

A STUDY OF THE EFFICACY OF THE SYSTEM OF WORKERS' PARTICIPATION IN MANAGEMENT IN PAPER INDUSTRY OF INDIA WITH SPECIAL REFERENCE TO CACHAR PAPER MILL

Bhartrihari Pandiya¹, Arti Gupta²

^{1,2} Indian Institute of Information Technology, Allahabad, (India)

ABSTRACT

Industrial revolution in the 18th century has redefined industrial democracy and it is one of the vital issues in industrial management as it influences the functioning and efficacy of the industry. Paper is more than an industrial product. It is the cultural barometer even in the age of computer and internet. Thus in our study, efficacy of workers participation in management (WPM) is analyzed in Cachar Paper Mill (CPM), which is a unit of Hindustan Paper Mill (HPC).

I. OBJECTIVES

Our objective was to study the existing system of workers participation in management in CPM and to measure the efficacy of the system of WPM in CPM as per the perception of the executives and workers representatives.

II. METHODOLOGY

A variety of literature was surveyed for the theoretical aspect of the study. Then initially some selected managers and union leaders were interviewed to know their perceptions about the tools and parameters which may ascertain the degree of efficacy of WPM in that unit. After their views on the tools, two different sets of questionnaires were prepared for Workers' representatives and executives. Since the unit chosen employs a large no. of employees, thus sampling was done. 5 % of the workers representatives and 10 % of executives of the unit were targeted. After collecting the views of both the parties the data was compiled, analyzed and interpreted.

III. MAJOR FINDINGS

The study reveals that there are four trade unions in operation in CPM. Cachar paper Project Workers and Employees' Union, Project Workers' Union, Project Mazdur Union, Mill Mazdur Union. The first one is recognized and rest three only registered. Thus right to sign the agreement lies with the recognized unions for three years. Also it was found that there were seven forums in operation where workers participate. The tenure for the forums is two years. The ten questions put to the managements representatives aimed to understand their opinion about workers representation and issues related to it. Its results were very interesting as percentage of the responses were moderate.?? Finally it was found that the performance of the Joint Bipartite Forum was found as the best on almost all the counts and Works Committee was next. The performance of Canteen

Committee, Shop Floor Council and Safety Committee was found poor. The other forums such as House Allotment Committee and Communication Committee were found moderate.

IV. IMPLICATION TO INDUSTRY

Thus our hypothesis that in view of the Workers' Representation of CPM, the system of WPM in CPM is efficacious to little extent, in this case does not hold fully true as good number of Workers' Representatives held good opinion about the functioning of at least one-third forums. Thus the functioning of the Forums/Committees should be improved. The management should initiate certain efforts to improve the perception of the parties.

V. SIGNIFICANCE OF THE STUDY

The importance of contribution of industries towards economic growth of a country is well known. Not to say that this contribution becomes more important when the countries are developing ones specially the one like India.

Ensuing a smooth functioning of industries, specially the large ones, therefore becomes a compulsory requirement. However, it is not an easy task to ensure the smooth functioning of the industries because of the increasing challenges like liberalization and globalization which has apart from others, brought on the fore cut throat competition, which insists for further reduction in cost, transfer of technology which apart from others requires timely updating the knowledge and the skills of employees, fast changing requirements and preferences of the customers which forces more spending on Research and Development on the one hand and the shortening of the life cycle of the product and services on the other and the fast changing amount and type of control over the industries by governmental and even the non governmental agencies like consumer protection forums etc.

Experts have been devoting their energy to identify the factors which are capable of motivating the workers to perform and contribute the best. During the initial days of industrialization it was thought that it is the money alone that helps in addressing various needs of the workers which can motivate the workers to work more. It was only in course of time that experts discovered that money can help in motivating workers only to a certain extent. Beyond this they can be motivated by such incentives which help them in addressing their esteem needs and the needs related to self actualization. Money can help in ensuring their physical presence on the work place. If the mental and emotional involvement of the employees is to be ensured then they may have to be given authority in sharing the decision making. Experiments then started taking place to test the efficacy of this tool. Surprisingly in most of those regions and industries where the workers had already been provided fair wages the schemes like WPM, which gives an opportunity to workers to share in the decision making process of the industry, showed encouraging results though in varying degrees.

It was experienced that when given the opportunity of participation they consider themselves an integral part of the industry rather than mere working hands. Participation provides the employees to satisfy their esteem needs by expressing themselves their views and realizing that they are the equal partners in the industry.

(1). Tom Peters contends that the emphasis on human resource in the development of new ways of organizational thinking requires "flexibility by empowering people". More specifically, he argues that this power can most effectively be tapped when people are gathered in human –scale groupings that is, teams, more precisely, self managing teams. (1)

(2). The problems according to theory y, is human being. Managers should take advantage of their subordinates' willingness and ability to work by providing a climate that will not only bring out the best in staff members but will give them room for personal improvement. Participative management becomes the ideal. (2)

(3). Managers must encourage full participation (of workers) in important matters continually broadening subordinate self direction and self control. (3)

(4). In organizational terms, people want to be good at their jobs; they also want to feel that they are achieving something important when they perform their jobs. Managers have many ways of fulfilling both types of esteem needs in subordinates by providing challenging work assignment, by obtaining performance feedback, by recognizing performance, by encouraging them and by involving subordinates in goal setting and decision making. (4)

But ensuring the willing co-operation of the workers, in order to have their best contribution towards the attainment of the organizational goals, has always been an arduous task for experts. Unlike the past when the workers in many cases were treated like a commodity, today's workers are more educated, cautious, united and sensitive to their need and preferences and aware of their rights. Even otherwise a worker, being a human being needs to be treated differently than the other factors of production.

VI. HYPOTHESIS

1. In view of the executives of CPM the system of WPM in CPM is efficacious to a large extent.
2. In view of the Workers' Representatives of CPM the system of WPM in CPM is efficacious to a little extent.

VII. METHODOLOGY

To achieve the objectives of the study the investigations have been carried out in the following ways:

Initially some selected managers and union leaders were interviewed to know their perceptions about the tools and parameters which may be used to ascertain the degree of efficacy of workers' participation in management in any industrial unit and more so in the units like Cachar paper mill.

This exercise was conceived as pilot survey. This exercise was considered necessary for the reason that often the set of audience selected for interview/answering the questionnaire do not feel fully satisfied with the tools and parameters used by the researcher to elicit their opinion on the matter concerned, partly because they feel that the tools and parameters used are insufficient while partly they do not find themselves in full agreement with those tools and parameters which have been proposed by the researchers to conduct the study.

After the views of selected managers and union leaders, over the tools and parameters, were elicited these were merged with the ones which have till now been developed by the experts of the subject over the matter-off course after ensuring the avoidance of any duplication of these.

After discovering the tools and parameters, with the help of which the matter could be probed thoroughly, two different sets of questionnaires were prepared for two different sets of work-force of the industry i.e., Workers' Representatives and the Executives so that the views of not only each category of personnel could be had but also these could be cross- checked on vital matters wherever so possible and necessary. Since the unit chosen for the study employs a large number of employees, the number of persons interviewed through questionnaires had to be limited and therefore sampling was naturally an ideal way to address the objectives.

Even though initially it was proposed to interview, through questionnaires, approximately 5% of the Workers' Representatives and 10% of Executives of the unit, this target had to be reviewed in light of the fact that a good number of Workers' Representatives and also Managements' Representatives were found representing their class in many forums. Finally approximately 7% of the executives i.e. 17 and 3% of the Workers' Representatives' i.e. 30 were interviewed for the purpose. The sample includes not only blue and white collar workers and executives but also a cross-section of the employees/executives covering major departments/sections/ shop floors, both the genders, variety of educational background, various income and age groups and other such categories on the basis of which a work force is ordinarily divided.

These 30 Workers' Representatives are those who represent the workers in various bi-partite forums of CPM and are drawn from all kinds of unions i.e. the recognized union and also the non-recognized ones i.e. registered, though a majority of them are apart from recognized union.

After collecting the views of both the groups, the same have been compiled, analyzed and interpreted. In order to address the theoretical needs of the study the dependence has been made on a variety of literature which includes books, text and reference both, journals, research studies, published and unpublished along-with the material which was provided by the management of CPM in the form of booklets, circulars, cyclostyled materials and in other forms.

VIII. MAJOR LIMITATION OF THE STUDY

The efficacy of the system of WPM in CPM is proposed to be measured only through the study of perceptions of randomly selected Workers' Representatives and the Executives of CPM on the functioning of selected bi and tri-partite forums under operation at CPM.

IX. CONCLUSIONS AND SUGGESTIONS

In order to address the thrust of the first objective a detailed study of the existing system of Workers' Participation in Management at work in Cachar Paper Mill was carried on and completed.

Since the trade unions are indispensable for the schemes like Workers' Participation in Management it was considered apt to have a detailed study about these too and even before having a study about the scheme of Workers' Participation in Management at work in Cachar Paper Mill.

X. TRADE UNIONS IN CACHAR PAPER MILL

The study revealed that there are four trade unions in operation in Cachar Paper Mill. These are:

1. Cachar Paper Project Workers' and Employees' Union
2. Cachar Paper Project Workers' Union
3. Cachar Paper Project Mazdur Union
4. Cachar Paper Mill Mazdur Sangh

Out of the four above the first one i.e. Cachar Paper Project Workers' and Employees' union is a recognized one and the remaining three are only registered ones. Not to say that the right to sign the agreements with management on behalf of the workers lies with the recognized unions i.e. Cachar Paper Project Workers' and Employees' Union. As per the provisions in this regard a union is allowed to enjoy the status of a recognized Union for a period of three years.

In CPM out of the registered unions that union is declared as the recognized one which enjoys confidence of the majority of the workers. The fact that which union enjoys the majority support is ascertained through a process of election. However in case any one union fails to enjoy the confidence of workers then a combination of two (or more) such unions is accorded the status of Recognized Union who together enjoy the support of more than half of the permanent workers of CPM.

The union which is now operating as the recognized one i.e. Cachar Paper Project Workers' and Employees' Union has been working since 1984 and is the oldest one. The union has been functioning democratically as the elections to elect the office bearers and the members of the Executive Body take place regularly as per the provisions of the constitution of the union.

XI. THE SCHEME OF WORKERS' PARTICIPATION IN MANAGEMENT IN CPM

The study revealed that there are seven forums in operation in the unit which provide the opportunity to workers to participate in it through their representatives. Out of these seven forums one i.e. Joint Bi-partite Forums operates at corporate level i.e. Hindustan Paper Corporation and five i.e. Works Committee, Safety Committee, House allotment Committee, Communication Meeting and Canteen Committee contribute at unit level. One committee i.e. Shop Floor Councils function at departmental/shop floor level.

Out of these seven Forums four are represented by the workers through such Workers' Representatives who are nominated by the Recognized Union for the purpose. These are Safety Committee, House allotment Committee, Communication Meeting and Shop Floor Councils. Thus it is clear that these four Forums get representation of the workers only through Recognised Union whereas two forums i.e. Works Committee and Canteen Committee are such which are represented by the workers through their representatives who are elected for the purpose (not nominated by the Recognised Union) from amongst (any of) the four unions operating in the organization. Not to say that these representatives could be those too who belong to registered unions and not necessarily from the Recognised one. One forum i.e. Communication Meeting gets representation of the workers through all the members of the Executive Committee of the Recognized Union.

The tenure of all the forums is two years, except the joint Bi-partite Forum which is restructured after a period of three years.

Out of the seven forums one i.e. Canteen Committee, is such where the representation from both the sides i.e. the management and the workers is equal with three members from both the sides. Further House Allotment Committee is one such where the composition is 3+2 i.e. three 3 Representatives from the side of the workers and two representing management. Different from the composition of the above two committees the Works Committee and the Safety Committee are represented by ten representatives each from both the sides. Communication meeting and Shop Floor Councils are such forums where the representation of both the sides is not equal. In communication meeting the management is represented by all the Chief Executive Directors concerned and the HODs, and the workers by the entire Executive Body of the Recognized Union. The Shop Floor Councils too are not represented equally by both the sides.

The Shop Floor Councils are headed by the Head of the concerned Shop Floor Councils. Other Management Representatives, in this Forum, are nominated by DGM HRES. Generally Sr. Managers are nominated in Shop Floor Councils as

members by DGM-HRES-Joint Bi-partite Forum, a corporate level body is represented by the management generally by Director-Finance, General Manager HRES of CHQ and DGMs of all the four units (Ex-Officio). The workers representatives in this Forum are nominated by the Recognised unions of all the four constituent units of HPC.

Except the Joint Bipartite Forum, which meets once in six months, all the other Forums' meetings' frequency is either once in three months or monthly. Those which meet once in three months are Works Committee, Safety Committee and House Allotment Committee. Forums meeting monthly are Canteen Committee, Communication Meeting and Shop Floor Councils.

In order to address the requirements of the second objective i.e. to measure the efficacy of the system of WPM in CPM as per the Executives' perception. 17 selected Executives were interviewed on a variety of matters related to WPM in CPM.

In reply to first question, which was aimed at knowing the Executives' perception about the extent of Workers' Representatives understanding of the matters in the agenda of the meeting concerned, almost 95% (94.11%) managers reported that the understanding of the Workers' Representatives of agenda matters is Moderate.

The responses of the Management Representatives for the second question which was aimed at knowing the extent of Workers' Representatives sticking to agenda matters during the meetings as per the perception of Executives, was almost on the same lines i.e. Moderate as reported by 82.35% Executives interviewed, as it was in earlier case.

When asked from Executives about the degree of Co-operation Workers' Representatives extend during the meetings of participative forums, they were divided in almost two equal lots. A majority of the executives (52.94%) reported the co-operation of the Workers' Representatives as Moderate, whereas almost a similar percentage of them (47.05%) found it high.

The fourth question, the replies of which had to be given in a descriptive form, tried to know the special efforts that are taken by the management to ensure the presence of quorum. Almost two third Executives did not reply this question and remaining one third narrated that the information is communicated to the members of the forum, which means practically no special efforts, are made to ensure the quorum by the management.

The fifth question too tried to know the perception of the Management Representatives in a descriptive manner. It was about the reasons related to late implementation of some of the decisions of the participative forums. Like in case of earlier question, here too almost two third respondents did not mention any reason, whereas among the remaining once most of them wrote that the decisions are implemented in time.

The next question was about the extent of the implementation of the decisions as per the letter and the spirit. Less than half (41.17%) of the executives were of the view that the decisions are implemented in the letter and the spirit to a Moderate extent, whereas 23.52% of them were of the view that these are implemented following the spirit to a High extent.

Against the supplementary question of the above, which tried to elicit the reasons of non-implementation of some of the decisions in letter and spirit, literally nothing came out as no one mentioned any reason. Instead, some of them preferred to write Not Applicable, whereas others left the column blank. Technically speaking those respondents who had in response to earlier question agreed that the decisions in some cases are not implemented in letter and spirit, should have attempted this question. This was perhaps because of the apathetic/negligent attitude of the Management Representatives towards the task of filling in questionnaires

quite often as good number of researchers from many educational institutions approach them for the purpose. May be that they did so because they were in hurry.

The last but one question was aimed at noticing the degree of satisfaction of the Executives over the overall functioning of WPM in CPM. Almost 53% (52.94%) of the Executives interviewed were moderately satisfied on the matter whereas a little less than these i.e. 47.05% were highly satisfied.

The last question was put to them to know their perception over the existence of two different systems of representation of the workers in the forums i.e. Election and the Nomination by the Recognized Union. Since the replies were not sought against any structured objective type of possible answers, here too the respondents in good number left the question unattended.

Our hypothesis that in view of the executives of CPM the system of WPM is efficacious to a large extent thus comes true as a large percentage of Executives has reported favorably about the functioning of various counts of WPM in operation at CPM.

The requirements of the third objective, i.e. to measure the efficacy of the system of WPM in Cachar Paper Mill as per the perception of Workers' Representatives, were tried to be addressed by knowing the views of 30 Workers' Representatives on a variety of matters related to WPM in CPM.

The first query was aimed at knowing as to how many Workers' Representatives are acquainted with the existence and the functioning of seven participative forums of CPM. What came out was a very high percentage of Workers' Representatives ranging from 90 to 93) knew that Works Committee, Safety Committee, Communication Meeting, House Allotment Committee, Canteen Committee and Shop Floor Councils were in operation at CPM. Those who knew about Joint Bipartite Forum were only 53.33% of the respondents.

On an enquiry that whether the existing number of committees is sufficient to ensure a fair participation by workers, almost two third respondents (63.33%) were of the view that the existing forums are sufficient. All remaining 36.67% did not attempt the question and left the column blank. Not to say that none wanted to add more forums in the list.

To the question that which of the committees meetings are not held as per the provisions of interval in this regard, it came out that the Canteen Committee is the major defaulter on this count as 53.33% Workers' Representatives reported adversely about it. Joint Bi-partite Forum and Safety Committee were noted as the good performers on this count.

To the question that notices regarding which of the committees meetings are not sent in time as per the provisions, it is found that the performance of House Allotment Committee and Canteen Committee is comparatively poorest as 33.33% Workers' Representatives (in each case) opined like that. The performance of Joint Bi-partite Forum and Works Committee was found good on this count too as none spoke against these.

To the question that whether or not the agenda of the meetings is circulated in time, it came out that except Joint Bipartite Forum and Safety Committee (0 percent in both the cases) the performance of almost all the committees was considered poor by approximately 30% of the respondents.

On the enquiry that whether or not the minutes of the blast meeting are circulated well before the next meeting, we found that Shop Floor Councils and Communication Meeting were the major defaulters as 40% and 36.66% Workers' Representatives respectively opined negatively about these two. Whereas Joint Bipartite Forum and Works Committee were found Champions here too as none opined against these two.

On the enquiry that which of the committee's meetings could not be held because of lack of quorum, we found that Joint Bipartite Forum, Communication Meeting, House Allotment Committee and Canteen Committee performed well as none raised any finger against these. About other matters of lack of quorum there were discrepancies found in the replies by the Workers' Representatives for the question numbered 6 (including the one on personal information) and the one under discussion.

While trying to know that the decisions of which of the following committees were not implemented in time, what came out was the performance of Shop Floor Councils was considered to be the worst as 76.67% of the Workers' Representatives opined so, and that of the Joint Bipartite Forum as the best as none opined his mouth against this. The performance of other forums on this count was somewhat poor.

In the process of knowing that the decisions of which of the committees were not implemented as per the letter and the spirit, the enquiry revealed that the performance of Joint Bipartite Forum is the best on this count as none made an adverse entry. The negative remark for Works Committee on this count was by only a negligible percentage (3.33) of Workers' Representatives. The performance of all other forums on this count was not good in the opinion of a comparatively lesser percentage of Workers' Representatives (ranging between 6.67% to 16.67%).

To the question that how many times it had happened that a part decision, over a matter which was scheduled to be discussed in the meeting, was already taken by the management, 63.33% Workers' Representatives opined-Always. The position of the Safety Committee and Communication Meeting was only slightly better as 60% and 56.67% Workers' Representatives had a similar opinion about these two i.e. Always. Surprisingly the Workers' Representatives views about Canteen Committee on this count-were quite favorable as none suggested the frequency as-Always.

The next question which enquired the views of the Workers' Representatives was about accuracy of the recording of the minutes of the meetings. This, unlike the other questions, was put in a positive form. Communication meeting topped the list on this count as 53.33% Workers' Representatives held a high opinion about this forum. The percentage of Workers' Representatives declaring the recording of the minutes accurate was 40 each in case of Joint Bipartite Forum, Works Committee and Safety Committee, Canteen Committee was the lowest ebb in the performance on this count as only 6.67% Workers' Representatives said so.

Sharing their degree of satisfaction on the overall performance of the system of WPM in CPM, 66.67% Workers' Representatives in case of Communication Meeting and 60% of them in case of Joint Bipartite Forum held a high opinion in literal sense as they were satisfied to a high degree. The performance of Works Committee was in a sense better than others that 80% Workers' Representatives found it Moderate whereas in case of other committees the opinion of Workers' Representatives was poor.

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THE EFFECT OF CRASHWORTHINESS PARAMETERS FOR VEHICLE BODY

A.A. Faieza¹, H. Shahul²

^{1,2}*Mechanical and Manufacturing System Department, Faculty of Engineering,
Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia*

ABSTRACT

With the modernization and globalization of the world we live in, use of vehicles have become very important. Increasing number of vehicle on the road has led to an increase in accidents. Vehicle safety has become more paramount of an issue than it ever was and vehicle manufacturers strive to make their products safer for its occupants and other road users. One of the most important aspects of vehicle safety is the crashworthiness of the vehicle. Balancing the vehicle design, weight and crashworthiness features has become a dilemma for the safety engineers. This paper would review the core crashworthiness parameters and briefly discuss the effects of those parameters on a vehicle body.

Keyword: *Crashworthiness Parameters, Effects On Vehicle Body, Vehicle Design*

I. INTRODUCTION

Every year the amount of vehicle produced and the people using them have been increasing. Different types of drivers, some very careful and some very reckless, sit behind the wheels. With this increasing amount of vehicle usage, road traffic and reckless driving, the number of vehicle accidents and accident fatalities has also increased. Eventhough there are accident prevention guidelines and traffic rules, many fall victim to these life threatening accidents. According to the statistics from the National Highway Traffic Safety Administration (NHTSA) of the United States [1], after a decline in motor vehicle crashes and fatalities for 6 straight years since 2005, the number had increased again in 2012. In United States alone, 45,586 vehicles were involved in fatal crashes [2] from which 78 percent were passenger vehicles constituting a total of 21,667 deaths and an estimated 2.09 million injuries. Vehicle safety issues have been a topic of utmost importance for decades now. To minimize the accidents, more importantly the fatalities involved, extensive research has been made into areas of vehicle safety and protection. Active (primary) safety and passive (secondary) safety measures have been implemented. Active safety [3] refers to the systems, mostly automated, that are designed for accident prevention and accident mitigation while passive safety [4,5] refer to the features of the vehicle that prevents or minimizes the injury to the vehicle occupants without the driver or occupant action.

Passive safety includes crashworthiness of the vehicle. Crashworthiness [6] is the ability of a vehicle structure and its components to protect its occupants in case of a crash and maintain a survivable space for the occupants.

