logical reason behind. This leads towards the necessity of a new system to make the decision to condemn the rolling stock. The required new system should be less biased from human factors.

Deterioration percentage to decision on condemning

If the average decayed percentage calculated in the RSI report is greater than 60%, then it suggests for condemn and condemn board is formed. 60% of respondents say that the RSI report decision change at condemn board stage. 80% of respondents are not happy with the current system and they need a further improved system. As per the suggestions, the respondents made it describe there is a requirement of a new system.

Ranking the criteria for value each sub part

Through the questionnaire, it found that in current method only the decayed level of the main parts is considered to get the decision on condemning, but 100% of respondents believe that the decayed level of each sub part and importance of that part should consider when condemning rolling stock. In the current system, there is no any well-defined sub part list for each main part and each part is counting in equality.

As per the respondent, there is a requirement of the new decision supporting system which is weighted all the sub categories based on their importance. So, the criteria were identified and decided the importance of each sub part based on this questionnaire. The order as per the importance of criteria received through the questionnaire as follows.

Rank 1: Ability to replace main part

Rank 2: Maintainability of parts

Rank 3: Availability of those parts in the market

Rank 4: Price of the decayed parts

It can allocate weights for these criteria as per the obtained ranks. Once the importance of all the criteria is decided the aggregate scores are calculated and the rankings are determined [20]. The data that received can be displayed as follows.

.

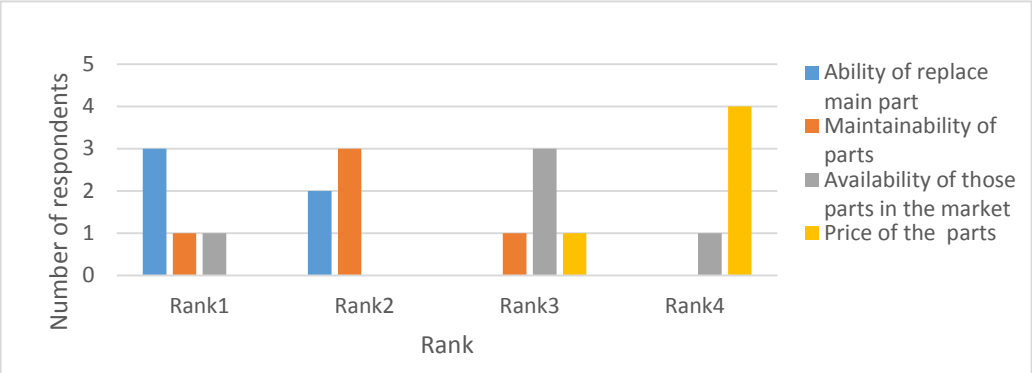

Figure 4.1: Rank of each criterion based on importance

Weights for each criterion assignedas W_R= 4, W_M= 3, W_A = 2, W_{PR} = 1 where W_R, W_M, W_A and W_{PR}represents Ability to replace main parts, maintainability of parts, Availability of those parts and price of the part respectively.

WSM scores for each sub part

Questionnaire on Maintainability of Chinese BCGS (Appendix 06) is a 5 point Likert scale. The data which was received is an ordinal type of data. Ordinal data refer to the data in which an ordering or ranking of responses is possible, but no measure of distance is possible [21]. The interval between values is not interpretable in an ordinal measure [22]. The most appropriate measure is the mode or the median. The best way to display the distribution of responses, i.e. (% that agree, disagree, etc.) is to use a bar chart [23]. In this analysis, mode value is considered in analyzing data.

Two FGDs did on the availability of each part of Chinese BCGS and on the replaceability of Main parts of Chinese BCGS. A focus group discussion (FGD) is a good way to gather together people from similar backgrounds or experiences to discuss a specific topic of interest [24]. For the FGD on the availability of parts of the Chinese BCGS survey scale was highly available in the local market, Available in the local market, but difficult to find and cannot find in the local market and should import and allocated scale values are 1, 5 and 10 respectively. For the replaceability of the main parts of Chinese BCGS, there are only two survey scales were considered those are the whole main part can be replaced and main part cannot be replaced and the allocated scale value is 1 and 10 respectively.

The price of each sub part was gathered from purchasing department as secondary data. Secondary data has the advantage of being available immediately, is often cheap and easy to obtain, but the disadvantage is that it may not meet all needs [25]. So, it has arranged as per the scale low, medium and high. Allocated scale values for the price of each part is 1,5 and 10 for low, medium and high respectively.

MCDM method is used to find the weight for each sub part. MCDM is one of the most well-known branches of decision making and Each MCDM problem is associated with multiple attributes. Attributes are also referred to as "goals" or, decision criteria". Attributes represent the different dimensions from which the alternatives can be viewed [26]. WSM is the decision-making technique that used in this study. Weighted sum models had to be used in this study to score the sub parts accordance with the importance.

The WSM is required to allocate scores for each sub part base on selected criteria. The score calculated through the first model is unique for each part. There are 4 criteria which considered in this aspect are maintainability, availability of each part, replaceability of parts and price of each part.

WSM method is used as the decision-making technique. It is the most commonly used approach in single dimension problems [26].

$$\textbf{WSM score} = \sum_{i=1}^{n} a_{ij} w_j \qquad \text{for i = 1,2,3…n}$$

Where: WSM-score is the WSM score, n is the number of decision criteria, $a_{ij}$is the actual value of the i^{th}alternative in terms of thej^{th}criterion, and w_j is the weight of importance of the j^{th}criterion [26].

In this model, there are decision criteria as maintainability, availability of each part, replace ability of parts and price of each part where i= 1,2,3,4

46 sub parts can consider as alternatives which required to find out scores where j=1,2, 3… 46

Ex:Table 4.1 WSM score calculation

		CRITERIA			
		C1	C2	C3	C4
		$W_M = 3$	$W_A = 2$	$W_{PR} = 1$	$W_R = 4$
ALTERNATIVES	1.Roof Sheets	10	1	10	10
	2.Roof beams	10	5	10	10
	3.End Wall	6	1	10	10
	4. End Wall columns and beams	10	5	5	10

WSM score of roof sheet: (10x3) +(1x2) +(10x1) +(10x4) = 82

Where, W_R, W_M, W_A and W_{PR} represents Ability of replace main parts, maintainability of parts, Availability of those parts and price of the part respectively.

Conditions of sub parts at inspection stage and assign weight

At the second phase of the questionnaire on current condemning procedure and further improvements was done at the middle of the study and it found out that sub parts can be identified at five conditions in RSI stage. Here the mode respond was considered.

Those five conditions are

Condition 1: part is missing

Condition 2: part cannot use

Condition 3: part can use with heavy repair

Condition 4: part can use with normal repair

Condition 5: part can use without repair

And the weights can be allocated as 0,0,0.25,0.75.1 for each condition respectively. These weights have given based on the good condition of the parts, but at the tool development stage since it considersthe bad condition of the part. It means the decayed portion of the part. So, in that case the weights should consider as,

Weight of the condition 1 = 1-0 = 1

Weight of the condition 2 = 1-0 = 1

Weight of the condition 3 = 1-0.25 = 0.75

Weight of the condition 4 = 1-0.75 = 0.25

Weight of the condition 5 = 1-1 = 0

Five criteria are identified as, part is missing, part cannot use, part can use with heavy repair, part can use with normal repair and part can use without repair and further these criteria named as Cr_1, Cr_2,Cr_3,Cr_4 and Cr_5. Assign weights are 1,1,0.75,0.25 and 0 for Cr_1, Cr_2, Cr_3, Cr_4 and Cr_5respectively.

The weighted average method can be used to calculate the final decayed value of each part.

In this model the5 decision criteria are,part is missing, part cannot use, part can use with heavy repair, part can use with normal repair and part can use without repairwherei= 1,2,3,4,5and 46 sub parts can consider as alternatives which required to find out scores where j=1,2, 3… 46

Ex: If examined BCGS at the RSI stage result as below, the Weighted Average Model can be developed accordingly.

Table 4.2 Condition of selected sub parts

Sub Part	**Condition**				
	1 Whether the Part is missing	**2** Cannot Use	**3** Can use with heavy repair	**4** Can use with minor repair	**5** Can use without repair
1.Roof Sheets	No		Yes		
2.Roof beams	No			Yes	
3.End Wall	No			Yes	
4. End Wall columns and beams	No			Yes	

Table 4.3: WAM calculation

		WSM score of the sub part	CRITERIA				
			Cr_1	Cr_2	Cr_3	Cr_4	Cr_5
			$C_{r1} = 1$	$C_{r2} = 1$	$C_{r3} = 0.75$	$C_{r4} = 0.25$	$C_{r5} = 0$
ALTERNATIVES	1.Roof Sheets	3.54	0	0	0.75	0	0
	2.Roof beams	3.88	0	0	0	0.25	0
	3.End Wall	3.02	0	0	0	0.25	0
	4. End Wall columns and beams	3.67	0	0	0	0.25	0

WAM final decayed value of roof sheet: (3.54x0.75) = 2.65

Factors to consider removing parts for reuse

All the received factors in the survey was considered in this case. Three factors were identified for the reuse parts, and those are

i. Items that can use without repair
ii. Items can use with a normal / minor repair.
iii. Item which is very difficult to find and the price is high and it can be used with heavy repair

4.1.3 Proposed Condemn procedure

Based on the results which were obtained through the analysis, new condemning procedure was developed. There only are 2 steps of this procedure.

At the first step the BCGS should be examined and fill the given new RSI report (Appendix 12) accordingly. In the new RSI report, main parts have been more categorized in to sub parts in the new RSI report. As well as in this report user should tick 5 columns on each subpart based on the condition of those parts. The 5 columns state the condition of the parts of BCGS whether a part is missing, Part cannot use, part can use with heavy repair,part can use with normal repair and part can use without repair. The guideline shows the corrosion levels and directs the user on which decision should be taken. The guidelines were attached in appendix13.

Next step is to feed the data intothe developedtool, which is based on Excel. There are only few steps to proceed in that case. In the excel file tool there is a sheet named "RSI report". The user needs to feed obtained RSI report from the inspecting BCGS at step 1 into that sheet. User needs to fill wagon type, sub category, wagon number and current price of scrap into this sheet. Then the subpart list will be generated. Then the condition of the wagon parts needs to be filled accordingly.

Then the tool will be generating the decision, whether the wagon is to condemn or repair and the decision will be displayed in the sheet "output".

4.2Tool development

This is a tool which based on Microsoft Excel. This tool consists with 10 sheets. Out of those 10 sheets 8 sheets are data stored sheets and other 2 sheets for the user to input the data and get the supportive decision.

4.2.1 Excel file

The first 8 sheets consist with all the primary and secondary data. This is the data source for the developed tool. Primary data was collected through the questionnaires, FGD and secondary data were gathered through planning department and the purchasing department of the CME sub department. These 8 sheets are locked sheets and user cannot change the values.The last 2 sheets are unlocked sheets which use for the user to input the data and get the supportive decision.

Sheet 01: All BCGS

Sheet 02: Maintainability

Sheet 03: Availability

Sheet 04: Replace ability

Sheet 05: Market price

Sheet 06: Avg. weights and part list

Sheet 07: Calculation

Sheet 08: Usability of parts

Sheet 09: RSI report

Sheet 10: Output

Sheet 1: All BCGS

The data were collected from Planning office, CME sub department. This data sheet consists with 8 columns and 322 numbers of BCGS details.Though there are many types of wagons and tanks, it has considered only about BCGSwagons under this research. Sheet no 1 consists with all the data of this BCGS wagon which linked to other sheets. Details of BCGS (Bogie covered Good steel), are stored here.

There is only one type of wagons comes under "Wagon Type" which is in column no1 and it is BCGS. EachBCGS has an identical number which states in column no 2 as "Wagon number". There are322 different numbers of BCGS data in this sheet under this column.

In Sri Lankan railroadsystem, there were two types based on the width of the track. Those are narrow gauge with 2 feet 6 inches (762mm) width rail track and broad gauge with 5 feet 6 inches (1676mm) width. The narrow gauged rail track has been used for "Kelani Valley" line, which was originally built from Colombo to Yatiyanthota via Avissawella during 1900 - 1902. It was branched off at Avissawella and extended up to Opanayaka via Ratnapura (completed in 1912). Line to serve the rubber plantations in the area, the railway line between Avissawella and Yatiyanthota was removed in 1942, the line from Homagama to Opanayaka abandoned in 1973. The services were restarted up to Avissawella in 1978. In 1992, a project was started to convert the line to broad gauge. The project was finally completed up to Avissawella (58 km or 36 km) in 1996[27].So at present ball the tracks are broad gauged. When these projects run, there was rolling stock which has imported with narrow wheel gauge to run in this line. But due to this gauge conversion this rolling stock could not be used further. So in this research it has to consider gauge of this wagon to get a decisionin condemning. In this table at column no 3 it states gauge as "Narrow/Broad gauge".