This review paper would:

1. explore and discuss the core crashworthiness parameters
2. briefly discuss crashworthiness in different directions of impact
3. discuss the effects of crashworthiness parameters on the vehicle body

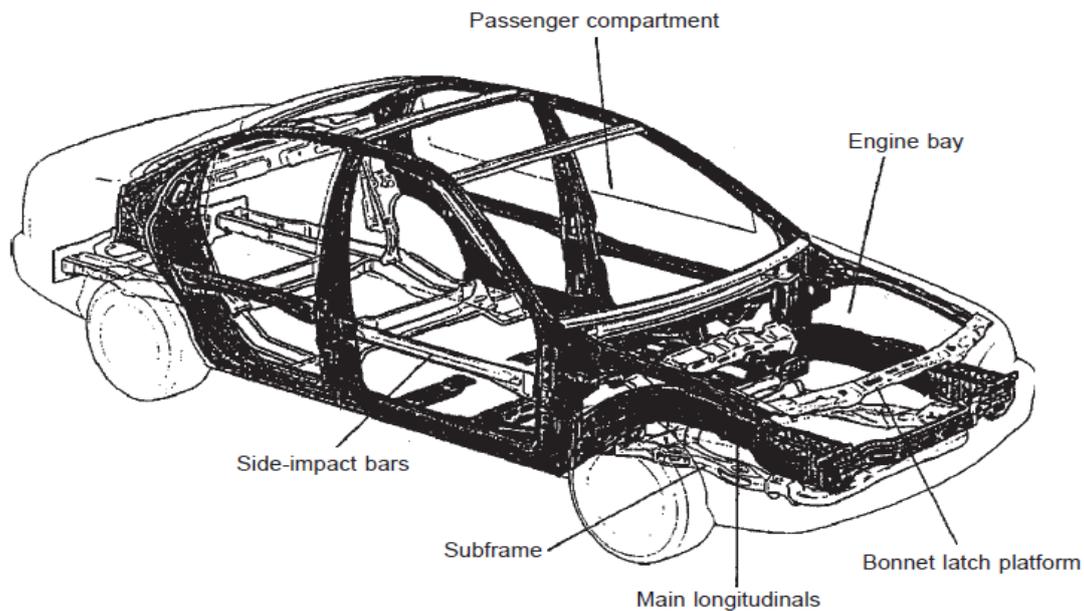


Figure 1: Basic Structure of Modern Saloon Car [7]

II. CRASHWORTHINESS PARAMETERS

This chapter would discuss the following parameters of crashworthiness:

1. The maximum load (P_{max})
2. Total Energy absorbed (E_a)
3. The mean load (P_m)
4. Specific Energy Absorption (SEA)
5. Crush Force Efficiency (CFE)

2.1. The Maximum Load (P_{max})

The maximum load (P_{max})[8], also referred to as peak crushing force[9], is the force required for the vehicle body to start the energy absorption process and initiate plastic deformation. In the design of a vehicle, the front of the vehicle is designed with a series of crumple zones [10], each of which would resist deformation until a certain load level is reached after which the zone deforms constantly until next zone is reached. This is sometimes true for rear of the vehicle [11] in case of any impact from rear. The higher the peak force/load, the higher the deceleration of the vehicle would be during the impact. Higher deceleration levels cause higher risk of brain injury[12]. The maximum load could also be defined as the compressive strength of the material.

2.2. Total Energy absorbed (E_a)

Total Energy absorbed (E_a) is the total energy absorbed during the crash or deformation. This could be calculated by calculating the area under the force-displacement graph [8,13] and can be mathematically represented as follows:

$$E_a = \int_0^{\delta_p} P \cdot d\delta \quad (1)$$

In the formula P is the instantaneous crushing load and δ_p is the length of crushing specimen.

During energy absorption, kinetic energy is converted to other forms of energy as the material deforms. As the kinetic energy is lost during the process, the forces acting on the vehicle and its occupants will also decrease [14]. As such, the energy absorption parameter is very imperative for crashworthiness of a vehicle.

In the earlier vehicle designs, designers believed that stiff vehicles would provide the best safety in collisions [11]. Therefore the vehicles were designed with stiff, non-deformable front ends, rear ends and the occupant cell. However this proved to be fatal, as the vehicle's front and rear ends did not crush in collisions allowing all crush force to be directed towards the occupant cell [11]. This caused the occupants to experience high deceleration leading to brain injuries [14].

2.3. The Mean Load (P_m)

The mean load (P_m), also referred to as mean crushing load [8,15] could be interpreted as the average or specific energy absorption per unit crush of the structure [16] and can be defined by the following formula:

$$P_m = \frac{E_p}{\Delta L} \quad (2)$$

2.4. Specific Energy Absorption (SEA)

Specific Energy Absorption (SEA) is the energy absorbed per unit mass (m) of the material [8] and is an important factor while considering low weight objectives [16]. It can be calculated by the following formula:

$$SEA = \frac{E_p}{m} \quad (3)$$

	Material	Relative Density	Density	Energy Dissipation/	Energy Dissipation/
				Unit volume (MJ/m ³)	Unit mass (MJ/kg)
Aluminium Foam	Cymat Foam	0.2	560	6.3	0.01
	Alulight Foam	0.35	1000	11.2	0.011
	Alporas Foam	0.1	250	1.394	0.006
	ERG Foam	0.1	250	2.7	0.011
	Duracore Foam	0.35	1000	17	0.017
Ultra high strength steel	DP500	-	7800	70	0.009
	DP600	-	7800	66.5	0.009
	TRIP800	-	7800	132.3	0.016
	CP-W800	-	7800	64	0.008
	MS-W1200	-	7800	52	0.007

Table 1: Comparison of Energy Dissipation of Various Materials [17]

Table 1 shows that Carbon Fiber Reinforced Polymer (CFRP) has better energy dissipation with regards to unit volume and unit mass. However, in metals, Ultra high strength steel has better energy dissipation per unit volume whilst Magnesium has a better energy dissipation value per unit mass.

2.5. Crush Force Efficiency (CFE)

Crush Force Efficiency (CFE) [18] is the ratio of mean crushing force (P_m) to the maximum crushing force (P_{max}). CFE can be used to categorize load consistency [19] and measure the performance of an absorber [20]. CFE can be mathematically represented by:

$$CFE = \frac{P_m}{P_{max}} \quad (4)$$

III. ACHIEVING CRASHWORTHINESS IN DIFFERENT IMPACT DIRECTIONS

From the previously discussed parameters, we see that core components of crashworthiness parameters revolve around absorbing the impact energy by a controlled means of failure of the structure. The better a material absorbs energy, the safer the material could be in an impact. In automotive design, crashworthiness in frontal and side impacts are imperative to save the occupant fatality. For frontal impact, the crash structures are front end and long members that would go through progressive axial collapse during impact [17]. For side impacts, the door structures along with the components of the body dissipate crushing energy by deforming in bending [17]. The side impact beams or bars play an important role in providing the lateral stiffness of the side structure giving a survivable space for the occupants in an impact [21]. Door padding is also used to reduce the effects of a side impact [22].

IV. EFFECTS OF CRASHWORTHINESS ON THE VEHICLE BODY

In 1951 Béla Barényi revolutionized car safety by developing the concept of rigid structure to prevent the collapse of the passenger compartment with crumple zones at the front and rear to absorb the crash energy [23, 24]. Generally, it is known that the design of a vehicle body structure should meet the following requirements:

- Passenger compartment/box should be rigid enough to allow a survivable space during a crash
- The deformation zone should be sufficient to absorb the impact energy
- Should be compatible with other road users

In a crash scenario, the longitudinal members have to absorb most crash energy with a progressive folding deformation [17, 25]. The energy absorption should be such that the amount of deceleration force should be as low as possible to decrease the occupant injury to an acceptable level.

4.1. Effect on Weight

In terms of weight of the vehicle body, it is generally understood that increasing or improving crashworthiness of a vehicle will add up to weight of the vehicle body. This is mainly due to the fact that stiff and stronger materials have to be used to achieve crashworthiness for both frontal and side impact scenarios. The materials used in the crumple zones should be stiff and strong enough to absorb the impact well while the side impact beams, safety cages and side pillars [26] should be strong enough to withstand an impact without allowing any intrusion or too much reduction in occupant compartment. Many academics also believe that heavier cars correspond to better safety [27]. On the other hand, the equation (3) suggests that in order to have a better energy absorption factor, more of that material should be used. Hence, increasing the mass of the body.

4.2. Effect on Size and Thickness

The size of the vehicle body, in this context, refers to the dimensions of the car including crumple zones, engine compartment and the occupant compartment. Research in this field suggests that vehicle size is an important safety variable in collisions between similar vehicles [27]. The automotive designers adjust the crumple zones of

the vehicle depending on the size of the vehicle [4]. Larger vehicles have a bigger and softer crumple zone while the smaller vehicles have small and stiffer crumple zone. At any case, having the crumple zones in the front and rear to absorb impact energy adds up to the overall size of the vehicle body. The size of the occupant compartment also adds up to the overall size. Since crashworthiness principles dictate that occupant compartment should retain a survivable space for the occupants during a crash [28], decreasing the cabin size would compromise occupant safety and increase the risk of the injuries or fatalities. In side impact crash scenario, the incident car hits the striking car from the side where there are no crumple zones and the occupants are directly involved. In such cases, the main objective is to minimize intrusion and divert the impact forces away from the occupants [4, 6]. To achieve this, the side beams, door designs and the side structure should be made of stiff material that would dissipate crush energy in bending [17] at the same time retaining a survivable space. Crashworthiness in side structure would be achieved by using thick and reasonably stiff material. The thicker the material would be, the better it is in crashworthy aspects.

4.3. Effect of Shape

The shape of the car should not be such that it would reduce the crumple zones to an extent that these zones cannot perform their function and the occupant cell is not able to protect occupants in a crash. Crashworthiness is significantly improved by a good body design and many researchers argue that bigger cars generally offer better crashworthiness than smaller cars [4, 27].

V. SUMMARY

Consumers are beginning to be more aware of the importance of vehicle safety and prefer vehicles with more safety features. With this demand from the consumers, manufacturers are left with no choice but to improve the safety features of the vehicles. Many researches have been done on improving the crashworthiness of the vehicle by optimizing the vehicle and impact absorbing structures. Fuel economy demand, safety demands and other demands from consumers, regulatory bodies and governments have driven the manufacturers to come up with designs that are lighter yet safer. The dilemma that safety engineers face at design stage is that crashworthiness parameters do not allow significant change to the body design and weight without compromising the safety of the occupants. Even though new composite materials have emerged in the recent years that would make the vehicle body lighter compared to the steel or metal bodies used now, research has still to be done on crashworthiness applications of such material and their cost-benefit analysis. Vehicles made up of strong composite material body structure that is as good as metals in crashworthy aspects would be much more expensive and unfeasible for consumer production. Further research has to be done on optimizing vehicle design, weight and size and retain an acceptable level of crashworthiness in order to comply with the legislations and regulations to improve vehicle fuel efficiency and safety, and cater to the consumer demands to make vehicles modern, sportier and more crashworthy.

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USABILITY STUDY OF CHILD RESTRAINT SYSTEM (CRS) FOR INFANTS IN THE AIRCRAFT

A.A. Faieza¹, N.M.H.A.Halim², K. Syakirah³

^{1,2,3}*Mechanical and Manufacturing System Department, Faculty of Engineering,
Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia*

ABSTRACT

It is not an exaggeration to say that safety is a must while travelling either on land, sea or even air. Especially for small travellers that would not be able to take care of themselves alone when unexpected situations happen during the journey. A seatbelt is so far very essential for everyone to stay put on seat, but it is widely designed as built-in which specifically for normal adult size and body structure, while for children they need a special design safety device for travelling. The well designed device for their protection, especially during a crash is known as Child Restraint System (CRS) that was first introduced by the National Transportation Safety Board (NTSB) and issued to the Federal Aviation Administration (FAA) about the CRS for aircraft as air transportation. This paper reviews features of CRS, types of CRS, guidelines and installations of CRS for infants in the commercial aircraft.

Keywords: *Child Restraint System (CRS), Usability, Installation, Safety*

I. INTRODUCTION

Since 1993, National Transportation Safety Board (NSTB) had reviewed the safety statistics on aircraft operations and had calculated aircraft accident rate [1]. As a result of almost 30 years studying about the aircraft accidents, the Safety Board has issued eight recommendations to the Federal Aviation Administration (FAA) and one of the recommendations, concerns about children aircraft occupants which the infants or children under age 2 must be restrained in their own seats by using the government approved child restraint system (CRS). In agreement to the recommendation, the FAA was emphasized that, during turbulence or an emergency, the infant should be in the safest place that is their CRS rather than to be in their parent's laps because the parents are unable to securely hold on the lap-held child during turbulence or emergency. According to the FAA, turbulence can be caused by the atmospheric pressure, jet streams, thunderstorms, unexpected weather fronts and also caused by the air around the mountains [2].

Civil Aviation Safety Authority (CASA) had prepared a Civil Aviation Advisory Publication (CAAP) as to cater the relevance and interpretations towards regulations 235 and 251 of the *Civil Aviation Regulations 1998 (CAR)* and specifically to paragraph 13 of Civil Aviation Orders (CAO) 20.16.3 'Air Service Operations – Carriage of Persons'. CRS is a well-designed device specialized to protect small aircraft occupants whose body structures and figures are still developing where their sizes and ages take into accounts. Some studies had reviewed the principles and mechanisms of CRS as well as the utilization of CRS.

II. THE FEATURES OF CRS

A CRS is a government approved device for use in motor vehicles and aircraft with hard-backed design of child safety seat [2]. Child Aviation Restraint System (CARES) is an FAA approved device for special safety seat use in aircraft due to not all automotive CRS can be used in aircraft because of their unrecognized designs and may cause harm to the users. CARES child safety device is approved in accordance with 14 CFR 21.8(d) "Approved for Aircraft use Only" [3]. The approval is clarified due to fulfillment of the specifications of the CRS from the components to their mechanisms and functions.

Seatbelt. A seatbelt is former standard equipment in most of the vehicles. It is a combination of lap and shoulder belts. In vehicles, including aircraft, the seatbelts are designed normally for adult size, which is not relevant for children with small body structures and stability. Seatbelts may not give harm, even for kids and should be innovated to complement the structures of CRS [4, 5]. A statistical analysis by Canadian researchers stated that seatbelts can reduce fatalities and severe injuries for small occupants age 4 through 14 approximately by 40% [6]. There is a standard for child size and measurements, including the weight and height of the child. A study by Klinich *et al.*, found that a child needs to sit straight to have a sitting height of 74cm for effectively use the belts and in order to get the best fit, the kid is required to sit in a forward facing manner as it pelvis as vertically far back into the seat [7].

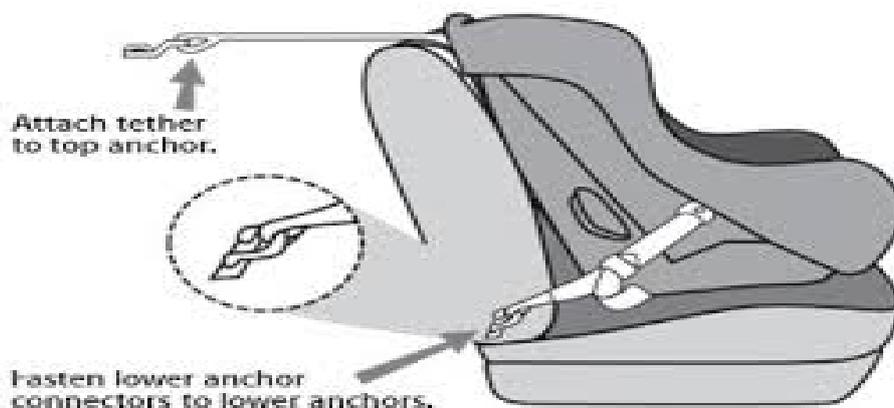


Fig. 1: Position Of Anchor And Top Tether [12]

Top tether. Early 1980s, the top attachment strap for safety of the passenger head was then concerned. Top tethers keep the child's head safe during the crash, but people at that time refused to install the top tethers in their vehicles [8]. Top tethers are very easy to install as compared to seatbelts. In the United States, most of the vehicles are recommended to install the restraint system with standard or advanced tethers as the regulations made need the manufacturer to install user-ready anchor. Besides that, the installation approach is supported by having older vehicles to also install the system of restraint for safety prospective [9].

Anchor. ISOFIX is the first concept introduced in 1991 to propose standard rigid interface hardware for vehicles and on child restraints [10]. This approach was to reduce the degree of error while doing the child restraint system installation as well as to improve crash performance of the vehicles. In the development of child restraint system, the use of additional anchors was introduced as the two lower anchors at the seat bight were not enough to isolate the restraint system from the seat cushion [11]. There are two types of anchorage; the flexible

anchorage and rigid anchorage. The figure 2 below shows the anchorages and attachments of the child restraint system.

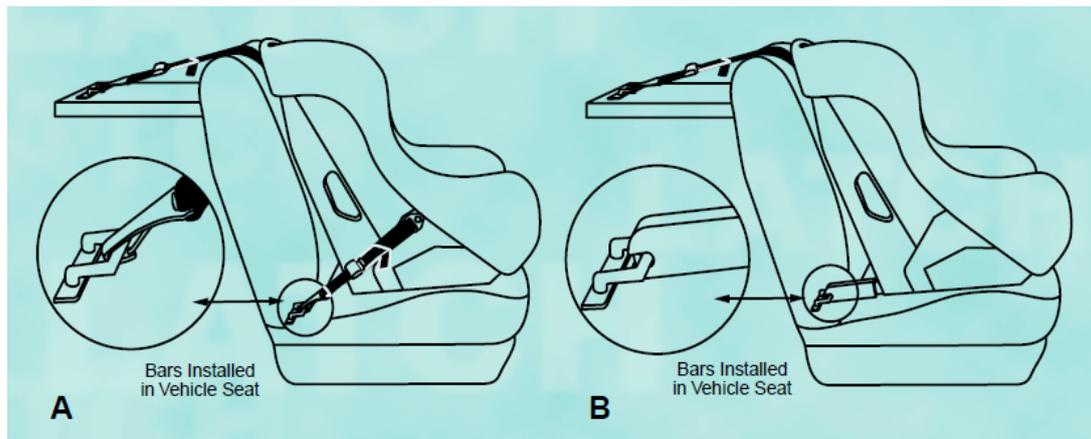


Fig. 2: (A) Flexible Anchor And (B) Static Anchor [12]

Harness. The harness was firstly design in military with a pattern of 5-point harness which strap over shoulder, pelvis and legs by each point is buckled firmly for safety purposes. The harness gives more lateral support for the child by applying the concept of lap-held positioning to ensure comfort for the kids as they tend to squirm around during the journey. This will definitely reduce the risk of falling during take-off or landing. The use of firm padding could keep the children from slouching [13] as it will compress during impact and serve as energy absorbency to protect the child's body [12]. Currently, there are few designs of harness available besides traditional 5-point harness, such as tray shield and T-shield. Tray shield is designed to have shoulder and crotch straps while the T - shield is more likely to come with shoulder straps as shown in figure 3.

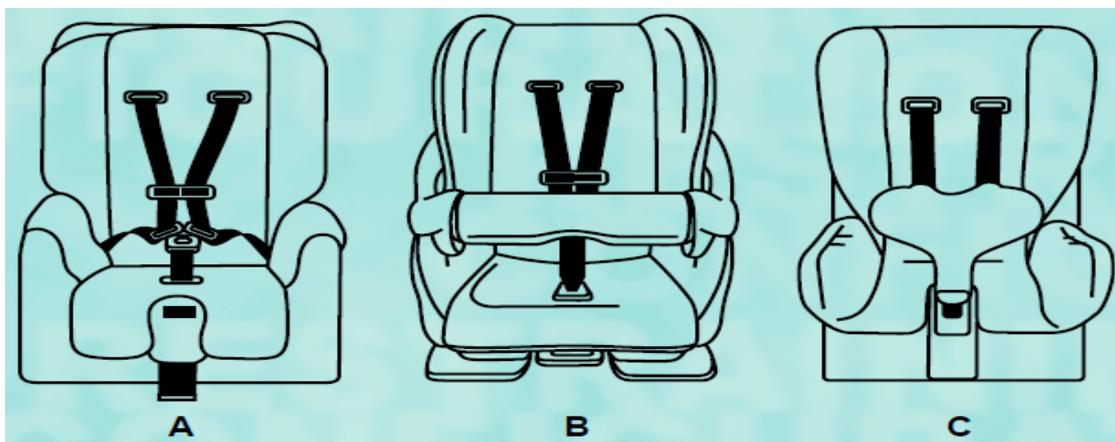


Fig. 3: Types of harness designations of CRS: (A) 5-point harness, (B) tray shield and (C) T-shield [12]

III. TYPES OF CHILD RESTRAINT SYSTEM

Built-in airplane seatbelts. A built-in seatbelt also known as an integrated seatbelt is an approach studied in Sweden and currently in North America [14, 15]. This built-in system is to directly link the child to the seat of the vehicle. The installation is very perfect with correct parameters of buckle size, belt anchor location, type of retractor and latch plate [16]. Unfortunately, this kind of restraint has its disadvantages. Recent analysis has stated that children in seat belts are 3.5 times more likely to suffer serious injury, especially to the head as compared to the restrained children [17]. Since the system is built in and integrated, it is unable to be uninstalled or reinstalled. The system is unable to be removed when it is no longer needed. In marketing view, this system is

not marketable and been analyzed to reduce in the future, even the National Transportation Safety Board (NTSB) suggested the vehicle producers to offer this system in their vehicles.

Rear-Facing Child Restraint System (RFCRS). RFCRS has the ability to reduce about 70% the risk of deaths and serious injury if the system is properly installed and secured [18] as to compare with the lap held practise which approximately reduce the risks by only 50% [19, 20, 21]. The design with carrying handles and have detachable base for repeating installation. This device has a very close relationship with a factor of weight. There are certain weights concerned to use this type or restraint as well as for installation. This type of restraint is used to minimize the impact or injury to the upper structures especially necks and heads. According to Melvin *et al.*, [22] a proper installed RFCRS is said to be super effective during crash with 96% of injury-reduction effectiveness [23].

Forward-Facing Child Restraint System (FFCRS). Forward-facing orientation is a common positioning of children, which most parents believe that this position is more likely to be safest position. The installation of FFCR must be very proper since the safety degree and stability of this device totally depend on the anchorages and attachments credibility. There is a study of Bioengineering that proved this understanding is wrong because it found the risk of child's cervical spine can be pulled apart is very high because the shoulders are held back during the crash [24]. According to CAAP (2013) [25], under 6 months, infants are restricted to be seated in FFCRS but need to be lied down in RFCRS due to their small body sizes unlike the over 6 months infants whose can sit upright in FFCRS provided with the installation of shields, harness and tethers. Not only the features and designs, but the orientations of devices also need to be approved under no circumstances.