It states the current status of the wagon under “status” in column no 4. It means, whether it is in service or already condemn. Some of the already condemn rolling stocks are still available due to delay in condemning and post condemn procedures.
In columnno 5 is named as “Subcategory”. The most of the BCGS are referred based on manufactured country. Each type is different from others in many features. So, the type is very important when analyzing the data.
Type of Wagon and Tanks
BCGS: Chinese, Indian,Korean, German, Pakistan

“Date put to the traffic” is described in column no 6 which sourced to calculate depreciation of the wagon. Due to these data, there are very old wagons still in running condition. Year 1930 is the oldest BCGS in service related to this data.

Column no7 offers capacity and column named as “Capacity”.The capacity of the wagons which transport solid goods has indicated in metric tonnes (MT) and wagons which transport liquid has indicated in gallons (gal). 47mt is the highest carrying capacity of a BCGS. Column no8 “Cost” provides the cost of each wagon when it purchasing and it is given in Rupees. It is an additional data which can use in future.

Sheet 02: Maintainability data base
This sheet is based on the result which obtained from the questionnaire on maintainability of Chinese BCGS and this sheet consists with 13 columns where the first column provides the main parts of the Chinese BCGS. There are 09 main parts which were divided to sub parts. The second column states 46 numbers of sub parts. There are nine respondents participated in this questionnaire and Column three to eleven provides the responds of each those respondents and heading of each column states the position of the respondent. Twelfth column displays the mode value of each respondent and the thirteenth column shows the assigned value based on 1-10 scale for related to the mode values.

Sheet 03: Availability data base

This sheet is based on the result which obtained from the FGD onavailability of each part of Chinese BCGS. This sheet consists with 4 columns where the first and second columns provide main parts and the subparts of the BCGS.Third column states the respondent value based on 1 to 3 scale and the fourth column shows the assigned value based on 1-10 scale for related to the respondent values.

Sheet 04: Replaceability data base

This sheet is based on the result which obtained from the FGD onreplaceability of each main part of Chinese BCGS and as same as the sheet 03, this sheet consists with 4 columns where the first and second columns provides main parts and the subparts of the BCGS. Third column states the respondent value based on 0,1 scale and the fourth column shows the assigned value based on 0-10 scale for related to the respondent values.

Sheet 05: Market price

This is a secondary data which was gathered from the purchasing department. This sheet is consisting with 5 columns and first and second columns provides main parts and the subparts of the BCGS. Third column consists with the approximate price of each item. There are some sub parts which purchase as a set and others which purchase in the form of raw material. Based on the prices of raw materials and whole set prices the market price is given by the purchasing department. The price has categorizedinto three ranges as low, medium and high based on that price. It is stated in the fourth column and the assigned value based on 0-10 scale is in the fifth column.

Sheet 06: Average weights and part list

This sheet is displayed the summarized data of databases and mass and the material of each sub part. Sheet consists with 11 columns where first column shows the wagon type and second and third column state the main and subparts of the Chinese BCGS accordingly.

Fourth, fifth, sixth and seventh columns consist with assigned values based on 1-10 scale for decision criteria that is maintainability, availability, replace ability and

market price of Chinese BCGS and the weights which were considered on these criteria is displayed above each heading. Based on these assigned values WSM score is calculated and it is stated in column eight. Weights for each criterion assigned as W_R= 4, W_M= 3, W_A = 2, W_{PR} = 1 where W_R, W_M, W_A and W_{PR} represents ability to replace main parts, maintainability of parts, availability of those parts and price of the part respectively.

The ninth column shows the weight of each part based on the average of WSM score. The tenth column shows the material of the subpart. Most of the parts are made fromsteel, but with different grades. As well as very little percentage of other materials such as rubber, copper, aluminium etc. are included here, but in this study only considered material which is in higher percentages in relevant item. Eleventh column displays the mass of each part. It explains the weight of each part before decayed. Mass is rounded figure and it is given in kilograms.

Sheet 07: Calculation

This sheet does the calculationsand summarise the data to express the result using founded data. The sheet consists with 13 columns. All the data in this sheet recall data from relevant sheets and store here for the output.First column states the wagon type and the second column states the wagon number and both these data call from the RSI report of the result file. Third column consists whether it is broad or narrow gauged. The data is called from the sheet all BCGS data. Fourth and fifth columns state for Main part and sub parts respectively, and those data is imported from the RSI report of the result file. Weight of each sub part displayed in column six and these data is called from sheet 06 average weights and mass.

Column seven states the decayed percentage of each sub part and this value is calculated based on condition and average weight of the relevant subpart. Column eight displays whether the part is missing or not. The relevant data is called from RSI report and if the item is missing it is assigned “1” and if it is not “0” is assigned for the relevant subpart. Column nine, ten, eleven and twelve present the conditions of

the subpart and the relevant data is imported from the RSI report. 4 types of conditions are considering here. Those are whether the sub part is “cannot use”, “Can use with heavy repair”, “can use with minor repair” and “can use without repair” and the weights assign for each criterion is 1, 0.75, 0.25 and 0 and these criteria shows in column nine, ten, eleven and twelve respectively. Column thirteen states the mass of the subpart based on condition. If the part is “missing” or in the “cannot use”condition, the mass has sent to zero and if it is not whole mass is considered as current mass. The totalof this column gives the approximate total weight of the condemned wagon.

Sheet 08: Usability of parts

This sheet consists with07 columns and the data which was gathered from the survey conducted in two workshops.The parts of BCGS are interchangeable. Since the scarcity and high price of the parts the removing parts from some wagons are fixed to another. So, the First column shows the sub category and the second column states the replaceable parts.The third column is stated that for which type of wagon can be use this part. The column four, five and six state whether the part can be reused or not. As per the survey finding it can be considered as there are 03 conditions should be fulfilled for the reuse of a subpart.

Condition 1: If the sub part can use without any repair

Condition 2: If the subpart is very difficult to find and the price is high and it can be used with heavy repair

Condition 3: If the part can use with minor repair

Column four, five and six consist with above condition 1,2 and 3 respectively. If the “1” is in the relevant cells belong to those three columns those are the parts that fulfilling the conditions and “0” express the relevant subpart is not fulfilling the condition. The last column states the final decision on the relevant sub part whether to replace or not. If the column cells display as “1” those sub parts are suitable for the replacement and the subparts express “0” do not suitable for the replacement.