CARES child safety device. This device is perfectly designed specialized for the aircraft with certain optimization of common devices available for all types of vehicles. The interfaces are complementary to the structures and materials of aircraft seat types and the only device that has an approval from the FAA. The FAA is one of the organizations that urges whole world parents to use CARES for their children when opt to travel by planes. According to CAAP [25], there is a list of CRS designs which meet the standard of approval in accordance to specifications and can be safely used in aircraft. The designs are listed as follows:

1. CRS, which has FAA Technical Standards Order (TSO) TSO-C100, TSO-C100a, TSO-C100b, or TSO-C100c certification.
2. Type 2040-1 Carechair, manufactured by Aviation Furnishings International Limited in acceptance by the Civil Aviation Authority (UK).
3. Skykids® Child Seat, manufactured by Innovint Aircraft Interior GmbH in acceptance by Luftfahrt-Bundesamt (Aviation Authority of Germany).
4. CRS-2000 PlaneSeat™, manufactured by Amsafe, certified by FAA under Federal Aviation Regulations 21.305(d).
5. Any CRS with integrated and certified as a part of aviation based seat.

IV. INSTALLATION OF CRS

Restraint system installation has its own challenges and difficulties. In agreement to the purpose of installing this system, the safety is obviously concerned hence the installation must be made perfect with zero error. Once the system is tested and approved by the established accreditation and specifications, then only the system can be widely used by the community. Here comes the matter when a very basic device of restraint system is seat

belt that originally constructed in a vehicle for adult-size passengers. The design is not compatible with the body structures of infants or children. Therefore, special designs and innovations for the restraint system have been created to improve the level of transportation safety standard. There are a few improvements in restraint system specifically for child occupants such as built in child restraint, top tethers, and anchorages. In addition, there is a standard provided by FAA to assist technicians or even parents in installing a CRS on airplane by choosing a CRS based on a child’s weight. The FAA also urges parents to correctly decide the best choice of CRS approved by that board during all phases of flights. The right manuals and procedures of installation must be perfectly followed by the installers who might be the plane crews, technicians or parents for self-installed devices. Table 1 shows a CRS type selection based on weight as a guideline for best safety choice.

Child weight	Types of CRS
Less than 20 pounds	Rear-Facing CRS (RFCRS)
20 pounds to 40 pounds	Forward-Facing CRS (FFCRS)
22 pounds to 44 pounds	CARES child safety device
More than 40 pounds	Built-in airplane seatbelt

Table 1: CRS Selection Based On Weight Range Of A Child [2]

V. CONCLUSION

Child Restraint System is proven to have significant safety value towards the child occupants of all types of vehicles, especially for aircraft whenever it is experiencing turbulence or crash. The degree of protection is non questionable as the CRS is well innovated with the functionalities of each of the features that meet the standard of performance and accreditation. Every single part of CRS is well studied and engineered to focus perfectly for the crash and impact encounters in order to save lives of the occupants thus reducing the death or injury statistics. All parts integrated with each other and work accordingly, such as seatbelt and tether, harness and shield as well as the attachment system of anchor.

The types of CRS also distinguished according to the size, height and weight of the occupants to ensure safety, stability, effectiveness and also comforts. Each design gives specificity to encourage good safety practices during travelling. Normally, forward-facing CRS is used with a belief of the safest position for children, luckily this study has highlighted the best orientation and structures that suit the infants and the importance of to correctly select the appropriate CRS type according to physical factors of the this group of travelers. Besides features, structures and types of CRS, the installation technique of CRS also play an important role in making sure that the CRS is 100% secured and well installed, thus increase the level of safety for children to sit on an airplane during travelling.

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CRASHWORTHINESS STUDIES ON VARIOUS MATERIALS, FORMING PROCESS AND THE EFFECTS ON VEHICLE BODY

A.A. Faieza¹, A.R.M. Hazwan², A.H. Lilehkoohi³

^{1, 2, 3} *Mechanical and Manufacturing System Department, Faculty of Engineering, Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia*

ABSTRACT

Crashworthiness has been a major criterion in making vehicles safe to be used and manufactured. There are many factors contributing in determining the level of crashworthiness, one is in determining the right type of material to be used and one in the consideration of process that can change the properties and characteristic of the material and design. This review paper discusses briefly on type of material that being used in car manufacturing today and the processes to form desirable shape of vehicle that can affect the material properties and thickness, thus, differ the value of crashworthiness of a vehicle. This review paper also intended to review about the type of materials and their properties used in manufacturing vehicles, to explore about manufacturing process that affects the thickness of the car body panel and to discuss the effect on change in vehicles structures properties and thickness with and without forming.

Keywords: *Crashworthiness, Materials, Metal forming, Vehicle manufacturing, Vehicle safety, Lightweight design*

I. INTRODUCTION

The ever-increasing varieties as well as complexity of vehicle body materials make this a field of interest and complicated technological development. A manager in die company, Jody N. Hall states in his slide presentation that there has been a shift at a fairly common range of mild steel as well as occasionally aluminium only 40 years past to the extensive array of sophisticated specifications apparent today [1]. Elaheh Ghassemieh from University of Sheffield agreed that steel has continued the predominant material throughout car bodies for over the century by means of keeping pace with the entire evolving car [2]. Improved corrosion-resistance, more refined mechanical properties, higher strength characteristics, and advanced manufacturing technologies have kept steel at the top in terms of content in the average vehicle on the road where it is estimated about 60% by weight today [2].

Nevertheless, in Akihiro Unishi et al technical report for Nippon Steel company dated January 2000 stated that the increased choice of more advanced kind of alloy has been recently utilized respect in order to properties and the fact that possibilities are achieved to scale back the percentage of steel utilized in today's automobiles entire world [3]. Lena Smidfelt Rosqvist attempted to say there are also has been a similar widening of choice for aluminium alloys and the increasing utilization of magnesium alloys, to achieve the target for lighter weight bodies to reduce fuel consumption, as by 10% weight reduction in passenger cars, the fuel economy improves

by as much as 6–8% [4]; and attendant emissions, and also to increase performance which all of this criteria have been a focus for every cars manufacturers nowadays to being able to penetrate the market better than the competitors.

Vehicle body members for instance front side members, pillars and side sills needs to be designed to take in the kinetic energy efficiently throughout the car crash so as to secure occupants from the impact and penetration which in turn increases the crashworthiness of any vehicle are present by Richard Sturt et al paper [5]. POSCO Technical Research Institute paper published also agreed the design of the chassis itself plays a crucial role in protecting the occupants from having undesired consequences due to crash [6]. Briefly, the type of materials implemented on the vehicle's chassis as well as its design contributes the vehicle crashworthiness. Lilehkoohi et al [26, 27] have conducted several simulations to investigate the effect of material on crashworthiness in side impact test and pole side impact test.

II. TYPES OF MATERIALS USED FOR VEHICLES CHASSIS

2.1 Steel

There are two kinds of steel that can be found, plain carbon steel and alloy steels. Under plain carbon steel, there are 3 more categories of steel which are low carbon steel also known as mild steel, medium carbon steel and high carbon steel [7]. Séblin. B et al point those out in a paper. Table 1 shows the type of carbon steel and their uses specifically for automobile component tabulated in an Industrial Education book volume 52 [8].

Carbon Steels and Their Uses		
	% by weight of carbon in steel	Uses
Low carbon	0.05-0.20	Automobile bodies, buildings, pipes, chains, rivets, screws, nails,
	0.20-0.30	Gears, shafts, bolts, forgings, bridges
Medium carbon	0.30-0.40	Connecting rods, crank, pins, axles, drop forgings
	0.40-0.50	Car axles, crankshafts rails, boilers, auger bits, screwdrivers
	0.50-0.60	Hammers, sledges

Table 1: Carbon Steels and Their Uses [8]

Alloy steels are designed by combining steels with a number of other elements according to the strength needed per application. The other components are purposely blended with steel as to have properties that is not achieved by basic carbon steel.

A word by Tamarelli show the requirements for safety, efficiency, emissions, manufacturability, durability and quality at a low cost in automotive manufacturing can be satisfied by using Advance High Strength Steel, (AHSS) material [9]. The statement made by Akihiro Unishi also support the characteristic of AHSS which has high yield strength and high work hardening rate compared to conventional steel such as mild steel contributed in making of thinner design of components while maintaining the same load bearing capability[3]. Besides that according to Gan et al [10], the unique combination of material and mechanical properties from AHSS grades was formed by carefully selecting the chemical compositions and multiphase microstructures resulting from precisely controlled heating and cooling process. Moreover, Itan, T. state that the HF type of AHSS or can be

call as boron steel which contain boron alloy ranging from 0.002 -0.005 % is the most commonly used in automotive industry [11]. Stainless steel is also a material of choice due to passivity and resistance to corrosion [2]. Some of the stainless steel grades suggested for automotive are as follows:

- a) Duplex austenitic-ferritic stainless steel
- b) Austenitic stainless steel

Property	Duplex Stainless Steel (1)	Austenitic Stainless steel			6061 Aluminium Alloy		High Strength Steel HSLA
		Annealed	C850(2)	C1000(3)	T4(4)	T6(5)	
Density: ρ (g/cm ³)	7.8	7.9	7.9	7.9	2.7	2.7	7.83
Yield Stress: σ (N/mm ²)	640	370	600	880	130	275	410
Specific Strength (N/mm ² /g/cm ³)	82	46.8	76	111.4	48.1	100	52.4

Figure 1: Specific Strength of Stainless Steels, 6061 Aluminium and High Strength Steel [2]

- (1) In the solution annealed condition,
- (2) In the cold worked condition C 850 (850<UTS (N/mm²)<1000),
- (3) In the cold worked condition: C 1000 (1000<UTS (N/mm²)<1150),
- (4) In the solution heat treated condition,
- (5) In the precipitation heat treated condition

2.2 Aluminium

The aluminium is much more desired in car makers because of the lightweight properties that can be offered where as being mentioned before lightweight is very crucial in increasing efficiency and reducing fuel consumption to go further. On the other hand, the price tag of aluminium and cost stability are its main impediment to be used within large-scale sheet applications [1]. Ron Cobden et al talking about the properties of aluminium in their training module as lightness are the outstanding and best known characteristic of aluminium. The metal has an atomic weight of 26.98 and a specific gravity of 2.70, approximately 1/3 the weight of other commonly used metals; with the exception of titanium and magnesium [12]. Moreover, the addition of other metals inside the amounts commonly utilized in aluminium alloys isn't going to appreciably change the particular density, plus minus 2 to 3 % except in the case of Lithium alloys where the density of the particular alloy is reduced by nearly 15%. [4].

Weight is vital for all purposes involving motion. Saving weight leads to more payload or perhaps greater economy in terms of operation. Saving excess weight also saves power, reduces vibration, and improves the actual performance of reciprocating and also moving parts. Low weight combined with the high strength possible with special alloys has placed aluminium as the major material for aircraft construction for the past sixty years [12]. A book published by NPCS shows that aluminium usage in automotive applications has grown substantially within past years. A total of about 110 kg of aluminium: vehicle in 1996 is predicted to rise to 250 or 340 kg, with or without taking body panel or structure applications into account, by 2015 [13].

An addition criterion of lightweight aluminium metal is that aluminium features a higher resistance in order to withstand corrosion than several metals owing on the protection conferred with the thin but intense film of oxide [2]. This oxide layer is always present on the surface of aluminium in oxygen atmospheres. Fig 2 shows the degree of corrosion and its effect on strength in two different environments.

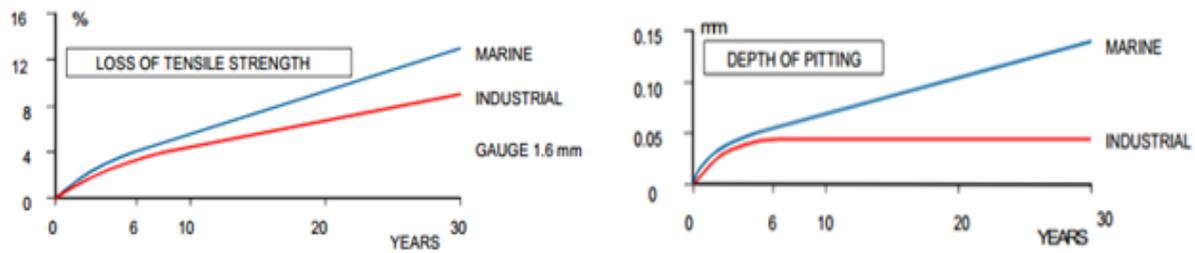


Figure 2: Pitting Corrosion Behaviour of 3103 Mill Finish Aluminium Sheet [12]

2.3 Magnesium

Magnesium is 33% lighter than aluminium and 75% lighter than steel/cast-iron components [2]. The corrosion resistance of modern, high-purity magnesium alloys is better than that of conventional aluminium die-cast alloys [13]; but magnesium components possess many mechanical as well as physical property disadvantages that need unique design intended for application to automotive products. The disadvantages regarding magnesium alloys are usually high reactivity inside molten state, inferior fatigue and creep when compared with aluminium and galvanic rust resistance [2]. Although its tensile yield strength is about the same, magnesium has lower ultimate tensile strength, fatigue strength, and creep strength compared to Aluminium. The modulus and hardness of magnesium alloys is lower than aluminium and the thermal expansion coefficient is greater [11]. Even so, it should possibly be noted that appropriate ribbing and helps often can triumph over the strength as well as modulus limitations.

Despite the above issues, Mark Easton point out that magnesium alloys have distinct advantages over aluminium that could not be dismissed. These include better manufacturability, longer die life and faster solidification due to lower latent heat [14]. Therefore more castings can be produced per unit time compared to aluminium. Magnesium components also have higher machinability which its component can be produced with improved dimensionality and surface quality, and smaller draft angles compared to aluminium [2].

Property	Magnesium	Aluminium	Iron
Crystal Structure	hcp	FCC	BCC
Density at 20°C (g/cm ³)	1.74	2.70	7.86
Coefficient of thermal expansion 20-100°C (*10 ⁶ /C)	25.2	23.6	11.7
Elastic modulus (10 ⁶ MPa)	44.126	68.947	206.842
Tensile strength (MPa)	240	320	350
Melting point (°C)	650	660	1536

Figure 3: Properties of Mg, Al, Fe [2]

III. MANUFACTURING PROCESS THAT AFFECTS THE THICKNESS OF THE CAR BODY PANEL

The properties of formed vehicle structures have been effected and changed by such as work hardening and non-uniform thickness distribution resulted from forming process. Crash analysis regarding vehicle structures while using forming effects, causes different results coming from those without this forming effects [5]. In order to obtain reliable crash simulation, crashworthiness of vehicle structures should be evaluated considering the consequence of stamping and forming in addition to the dynamic properties regarding materials [6].

3.1 Hydro Forming

The hydroforming process results in very significant left over thickness changes as well as work hardening, and will have a major impact on crash results. Hydroforming uses fluid pressure rather than the punch as comparing a conventional tool set in order to create the component into the desired shape from the die is an illustration by A. Kocańda et al [15]. Gary Morphy defined the hydroforming as a system that uses high internal pressure so that the tube hoop stress at the corner radius is higher than the material yield strength [16]. Basically there are 2 main hydroforming methods: tube hydroforming and sheet hydroforming.

Tube hydroforming process as mentioned by F.J. RípodasAgudo et al [17] is a tube that will first being placed in a closed cavity of a forming dies. Once the ends of the tube are sealed, the tube is filled and pressurized with hydraulic fluid. The internal pressure forces lead the tube to form into the shape of the tool cavity. Nader Abedrabbo et al and Mikael Jansson both agrees [18, 19] that tube hydroforming technology has drawn increasing attention in the automotive industry because of its enormous advantages which include part consolidation, weight reduction due to improved part design, improved structural strength and reduction in the associated tooling and material costs. However, a journal by Peng Jun-yang et al [20] says that there are disadvantages due to many variables, such as loading paths, material formability and tribological conditions, which limit its applicability and influence parts failure such as excessive thinning, wrinkling, and buckling.

Sheet hydroforming is simply a sheet metal part formed by water pressure generated by the punch drawing the sheet into a pressurized water chamber [15]. Sheet hydroforming is further classified by Hong Huh et al [6] into sheet hydroforming with a punch and sheet hydroforming with a die, depending on whether a male (punch) or a female (die) tool will be used to form the part. Hydroforming allows 50% less material thinning than for conventional deep drawing is one of hydroforming advantage mentioned by Seward E. Matwick[21]. The main drawback to sheet hydroforming is its longer cycle time which causes the process to be cost prohibitive at high volumes[21].

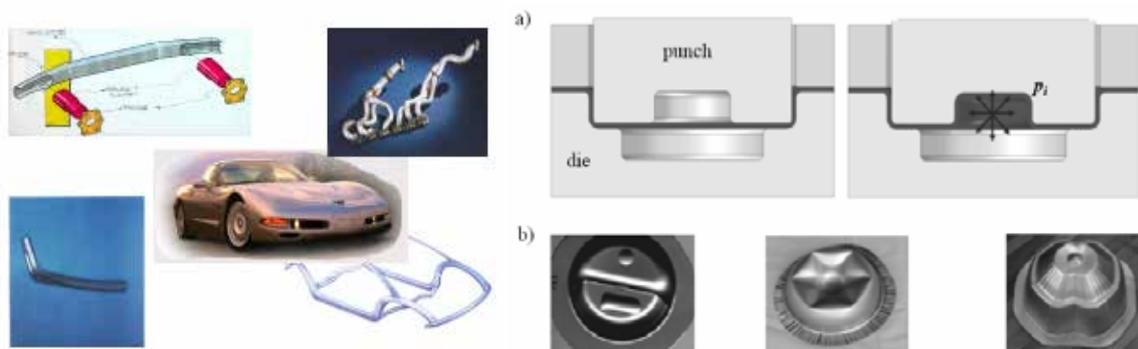


Figure 4: (A) Typical Hydroformed Components in a Car Including (B) Scheme of Sheet Hydroforming and Examples of Products [15]

3.2 Stamping

Stamped parts show much less sensitivity, because areas which are work hardened would also normally be thinned from the stamping process; each effect might approximately cancel one another [15]. Stamping presses and stamping dies are tools accustomed to produce high level sheet metal parts. These parts achieve their shape from the effects of the die tooling. Production stamping is generally performed on materials .020" to .080" thick, but the process also can be applied to foils as thin as .001" or to plate stock with thickness' approaching 1.000"

[6]. Nowadays there are 2 types of stamping, one is hot-press stamping and another would be cold-press stamping.

Taylan Altan explained about hot stamping, in a magazine where in hot stamping, forming and hardening are combined in a single operation. There are two different methods, one is direct and one is indirect. In the direct method, the blanks are austenitized at temperatures between 900 and 950 degrees Celsius for 4 to 10 minutes inside a continuous-feed furnace and subsequently transferred to an internally cooled die set via a transfer unit [24]. Indirect hot stamping provides for a part to be drawn, unheated, to about 90 percent to 95 percent of its final shape in a conventional die, followed by a partial trimming operation. As for cold stamping, it is similar to hot stamping but the difference is that it does not involve any conduction of heat on the blank and die. In a paper by Hande Güler et al [25] that differentiate between hot press and cold press, based on the simulation that had been done, hot press stamping is safer than cold press stamping.



Figure 5: Example of Stamping Product for Vehicle Manufacturing

IV. EFFECT ON CHANGE IN VEHICLES STRUCTURES PROPERTIES AND THICKNESS WITH AND WITHOUT FORMING

T. Dutton et al [22] proposed that metal forming processes result in a number of changes in the material properties of a formed component. The initial blank material is subjected to large deformation during forming which results in changes in the thickness and yield point of the material. A forming analysis done by T Dutton et al (a) shows the results of the hot forming process, indicating thickness strain, plastic strain (b) and residual Von Mises stresses before and after springback. It was notable that the overall change in thickness was not dramatic with thinning mostly restricted to the outside of the bends; axial end flange causes thickening concentrated at the rail ends. However, a large amount of material experienced considerable work hardening, as indicated in Fig 6 (b), with many areas showing more than 10% strain. The average thickness change measured from the tensile test specimens was -5.1% among 24 specimens cut from the material.

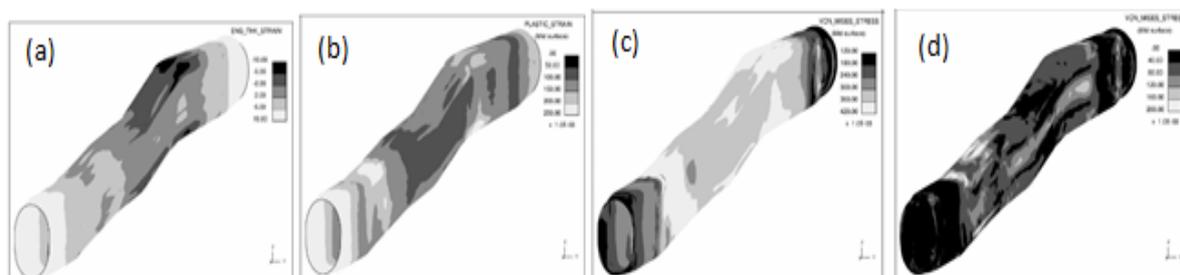


Figure 6: Results Of Forming Analysis (A) Thickness Strain (B) Plastic Strain (C) Von Mises Stress (Before Springback) (D) Von Mises Stress After Springback [22]

A crash analysis has been carried out by another researcher on determining the crashworthiness in four different cases. One without considering fabrication effects; one with considering the thickness distribution only; one with considering the effective plastic strain distribution only; and one with considering all fabrication effects[6].

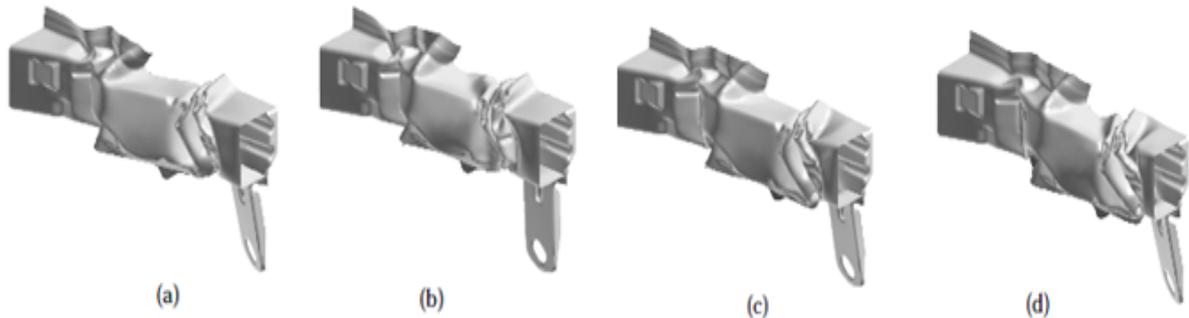


Figure 7: deformed shapes of the front side member at 30m/sec: (a) without forming histories; (b) with the thickness distribution; (c) with the effective plastic strain distribution; (d) with all forming histories [6]

The end result in Fig. 7 shows that the first as well as second ones deform greater than the third and fourth ones. The third one with taking into consideration the effective plastic strain distribution would be the strongest while the other one with consideration of the thickness distribution would be the weakest. It is because that the effective plastic strain distribution plays a role as reinforcements in crash with the increased flow stress and the thickness distribution plays a role as defects in crash because of thinning due to stamping [6].

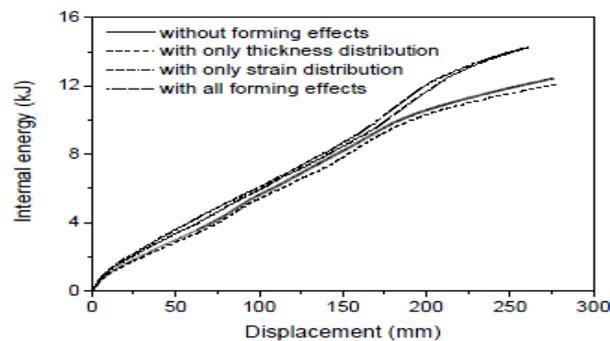


Figure 8: Comparison of the Energy Absorption With Respect To the Displacement in the Front Side Member during the Crash for 30 Milliseconds [6]

Fig. 8 demonstrates in which energy absorption increases remarkably if the effective plastic strain is considered and decreases slightly if the non-uniform thickness distribution is regarded. The energy absorption from front side member features a larger value whenever all forming effects are thought than the one without forming impact. The difference is 5.3 % at the crushing distance of 100 mm, 10.2% when the crushing distance is 200 mm, and 17.3 % when the crushing distance is 250 mm [6].

According to a paper made by Dr. Kim Kose et al [23], a simulation is done by considering the effect of plastic deformation of a metal due to the history of forming while doing an analysis for better result. It is known that the material state is changed by every step in the production process. Thus, the behaviour of the final part depends on every previous step. In the paper, they were using upper shell of a steering knuckle made by thick steel sheet as the subject. Fig. 9 shows that in the load-displacement curves, it can be easily seen that the inclusion of the forming history has a significant effect on the strength of the part. In this example the deviation

is about 30 percent. This concludes that the history forming process affects the behaviour and strength of a component thus, differ the value of crashworthiness.

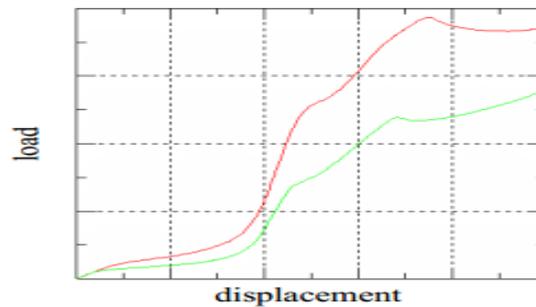


Figure 9: Load Case And Simulated Load-Displacement Curves With (Red) And Without (Green) Plastic History [23]

V. SUMMARY

This review paper can be summarized in words that describes crashworthiness is not all about obtaining the best results is crash test but it is to investigate the root cause of the manufacturing where there are always room for improvement. In auto industries, there are always a need on chasing the lightweight design and mass of the product as to achieve the specified regulations as well as keep on decreasing the fuel consumption. This demands feature not only can be achieved using expensive lightweight material such as aluminium and magnesium, it also can be achieved using steel as there are lot on improvement done to making steel as lightweight as possible while maintaining the needs of strength. The characteristic and material properties of earth compound have been studied and new development have been made and improved to make a car structure more crashworthiness. It can also be conclude that material shape forming affects the structure analysis and material properties. Thus, the crashworthiness assessment has to be carried out with the consideration of the fabrication histories of auto-body members for accurate and reliable evaluation. This is due to the changes and movement of the metal grain in atomic level and the thickness distribution along the metal after being forming with extreme forces and conditions. Many research that have already been made to make the automotive world a better place in terms of methods uses and material selection just as to make sure that safety is the priority matter in designing vehicles for the people.

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VIRTUAL REALITY APPLICATION IN DESIGN, PROTOTYPE AND TEST DRIVE PROCESSES IN AUTOMOTIVE INDUSTRY

A.A. Faieza¹, A.H.Z. Azreen², M.W. Rohidatun³

^{1,2,3}*Mechanical and Manufacturing System Department, Faculty of Engineering, Universiti Putra
Malaysia, UPM Serdang, Selangor, Malaysia*

ABSTRACT

Currently, most researchers find out that Virtual Reality (VR) systems are now a highly implemented in automotive industry especially in design and development process. The automotive industry was amongst applied this technology since VR was developed. In the real manufacturing practice, they need to cater the demand in shortening the production time. Therefore, the VR systems become a crucial stage in car manufacturing. The use of VR technologies allows a large amount of variants can be shown, modified and assessed at a very early phase of the process hence cost and time saving. This paper reviews current applications of Virtual Reality for Design, Prototype and Test drive in automotive industry.

Keywords: *Automotive, Design, Prototype, Test drive, Virtual Reality.*

I. INTRODUCTION

Currently, the increase demand in automotive industry is accompanied with growing complexity within product development, manufacturing, supply chain and logistics processes that are the lifeblood of the modern automotive company [6]. The automotive industry has become one of the world largest economic contributors and therefore it is important for car makers to sustain good momentum in supplying demand for the customers with the help of technology advancement. Gusikhin et al. [5] have stated that since the introduction of moving assembly line, the automotive industry has become one of the big leaders of developing new advanced technologies.

To stress the importance of the technology in automotive industry, in 2006, National Automotive Policy (NAP) was introduced by the Malaysian government to transform the domestic automotive industry and integrating NAP into the highly competitive global industry network and in 2009 NAP was reviewed with one of the objective is fostering the development of the latest, more sophisticated technology in the domestic automotive industry [7]. This is to encourage Malaysian automotive industry to compete with international car makers in producing top notch product in the shortest time possible. Therefore the adopting of VR systems in this automotive industry is very effective to meet the objective itself.

The technology of Virtual Reality (VR) systems is seen as a powerful tool in developing and implementing more natural and intuitive interface, minimize the use of expensive physical mock-ups, allows users to predict and prevent problems early in the product-development process, to meet critical time-to-market objectives and enabling vehicle design department to maximize their profit margins. Also by adopting VR with fully human

interaction in the real time could help generate saving through enabling better project coordination, quicker testing, engineering change reduction and process optimization in the stage of conceptual design of the product. Virtual Reality (VR) is commonly known as “reality simulated by the computer” or as an “artificial world”. There are a few definitions of VR as reviewed in literatures as follows. For instance H. Fuchs, G. Bishop et al define VR as Real-time interactive graphics with three-dimensional models, combined with a display technology that gives the user the immersion in the model world and direct manipulation [1]. M. Gigante defines VR as the illusion of participation in a synthetic environment rather than external observation of such an environment. VR is obtained at no additional time expense because everything needed to perform motion simulation has been defined in CAD assembly model [17].

VR relies on a three-dimensional, stereoscopic head-tracker displays, hand/body tracking and binaural sound [2]. In a study conducted by Mujber et al., [3] VR is categorized in three types; (i) Non-immersive VR, (ii) Semi-immersive VR, (iii) Fully-immersive VR. VR can be traced back starting in 1860s with 360° art "Baldarsare Pesuizzi" to the revolution of “Oculus Rift HMD” in 2012. The vast change in VR technology has been applied in various fields such as medicine, architecture, games and also automotive industry.

Presently hardware technologies such as Head Mounted Display (HMD), Binocular Omni Orientation Monitor (BOOM), Cave Automatic Virtual Environment (CAVE), Data glove, Control devices and software technologies such as Multiverse, Virtual Reality Studio, Sense8 World Tool Kit and Autodesk Cyberspace Development Kit are widely used with VR systems [4]. VP is a natural development of VR and CAD systems. The competitive nature of the industry dictates a rapid prototyping turnaround and traditional physical prototyping methods are no longer fast enough thus the use of VR in design and prototyping process.

II. APPLICATION OF VR IN AUTOMOTIVE INDUSTRY

VR is essential to the automotive industries as now designers and engineers works on one and same digital model, fully utilizing the model rather than building several prototypes. The elevation of VR since the last decade not only provide an environment for virtual visualization but also hold great potential in solving problems before being manufactured [5]. Since the introduction of moving assembly line, the automotive industry has become one of the big leaders of developing new advanced technology [8].

VR mostly applied in the fields of design, collaborative design and engineering, ergonomics or human factor, maintenance analysis, training and education, styling, simulation, digital prototyping, marketing and sales in the automotive world. It represents a user interface technology that enables the interaction of the engineer with the virtual models of the car, thanks also to the immersion feature. VR allows, in fact, intuitive analysis and simple presentation of complex three-dimensional systems.

In real practice, car manufacturers even established VR Center, so that designer can chooses the car style model, development team can executes design reviews, analyses alternative solutions and deliberates product and process validation all in one place. In 2007, PROTON, Malaysia's national car maker established its own Virtual Reality Center to fully use VR technologies in their research and development process as shown in Figure 1 [9]. Furthermore with immersive virtual environment, ergonomist can study the “man-car-environment” interaction and evaluate the comfort of a new car [10].

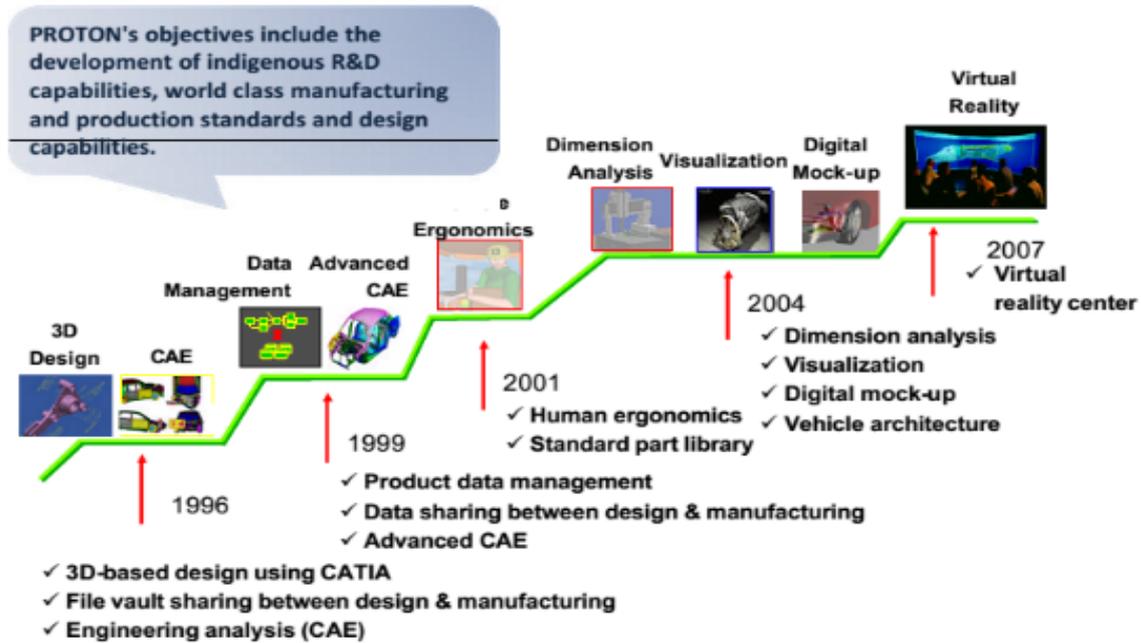


Fig.1: PROTON Vehicle Engineering Milestone

III.VIRTUAL DESIGN

The very first data set representing a new design concept can be shown in VR offering foundation for virtual tests. Even though it is possible to create VR model using VR package, the transfer of geometrical data between CAD and VR is desirable to avoid repetitive work[11]. Computer Aided Design (CAD) is used to create a geometrical product representation within a virtual environment. In automotive development, the product is composed of three-dimensional models in so-called 3D CAD programs.

From previous study, the use of CAD programs such as Autodesk can be link into VR system such used by Ford Motor to examine the entire exterior and interior of a car design, as well as to focus on how certain elements looks such as dashboards and upholstery during the design stage. The engineers at Ford's immersive Virtual Evaluation Lab (iVE) collaborated with United Space Alliance's imaginary lab to evaluate early vehicle designs against backdrop of virtual conditions to help create a car that provides perfect environment for the customers. Details such as light positioning, size or brightness can be observed and improved by using CAD integrated with VR systems [12].

Analysis for Virtual design also can be done using Computer Aided Engineering (CAE). CAE includes a wide range of product calculation, simulation, optimization and planning processes in several disciplines which are performed parallel to the geometry creation. Of course, throughout the virtual development cycle, design always goes hand in hand with computational engineering processes. In some literature, virtual development in general is denoted as CAx (computer aided technologies)[12]. However, even with the predictive capability of CAE tools, physical testing is still used as a final confirmation for subsystem since there is limitation for variables such as metal stretch and thinning cannot be predicted using CAE.

CAE based software's was developed by MSC.Software for PROTON to create reliable engineering environment that develops and test virtual prototypes, VP of component and subsystems, saving time and resources compared to conventional build and test process. Siemens PLM Software introduces NX CAE for automotive companies to create better designs by leveraging design data directly through integrated modeling and meshing tools, analysis data can be obtain earlier in the design stage, integrate multiple solutions in a single

environment. The data then can be used as input data in VR Tools to further improve the design without having unnecessary data to be analyzed twice.

Modern VR studio or commonly called as Cave Automated Virtual Environment (CAVE) is also widely used throughout design stage. The CAVE is a room where stereo computer images are projected on three walls and the floor. Multiple users can be in the CAVE at the same time, however, only one person controls the view with the position tracker. The users wear stereo shutter glasses that convert the images on the walls and floor into stereo images [13]. In the CAVE all perspectives are calculated from the point of view of the user. A head tracker provides information about the user's position. Offset images are calculated for each eye. To experience the stereo effect, the user wears active stereo glasses which alternately block the left and right eye.

This application enables user to move around a virtual environment in which the user is surrounded by up to six walls presenting pictures projected in real time [14]. French automotive manufacturer Renault has implemented a new CAVE, a 5 rear projected wall virtual reality room with a combined 3D resolution of 100Megapixels distributed over sixteen 4k projectors and two 2k projector as well as an additional 3D HD collaborative powerwall. Renault's CAVE™ aims at answering needs of the various vehicle conception steps [15]. Initially CAVE was used for interior ergonomic design, it has been broaden into other departments in Renault.



Fig.2: Renault Vr Cave

IV. VIRTUAL PROTOTYPING

Car development is a complex process but it's in sequence of decisions and fine tuning until it is produced. Beside, in production, decision making process is very crucial thus VR helps to take part in decision making procedure by providing virtual prototype, VP of new vehicles before the physical component are made [16]. Prototype development can affect the final stages, prices and the product itself. Physical prototype is not cost-saving as it takes longer time to finish therefore most automotive industry players uses Virtual Prototyping (VP) as a way to reduce prototype construction time without the physical prototype construction. Therefore, by using VP techniques also can be minimized therisk, which periodically confirmed that design was headed on right directions. VP is about presentation, testing and analysis of three-dimensional CAD models prior to creating any physical prototypes. The technology for using virtual prototypes was pioneered and adopted initially by large automotive and aerospace industries [19].

A lot of capabilities of using VP, for example Zorriassatine [19]identified that VP can be used for several process such as checking and analyzing parts in visualization, examine part for considering fit and interference of mechanical assemblies, testing and verification of functions and performance, evaluation of manufacturing and assembly operation, and capable of human factor analysis. Besides, it's capable to perform motion simulation. The VP technique using motion simulation also checks for interferences, and this is a very different

process from interference checking available with CAD assembly animation. Motion simulation conducts interference checks in real time, and provides the exact spatial and time positions of all mechanism components as well as the exact interfering volumes. This process not only solves analytical problems but also can be extended to generate the new parts in the assemblies using trajectories of motion into CAD geometry [20].

Different prototypes were prepared and verified to formulate the final car carrier design [18]. In VP basic models are transferred to motion simulation program. These processes not only avoid using physical prototyping techniques, but also validate products in all stages of designs. Thus in today's sustainable environment use of virtual prototyping is becoming popular with virtual enterprising designs in automotive industries [19]. Product marketability is increased with use of VP techniques allied with concurrent engineering. VP brings several advantages: reduce the time and cost of new product development; reduce the product cycles; reduce the number of expensive physical prototypes and experiment with more design alternatives; automotive engineers can quickly exploring multiple design variations, testing and refining until optimizing suspension behavior, long before building the first physical prototype. Virtual prototyping platform includes CAD (ex. EUCLID, CATIA, PROENGINEER), MBS (example ADAMS, DYMES, SDS) and FEM (ex. NASTRAN, NISA, COSMOS) software as in Figure 3 [21].

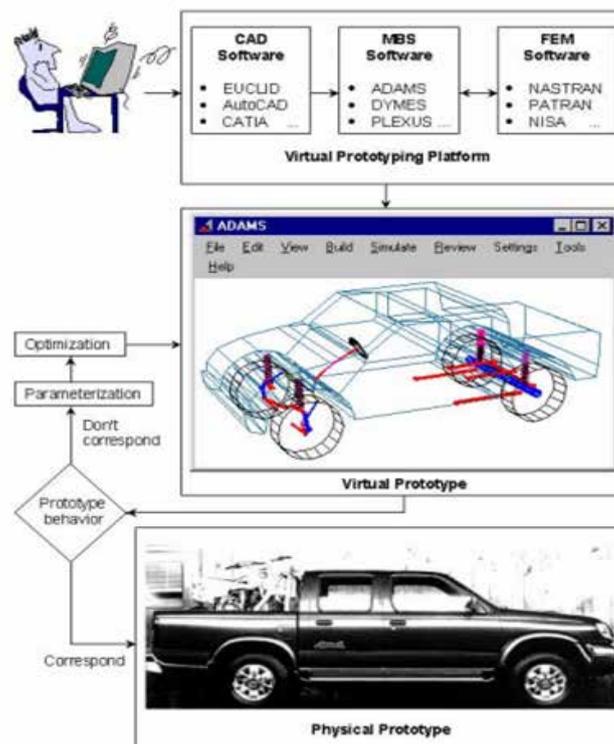


Fig.3: Virtual Prototyping Platform

In previous study, VP system provides tools for simulation and visualization to analyze and improve product design and its fabrication process. Hence the key factor such as product shape and manufacturability that can affect the product maturity and profitability can be optimized quickly [22]. CoMET-METeor applied VP for the solution of embedded software development environment developed by Synopsys, Inc for Mazda to conduct testing for ECU verification which is taking a longer time during design stage. This software helps Mazda to save time and cost by decreasing the number of tests on real vehicles and Hardware in the Loop (HIL) test equipment. It's designed to improve developer productivity with ease of integration, non-intrusive multicore debugging and analysis, real-time execution speeds, and the ability to apply real-world user interfaces. This

enables concurrent development of hardware and software, which shortens embedded system suppliers' hardware/software integration and test cycle time, resulting in accelerated time to market. For PROTON, Autodesk Digital Prototyping was used for sketching, illustration, image editing and integrated 3D environments that allow PROTON to reduce the use of expensive, physical models along with time consuming linear processes. Autodesk software enables Virtual Reality prototyping being combined to save time. Physical still are necessary at some downstream step (for example, car industry uses sculpture clay models for designers to check the physical form of a car). But, when applicable, the use of virtual prototypes provides many advantages. VP also plays an important part in analyzing the ergonomics features of an automobile. Zsolt et al [23] stated that by dynamic simulation it can verify kinematic assembly in real conditions of function and load, respectively design validation and making the testing process more efficient and also the study of car ergonomics can be determine. Car test crash are also able to be simulated using VR without having the physical prototype. At BMW, test crash is conducted using VP within 2-4 days in Virtual Environment. The computer simulate a head-on collision against a wall, operating day and night in the process and subdividing the tenth of a second in actual the impact into increments each lasting just a thousandth of a second. This procedure saves a lot of time, since a "real" prototype car costs up to three-quarters of a million Euro. By comparison, a computer "crash" of the type described costs only about Euro 400, despite the long computer time required.

V. VIRTUAL TEST DRIVE

Another addition to VR is the use of Virtual Test Drive whereby potential car buyers doesn't need to go to showrooms to test drive a car. However there is lack of literature on this topic as this is fairly new in the automotive industry. VR Test drive system comprises a control means with an associated memory where the control means is being programmed with distant server computer. The server computer is control through a network particularly the Internet [24]. VR is adopted into Virtual Test Drive where it's designed to give users a sensation of being in certain surroundings, given adequate hardware. Potential buyers can compare car models of different brands without having to leave home. VR systems are coupled with the internet and also with headgear to complete the VR Test Drive. Virtual Test drive is more convenient for car retailers as they don't need to set up store with the physical car displayed, flagship store or digital store will replace the physical store. Dealerships are changing in format, size and concept emphasizing on going fully digital thus incorporating VR into the sales of the cars. Major market players in the automotive industries have begun to introduce Virtual Test Drive in order to get potential customers. In Nov 2014, Volvo introduces Volvo XC90 Virtual Test-Drive Uses Google Cardboard which combines a Volvo application with Google Cardboard [25]. Google Cardboard is developed by a group of VR enthusiast at Google that uses smartphone to create VR experience. By using a cardboard accompanied with open software toolkit makes VR software coding as easy as building a website. The VR Toolkit enables developers familiar with OpenGL to create VR applications. The toolkit simplifies VR development tasks, including head tracking, 3D calibration, side-by-side rendering, stereo geometry configuration and user input event handling [26]. Figure 4 shows the simple build-up of google cardboard than can create immersive experience for users. To name a few there are Nissan "Detour", Kia "Venga MPV Virtual Test Drive" and BMW "i3 Virtual Test Drive"



Fig.4: Google Cardboard Head Gear

In VR testdrive, another important data that need to be incorporated is Global Positioning System (GPS). Thomaidis et al [27] stated that by using VR, it is able to produce virtual trajectories of a vehicle along a given route and produce GPS log files in various protocols. The benefit that stems from this application is that many driving styles and road conditions can be applied while creating as many logs as the user wishes. The specific application was developed for stimulating and testing a navigation system extension that automatically detects deviations between car movement and digital map hence making the VR Test drive data more accurate.