Sheet 09: RSI report

This is the Rolling Stock Inspection report. The user can examine the decayed wagon and feed the data into RSI report which gives you a supportive decision. The user input the data to the excel based tool through this sheet. This sheet link with the excel file “data” as well as “Output” sheet. So, through the RSI reportit gathered inputs, align with the data and present the outputs. There are two types of cells, the usershould feed the data for some cells and other cells cannot enter data and those cells generated data the selves. In this sheet, only the white colour cells are to be filled by the user.

In the top of the sheet it displays the topic “RSI Report” and next row displays the date and it is generated by the sheet. The second row is for the user to fill the current price of steel scrap. Since the steel scrap price varying time to time in the world market as well as in local market it can feed accordingly. There is a comment box which says “Enter the current Steel scrap price” and it helps the user.

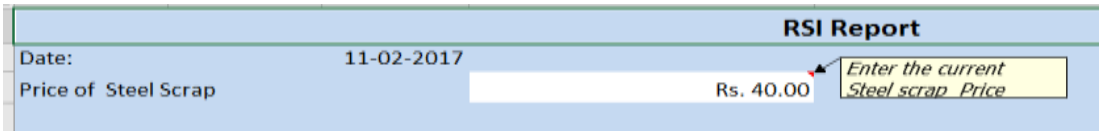

Figure 4.2: Entering scrap price into the RSI report

Then the table comes below and in the first column of the table states for wagon type. Since in this study it only focuses for BCGS the only selection for the wagon type is BCGS. The next column for the sub category of the wagon type and there are five types of sub categories as Chinese, Indian, Korean, German and Pakistan. The user can be selected which type of wagon that he is inspected, and if he cannot be identified the category this cell can leave empty.

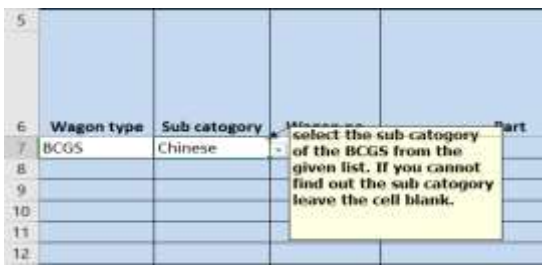

Figure 4.3: Entering sub category in the RSI report

The third column asks for the wagon number. As well as the sub category, the cell can leave blank if the wagon number cannot be identified.

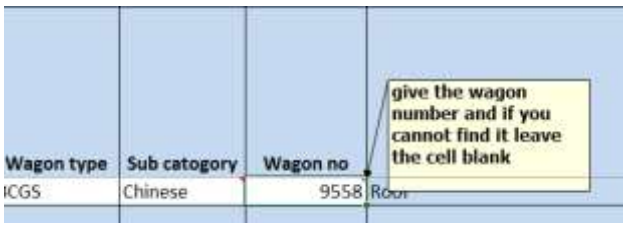

Figure 4.4: Entering wagon number in the RSI report

The fourth and fifth columns states main parts and subparts. These data linked with the wagon type and therefor when the user fills the wagon type these two columns are filled automatically.

The sixth column states "whether the part is missing". The user should indicate "Yes" if the part is missing if the part is available, usershould select the "No" for the relevant cell. The relevant guideline is given in the comment box.

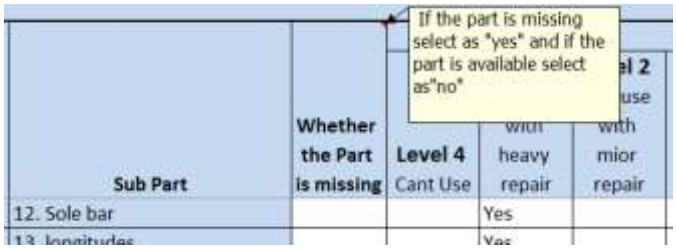

Figure 4.5: Filling the column "whether the part is missing" in the RSI report

Next four columns are to state the decayed condition of the relevant part.This decayed condition has categorized into four levels.

Level 1: Can use without repair

Level 2: Can use with minor repair

Level 3: Can use with heavy repair

Level 4: Cannot use.

These levels are addressed the corrosion level of the subpart. Level 1 to 4 is ordered as corrosion level is increasing. A guideline(Appendix 13) is issued with

photographs of corrosion levels, which clarify levels of corrosions clearly. The guideline only covers the sheet metal and bars whichare covered in large part in a wagon, including wagon body, roof, floor and underframe.

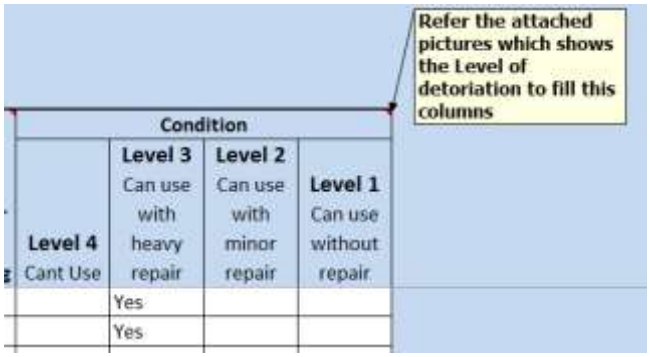

Figure 4.6: Filling condition of the parts ofthe RSI report

If the user fills the RSI report in wrong manner giving “yes” for both part is missing column and “yes” for decayed condition column, it displays an error on the right hand side top corner of the sheet.

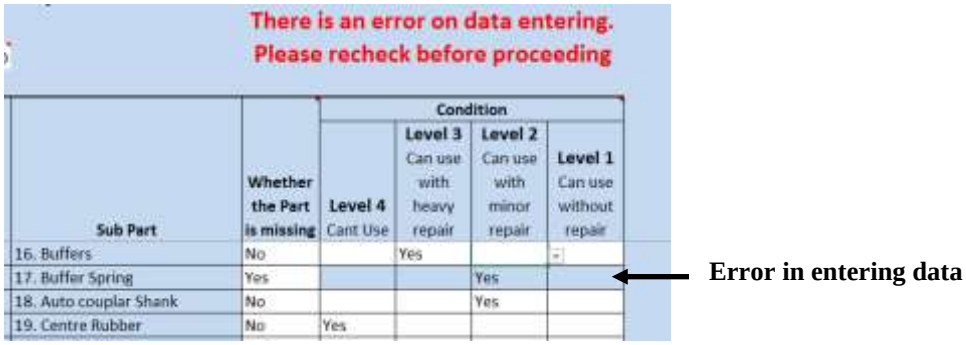

Figure 4.7: When an error occurs in the data entering at the RSI report

Sheet 10: Output

The result is displayed through this excel sheet. All the gathered and analyzed data is used to interpret the output via this sheet. Basically, it gives the decision on the related wagon whether to condemn or repair based on decayed amount. The date is displayed in the first row and wagon type and sub category is given in the second row and wagon number is given in the third row. These data are imported from excel sheet “All BCGS data”.

Seventh row is given the recommendation whether to repair the BCGS or condemn for the scrap.And the column next to the recommendation is given the reason for the decision. If the decayed percentage of the wagon is more than 60% and since it is beyond the economical repair the wagon is recommended for the condemn for the scrap. As well as if the wagon is narrow gauged, it is not in use at present and recommended to the condemn for the scrap. If the decayed percentage of the wagon is less than 60% it is recommended for the repair because the wagon can be used further.

Next three rows provide detail about the scrap. It is displayed as “Scrap” in eighth row and in front of that row it gives the answer “Yes” or “No”. If the answer is given there is “Yes”, then in the next two rows it occurs total scrap value of the wagon and the scrap value after removing usable parts. The scrap value is given in this tool is only for Chinese BCGS because mass has only taken in that type. The total scrap value is calculated based on the current market steel scrap price which given in the RSI report andtotal mass of the BCGS given in the excel sheet “calculation”.

As well as the sub parts, which can be removed from the condemn BCGS for the reuse is given in this sheet. And it conveys for the which type of BCGS can use these parts. That data are given in the table below. The table consists with two columns and first column states the usable part where second column states for which wagons these parts can be used for.

If the user leavesthe wagon sub category and wagon number blank it gives “0” in related cells. The fourth, fifth and sixth rows state the status, age and capacity of the BCGS respectively. As well as it appears #N/A for the Status, Age and Capacity.

Date:	**12-02-2017**	
Wagon:	**BCGS**	**Chinese**
WagonNumber:	**10266**	
status	Not in Service	
Age	37	
Capacity	30 T	
Recomanded to	**Condemn for Scrap because the wagon is beyond echonomical repair**	
Scrap	Yes	
TotalScrap value	Rs. 315,880.00	
Scrap value after removing usable parts	Rs. 147,880.00	

Usable parts:	***For which BCGS this parts can be used for***
Buffers	*BCGS chinese*
Buffer Spring	*BCGS chinese*
Auto coupler Shank	*BCGS chinese*

RSI report | Out put

Figure 4.8: Output excel sheet

5. TOOL VALIDATION

This study is the first attempt to done on rolling stock condemning at SLR. The validation method was conducted to compare current method and the proposed method. Through the validation consistency and the transparency of the results are expected. Consistency states the same result obtain by anyone who examines the same wagon. The transparent refers the way of obtaining results could be explained to another one.Since the current method used in SLR is not a rational based condemning method, the mismatch of the results does not direct that received results are wrong.

Three BCGS were used to validate the tool at the end of the study. Three examiners were examined 2 BCGS and fill the current RSI report accordingly. Then proposed RSI report was filed for the same 2 BCGS by the same 3 examiners and the results were compared. One Indian and one Chinese BCGS were selected in this aspect.

5.1 Indian BCGS 10147

Figure 5.1: Indian BCGS 10147

Indian BCGS 10147 is at Rathmalana CME premises and since it is in very bad condition it was selected to examine at the tool validation stage. At the validation stage, the BCGS has examined by three examiners and submitted the current RSI

report and proposed new RSI report. Then the data new RSI report data feed to the excel based tool which was developed in his study and receive final output. At last the both current and proposed methods can be compared.

Step 1: Examine and filling current RSI report

The Indian BCGS 10147 was inspected individually by examiner 1,2 and 3and current RSI report was filled and submitted. Summary of those 3 current RSI reports is given as below.

Table 5.1: Summary of current RSI reports of Indian BCGS 10147

		Examiner 1	**Examiner 2**	**Examiner 3**
	Number	10147	10147	10147
	Type	Indian BCGS	Indian BCGS	Indian BCGS
	Date put to the traffic	-	-	-
	Age (years)	-	-	-
	Last heavy repaired date	-	-	-
	Parts	**Condition**	**Condition**	**Condition**
1	Roof	70%	75%	70%
2	Body	60%	70%	50%
3	Paneling and ceiling	-	-	-
4	Seat and parcel Racks	-	-	-
5	Doors, Shutters and Shutter frames	50%	70%	60%
6	Water tank and pipes	-	-	-
7	Wiring	-	-	-
8	Floor	75%	80%	70%
9	Underframe	50%	60%	40%
10	Buffer and auto coupling	50%	50%	50%
11	Brake pipe and brake cylinders	40%	50%	60%
12	Bogie	50%	50%	40%
13	Wheels	3'Jipsem Ring wheels, axles can be used	3'Jipsem Ring wheels, axles can be used	0%
14	**Total maintenance**	**56%**	**63%**	**49%**
15	Lacking parts	Brake beam, pull rod, auto coupling, piston rod	Pull rod, auto coupling, piston rod	Brake beam, piston rod, pull rod
	Recommendation	**To repair**	**Form a condemn board**	**To repair**

Step 2: Examine and filling proposed RSI report

As well as the step 1 the Indian BCGS 10147 was inspected individually by examiner 1, 2 and 3and proposed RSI report was filed and submitted (Appendix 15). Summary of those 3 proposed RSI reports is given in (Appendix 16). When the submitted proposed RSI report is examined, it can be identified that deviations among those three reports are very few. All the data that filled in column "Whether a part is missing" is identical in three RSI reports. As well as there is no any deviation among the data filled in level 4 (Cannot use) and level 1 (can use without repair). Minor deviation can be obtained among the data filled in level 3 (Can use with heavy repair) and level 2 (Can use with minor repair).

Step 3: Feed the data into work sheet "RSI report" in tool and generate the output.

At the step 3 the data which obtained through the proposed RSI sheet is entered to the developed excel based tool. Data was entered to the data sheet "RSI report" in excel file "Tool". Output can be given in excel sheet "output" and the data generated there can be summarized as below table.