VI. CONCLUSION

In conclusion, application of Virtual Reality is limitless inside the automotive industry. In design development stage, VR helps designers to simplify design process and identify parts problems earlier and reducing production cycle time. Computer aided design, CAD/CAE helps to integrated data into VR and enabling intuitive data to be analyze. Virtual Prototype has rapidly transform the automotive industry where it reduce the product cycles, reduce the number of expansive physical prototypes and can be use countless time within the process. Another new application for VR is VR Test Drive where potential customers can test drive without having to go to showrooms and provide better insight view of the car. It's more convenient and also helps to introduce VR to the public. It is certain that VR is very important part of the automotive industry that helps the industry fast growth to cater the market demand.

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TERRORIST NETWORK MINING: ISSUES AND CHALLENGES

R. D. Gaharwar¹, Prof. D. B. Shah², G. K. S. Gaharwar³

^{1,2} *G. H. Patel Department of computer Science and Technology, Sardar Patel University, Vallabh Vidyanagar (India)*

³ *School of Business and Law, Navrachana University, Vadodara (India)*

ABSTRACT

Before few decades Terrorism was merely considered as a law and order problem in many countries. But due exponential increase in the number of such organizations and their activities, they become threat for very existence of many countries. Many of these terrorist organizations are equipped with the advance technology based weapons. Also, it has been observed in last few decades that these terrorist organizations are communicating and coordinating with other terrorist organizations. Traditional war methods are not equipped to counter such an organized network of terrorist organizations and a systematic effort is greatly to study the architecture of such terrorist networks. This paper is a small step in that direction. This paper looks at the usefulness of Social Network Analysis and Graph Theory for decoding the structure of terrorist networks through Terrorist Network Mining.

Keywords: *Betweenness, Closeness, Graph Theory, Prestige, Terrorism, Terrorist Network Mining, Social Network Analysis.*

I. TERRORISM

During the past few decades terrorism is becoming a worldwide phenomenon and emerged as a threat to internal security to many nations. What can be called as the definition of the term “terrorism” is an attention seeking question. Criminal acts intended or calculated to provoke a state of terror in the general public, a group of persons or particular persons for political purposes are in any circumstance unjustifiable, whatever the considerations of a political, philosophical, ideological, racial, ethnic, religious or any other nature that may be invoked to justify them [1].

Terrorism is a pejorative term; it is a word with inherently negative connotations that is generally applied to organizations working against the citizens of the country. All dictionaries agree that terrorism is all about fear, uncertainty and violence, and a terrorist is one who uses act of violence and terror, or other fear-inspiring means, to coerce a government or a community to agree on something that the terrorist wants. Most of the times these terrorist and terrorist organizations are involved in the armed attack which results in death of innocent citizens, loss and/or damage of private and/or public property. These organizations make a long term impact to the region of their operations by hindering development of the affected region; Jammu & Kashmir and Palestine are the examples of such terrorism. In the era where many countries are equipped with nuclear warheads, the traditional war between countries is distant reality and so such wars are been replaced by proxy wars better known as terrorism. The greatest security threat facing countries like India, Afghanistan, Pakistan, United States and

United Kingdom is not from other countries, but from terrorist organizations that attack informally, using terror at any time and place. The war against such proxy war can no longer be fought with structured battle that with structured military establishment, the war against terrorism can only be won with superior knowledge about these terrorist organizations. Knowledge which can be used to study the terrorist network helps security organizations to identify the role of each organization in the network, finding association of each of the organizations in the network and to foresee their next action. This systematic approach, called as Terrorist Network Mining (TNM), towards will lead us to the use of Social Network Analysis (SNA) and Graph Theory concepts for studying the behavior of these terrorist networks.

II. NETWORK ANALYSIS

Network analysis is the study of social relations among a set of actors. It is a field of study -- a set of phenomena or data which we seek to understand. Network analysis is based on the uncovering the patterning in data that seems unrelated initially. There are some theoretical perspectives in network analysis which focuses on relationships between actors and not on the attributes of these actors and that these patterns display important features of the lives these actors. Network analysis helps in explaining that how an individual actor's importance is defined by a fact that how that actor is tied into the larger web of social connections. Network analysis has following perspectives:

- focus on relationships between actors rather than attributes of actors
- structural and locational properties of actors
- focus on structural properties of actors
- emergent effects

Network Analysis focuses on the intuitive notion that the patterns of human interaction represent the behavior of the individuals who display them. Network analysts believe that the characteristics of individuals can be analyzed in better way by focusing on their role in web of social connections and this role will determine the stature of the individual in the society. Moreover the success or failure of any organization or social structure depends on the strength of the social connections.

III. TERRORIST NETWORK MINING (TNM)

Relationship among terrorists form the basis for the organized crimes and are essential for smooth operation of a terrorist organization which can be viewed as a network where nodes represents a terrorist or an terrorist organization and links represent relationships between terrorists and/or terrorist organizations. TNM has emerged as a novel field of research often applied to investigation of organized crimes. Relationships among criminals/terrorists form the basis for the organized crimes and are essential for smooth operation of a criminal/terrorist organization [2]. TNM is emerged a field of research often applied to investigation of such organized crimes from terrorists.

TNM is the process of posing questions and digging useful information often earlier unknown from huge amounts of data of social communication using various known techniques.

Recently data mining is becoming an effective tool for counter-terrorism applications. For example, data mining can be used to detect unusual patterns, terrorist activities and fraudulent behavior. To carry out effective terrorist network mining and extract useful information for counter-terrorism and national security, we need to gather all

kinds of information about terrorist organizations. However, these terrorist organizations operate in a covert manner and their secrecy proves to be their strength hence this information is not available in open source.

IV. SOCIAL NETWORK ANALYSIS (SNA)

Nowadays TNM can successfully be used for the investigation of organized crimes. Relationships among criminals/terrorist form the basis for the organized crimes and are essential for smooth operation of a criminal/terrorist organization which can be viewed as a network where nodes represent terrorist and links represent relationship or associations between terrorist [3]. This mining of terrorist networks used to be a time consuming task in past because it was done manually, moreover no prominent techniques were available for it. However nowadays SNA has emerged as an effective technique for destabilizing these terrorist networks. In past few years the techniques of SNA have brought about a paradigm shift in counter terrorism planning and strategies [4]. Study of the linkage patterns of terrorist networks can usefully draw upon the academic perspectives provide by Social Network Analysis and modern statistical and visualization tools [5]. In past few years there has been tremendous increase in the number of articles on Social Network Analysis. Fig. 1 shows the increase in number of users on social network (Data Source: <http://dstevenwhite.com/2013/02/09/social-media-growth-2006-to-2012/>).

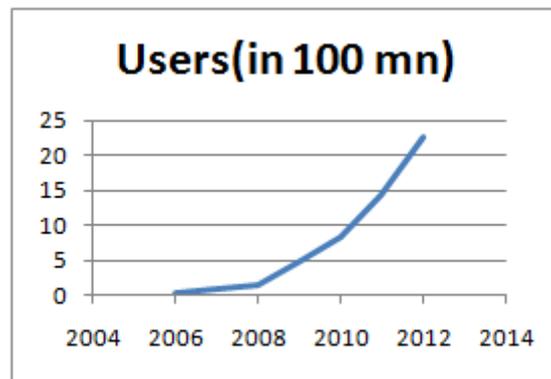


Fig. 1: Increase in Number of Social Network Users

The social network paradigm which is the theoretical and formal bases for the relational study for social structures is nowadays used for the analysis of relational data measured on groups of social actors and studying structural properties of actors interaction. The SNA focuses on destabilizing the pattern of human interaction.

SNA uses graph theoretic calculations to study the behavior of networks and multivariate analysis to create visual displays [6]. In some form or other these methods have been used to track and uncover associations of criminals. SNA has a long history of application to evidence mapping in both fraud and criminal conspiracy cases [7]. The terrorist organization can be represented as a network using a technique known as SNA which studies social relationships amongst nodes and ties. In case of a terrorist network, the members are considered as the nodes and the ties describe the interactive or collaborative relationships between the pairs of nodes [8]. SNA helps to answer the following questions [9]:

- Who is central node in the networks?
- What sub-groups exist in the network?
- What are the patterns of interaction between sub-groups?
- What is the overall structure of the networks?
- How does information flow in the network?

Terrorist networks are well-suited to study using social network analysis, as they consist of networks of individuals that span countries, continents, and economic status, and form around specific ideology. Most importantly, social network analysis can be used to understand terrorist networks and form the basis of a more effective counter-measure.

V. DIFFERENT APPLIANCE OF SNA FOR TNM

The government agencies are intensely interested in data mining. A 2004 survey by the Government Accountability Office found that federal agencies were engaged in or planning 199 data mining projects, including 122 involving personal data. A database of phone records wouldn't be hard to create; the data exists.[reference]

Valdis Krebs, founder of social networking analysis company OrgNet.com, conducted his own analysis of the 9/11 terrorists by collecting information from press reports such as who called whom, the addresses shared by the terrorists and their known associates, and information that they used the same frequent flier number. Krebs found that more links led to the group's leader, Mohammad Atta, than to any other terrorist.

One data mining effort within the Defense Department, called Pathfinder, involves analyzing government and private-sector databases, including rapidly comparing and searching multiple large databases for anti-terrorism intelligence. The FBI's Foreign Terrorist Tracking Task Force culls data from the Department of Homeland Security, the FBI, and public data sources to prevent foreign terrorists from entering the country. Other tools for counterterrorism include technology from Autonomy that searches Word documents across various intelligence agency databases; Verity's K2 Enterprise, which mines data from the intelligence community and through Internet searches; and Insight's Smart Discovery, which looks into and categorizes data in unstructured text.

VI. GRAPH THEORY FOR SOCIAL NETWORK ANALYSIS

The graph theories are use to create the models which will help in the analysis of network. Basically, the graph is the collection nodes (n) and the edges (e) such that $e = (n_i, n_j)$ where n_i and n_j are any two connected nodes. When graph theory is used to represent the social network then such graph is called sociogram, where nodes are the actors and edges are the lines of connection between these actors. These sociogram can be both directional as well as non-directional.

There are various concepts of graph theory like closeness between the actors, positions of prestige, centrality etc which can be applied in the analysis of social networks.

Degree	Number of <i>direct connections that a node has</i>
Betweenness	The number of paths that <i>connect pairs of nodes that pass through a given node</i>
Prestige	A measure of <i>links to other highly central nodes</i>
Closeness	The number of <i>other nodes that are linked to a given node</i>

These parameters have calculated indices based on matrix algebra with direct network implications. An entity with a high Degree index means that it is very strongly networked and active. An entity with a high Betweenness index would have a strong 'brokerage' role. A centralised network with a very high Degree index in one or a few nodes can become a single point of failure. A less centralised network would be resilient in the face of collapse or failure; it would experience graceful degradation. [Application of Social Network Analysis (SNA) to Terrorist Networks]

VII. PRIVACY ISSUES

Data mining is nowadays used for detecting unusual behavior patterns, terrorist activities and fraudulent behavior. Terrorist network data mining applications can be beneficial to human lives but it may pose threat to the privacy of individuals. Data mining tools that are easily available on the internet can be used by the notorious individuals to extract the information of some individuals from the data stored on the databases and this may consequently violate the privacy of individuals. Therefore there is very thin line of difference between gathering the information about individuals for national security and for violating the civil liberties.

VIII. CONCLUSION

The complex web of terrorist organizations can be decoded with the help of systematic approach of Social Network Analysis. Good old graph theory concepts like degree, betweenness, prestige and closeness can effortlessly identify the role and contacts of each organization in the terrorist network. Terrorist network mining tools develop to study these terrorist networks and help law enforcement agencies to destabilize this networks.

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STATISTICAL PERFORMANCE BASED ON DIFFERENT EDGE DETECTION TECHNIQUES

Toshi Patel¹, Dimpy Singh², Amrita Kaur³

^{1, 2, 3} Student, M.Tech Scholar (S.E), SRMSCET, Bareilly, (India)

ABSTRACT

Paper is concerned with the study of various edge detection techniques like Prewitt, Robert and Sobel on various images to detect edges and extract its data statistics. Edge detection is a name for set of mathematical methods which aim at identifying point in digital image at which image brightness changes sharply or more formally has discontinuities. Edge detection refers to the process of identifying and locating stridently discontinuities in an image. Hence edge detection is vital step in image analysis and it is the key of solving many difficult problems. In this paper we show the performance analysis of edge detection techniques.

Keywords: *Edge Thinning, Convolution, Gradient*

I. INTRODUCTION TO EDGE DETECTION

Edge detection is a decisive step in the computer vision and object recognition, because the most fundamental trait for image recognition is the edges of an image [12]. Detection of edges for an image may help for image segmentation, data compression, and also support for image reconstruction and so on. Edge detection is a vital tool in image processing, machine vision and computer vision, mostly in the areas of feature detection and feature extraction. Edges are major local changes of strength in an image. Edges typically happen on the boundary between two different regions in an image. The purpose of edge detection is significantly reducing the amount of data in an image and preserves the structural properties for further image processing. The edge in a grey level image is a local feature that, within a neighborhood separates regions in each of which the gray level is more or less uniform with in different values on the two sides of the edge. For a noisy image edges detection is difficult as both edge and noise contains high frequency filling which results in blurred and distorted result [4]. Edge detection is one of the most frequently used operations in image analysis. If the edges of images could be recognized exactly, all of the objects can be located efficiently and performance can be measured easily [10]. The quality of image is affected when there is a jump in intensity from one pixels to the another. Thus important objective is to detect an edge while preserving the important structural properties of an image. In order to analyze various edge detection techniques, comparative analysis of these techniques based on certain parameters like type of edge, edge localization, environment, cost, role etc. are discussed.

Edge detection converts a 2D image into a set of curves, Extracts salient features of the scene, more compact than pixels.

1.1 Goals of Edge Detection

- Produce a line drawing of a sight from an image of that scene.
- Important features can be extract from the edges of an image (e.g., corners, lines, curves).
- These features are used by higher-level computer vision algorithms (e.g., recognition).

1.2 Applications of Edge Detection

Edge detection is an important image processing technique with wide range of applications. Several edge detection algorithms have been developed in the past few years, though no single algorithm is appropriate for all application type of applications of edge detection. One of the main use of edge detection techniques is in the process of image segmentation and object detection [5].

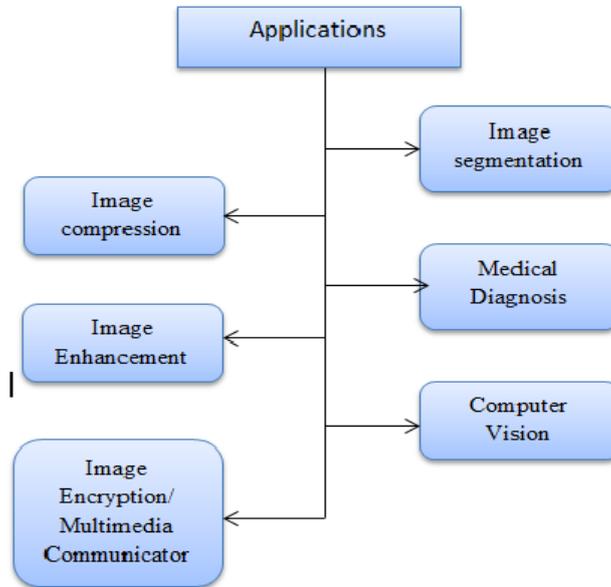


Fig. 1 Applications of Edge Detector

1.3 Edge Detection Methodologies

Edge detection makes use of differential operators to detect changes in the grey levels gradients. It is distributed into two main classes:

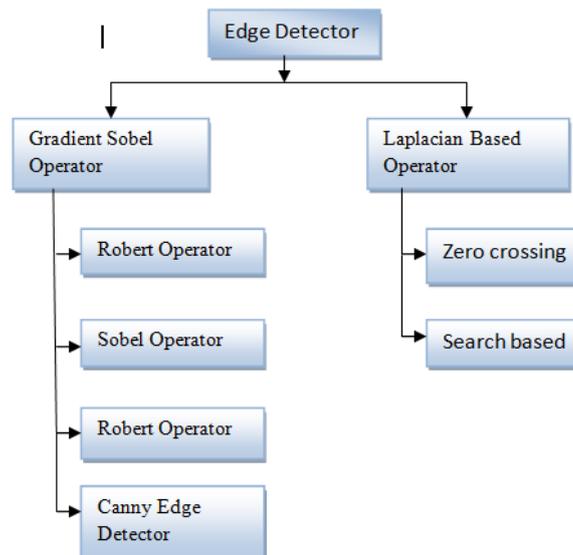


Fig. 2. Edge Detection Methods

The entire paper is organized in the following sequence. Section -1 had the brief introduction of edge detection, which includes goals, applications and methodologies of edge detection. Section -2 explains steps of edge

detection; Section -3 states the types of edges. In section -4 Robert, Prewitt and Sobel edge detection techniques are stated. Section -5 shows the result. Lastly, Section -6 ends with conclusion and future work.

II. STEPS OF EDGE DETECTION

Edge detection consists of following four steps.

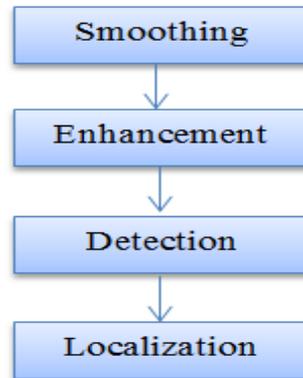


Fig. 3 Applications of Edge Detector

A. Smoothing

Conquer as much noise as possible without terminating the true edges.

A. Enhancement

Apply a filter to enhance quality of images (sharpening).

B. Detection

Determine which edge pixel should be discarded as noise and which should be retained (usually thresh holding provides the criterion used for detection).

C. Localization

Determine the exact location of an edge (Sub pixel resolution might be applicable for some applications,i.e, estimate the edge location to better then the spacing among pixels). Edge thinning and networking are usually required in this step.

III. TYPES OF EDGES

Changes in intensity can occur due to various physical actions like discontinuity in object boundary, surface direction and in geometry changes in intensity [7]. Edges can be shaped according to their amplitude changes as follows:

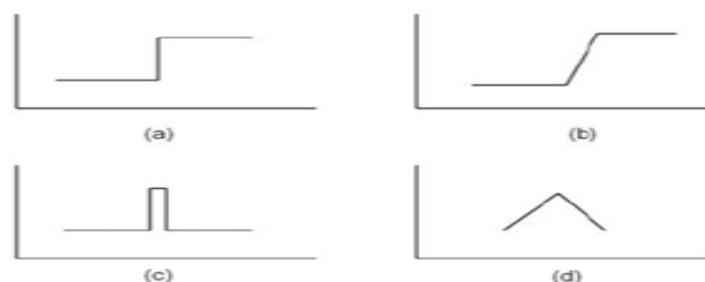


Fig. 4 Different Types of Edges

A. Step Edge

The image intensity suddenly differs from one value to one side of the breakage to a different value on the other side.

B. Ramp Edge

When the intensity change is not natural and seems over a limited distance then step edges become ramp edges.

C. Ridge/Line Edge

The intensity of an image rapidly changes values and then returns to the initial point within short distance.

D. Roof Edge

When the intensity change is not spontaneous and appears over a finite distance usually generated by connectivity of surfaces then line edges become roof edges [7].

IV. TECHNIQUES FOR EDGE DETECTION

4.1 Robert's Cross Edge Detection

Define Roberts edge detection method is one of the oldest methods and is used often in hardware implementations where simplicity and speed are dominant factors. Robert's edge detection operator is based on the principle that difference on any pair of mutually perpendicular direction can be used to calculate the gradient [10].

The Robert's cross operator is used in image processing and computer vision for edge detection. It was one of the first detectors of edge and was initially proposed by Lawrence Roberts in 1963. As a differential operator, the idea behind the Roberts cross operator is to approximate the gradient of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels.

In order to perform edge detection with the Roberts operator we first convolve the original image, with the following two kernels:

$$\begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \text{ and } \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix}$$

Let $I(x,y)$ be a point in the original image and $G_x(x,y)$ be a point in an image formed by convolving with the first kernel and $G_y(x,y)$ be a point in an image formed by convolving with the second kernel.

The gradient can then be defined as:

$$\nabla I(x,y) = G(x,y) = \sqrt{G_x^2 + G_y^2}$$

The gradient direction can also be defined as follows:

$$\theta(x,y) = \arctan\left(\frac{G_y(x,y)}{G_x(x,y)}\right)$$

4.2 Prewitt Edge Detection

Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images.

The Prewitt operator is used in image processing, mostly within edge detection techniques. Technically, I is a discrete differentiation operator, estimate the gradient of the image intensity function. At all points, the result of the Prewitt operator is either the consistent gradient vector or the custom of this vector. The Prewitt operator is depends upon convolving the image with a small, discrete and integer valued filter in parallel and perpendicular directions and is therefore relatively inexpensive in terms of computations.

The Prewitt edge detector is a suitable way to estimate the magnitude and alignment of an edge. Though differential gradient edge detection needs a rather time consuming calculation to estimate the coordination from the magnitudes in the x- and y-directions, the Prewitt edge detection gain the orientation directly from the kernel with the maximum response [10].

Mathematically, the operator uses two 3x3 kernels which are convolved with the original image to calculate estimates of the derivatives – one for parallel changes, and one for perpendicular. If we define A as the source image, and G_x and G_y are two images which contain the horizontal and vertical derivative estimates, the latters are calculated as:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * A \text{ and } G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} * A$$

Where * denotes the 2-dimensional convolution operation. Since the Prewitt kernels can be decomposed as the products of an averaging and a differentiation kernel, the compute the gradient with leveling. Therefore it is a separate filter. For example, G_x can be written as:

$$\begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

The x- coordinate is well-defined here as growing in the “right” –direction, and the y-coordinate is well-defined as growing in the “down”- direction. At each point in the image, the resultant gradient approximations can be combined to give the gradient rule, by:

$$G = \sqrt{G_x^2 + G_y^2}$$

Using this information, we can also calculate the gradient's direction:

$$\theta = \text{atan2}(G_y, G_x)$$

Where, for example, θ is 0 for a perpendicular edge which is obscurer on the right side.

4.3 Sobel Edge Detection

The Sobel operator, sometimes entitled Sobel Filter, that is used in image processing and computer vision, for the most part inside edge detection algorithms, and creates an image which emphasize edges and transitions.

Sobel method is practical to detection an edge. The Sobel edge detector uses two covers with 3x3 sizes, one estimating the gradient in the x-direction and the other estimating the gradient in the y-direction. The cover is slid over the image, using a square of pixels at a time. The algorithm estimates the gradient of the intensity of the image at all point, and then provides the direction to the growth of the image intensity at all point from light to dark. Edges areas represent strong intensity contrasts which are darker or brighter [5].

The maximum value of two convolutions will be referred as output value of the exchanging point. Sobel operator is easy to accomplish in space, has a smoothing effect on the noise, is nearly affected by noise, can provide more accurate edge direction information but it will also detect many false edges with coarse edge width [3].