As per result obtained through the proposed system all the three examined reports are given the same decision to repair the Indian BCGS 10147because the wagon is still can be used. Even the decayed value generated in proposed system is near values as 56.88%, 56.24% and 57.92%.

Table 5.2: Summarisedoutput of BCGS 10147 of proposed system

	Examiner 1		Examiner 2		Examiner 3	
Date:	14-02-2017		14-02-2017		14-02-2017	
Wagon Type:	BCGS		BCGS		BCGS	
Sub category:	Indian		Indian		Indian	
WagonNumber:	10147		10147		10147	
Status	In Service		In Service		In Service	
Age	39		39		39	
Capacity	45 T		45 T		45 T	
Decayed percentage	56.88%		56.24%		57.92%	
Recommended to	Repair because the wagon is still can be used		Repair because the wagon is still can be used		Repair because the wagon is still can be used	
Scrap	No		No		No	
Total Scrap value	-		-		-	
Scrap value after removing usable parts	-		-		-	
	Usable parts:	***For which BCGS this parts can be used for***	***Usable parts:***	***For which BCGS this parts can be used for***	***Usable parts:***	***For which BCGS this parts can be used for***
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

5.2 Chinese BCGS 9619

Figure 5.2: Chinese BCGS 9619

Chinese BCGS 9619 was found at Rathmalana CME premises which is not taken to repair or even not condemn. This wagon has stopped at the CME yard more than 1 year without taking any decision on it. When visually inspects the wagon, it can be identified as many parts are corroded. So, this Chinese BCGS was taken to evaluate the tool using current and proposed methods.

Step 1: Examine and filling current RSI report

The Chinese BCGS 9619 was inspected individually by examiner 1, 2 and 3and current RSI report was filled and submitted. Summary of those 3 current RSI reports is given as below.

Table 5.3: Summary of current RSI reports of Chinese BCGS 9619

		Examiner 1	**Examiner 2**	**Examiner 3**
	Number	9619	9619	9619
	Type	Chinese BCGS	Chinese BCGS	Chinese BCGS
	Date put to the traffic	-	-	-
	Age (years)	-	-	-
	Last heavy repaired date	-	-	-
	Parts	**Condition**	**Condition**	**Condition**
1	Roof	50%	60%	50%
2	Body	60%	65%	50%
3	Paneling and ceiling	-	-	-
4	Seat and parcel Racks	-	-	-
5	Doors, Shutters and Shutter frames	60%	70%	60%
6	Water tank and pipes	-	-	-
7	Wiring	-	-	-
8	Floor	70%	60%	50%
9	Underframe	50%	40%	50%
10	Buffer and auto coupling	75%	75%	65%
11	Brake pipe and brake cylinders	80%	85%	70%
12	Bogie	70%	75%	70%
13	Wheels	70%	3'Jipsem Ring wheels, axels can't be used	70%
14	**Total maintenance**	**65%**	**66%**	**59%**
15	Lacking parts	Auto coupler sets, brake cylinder, brake beam, bearing	Auto coupler set, QSA valve, brake beam, coil spring, bearing	Auto coupler set, brake cylinder, QSA valve, brake beam, coil spring, bearing
	Recommendation	**Form condemn board**	**Form condemn board**	**Repair**

Step 2: Examine and filling proposed RSI report

Same as the step 1 the Chinese BCGS 9619 was inspected individually by examiner 1, 2 and 3and proposed RSI report was filled and submitted (Appendix 18). Summary of those 3 proposed RSI reports is given in (Appendix 19). When these three reports are comparedtogether, it can be identified that the two reports are identical and other report has minor deviations from the others.

Step 3: Feed the data into work sheet “RSI report” in tool and generate the output.

The received data through the new RSI report were fed to the developed excel based system and generated the output in the step 3. Data was entered to the data sheet “RSI report” in excel file “Tool”. Output can be given in excel sheet “output” and the data generated there can be summarized as below table.

The result obtained by 3 examiners is same and the decayed value gives close values as 58.02%, 59.87% and 58.02%. Andthe proposed method recommended to repair the wagon by due to this wagon is still can be used.

Table 5.4: Summarised output of BCGS 9619 of proposed system

	Examiner 1		Examiner 2		Examiner 3	
Date:	02-02-2017		02-02-2017		02-02-2017	
Wagon Type:	BCGS		BCGS		BCGS	
Sub category:	Chinese		Chinese		Chinese	
Wagon Number:	9619		9619		9619	
Status	In Service		In Service		In Service	
Age	52		52		52	
Capacity	30 T		30 T		30 T	
Decayed value	58.02%		59.87%		58.02%	
Recommended to	Repair because the wagon is still can be used		Repair because the wagon is still can be used		Repair because the wagon is still can be used	
Scrap	No		No		No	
Total Scrap value	-		-		-	
Scrap value after removing usable parts	-		-		-	
	Usable parts:	***For which BCGS this parts can be used for***	***Usable parts:***	***For which BCGS this parts can be used for***	***Usable parts:***	***For which BCGS this parts can be used for***
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

5.3 Results

- Indian BCGS 10147

When evaluating the results obtained through the 3 current RSI reports variation between results can be identified. All the 3 examiners have filled number and type of the wagon, but none of them filled date put in the traffic, Age, last heavy repaired date as they do not have relevant information available to them. Different values received for total maintenance percentage among 3 examiners as 56%, 63% and 49% by examiner1, 2 and 3 respectively. Out of 3 reports 2 reports were obtained total maintenance percentage below 60% and recommended to repairwhile 1 report was obtained total maintenance percentage above 60% and recommended to form a condemn board for further evaluation.

If evaluate the received RSI reports, higher deviation of total maintenance in the third examiner's report compared to the other two reports can be identified. The total maintenance value in third report is less and can figure out that he allocated 0% for the condition of the wheel while other two does not allocate any value for the wheel and only given comments. Because of that the total maintenance percentage has decreased in his report. Lack of standardized method can be realized through this result.

As per result obtained through the proposed system all the three examined reports are given the same decision to repair the Indian BCGS 10147 because the wagon is still can be used. Even the decayed value generated in proposed system is near values as 56.88%, 56.24% and 57.92%. Consistency among final decision can be identified in the new system.

Comparing obtained results by both procedures, it can deduce that proposed method has consistency in results which does not change with the user. As well as can examine the decayed value generated in the new system is very closer where in current system got varying values.

- Chinese BCGS 9619

When compare the 3 current RSI reports which were submitted by examiners, 2out of 3 recommendedto form a condemn board for further evaluation since this BCGS is beyond economical repair while one report recommended to repair the BCGS. The values obtained for total maintenance as 65%, 66%, and 59% by examiner 1,2 and 3 respectively. All the 3 examiners have filled number and type of the wagon, but none of them filled date put in the traffic, Age, last heavy repaired date as they do not have relevant information available to them.Evaluating by this RSI reports it can see the critical parts of the wagon such as under frame, roof and body are in good condition where easily replaceable parts such as bogie, buffer and auto coupling, wheel are in bad condition.

When consider the result obtained through the new method, all 3 respondents were given decision to recommending repair the Chinese BCGS 9619 because the wagon is still can be used. Even the decayed values are closer as 58.02%, 59.87% and 58.02%.

When the Received resultsfrom both methods arecomparing a deviation was identified.In current method 2 reports out of 3 reports proposed to form a condemn board for further evaluation whileanother report proposed to repair the BCGS. In the proposed method, all the examiners recommended to repair the wagon due to this wagon is still can be used.When further evaluate the deviation of this result, it can be seen that the parts with the high weight are still in good condition while the parts with low weights are in bad condition. Since in the current method does not consider about the importance of the parts the result has got deviation.

Comparing obtained results by both procedures, it can be concluded that the proposed method has consistency in results which does not change with the user. As well as can examine the decayed value generated in the current system is very close.

6. DISCUSSION AND CONCLUSION

The intention of this study is to develop a decision support mechanism to condemn train wagon in the SLR. When consider the railway transportation, there are locomotives, carriages, wagons, tanks, rail buses, machineries, rail tracks etc. which subject to deteriorate with the time. Most of thisstuffismade frommetal and when these stuffs are disposed a large monetary value hide in there.So, it is very important to identify the correct time to dispose each item.

In the current method, condition of rolling stock is identified by visual inspection and decayed percentage is decided by experience and there is no any other rational is considered in this aspect. Therefore the decision is varying from person to person. Since the current method is a subjective,the delaying in the decision makingon condemning isoccurred.Due to delays in decision making,many deteriorated rolling stock can be seen in stopping conditionon rail tracks, sheds and yards. Thus, these deteriorated rolling stock subjected to environmental conditions and decayed further and their monetary value decreases rapidly.

It was found out the current method which is used in the SLR is subjective. A decision support mechanism to condemn train wagon in SLR in consistent and transparent manner is developed through this study. Involvement in the human factor in condemning process is minimized through this new method. Since the developed condemned method is well defined, the decisions on condemning can beacceleratedand it saves the money, time, much paperworkand free the space on rail tracks, sheds and yards.

Instead of considering all the rolling stock, machineries, rail tracks, etc., it is only focused on BCGS which comes under the wagon. In this developed methodthe decision is taken whether theBCGSis to be condemned or to be repaired. And if the BCGS is in condemning status this mechanism suggests what parts to be removed from the BCGS for future use.The scrap value of Chinese BCGS is calculated from

this tool. The tool was developed based on MS excel. Primary data were collected from SLR employees through questionnaires, FGD and surveys.

The lifetime of a vehicle depends on basically fatigue failure [1] and corrosion [2]. In that case, when a vehicle is disposed two of these factors should be considered. Vehicle's life time can be expanded through the proper maintenance and it is needed to be done a general overhaul for rail wagon once in three years[6]. As a developing country, which is not manufactured rolling stock,Sri Lankashould use rolling stock more than their evaluated life time. Since letting old rolling stock into the service it has increased risk at rail transportation as well. So, the frequent examination must be done in rolling stock. Repairs and replacements of parts must be done at the correct time. Depreciation represents the amount by which the average condition of the physical property has deteriorated below the original or new condition [6]. Out of two factors, fatigue and corrosion, in this study it considered only the factor corrosion for the decision on condemning the BCGS.

The depreciation rates in SLR vary from global depreciation rates. Though the useful lifetime of a wagon is around 20 to 25 years in global, 87 years old BCGSis in running condition in the SLR. It seems SLR is unusually behind from the global models. In that case need an evaluating method to check whether those rolling stocks in the service are good for running. So, this study helps SLR to lead towards the global models with making quick decisions on condemning or repair.

Four factors have been found out through this study, which are affected for the importance of each part and those are Ability of replacing main part, maintainability of parts, availability of those parts in the market and the price of the decayed parts and these factors can be ranked 1,2,3, and 4 accordingly. When calculate the decayed amount five conditions are considered and those are part is missing, part cannot use, part can use with heavy repair, part can use with normal repair and part can use without repair. Based on these factors and conditions, using WSM and WAM calculate the weight for each part.

In the current method if the average decayed percentage in RSI report exceeds 60%, the rolling stock is sentto the condemning board approval. As well as in the proposed method this value of 60% continuous in for the decision making on the condemning. This is the first attempt in SLR to develop a decision support mechanism to condemn the rolling stock.In the current method, the decision on condemning taking based on experience.So, this study is the first effort on converting this experience based method into rational based method.In that case,only availablemethod of data gathering and initializing of this study was their experience. Though the current method is not a rational based method proposed method had to be compared with the current method at the validating stage since no any other way to check the developed tool. On the other hand,less literature could be found in the method of condemning vehicles based on corrosion because most of the railways dispose rolling stock at the end of their lifetime.

SLR has bought many types of rolling stock so far. 57 types of wagons have been bought to the SLR from 1884. Under this 57 typeof wagons, there are many sub categories which were based on the country of origin and the batch of production. There are many differences can be found between each of these categories. Therefore, studying all these types and develops methods for each type is impossible. So BCGS were selected as a commonly used wagon type.

FUTURE WORKS

Since this is the very first attempt on developing a decision supporting mechanism to condemn rolling stock in SLR, there are great amount of future works ahead. Current method was based on experience and it was converted to excel based tool through this study. In that case surveys, FGDs, questionnaires were conducted to gather data. Based on gathered data weighted factors was assigned to each sub parts. Thus, these weighted values can be fine tune in future by conducting many surveys. As well as, at each RSI report filling occasion can be considered as a data gathering point and these data can be used to improve the developed system.

At the end of the study data validation was done based on two BCGS and three examiners. But this number is to be improved. Number of BCGS that evaluated in this study should be expanded in future to improve the developed system.