-1	-2	-1
0	0	0
1	2	1

-2	0	2
-2	0	2
-1	2	1

Fig. 5 Sobel Operator

The operator uses two 3x3 kernels which are convolved with the original image to calculate approximations of the derivatives – one for parallel changes, and one for perpendicular. If we describe A as the source image, and G_x and G_y are two images which at all point contain the parallel and perpendicular derivative estimates, the calculations are as follows:

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * A \text{ and } G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A$$

Where * signifies the 2-dimensional convolution operation.

Then the products of an averaging and differentiation Kernel decomposed by Sobel kernels they compute the gradient with leveling.

For example, G_x can be written as

$$\begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} [-1 \ 0 \ +1]$$

The X-coordinate is well-defined here as growing in the “right” –direction, and the Y-coordinate is well-defined as growing in the “down” –direction. At all point in the image, the resultant gradient estimates can be combined to provide the gradient rule, by:

$$G = \sqrt{G_x^2 + G_y^2}$$

Using this information, we can also calculate the gradient’s direction:

$$\theta = \text{atan2}(G_y, G_x)$$

Where, for example, θ is 0 for a perpendicular edge which is brighter on the right side.

The edge detection methods that have been published mainly differ in the types of smoothing filters that are applied and the way the measures of edge strength are calculated. As many edge detection methods depend on the calculation of image gradients, they also vary in the types of filters used for calculating gradient estimates in the x- and y-directions.

V. RESULTS

Figure below shows the original image on which different edge detection techniques are applied to detect the edges and find out the discontinuities in the image.



Fig 7 Original Image

5.1 Robert's Cross Edge Detection

Here we show the edge detected and data statistics obtained from Robert's cross Edge Detection method.

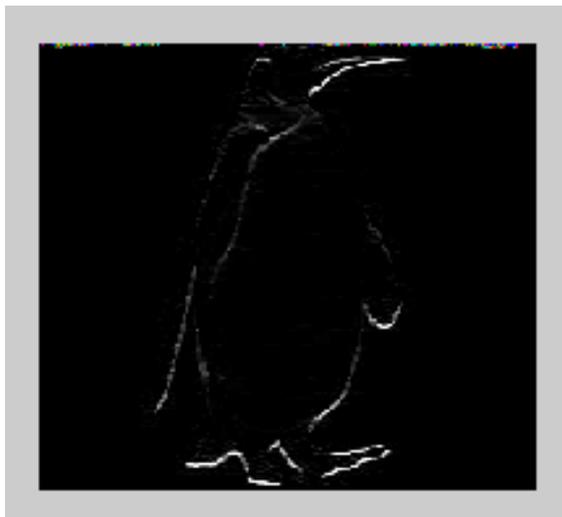


Fig 8 Edge Detected by Robert's Method

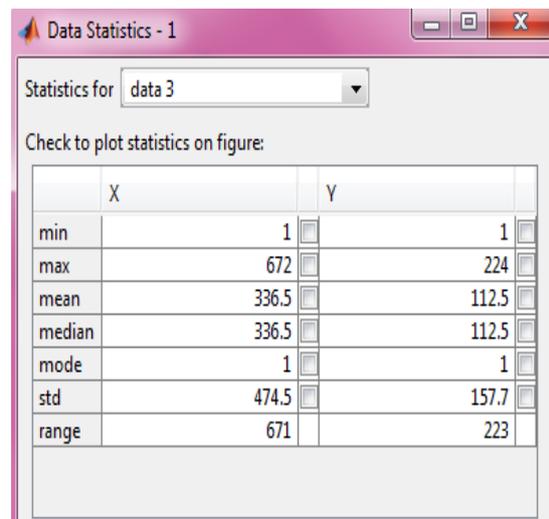


Fig 9 Data Statistics Obtained by Robert's Method

5.2 Prewitt Edge Detection

Here we show the edge detected and data statistics obtained from Prewitt Edge Detection method.



Fig 10 Edge Detected By Prewitt Method

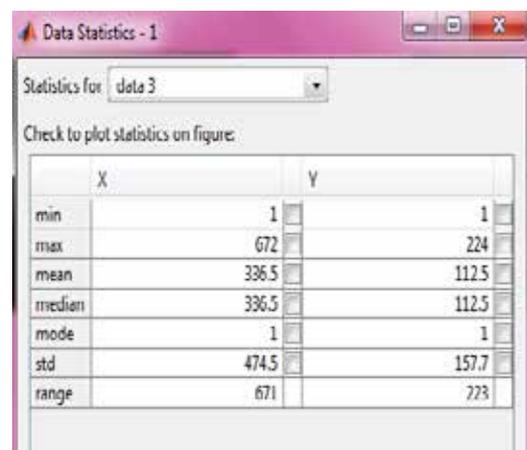


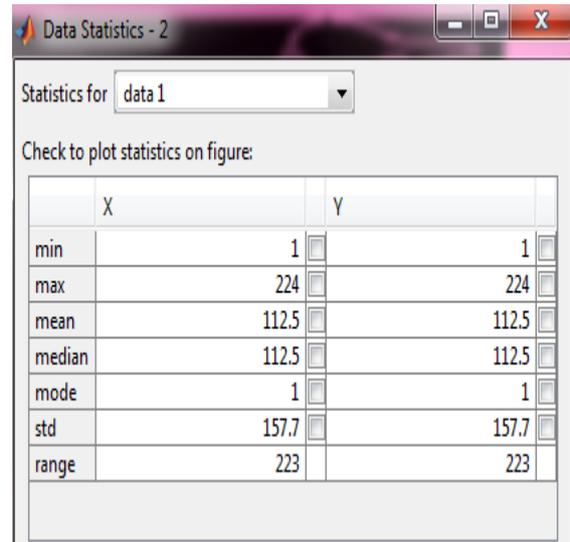
Fig. 11. Data Statistics Obtained by Prewitt's Method

5.3 Sobel Edge Detection

Here we show the edge detected and data statistics obtained from Sobel Edge Detection method.



Fig. 12 Edge Detected By Sobel Method

A screenshot of a software window titled "Data Statistics - 2". It shows a dropdown menu set to "data 1" and a table of statistics. The table has two columns, X and Y, and rows for min, max, mean, median, mode, std, and range. Each cell contains a numerical value and a small input field with a checkmark.

	X	Y
min	1	1
max	224	224
mean	112.5	112.5
median	112.5	112.5
mode	1	1
std	157.7	157.7
range	223	223

Fig. 13. Data Statistics Obtained By Sobel Method

VI. CONCLUSION AND FUTURE WORK

It is important to know the differences between edge detection techniques because edge detection is the very early stage in object recognition. For recalling most of the information of the image, representing an image by its edge has the advantage as it reduces the amount of data required to be stored. In this paper, we show the relative performance of different edge detection techniques is done with an image. These three techniques Robert, prewitt and sobel comes under the gradient edge detection technique. We observe that Sobel edge detection technique produces fewer discontinuities in detection of edges as compared to Robert and Prewitt edge detection techniques as shown in figure 7,9,11 respectively. Its corresponding data statistics obtained through MATLAB shows that data of Robert and Prewitt are almost same and data of Sobel differs from these two. In future, we can use fuzzy edge detection technique to resolve the discontinuities formed in Sobel edge detection algorithm.

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MICROTOPOGRAPHY, OPTICAL AND PHOTOELECTROCHEMICAL STUDIES OF $\text{SnSeNi}_{0.1}$

G K Solanki¹, I L Cahuhan², K D Patel³

^{1,3}Professor, Department of Physics, ²Research Student, Department of Physics
Sardar Patel University, Vallabh Vidhyanagar, Anand, Gujarat, (India)

ABSTRACT

A device for energy conversion i.e. Photo-electrochemical (PEC) solar cell can be fabricated from nickel doped tin selenide crystals, because of its unique electrical and optical properties. Nickel doped tin selenide crystals has two main properties i.e. Layered structure and band gap value, so this kind of crystals shows great promise for photovoltaic device fabrication. For the study of layered structure, growth mechanism and dislocation densities Surface microtopography is used; band gap value and various optical parameters can be studied by using absorption spectra achieved from UV-Visible spectrometer (200-2500nm). All these characterizations become important for fabrication of photovoltaic device i.e. Photo-electrochemical (PEC) solar cell (liquid-solid junction device). Efficiency and fill factor of this device is further calculated from I-V characteristics taken at 40mW/cm^2 intensities.

I. INTRODUCTION

The main purpose for fabrication of photovoltaic device is that, now a day there is an increased demand for renewable energy conversion devices like solar energy conversion device.[1-3] For this purpose in this paper authors have tried to carry out a brief study of a semiconducting crystals ($\text{SnSeNi}_{0.1}$) and its application as photovoltaic device fabrication i.e. study of structural and optical properties of $\text{SnSeNi}_{0.1}$ crystals and fabrication of device named Photo-electrochemical (PEC) solar cell. Nickel doped tin selenide crystal is one of the metal chalcogenide, have attracted considerable attention due to their interesting properties and potential applications as energy storage devices as well as photovoltaic device. This paper contains main three parts of device fabrication i.e. a) growth of $\text{SnSeNi}_{0.1}$ crystals; b) Study its surface and optical properties and c) Fabrication of energy conversion device by using these properties of crystals. There are different methods for the growth of nickel doped tin selenide crystals, have been described in the literature [1]. Such kind of device fabrication is basically depend on the surface properties of crystals so Surface microtopography becomes very important characterization for study structural properties of crystals like growth mechanism, dislocation density and defects. In photovoltaic devices absorption of solar energy takes place for the conversion of energy, according to allowed band gap of materials or crystals. In this case it is necessary to carried out UV-Visible spectroscopy characterization in the allowed range for obtaining absorption spectra in which absorption of polychromatic light can easily takes place, calculation of band gap value and various optical parameters also becomes possible. After the study of surface and various optical properties of crystals it is possible to fabricate Photo-electrochemical (PEC) solar cell device. Working and efficiency of this fabricated solar cell discussed further.

II. EXPERIMENT AND RESULT

Growth. Semiconductors with narrow band gap have been synthesized by solvothermal route, electrodeposition, vapor technique, sol-gel method and mechanochemical synthesis [1]. Tin selenide is high temperature; insoluble material which melts before its melting point reaches so after a faithful study it becomes clear that, the appropriate and successful growth technique for nickel doped tin selenide crystals is direct vapor transport (DVT) technique. With the help of this technique it is possible to grow large quantity quality crystals with flat and smooth surface for further characterization study.

Surface microstructure. The surface microstructure of the fresh as-grown faces of SnSeNi_{0.1} crystals were examined under 'Epignost' optical microscope (Carl Zeiss Jena GmbH, West Germany). Fig. 1 shows the layered type growth of crystal for orthorhombic crystal. SnSeNi_{0.1} crystals grow in the platelet form along bc-plane having thickness in the direction of crystallographic a-axis, which allows immediate access to observe (400) face by microscope. The reason of clean surface is absence of any dangling bond. Microtopography of the grown crystals shown in Fig. 1 indicates that the growth of SnSeNi_{0.1} crystals promoted by lateral spreading of layers. Moreover their regular shape of growth layers at the edges of smooth flat faces indicates that the growth was rapid [4]. In the case of SnSeNi_{0.1} growth spirals are observed on the crystal surface as shown in Fig. 1 indicating that their growth was driven by a screw dislocation mechanism. In growth from vapour, theory [3] predicts that the growth of a crystal surface with steps will be the result of three processes: (1) transport of molecule from vapour to surface of solid, (2) diffusion of adsorbed molecule to steps, and (3) diffusion of molecules along the edge of a step to a kink. [4-5]

UV-Visible Spectroscopy. The optical absorption data were taken by means of (Perkin Elmer Model: Lambda-19) Spectrophotometer. Morphological study of as grown surfaces of crystal consists of a variety of structures whose study leads to mechanism of growth. The surfaces of this type of grown crystals were mirror like. Crystal flakes were pasted on a thick black paper with a cut exposing the crystal flake to the incident light. The reference used for this work was a replica of the black paper, having the cut in the exactly the same position as the crystal flake. This arrangement was necessary because the crystal size was smaller than that of the sample compartment. In this present case, absorption spectrum taken over the spectral range 200-2500 nm. The absorption coefficient ' α ' was determined at every step of 5 nm and had scanning speed 240 nm/min. Fig. 2 shows the UV-Visible absorption spectrum of SnSeNi_{0.1}. Fig. 3 shows graph of $(\alpha h\nu)^{1/2}$ vs. photon energy. The point at which the extended line intersects gives the value of direct allowed band gap and it can be calculated using Tauc relation. UV-VIS reflectance spectrum has less effect in scattering than absorption. The sudden decrease of absorption at a particular wavelength, corresponding to the optical band gap means that the particles are almost uniformly distributed in the sample. [6]

The direct band gap energy (E_g) for the SnSeNi_{0.1} is determined by fitting the reflection data to the direct transition equation. For the analysis of the experimental results obtained at constant temperature, this equation is sufficient especially while we are interpreting results from semiconducting materials absorption spectra. Plotting $(\alpha h\nu)^{1/2}$ as a function of photon energy and extrapolating the linear portion of the curve to absorption equal to zero gives the value of the direct band gap to be 0.90 eV. Other than this various optical properties like reflection, transmission, reflective index, extinction coefficient, dielectric constant, dissipation factor etc. It may be mentioned that, in amorphous chalcogenide thin films, the number of defects are higher due to the existence of unsaturated bonds. [5] The reflective index and extinction coefficient linked to the light scattering mechanism and it brings its low dielectric losing. The complex dielectric constant is a fundamental intrinsic property of

materials directly linked to its refractive index. The real part of the dielectric constant, ϵ_r is linked to the electronic polarizability whereas the imaginary part ϵ_i is related to the absorption phenomenon due to dipole motion.

The Photoelectrochemical (PEC) solar cell. The Photoelectrochemical (PEC) solar cell is one kind of solid-liquid junction diode. The solid junction made up of electrode, made up of SnSeNi_{0.1} crystal, a copper wire for took out contact and a platinum wire as a counter electrode and the liquid junction is made up of freshly prepared transparent electrolyte i.e. 0.1M Na₂SO₄+0.1M KI+0.05M I₂+H₂SO₄. Polychromatic radiations made incident on the solid-liquid interface with the help of sodium light at 40mW/cm² illuminated intensity. Fig. 4 shows the schematic circuit diagram of fabricated Photo-electrochemical (PEC) solar cell arrangement. The main principle of the Photovoltaic cell involves the generation of photo voltage due to the absorption incident solar radiation by the semiconducting material and appropriate charge transfer.[8] In general the principle can be considered as combination of 3 steps (Fig 5)

Fig. 6 shows the I-V characteristic of SnSeNi_{0.1} electrode taken by using KEITHLEY LABTRACER 2.0 I-V CURVE TRACING application software at 40 mW/cm² incident intensity. Polychromatic light incident at the solid liquid junction of electrode and electrolyte assembly, as soon as light incident on the crystal surface kept in electrolyte assembly, charge transfer of majority charge carrier takes place. This mechanism gives rise to I-V characteristic of SnSeNi_{0.1} electrode. From the graph of I-V characteristic, it becomes possible to find out open circuit voltage (V_{oc}) and short circuit current (I_{sc}) as shown in Fig. 6. By using both these parameters i.e. open circuit voltage (V_{oc}) and short circuit current (I_{sc}); maximum power value (P_{max}), Fill Factor and efficiency (η) can be calculated by using equation 1, 2 and 3 respectively. The parameters calculated from Photoelectrochemical (PEC) cell characterization are displayed in Table 1.

III. EQUATIONS

$$\alpha h\nu = A (h\nu - E_g)^{1/2} \quad (1)$$

Where α is the optical absorption coefficient, $h\nu$ is the photon energy, E_g is the direct band gap and A is photon energy.

$$V_{oc} = \left(\frac{nkT}{e} \right) \ln I_L \quad (2)$$

Where, V_{oc} = open circuit voltage, n = ideality factor, $kT/e = 0.0259$ volt at 300K, I_L = Intensity of illumination.

$$I_{sc} = I_0 \left[\exp \left(\frac{eV_{oc}}{kT} - 1 \right) \right] \quad (3)$$

Where, I_{sc} = short circuit current, V_{oc} = Open Circuit Voltage, I_0 = Reverse saturation Current, k = Boltzmann Constant, T = Room Temperature.

$$FF = \frac{P_{max}}{I_{sc} \times V_{oc}} \quad (4)$$

Where, FF = Fill Factor, P_{max} = maximum power point, I_{sc} = short circuit current, V_{oc} = open circuit voltage.

$$\eta = \frac{I_{sc} \times V_{oc} \times FF}{I_L \times A} \quad (5)$$

Where, η =efficiency, I_{sc} = short circuit current, V_{oc} = open circuit voltage, FF= Fill Factor, I_L = Intensity of illumination, A= area of solar cell

IV.FIGURES AND TABLES

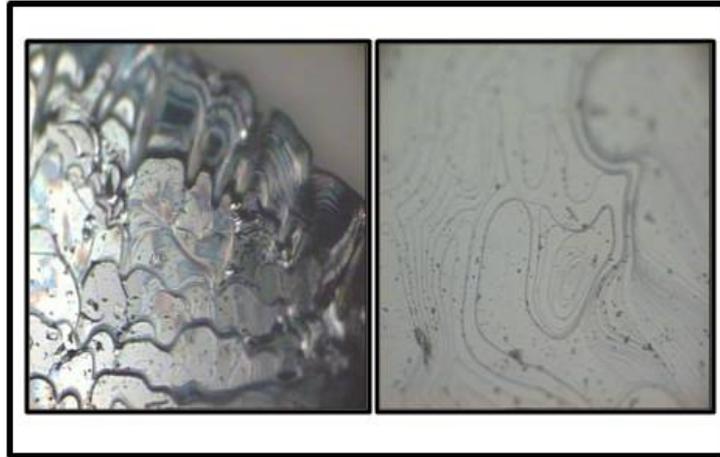


Figure 1 surface microstructure showing layered growth and spirals respectively

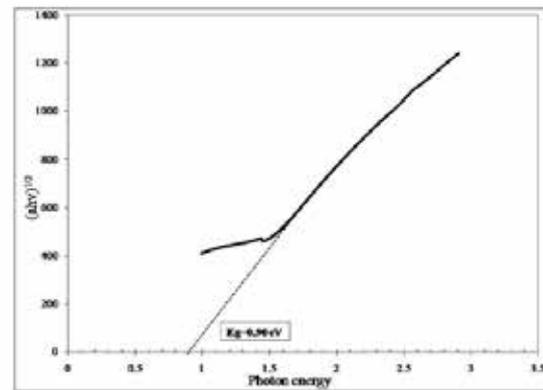
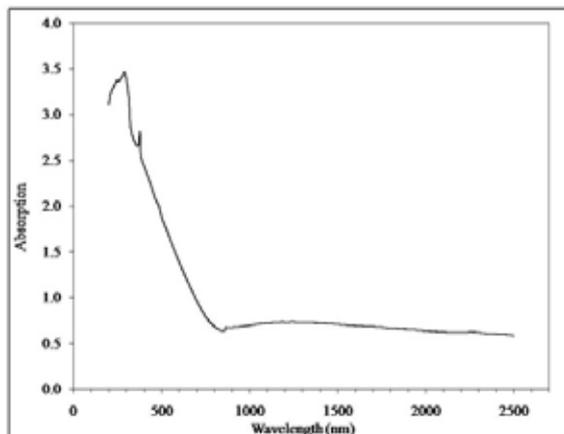


Figure 2 UV-Visible absorption spectrum of SnSeNi_{0.1} Figure 3 graph of $(ahv)^{1/2}$ vs. photon energy for SnSeNi_{0.1}

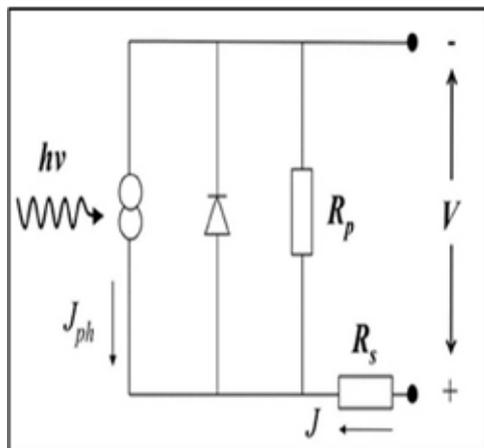


Figure 4 circuit arrangements for Photo Electrochemical (PEC) solar cell

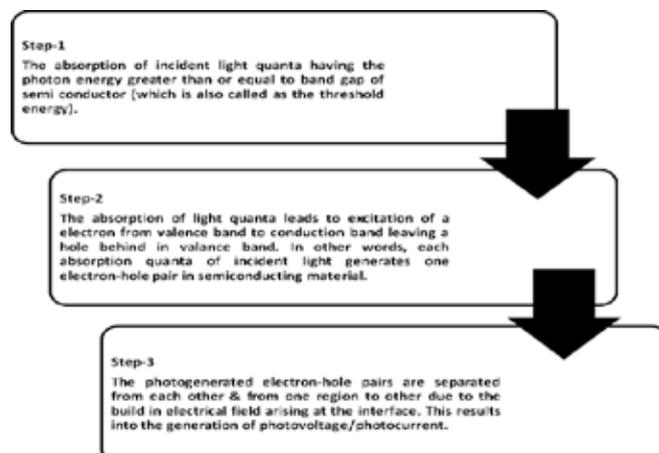


Figure 5 Photo Electrochemical (PEC) Solar Cell Principle

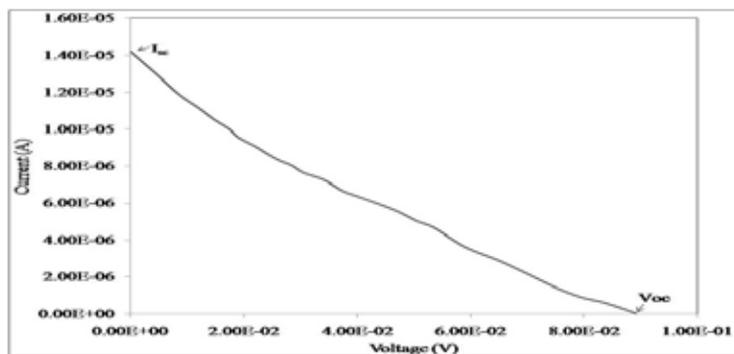


Figure 6 I-V Characteristics for SnSeNi_{0.1} Electrode at 40mw/Cm²

Table 1 Parameters Calculated From Photo Electrochemical (PEC) Solar Cell

Electrode	I _{sc} (A)	V _{oc} (V)	P _{max} (watt)	Fill Factor	Efficiency (η%)
SnSeNi _{0.1}	1.42E-05	0.08915	2.61633E-07	0.2	0.032

V. CONCLUSION

Good quality nickel doped tin selenide crystals can be successfully grown by Direct vapour transport (DVT) technique and the surface microstructure study confirms the layered growth of the crystal as well as it become essential tool for choosing less defect flat surface crystal. Another than that the band gap value (0.90 eV) of nickel doped tin selenide is falls in the range of semiconducting material, from the band gap value it can be concluded as good Photo-electrochemical (PEC) solar cell device can be fabricated from this crystal. In reference to that the UV-Visible characterization also shows there is maximum absorption in the visible range (solar radiation) of light spectrum. From all these characterizations it can be concluded that a very easy and a compatible device i.e. Photo-electrochemical (PEC) solar cell can be fabricated at low cost. From I-V characteristics and value of efficiency, it clears that this material can become very good solar cell if some modifications added to it.

VI. ACKNOWLEDGEMENTS

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A SYSTEMATIC WAY FOR ENERGY EFFICIENCY ON CLOUD COMPUTING ENVIRONMENT USING EELBVM MODEL

Harmanjeet Kaur¹, Ranbir Singh², Yogesh Kumar³

^{1,2}Department of Computer Science and Engineering, Shaheed Udham Singh College of Engineering
& Technology, Tangori, Mohali, (India)

³Department of Information Technology, Shaheed Udham Singh College of Engineering &
Technology, Tangori, Mohali, (India)

ABSTRACT

The popularity of cloud computing is increasing day by day so individuals, companies and research centers have started outsourcing their information technology and computational needs to on demand cloud services. Cloud computing is a thriving area in research and industry today, which comprises internet, virtualization and web services. Gradually more remote host machines are built for cloud services causing more energy consumption and power dissipation. The rising energy consumption of computing systems has started to limit further performance growth due to overwhelming electricity bills and CO₂ footprints. Therefore, the goal of the computing system design has been shifted to power and energy efficiency. This can be achieved by Load balancing.

Load balancing is one of the main challenges in cloud computing which is required to distribute the dynamic workload across multiple nodes to ensure that no single node is overwhelmed. It helps in finest utilization of resources and hence in enhancing the performance of the system. The objective of load balancing is to reduce the resource consumption which will further reduce energy consumption and carbon emission rate that is the dire need of cloud computing.

In this research work, we have studied and implemented three dynamic load balancing techniques using Java Programming and simulate through CloudSim. The Main contribution of CloudSim is to provide a holistic software framework for modeling Cloud computing environments and performance testing application services. And, we have proved that proposed EELBVM Model gives the better results than join idle queue and throttled load balancer. The simulation results show that our model has immense potential as it offers significant in the aspects of response time, execution time, throughput and energy consumption, which leads high improvement in energy efficiency of the data center.

Index Term: Cloud Computing, Load Balancing Algorithms, Energy Efficiency, Energy Efficiency Model, Cloudsim.

I. INTRODUCTION

1.1 Cloud Computing

Cloud computing is the access to computers and their functionality via the Internet or a LAN. Users of a cloud request this access from a set of web services that manage a pool of computing resources (i.e. machines,

operating systems, network, application programs, storage, and application development environments). When allowed, a fraction of the resources in the pool is dedicated to the requesting user until he or she relinquish them [37].

It is called "cloud computing" because the user cannot actually see or specify the physical location and organization of the equipment hosting the resources they are ultimately granted to use. That is, the resources are described from a "cloud" of resources when they are allow to a user and returned to the cloud when they are released [38].

A "cloud" is a set of machines and web services that implement cloud computing.

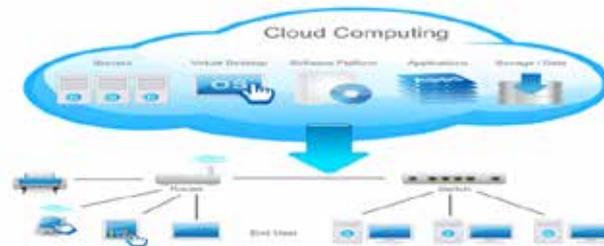


Fig. 1 Overview Of Cloud Computing

1.2 Energy Efficiency on Cloud Architecture

Cloud computing is a new technology which is offering IT services based on pay-as-you-go model to consumers from everywhere in the world. The rising demand of Cloud infrastructure and modern computational requests like business, scientific and web applications outcome in large-scale data centers and lead to extra electrical energy consumption. [5]

As Cloud computing becomes more scattered, the increasing data storage and computation needs raise the energy consumption of their large infrastructures. Energy consumption mainly aims at minimizing the processing and cooling costs of datacenters. High energy consumption causes high operational cost and also led to high carbon emission which is harmful for atmosphere. Hence, to minimize the negative effects of cloud computing on the environment, energy-efficient techniques are required. [6]

Thus energy consumption has become a considerable factor in designing modern Cloud environment.

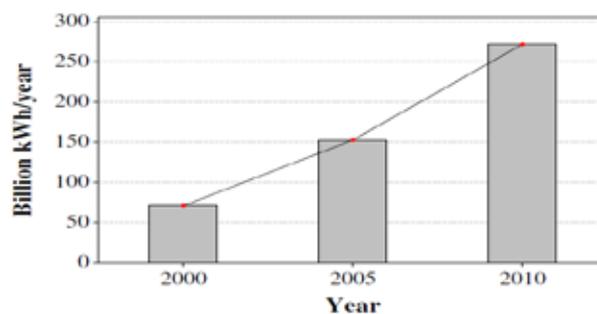


Fig. 2 The Worldwide Data Center Energy Consumption 2000-2010

1.3 Load Balancing on Cloud

Load Balancing is a process of allocating the total load to the individual nodes of the collective system to make resource utilization effective and to improve the response time of the job, at the same time removing a condition in which some of the nodes are over loaded while some others are under loaded.

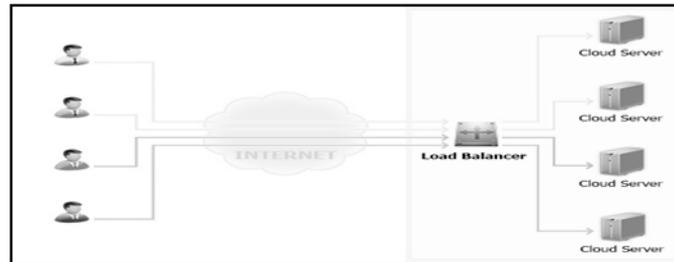


Fig. 3 Load Balancing

Load balancing in cloud computing systems is really a challenge now. Always a disseminated Solution is required, because it is not always practically feasible or cost efficient to maintain one or more idle services just as to fulfill the required demands. A load balancing algorithm which is dynamic in nature does not consider the previous state or behavior of the system.

The important things to consider while developing such algorithm are: evaluation of load, performance of system, stability of different system, comparison of load, interaction between the nodes, selecting of nodes and many other ones, nature of work to be transferred. This load considered can be in terms of amount of memory used, CPU load, delay or Network load.[13]

II. LITERATURE REVIEW

Wei Deng *et al.* [41] proposed the Harnessing Renewable Energy in Cloud Datacenters. They provided taxonomy of the state-of-the-art research in applying renewable energy in cloud computing datacenters from five key aspects, including capacity planning of green datacenters, intra-datacenter workload scheduling, generation models and prediction methods of renewable energy and load balancing across geographically distributed datacenters.

Ching-Hsien Hsu *et al.* [7] discussed Optimizing energy consumption with task consolidation in clouds. They presented Energy aware Task Consolidation (ETC) technique to minimize energy consumption. Taking into consideration the architecture of most cloud systems, a default CPU utilization threshold of 70% is used to demonstrate task consolidation management amongst virtual clusters. The simulation results show that Energy aware Task Consolidation can significantly reduce power consumption when managing task consolidation for cloud systems. ETC has up to 17% improvement over a recent work that reduces energy consumption by maximizing resource utilization.

Moreno, Ismael Solis *et al.* [25] introduced a novel approach to workload allocation that improves energy-efficiency in Cloud datacenters by taking into account their workload heterogeneity. They analyzed the impact of performance interference on energy-efficiency using workload characteristics identified from a real Cloud environment, and developed a model that implements various decision-making techniques intelligently to select the best workload host according to its internal interference level. The experimental results show reductions in interference by 27.5% and increased energy-efficiency up to 15% in contrast to current mechanisms for workload allocation.

Young Choon Lee *et al.* [42] discussed Energy efficient utilization of resources in cloud computing systems. Based on the fact that resource utilization directly relates to energy consumption, they have successfully modeled their relationship and developed two energy-conscious task consolidation heuristics. The cost functions integrated into these heuristics effectively capture energy-saving possibilities and their capability has been

verified by their evaluation study. In this study should the results not have only a direct impact on the reduction of electricity bills of cloud infrastructure providers, but also imply possible savings (with better resource provisioning) in other operational costs (e.g., rent for floor space) and the reduction in the carbon footprint of clouds is another important spinoff.

III. PROBLEM FORMULATION

Cloud computing is an evolving paradigm that has redefined the way Information Technology based services can be presented. It has altered the model of storing and managing data for real time, scalable, internet based applications and resources satisfying end users' needs. More and more remote host machines are built for cloud services causing more power dissipation and energy consumption.

To overcome this problem the energy efficient metric is used to compute power consumption and utilization. The proposing work is an Energy Efficiency Load Balancing Virtual Machine (EELBVM) Model that confirms to reduction of energy consumptions and helps to improve quality of service.

EELBVM Model includes the load balancing algorithm which ensure that all the processors in this system as well as in the network does approximately the equal amount of work at any instant of time.

Load balancing is a methodology to distribute work load across multiple computers, or other resources over the network links to achieve the optimal resource utilization, minimum data processing, minimum average response time and avoid overhead.

In the past number of load balancing algorithms have been developed specifically to suit the dynamic cloud computing environments such as WLC (Weighted Least Connection) algorithm, LBMM (Load Balancing Min-Min) algorithm, Bee-MMT (Artificial Bee Colony algorithm Minimal Migration Time), active Clustering algorithm, Honeybee Foraging Algorithm.

EELBVM model is to be built by using the Improved Cartron Dynamic load balancing algorithm which will be compared by Join-Idle Queue and Throttled dynamic Load balancer to meet the objective for systematically energy efficiency on cloud computing environment.

IV. EXISTING WORK

Existing Load Balancing Algorithms for Cloud Computing:

Allocate workload of multiple network links to achieve maximum throughput, minimize response time, low energy consumption and to avoid overloading.

We use three algorithms to distribute the load.

- **Throttled load balancer**

Throttled load balancer is a dynamic load balancing algorithm. In throttled load balancer algorithm, the client first requests the load balancer to search a suitable Virtual machine to perform the required procedure. In Cloud computing, there may be multiple instances of virtual machine (VM). These VMs can be grouped based on the type of requests they can hold. Whenever a client sends a request, the load balancer will first await for that group, which can handle this request and distribute the process to the lightly loaded instance of that group.

- **Join-Idle Queue**

Join-Idle Queue technique is basically used for large-scale systems. This algorithm uses distributed dispatchers by first load balancing the idle processors across dispatchers and then allotting jobs to processors to decrease average queue length at each processor. It effectively keeps down the system load, receives no communication overhead at job arrivals and does not increase actual response time. It can perform close to best possible when used for web services.

- **Round Robin Algorithm (RR)**

It is the simplest algorithm that uses the concept of time quantum or slices. Here the time is divided into several slices and each node is given a particular time quantum or time interval and in this quantum the node will perform its operations.

V. PROPOSED WORK

Earlier for enhancing energy efficiency in cloud environment some algorithms or techniques has been used. But now we will use:

- **Throttled load balancer**
- **Join-Idle Queue**

I have also create a technique i.e. EELBVM which would reduce the overall energy consumption in data center. EELBVM is Energy Efficient Load Balancing Virtual Machine (EELBVM) Model. EELBVM Model is based on Improved Cartron dynamic load balancing algorithm. Cartron dynamic load balancing algorithm integrates the use of LB and DRL. LB (Load Balancing) is used to equally distribute the jobs to different servers so that the associated costs can be minimized and DRL (Distributed Rate Limiting) is used to make sure that the resources are distributed in a way to keep a fair resource allocation. Distributed Rate Limiting also adapts to server capacities for the dynamic workloads so that performance levels at all servers are equal.

VI. EXPERIMENTAL SETUP

CloudSim using Java 1.6: CloudSim is a self-contained platform which can be used to model data centers, host, service brokers, scheduling and allocation policies of a large scaled Cloud platform. It is a framework developed by the GRIDS laboratory of University of Melbourne which enables seamless modeling, simulation and experimenting on Designing Cloud computing infrastructures.

VII. OBJECTIVES OF THE STUDY

The Objectives of the research work are:

1. To implement proposed EELBVM model using java programming and simulate on cloud computing environment using CloudSim toolkit.
2. To Analyze the behavior of EELBVM model using following parameters-
 - Energy Efficient Metric
 - Execution time
 - Response time

- Resource utilization
- Throughput

3. To Evaluate the performance and behavior of Improved Cartron dynamic load balancing technique by comparing it with existing load balancing methods such as Join-Idle queue and Throttled Load balancer.

VIII. METHODOLOGY

The complete flow chart of the methodology is shown as below:

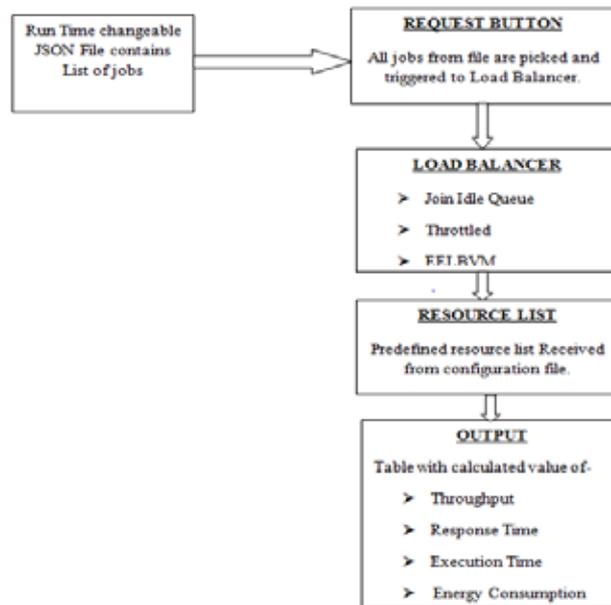


Fig. 4 Step by Step approach of research methodology

IX. RESULTS

In this we shall discuss the result of the experimental results done on the CloudSim with the existing and proposed optimization methods. However, here is a table showing the simulation results for Join_Idle_Queue technique for different number of jobs.

Table 1

Sr.No.	No. of Jobs	Parameters Name			
		Throughput	Response Time	Execution Time	Energy Consumption
1.	1	100	0	5.999	539.99
2.	9	100	0.0555	4.2944	386.5
3.	10	100	0.05	4.765	428.85
4.	12	100	0.0416	4.265	383.87
5.	14	100	0.0357	4.048	364.32

This table shows simulation results for Throttled Load balancer for different number of jobs.

Table 2

Sr.No.	Number of Jobs	Parameters Name			
		Throughput	Response Time	Execution Time	Energy Consumption
1.	1	100	0	5.999	539.99
2.	9	100	0.0370	4.8962	440.66
3.	14	100	0.0238	3.935	354.19
4.	18	100	0.0185	4.127	371.47
5.	19	100	0.0175	4.552	409.73
6.	21	100	0.0158	4.948	445.32

This table shows simulation results for EELBVM Model for different number of jobs.

Table 3

Sr.No.	No. of Jobs	Parameters Name			
		Throughput	Response Time	Execution Time	Energy Consumption
1.	1	100	0	0.5	45
2.	5	100	0	2.55	229.5
3.	7	100	0	3.6310	326.7899
4.	9	100	0	3.954	355.91
5.	10	100	0	4.317	388.55
6.	12	100	0	3.7995	341.95
7.	14	100	0	3.554	319.94
8.	18	100	0	3.332	299.88
9.	19	100	0	3.384	304.56

9.1 Comparison Tables

This table shows different algorithms are compared for 5 Jobs.

Table 4

Algorithms	Number of jobs/Tasks	Response Time	Execution Time	Energy Consumption
Join_Idle_Queue	For #5	0	2.8099	252.9
Throttled	For #5	0	4.1299	371.7
EELBVM	For #5	0	2.55	229.5

The table depicts the result of different parameters for twelve jobs.

Table 5

Algorithms	Number of jobs/Tasks	Response Time	Execution Time	Energy Consumption
Join_Idle_Queue	For #12	0.0416	4.265	383.87
Throttled	For #12	0.0277	4.1637	374.73
EELBVM	For #12	0	3.7995	341.95

The table depicts the result of different parameters for twenty one jobs.

Table 6

Algorithms	Number of jobs/Tasks	Response Time	Execution Time	Energy Consumption
Join_Idle_Queue	For #21	0.0238	4.514	406.32
Throttled	For #21	0.0158	4.948	445.32
EELBVM	For #21	0	3.598	323.85

9.2 Graphical Charts

Graphical charts shows the comparison between different techniques based on distinct number of jobs considering discrete parameters like energy consumption, response time and execution time.

Figure reveals the information about the energy consumption of datacenter and the results show that EELBVM model consumed less energy as compared to Join_Idle_Queue and Throttled load balancer. Therefore our proposed model is best in case of energy efficient.

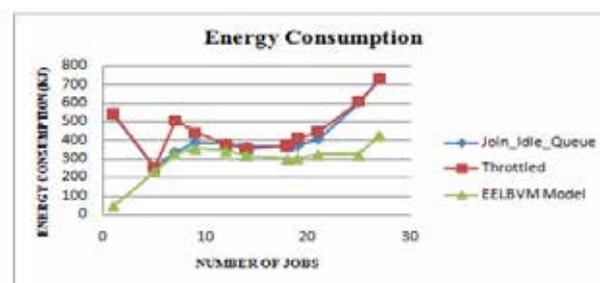


Fig. 5 Energy Consumption Comparison Based On Distinct Number Of Jobs

Response time is the time taken to respond by a particular load balancing algorithm in a distributed system. The response time is calculated by varying the number of jobs. Figure depicts that the response time is minimum in case of EELBVM model.

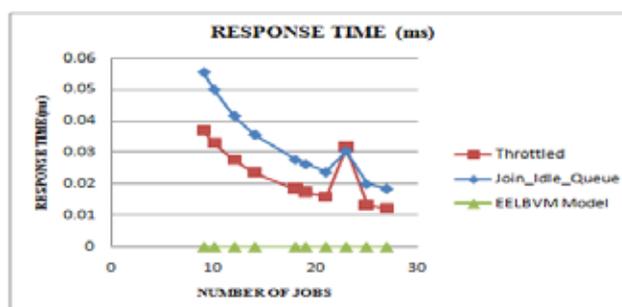


Fig. 6 Response Time Comparison Based On Distinct Number Of Jobs

Execution time is estimated by calculating the total number of jobs executed within a fixed span of time. Figure shows the execution time taken by three techniques for distinct number of jobs. After implementation results

show that the execution time of EELBVM model is less as compared to throttled load balancer and Join_Idle_Queue.

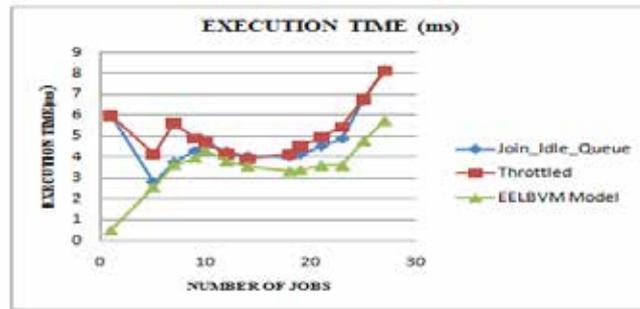


Fig. 7 Execution Time Comparison Based On Distinct Number Of Jobs

Figure depicts the comparison between three techniques Join_Idle_Queue, Throttled load balancer and EELBVM model based on minimum, average and maximum execution time. The results show that our proposed model takes less execution time which further results in high performance of the system.

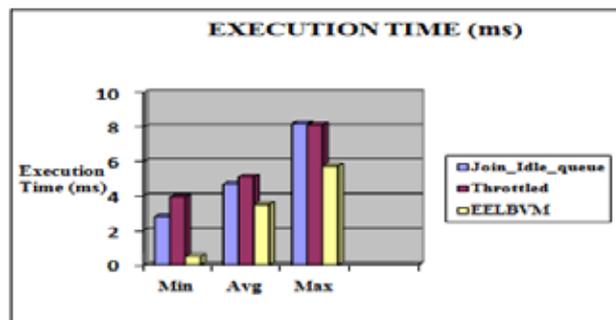


Fig. 8 Min, Max And Avg Execution Time Comparison

Figure reveals the information about the minimum, average and maximum energy consumption by three different techniques.

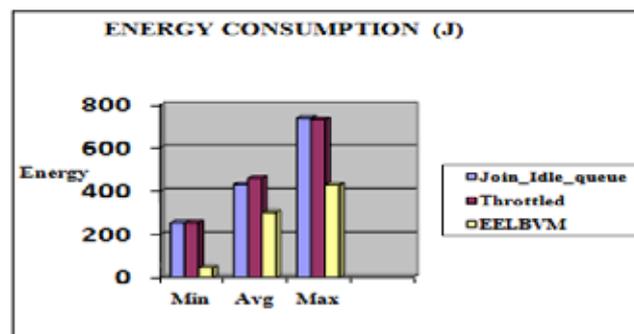


Fig. 9 Min, Max And Avg Energy Consumption Comparison

X. CONCLUSION

In the research work we have proposed and implemented an energy efficient load balancing virtual machine (EELBVM) model on cloud environment using CloudSim Toolkit. And compared it with the Join_Idle_Queue and throttled dynamic load balancing methods. The results show that proposed model are much better than the existing load balancing methods in terms of response time, execution time, and throughput. We also concluded that EELBVM model consumes less energy than Join_Idle_Queue and Throttled load balancer.

XI. FUTURE SCOPE

Cloud Computing is a vast concept and energy efficiency plays a very important role in case of Clouds. There is an epic scope of improvement in this area. We have implemented only 3 dynamic load balancing algorithms. But still there are additional approaches that can be applied to balance the load and energy consumption in clouds. The performance of the given algorithms can also be increased by varying different parameters. We can also migrate our research work on any Private Cloud for the Security and further enhancements.