As a very important factor fatigue failure should be studied in future studies and consider in the decision making on repair. New methods should be identified to analyze the cyclic fatigue of rolling wagons. In that case parts can be replaced before reaching to the fatigue failure. The new method should be implemented to identify the corrosion levels instead of visual inspection. Other than to the visual inspection there are method as Ultrasonic Inspection, Radiographic Inspection, Eddy Current Inspection, Electromagnetic Acoustic Transducer (EMAT) and Thermo graphic Inspection [28]. Some of these methods are very expensive methods. Therefore, after studying these methods, cost effective method can be identified. The most important thing is, it leads to develop a system with minimum bias to the human factors and human errors.

CONCLUSION

Inconsistency and opaque decision for condemning is caused to the loss in assets. A decision support mechanism to value and condemn train wagons in SLR was developed through this study.The tool which was developed based on MS Excel creates the consistency and transparent decision for the condemning process of the BCGS.

The experience of skilled employees in examining and inspecting wagon for the condemning was the basis for the development method. Through the study, practice of current method was improved and converted into the MS Excel based decision supporting mechanism and it presents unbiased decision.

Periodical inspection of BCGSwith the tool subjected to avoid decision delay for condemning wagons and accelerated decision facilitate more financial benefits to the Sri Lanka Railway Department.

REFERENCES

[1] *Fatigue Total Life Approaches* (2000) [Online]. Available: http://materials.iisc.ernet.in/~ramu/Fatigue.pdf

[2] *Modelling Corrosion for Automotive Applications* (n.d.) [online].Available:https://www.comsol.com/blogs/modeling-corrosion-for-automotive-applications/

[3] *Car durability and design* (n.d.) [Online]. Available: http://corrosion-doctors.org/Car/Life.htm

[4] *Depreciation Explained Car Finance Glossary*(n.d.) [Online]. Available: https://creditplus.co.uk/car-finance-glossary/d/depreciation/

[5] Y.C. Peles. (1990, Apr.). On Accounting and Economics Methods of Depreciation. *Journal of Accounting, Auditing {&} Finance* [Online].5(2), 309–327. Available:https://doi.org/10.1177/0148558X9000500214

[6] F.A. Delano. (1908, Nov.). The Application of a Depreciation Charge in Railway Accounting. *Journal of Political Economy* [Online]. 16(9), 585-601. Available: http://www.journals.uchicago.edu/doi/abs/10.1086/251472

[7] L. Revolvy. (n.d.).*Rail freight transport* [Online]. Available: https://www.revolvy.com/main/index.php?s=Rail freight transport

[8] L. Revolvy. (n.d.). *Goods wagon*[Online].Available: https://www.revolvy.com/main/index.php?s=Goods wagon&item_type=topic

[9] A. M. Guranowska, J. Merkisz, M. Jacyna, D. Pyza and H. Stawecka. (2014). Rail vehicles recycling. *WIT Transactions on the Built Environment*, 135,425-436. Available: http://doi.org/10.2495/CR140351

[10] Inland Revenue Department of New Zealand. (2015 Feb). General depreciationrates. 56-57. Available: http://www.ird.govt.nz/resources/3/0/303acb9b-f2df-4267-bdb9-b22e3f983889/ir265.pdf

[11] The Gazette of India Extraordinary. (2013). The Companies Act, 150(Dl), 294.

[12] K. Storchmann. (2004). On the depreciation of automobiles An international comparison. *Transportation*, 31(4), 371–408. Available: http://doi.org/10.1023/B:PORT.0000037087.10954.72

[13] Sri Lanka Accounting Standard SLAS 18. (2012 Jul). Property, Plant and Equipment (PPE), 1–4.

[14] M. Loughran. (n.d.)*Depreciation Methods* [Online].Available: http://www.dummies.com/business/accounting/depreciation-methods/

[15] Investopedia. (2014 Jun). *Types Of Depreciation Complete Guide To Corporate Finance* [Online].Available: http://www.investopedia.com/ walkthrough/corporate-finance/2/depreciation/types-depreciation.aspx

[16] *Y.C.Peles. (2016), "On the depreciation of automobile",International Journal of Transport Economics, Vol. 15, No. 1 pp. 43-54 Feb.1988*

[17] How Car Buy Rater Works The Methods It Uses To Evaluate Cars (n.d.) [Online]. Available:http://www.fountainware.com/Products/carbuyer/theory. htm

[18] *Chapter 3 Scrap Management in Indian Railways* (2008) [Online]. Available: http://www.cag.gov.in/sites/default/files/old_reports/union/union_performanc e/2007_2008/Railways/Report_no_8/chap_3.pdf

[19] Shotateken. (2012). *Guide to Great Survey Design*. [Online]. Available:https://www.scribd.com/document/355006745/SurveyGizmo-Ebook-Guide-To-Great-Survey-Design-pdf

[20] C. Kao (2010). Weight determination for consistently ranking alternatives in multiple criteria decision analysis. *Applied Mathematical Modelling* [Online]. 34(7), 1779–1787. Available: http://doi.org/10.1016/j.apm.2009.09.022

[21] I.E. Allen and C.A.Seaman. (2007,July).*Likert Scales and Data Analyses* [Online].Available: http://rube.asq.org/quality-progress/2007/07/statistics/likert-scales-and-data-analyses.html

[22] *Levels of Measurement*(2016,Oct.20) [Online]Available: http://www.socialresearchmethods.net/kb/measlevl.php

[23] *Analysing Likert Scale/Type Data* (n.d.) [Online]. Available:https://www.google.lk/search?q=ANALYSING+LIKERT+SCALE

%2FTYPE+DATA.&oq=ANALYSING+LIKERT+SCALE%2FTYPE+DATA.&aqs=chrome..69i57j0l5.1839j0j4&sourceid=chrome&ie=UTF-8

[24] *Research tools Focus group discussion* (2009, January 01) [Online].Available:https://www.odi.org/publications/5695-focus-group-discussion

[25] *Questionnaires, Focus Groups and Interviews* (2000) [Online]. Available: https://members.scouts.org.uk/factsheets/ FS310608.pdf

[26] E. Triantaphyllou(2000). *Multi-Criteria Decision Making Methods: A Comparative Study*. [Online]. Available: http://doi.org/10.1007/978-1-4757-3157-6

[27] V. Wickremeratne, and K.D. Perera (n.d.). *Railways of Sri Lanka*[Online]. Available: http://www.infolanka.com/org/mrail/slrails.html

[28] B.D. Howard, K. Gibbs, and J.B.Elder(2003 Dec.). *Corrosion detection devices.* [Online]. Available: http://sti.srs.gov/fulltext/ms2003881/ms2003881.pdf