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CONCEPTUAL DESIGN OF THE ERGONOMIC CHILD RESTRAINT SYSTEM FOR INFANTS IN THE AIRCRAFT USING TRIZ METHOD

K. Syakirah¹, A.A. Faieza², I. R. Fairuz³

^{1,2}*Mechanical and Manufacturing System Department, Faculty of Engineering,*

Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia

³*Aerospace Engineering Department, Faculty of Engineering,*

Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia

ABSTRACT

Positive trends in the statistics of infants travelling by air generated a momentum for the industry to develop an excellent Child Restraint System for infants in term of safety, as well as comfort, convenience and usability for infants and their traveling companion. This paper presents a conceptual design of an ergonomic Child Restraint System for infants in aircraft to maximize comfort, convenience and usability using a total design technique consisting of the TRIZ methodology solution. A market survey was conducted at the early stage to discover the needs and requirements of the end user. The product requirements for the Child Restraint System was also defined. The methodology was followed by the 'brainstorming' technique to generate preliminary ideas in between the implementation of the TRIZ methodology solution. Three conceptual designs were generated for selection. The weighted evaluation method used to determine the final design of an ergonomic Child Restraint System for infants. The final concept was analyzed and fabricated as a prototype for further validation.

Keywords: *Child Restraint System; conceptual; design; TRIZ method*

I. INTRODUCTION

The contribution of aircraft passengers traveling with infants between 0 – 24 months of age towards the airline industry currently increases. This group of travelers chooses air transportation as their main medium of travel from one place to another. As long distance travelers, besides the safety requirement, the comfort of infants becomes the main concern as well as the comfort, convenience and usability factors of the travelling companion. The rules and regulations for the Child Restraint System in aircraft is still an ongoing debate. The current Child Restraint System in this industry is limited due to the specified regulations.

In most parts of the world, infant passengers on a regular basis travel with the aircraft without being restrained in a way that afford them a level of safety equivalent to an adult passenger in the event of a survivable crash [1]. Compared to adult passengers, infants are not assigned to a specific restraint device that restrict them to the aviation safety standard. It is well acknowledged that this situation is currently being debated and researched. However, besides safety as a main concern, comfort, convenience and usability also play a big role in providing maximum comfort in a journey for the infants, the traveling companion and other aircraft passengers. In fact, the comfort and convenience of a journey in aircraft are widely offered to adult passengers without infant, but are rarely considered for the infant and their traveling companion.

II. CHILD RESTRAINT SYSTEM (CRS)

Current situation shows that there is no widely available Child Restraint System for an infant that is compatible with the typical aircraft seats. The most widely used Child Restraint System in the aircraft is the bassinet provided by the airlines. However, it is only for lap-held baby aging six months and below. In addition, the use of bassinet is only allowed during cruise and strictly prohibited during takeoff / landing and in any emergency situation [2]. Even though, as suggested by CASA (2014), the bassinet may provide a comfortable position for infants under six months, it restricts comfortable experience directly for older infants and the traveling companions.

In some cases, some airlines permit the use of the Automotive Child Restraint System on their aircraft, but some do not [3]. Improper use of the Automotive Child Restraint System may increase usability and safety issues in aircraft [4][5][6], increasing the level of uncomfortableness of infants and their traveling companions because they cannot use the device to ease their long haul flight journey.

Other than that, infants may be carried lap-held during the long haul flight using a supplementary loop belt provided by the airline management. This supplementary loop belt was designed by attaching the loop belt to the adult passenger's lap belt. However, the use of the supplementary loop belt is only permissible for Europe and Asia countries, while prohibited for Canada and US [7]. This rejection is due to a few studies on the ineffectiveness of the supplementary loop belt since it could maximize the danger towards infants in the case of survivable crash [2]. Besides, in the aspect of comfort, the mother will experience difficulty because of the static position, while holding the infant in a long period of time without any supporting device. This long period of inactivity may produce improper seating posture for the mother and will affect the level of comfort.

Since airline carriers need to serve their customers by considering the cost and the service load, a simple yet effective design is needed. In addition to safety requirement, it is important to offer a comfortable flight journey for infants and their traveling companions.

In the implementation of the conceptual design of infant's Child Restraint System in the aircraft, the application of Teoriya Resheniya Izobreatatelskikh (TRIZ) Method was applied. This method was proven to be effective in the revolution of new ideas in improving the existed design in certain aspects.

III. TEORIYA RESHENIYA IZOBREATATELSKIKH ZADATCH (TRIZ) METHOD

TRIZ or "Teoriya Resheniya Izobreatatelskikh Zadatch" is a tool developed by Genrich Altshuller in 1940s to solve most engineering problems innovatively [8]. Altshuller gathered approximately one hundred people by screening over 200,000 patents, from which he extracted 40,000 innovative patents to develop TRIZ. From their research, Hishihama and Hamada (2009) were convinced that TRIZ function and attribute analysis successfully identified the problems that were difficult to solve by conventional methods in designing a safety seat for children [5].

Fig. 1 represents the resulting TRIZ conceptual scheme to idealize the process that took place. Initially, the designer would be presented with the original design problem. Then, the designer would generate the TRIZ problem based on the design problem. Later, the TRIZ solution would be obtained and the design solution would be identified.

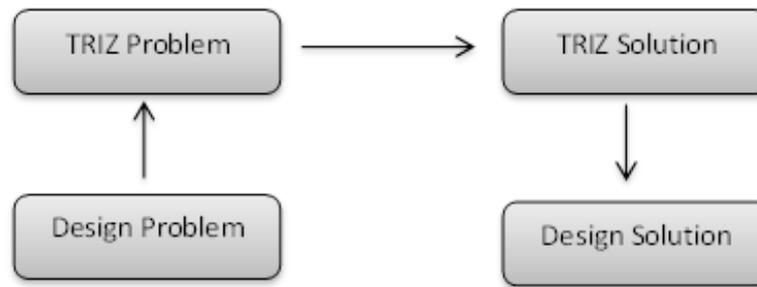


Fig.1: Conceptual scheme of TRIZ [Product Redesign Using TRIZ and Contradictive [9]

In the application of TRIZ method, three aspects were applied to improve these three features: products, services, and systems. The aspects are referred to as learning by repeating patterns of problem solutions, using scientific effects, and applying the general TRIZ patterns [10]. According to Natraj et al. (2002), to solve contradicting problems, a number of prior methods had been employed to aid the new design process [11]:

(1) Inspiration method: The designers who depend upon this method may be able to enhance a design. However, they can never be sure that they will be able to find the right solution to a design problem. In addition, this method is seen as very subjective for most problems.

(2) Trial and error method: The designers who hinge on the trial and error method can spend a great deal of time and resources in exploring design options, even though this approach is thought to be a conservative method. In addition, the outcomes may not be complete with inexperienced designers.

(3) Brainstorming method: The brainstorming approach is one of the most common methods employed in the industry. During 30-40 minutes discussion, a leader guides a group to voice out their ideas without hesitation. This method provides the chances and likelihood for designers to hear other people's ideas, nevertheless the designers may also be influenced by others.

IV. DESIGN METHODOLOGY

This section will discuss the overall design methodology to come out with the conceptual designs of the ergonomic child restraint system for infants in commercial aircraft

3.1 Market Survey Stage

The design process started with a market survey on Child Restraint System for infants in the airline industry. The market survey included survey on patents, journals, technical reports as well as websites from various airlines and others regarding the existing Child Restraint System for infants. Besides that, focus group interviews were also conducted in order to document the targeted passengers experience and the view of the targeted passengers regarding the existing Child Restraint System. The information gathered is important in the design process. The focus group served as a useful tool to explore various key issues on the use of Child Restraint System for infants in aircraft [12]. Participants discussed experiences and difficulties associated with the usage of Child Restraint System. The reviewed topics included issues on comfort, convenience and usability factors on infants and their travel companions.

3.2 Product Requirement Stage

The design process was followed by the product requirement stage. This stage was performed as an output of the market survey and was used as a reference and guideline to generate ideas on the new design [13]. The requirement of the product mainly focused on the performance of the Child Restraint System, material, size,

reliability, weight, strength, safety, incurred cost and finally, the design itself. These performances were developed based on their importance to Child Restraint System on aircraft.

The design process was then continued with the conceptual design stage consisted of the brainstorming method and TRIZ method. The brainstorming method was used as a tool to generate the conceptual design [14], while, TRIZ method served as the problem solving process based on logic and data, and not on perception. The ideas from the two combined methods based on the product requirement were then described in a Morphological Chart to ease visualization.

Finally, after the three main processes, the final concept was selected based on the weighted objective method and the design was then revealed using a Computer Aided Design in the last stage. Fig. 2 shows the total design model developed during the development of a new ergonomic Child Restraint System for infants in an aircraft.

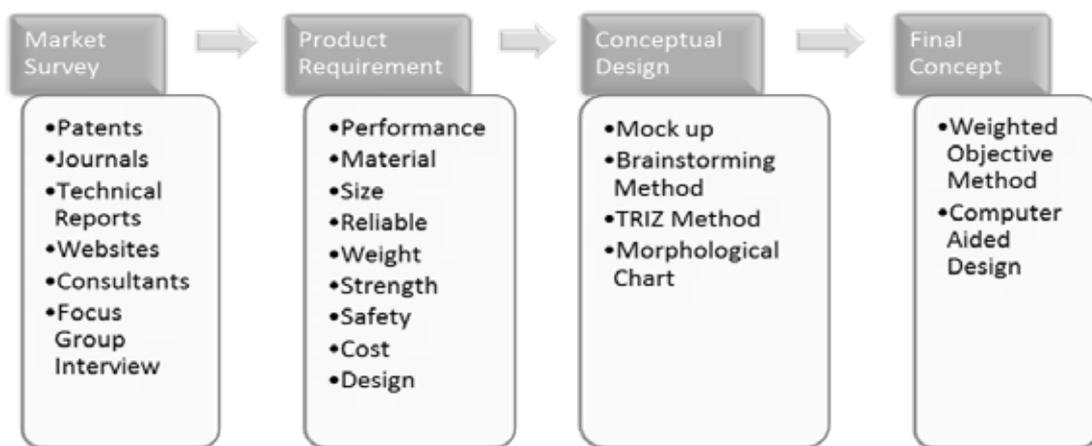


Fig. 2: The Total Design Process Of The Child Restraint System For The Infants In Aircraft

3.3 Conceptual Design Stage

During the development of the conceptual design, the product requirement of the Child Restraint System becomes the main guideline and reference. Throughout the design process, the brainstorming method was used to generate as many relevant ideas without any limitation. The first brainstorm session was conducted with two experts in the industry regarding the acceptable restriction of the design according to the airline industry rules and regulations. The second brainstorm session was conducted with four individuals who were encouraged to develop their ideas extensively. During the second brainstorming session, the application of TRIZ method was injected for more innovative solutions. The method has proven to be practical to the design team to come out with the boundless creative ideas [10].

The TRIZ method started with the analytical stage: in the beginning, the situation was analyzed, the object and the functionality were identified, and the main useful function of the system was identified. From the analysis, the problems that need to be solved were identified. After that, the next phase was to identify the contradiction. In a design scenario, there can be many contradictions and the core of the problem should be identified first. To identify those problems, the documented data collection from the market survey were used to generate the ideas and the problems.

For an improved design of the Child Restraint System for aircraft, the main problems are listed in a table of the good and the bad effects, as shown in Table 1.

The Good Effect/Improving Factor	The Bad Effect/Worsening Factor
----------------------------------	---------------------------------

(1) Infant can have their own seat. By creating new available spaces in front of the parent. (Length of moving object (3)).	Will involve the use of existing confined space. (Area of moving object (5)).
(2) The design is strong enough to support infants up to 13kg. (Strength (14))	The mechanism must have a good attachment / adjustable at the base structure. Strong base. (Reliability (27)).
(3) Ease parents' labor in loading/unloading their child by using a simple mechanism. (Ease of operation (33)).	The users/parents may be the person who can contribute to the complexity. (Device or system complexity (36))
(4) Restraint infant during travel while allowing free movement in normal condition facing their mom using a simple mechanism. (Reliability (27)).	The users/parents may be the person who can contribute to the complexity. (Device or system complexity (36))
(5) Can be stored easily and reused whenever required by having a simple design and structure. (Ease of operation (33))	The users/parents may be the person who can contribute to the complexity. (Device or system complexity (36))
(6) Provide comfort during travel for lap-held mom when they do not have to hold the baby all the time. (Adaptability or versatility (35))	Will involve the use of existing confined space. (Area of the stationary object (6))
(7) Can secure the infant in all phases of flight, while located as near as possible to the mom. (Reliability (27))	The structure could affect the mom's comfort. (Shape (12))

Table 1. The Good And The Bad Effects Of The Newly Proposed Design.

Based on the good and bad effects described by the problem, the design of an ergonomic Child Restraint System for infants with improved feature parameters consisted of the length of moving objects (3), strength (14), reliability (27), ease of operation (33) and adaptability and versatility (35). The worsening features consisted of the area of the moving object (5), area of the stationary object (6), shape (12), reliability (27) and finally, device or system complexity (36). The detail of the contradiction matrix is shown in Table 2. The shown contradiction matrix was constructed from the problems indicated earlier, which was matched with the improving and worsening factors. From the contradiction matrix study, the improving and worsening factors were identified.

Based on Table 1, the idea of giving infants their own seats in front of their travelling companions led to the improving factor for 'length of the moving object (3)', but, it would involve the use of existing confined space that lead to the worsening factor for 'area of the moving object (5)'. These parameters brought to the 40 inventive principle solutions of '#15 dynamics', '#17 another dimension' and '#4 asymmetry'.

The idea of implementing a strong device to support infants below 13kg was included under the improving factor of 'strength (14)' but, prior to that, the device must have a good basic structure included under the worsening factor of 'reliability (27)'. This parameter proposes '#11 beforehand cushioning' and '#3 local quality' as solutions.

The usability and convenience issues of easing parents' labor in loading/unloading their infant when using the system were included under the parameter of 'ease of operation (33)'. However, in order to achieve that, the users or parents might contribute to the complexity of the operation, which can be referred to as 'device or system complexity (36)' parameter, resulting to the solution of '#32 color changes', '#26 copying', '#12 equipotentiality' and '#17 another dimension' from the 40 principles.

The study of the fourth design problem on the need to restrain the infant during travel, while allowing the infants to move freely in normal condition facing their parents in the aircraft could be classified under the parameter of 'reliability (27)'. On the other hand, the users or parents might be the person to contribute to the

complexity of the process for those design mechanisms, and was classified under the parameter of ‘device or system complexity (36)’. The 40 principles indicated that ‘#13 the other way round’, ‘#35 parameter changes’ and ‘#1 segmentation’ as the proposed solutions.

Another problem stated in designing the Child Restraint System was to design a system that can be stored easily and reused whenever required by the parents. This problem can be classified under the parameter of ‘ease of operation (33)’. However, the users or parents might be the person to contribute to the operational complexity classified under the parameter of ‘device or system complexity (36)’. The 40 principles solution stated were ‘#32 color changes’, ‘#26 copying’, ‘#12 equipotentiality’ and ‘#17 another dimension’.

The design also focused on the need to provide comfortability for lap-held parents so that they do not have to hold their babies at all time. The parameter used to describe this issue was ‘adaptability or versatility (35)’. Conversely, the idea would require the use of existing space to accommodate the device, which described the parameter for ‘areas of the stationary object (6)’. The outcome indicates that ‘#15 dynamics’ and ‘#16 partial or excessive actions’ were the best solutions of 40 principles.

The last problem that needs to be solved for the design necessity was the ability to secure the infant in all phases of flight as near as possible to the mom. This problem was classified under the parameter of ‘reliability (27)’. However, overcoming this problem might affect the comfort of the travelling companion because of the design, which could be categorized under the ‘shape (12)’ parameter. From the contradiction matrix, the proposed 40 principle solutions were ‘#35 dynamics’, ‘#1 segmentation’, ‘#16 partial or excessive actions’ and ‘#11 beforehand cushioning’.

Based on the analysis made in the Contradiction Matrix, the most frequent solution principles were summarized in Table 3.

WORSENING FACTOR	Area of the moving object (5)	Area of the stationery object (6)	Shape (12)	Reliability (27)	Device or system complexity (36)
IMPROVING FACTOR					
Length of the moving object (3)	15, 17, 4				
Strength (14)				11, 3	
Reliability (27)			35, 1, 16, 11		13, 35, 1
Ease of operation (33)					32, 26, 12, 17
Adaptability or versatility (35)		15, 16			

Table 2. The Contradiction Matrix For Worsening And Improving Factor

40 PRINCIPAL	DETAIL DESCRIPTIONS

E		
#17	Another dimension	-Tilt or reorient the object, lay it on its side -Use another side of a given area
#15	Dynamics	-Divide an object into parts capable of movement relative to each other / Folding mechanism for better movement and adjustment.
#16	Partial or excessive actions	- If 100 percent of an object is hard to achieve using a given solution method, then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve
#35	Parameter changes	-Change the degree of flexibility -Reduce the parameter of the Child Restraint System frame without effecting the infant's comfort -Change other parameters/(the change in seat pitch may give more comfort on the travelling companion)
#1	Segmentation	-Divide an object into independent parts (independent main frame, independent fabric support, independent support system) -Make the object easy to assemble or disassemble (Rapid release /easy to use when in need or when to store)
#11	Beforehand cushioning	- Prepare emergency means beforehand to compensate for the relatively low reliability of an object (auto release the infant seat main frame from its base support for any situation e.i. Emergency, to stand up)
#32	Color changes	- In order to improve observability of the components that are difficult to see, use colored or luminescent elements (there will be different luminescent color on the push/release button for easy observe/visibility)
#26	Copying	- Instead of an unavailable, expensive, fragile object, use simpler and inexpensive copies
#12	Equipotentiality	- If an object has to be raised or lowered, redesign the object's environment so the need to raise or lower is eliminated or performed by the environment (travelling companion may adjust their seat recline for max comfort)
#4	Asymmetry	-Change the shape of the object to suit external asymmetry (ergonomic features)

Table 3.Summary Of The Finalize TRIZ 40 Principles Solutions

Resulted from the output of the TRIZ methodology, the brainstorming session was constructed in beneficially mode. 3 designs were generated as conceptual design. Table 4 depicts the detail concepts.

Design	Conceptual Design	Descriptions
n		

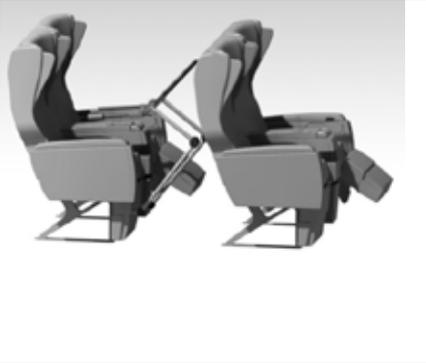
1		<ul style="list-style-type: none"> - The system is attached to the additional base structure, located/mounted under the passenger's main seat. - Have several segmentations. - The restraint device seat frame consists of several recline positions. - The system consists of retractable support arms to hold and store the whole system.
2		<ul style="list-style-type: none"> - The system can be attached to the table tray arm mechanism. - The restraint device seat frame can be inserted whenever needed, and pull out when not in use. - There will be a minor modification on the table tray part. - Have several segmentations. - The restraint device seat frame consists of several recline positions.
3		<ul style="list-style-type: none"> - The system is attached to a strong support on the passenger seat armrest. - The restraint device seat frame consists of several recline positions. - Have several segmentations. - The system is designed for take off/landing/emergency situation. - Emergency release button for evacuation. - The frame can be rotated according to the mother's need. - Asymmetry design.

Table 4: The Description Of Conceptual Design Of An Ergonomic Child Restraint System For Infants In Aircraft

IV. FINAL CONCEPT EVALUATION

Later, the different conceptual design was evaluated based on the weighted objective method, which were primarily centered on the product requirement constructed earlier as shown in Table 6.

Each product requirement was fixed with the corresponding weight score to specify the importance of each requirement. The relative weight score of product requirement are strength (0.2), reliable (0.1), performance (0.2), safety (0.2), size (0.1), materials (0.05), design (0.05), weight (0.05) and cost (0.05).

During the evaluation session, each design concept was rated with a score (S) of 5 point scale. Each design concept was then rated by the industrial personnel based on the level of importance of the given requirement. The highest point of 5 specifies the product requirement for the specific concept is significant, while, the lowest point shows it is insignificant. Later, each given point is multiplied by the weight to get the relative value (V).

Every value of the design concept is summed up to get the total value of each design concept. The total value of each concept was compared and the highest ranking of total value is selected for the final design. Table 5 of the Weighted Objective Evaluation Method shows that the design 3 was selected as the best concept that fulfilled the product requirement specification with a total value of 3.95. Design 3 was selected because it was almost fulfill the requirement of comfort, convenience and usability without neglecting the safety aspect of the ergonomic Child Restraint System for infants in the aircraft.

No.	Element	Weight	Concept 1		Concept 2		Concept 3	
			S	V	S	V	S	V
1	Strength	0.2	3	0.6	2	0.4	4	0.8
2	Reliable	0.1	3	0.3	2	0.2	4	0.4
3	Performance	0.2	3	0.6	2	0.4	4	0.8
4	Safety	0.2	2	0.4	2	0.4	4	0.8
5	Size	0.1	3	0.3	4	0.4	4	0.4
6	Materials	0.05	3	0.15	3	0.15	4	0.2
7	Design	0.05	2	0.1	4	0.2	4	0.2
8	Weight	0.05	3	0.15	4	0.2	4	0.2
9	Cost	0.05	3	0.15	3	0.15	3	0.15
Total Value				2.75		2.5		3.95

Table 5. Weighted Objective Evaluation Of An Ergonomic Child Restraint System For Infants In Aircraft

V. CONCLUSION

Three conceptual designs were developed with the Total Design approach as a guideline. The TRIZ methodology was implemented in the early conceptual design stage to develop innovative solutions for the conceptual idea. After the development of the conceptual design, the Weighted Objective Evaluation Method was used to recognize the most appropriate design of the Ergonomic Child Restraint System for Infants in the aircraft. Concept 3 is chosen as the best design that fulfilled both the product requirement and the final solutions on the TRIZ methodology. The design specification on the Concept 3 shown that, this design would benefit the end users; specially refers to infants and their traveling companion. Without neglecting the safety aspect, this design could improve the comfort level on parents and infants, as well as other passengers. This design also may possibly mitigate the convenience and usability issue occurs in current Automotive Child Restraint System used in the aircraft.

By adapting the new mechanism on the system that utilize the existing space in front of the adult passengers using the armrest as the support, this new system can be used in several conditions such as takeoff, landing and in any emergency situation. This design will be used in analysis and prototyping stage for further validation and study.

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