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An information technology suitability index for mass customization

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AN INFORMATION TECHNOLOGY SUITABILITY INDEX

FOR MASS CUSTOMIZATION

A Thesis

by

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ABSTRACT

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In today's manufacturing world, high competitive markets are pushing companies to find better ways to satisfy their customer's needs using several Mass Customization (MC) approaches. Consequently, new Information Technologies (IT) have taken a very important role in order to manage the increasing amount of data generated from those customers. The purpose of this thesis is to develop an IT suitability index for MC that would help to identify the critical IT factors to be addressed in order to efficiently support MC. A linear programming regression model was utilized to generate index values. Finally, the results of this model could be used as an estimator of an expert description of IT suitability based on linguistic variables of a particular scenario.

DEDICATION

From the bottom of my heart, this thesis is dedicated to three very important people: to my sister, Alejandra, for bringing happiness to my life; to my brother, Luiz Fernando, for being there when times were tough; and, to my mother, Laura, for being the best mom ever. They all gave me their unconditional love, devotion, understanding, and support needed to accomplish this goal. Without them, I wouldn't be who I am with all my weaknesses and strengths, and I wouldn't be even close to where I am now.

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CHAPTER I

INTRODUCTION

The purpose of this chapter is to provide a general understanding of the importance of a suitability index for the Information Technology (IT) infrastructure on the context of a Mass Customization (MC) production environment. This chapter consists of four sections. The first one provides a general background for this thesis including an overview for mass customization, an introduction to information technology, and an explanation of the implications of implementing MC on the existing IT of a manufacturing company. Section number two establishes the complete details of the problem description. The next section presents the research objectives and challenges of this study so they can be evaluated at the end of the thesis. Also, the former section also contains the methodology used during the research process. Finally, section number four deals with the organization of the thesis.

1.1: Background

Production systems throughout history have been evolving as new technology becomes available. It all goes back to the pre-industrial period around 1890 where manufacturing was characterized for high craftsmanship, long lead times, high costs, and usually single piece volumes. Typically, the producer was only one person with all the experience and knowledge to complete the job from scratch.

Then there was a significant breakthrough after 1920 when Henry Ford developed a new concept for mass producing automobiles. He was able to increase productivity by breaking the entire manufacturing process into simple elements that are connected in what is called the production line. Mr. Ford understood the idea of shortening the supply chain lead times in order to minimize all costs. However, major limitations of this manufacturing system include: low flexibility; low quality; poor communication; and virtually no customer involvement.

After the Second World War, between 1950 and 1980, ideas like Total Quality Management, Six Sigma, and Lean Manufacturing started to be successful on customer satisfaction. And that is when Mass Customization came to play a big role on production systems in order to increase market share against fierce competition.

The term Mass Customization can be explained as the vast production of highly individualized goods at a reasonable delivery time and price (Da Silveira, 2001). And those two benefits are precisely the reason why, in today's competitive global market, MC becomes significantly important. Furthermore, opposed to the old mass production system, MC has the advantage of providing a very good product variety to the end customer (Du et al., 2003; Pine, 1993). Nevertheless, companies have been challenged to modify their manufacturing systems, and update their supply chain infrastructures in order to survive in this fast changing, and highly demanding world.

In general, issues regarding Information Technology on any organization are having more and more relevance because of the increasing complexity of communication needs throughout the whole supply chain system (Reichwald et al., 2000; Meixell and Wu, 2003). Particularly, the manufacturing industry is having a hard time because either,

they are using the wrong IT, or, if they have the proper IT, they do not know how to use it properly (Blattberg and Glazer 1994; McCarthy, 2004). This problem is true for companies that still rely on the old mass production concept, and it gets even worst when trying to use new MC ideas.

During the last 10 years, many companies have been trying to implement the Mass Customization (MC) techniques so they can take advantage of the increasing consumer demand for personalized products (Bourke, 1999). To prove this, Table 1.1 shows the significant increment of choices of different products available to the general end user during a 20-year period (Cox and Alm, 1998). However, taking a closer look at the current literature and technical papers, the manufacturing industry is still well behind the line of understanding all the complicated aspects of MC (Blecker et al., 2004). Furthermore, most of the research that has been done in these fields is based mainly on theoretical information as opposed to an empirical assessment that would be more useful to the industry in general.

Table 1.1 Consumer Choice Increments

Product	Early 70s	Late 90s
Vehicle models	140	260
Movie releases	267	458
Magazine titles	339	790
New book titles	40,530	77,446
Community colleges	886	1,742
Amusement parks	362	1,174
Radio broadcast stations	7,038	12,458
Potato chip varieties	10	78
Breakfast cereals	160	340
National soft drink brands	20	87
Bottled water brands	16	50
Milk types	4	19
Toothpastes	2	17
Mouthwashes	15	66
Dental flosses	12	64

Over-the-counter pain relievers	17	141
Jean styles	41	70
Running shoe styles	5	285
Women's hosiery styles	5	90
Bicycle types	8	31

1.1.1: Mass Customization – An Overview

As stated in section 1.1 of this chapter, now a days there is a strong tendency for the general public to expect highly individualized goods from the manufacturing industry. However, it is a recent event that the ideas of Mass Customization (MC) have been the center of attention of the manufacturing and service community. While some companies have achieved significantly good results, others are still struggling with many challenges that MC presents to them.

The first thoughts about Mass Customization were identified by Toffler in the early 70's and later explained with more detail by Davis in 1987. Davis introduced the term mass customization as a contradiction for mass production. However, the fundamental idea of MC is based on the observation that there is a customer interest in products that are adapted to their individual needs because such adaptation will increase perceived performance. As the standard of living has increased during the last 50 years, individualization has received increased attention. Mass customization is coming within the reach of many consumers. At the same time, existing manufacturing companies are able to efficiently implement MC using the latest technologies of information processing, production control, flexible manufacturing systems, logistics, and mechatronics.

Furthermore, mass customization focuses on meeting customers' diverse requirements without compromising cost or lead time via economies of scope. This is in

contrast to the old paradigm of mass production, which is to mass produce standard products through economies of scale.

The main operational benefits (Pine, 1993) derived from MC include the following: just-in-time delivery and processing of materials and components that eliminate process flaws and reduce inventory carrying costs; reducing setup and changeover times, which directly lowers run size and the cost of variety; and compressing cycle times throughout all processes in the value chain, which eliminates waste in order to increase flexibility and responsiveness while decreasing costs.

In general, mass customization can be seen as a manufacturing technique that makes an effective use of information technology, flexible processes, and organizational structures to provide a great variety of products and services that meet specific needs of individual customers, at a reasonable and competitive price (Hart, 1995).

1.1.2: Information Technology – The Concept

It is imperative to start this section with a clear understanding of Information Technology, and one significant definition is the following: the relationship between computer hardware, software, data and storage technologies, and networks providing a portfolio of shared information technology resources for the organization (Laudon, 2001). Accordingly, the fundamental IT components may be described as follows:

- Computer Hardware: Is the physical equipment used for input, processing, and output activities.
- Computer Software: Comprises the detailed pre-programmed instructions that control and coordinate the computer hardware components.

- Storage Technology: Includes both the physical media for storing data and the software governing the organization data on these physical media.
- Communications Technology: It is made of both physical devices and software, which connects the various pieces of hardware and transfers data from one physical location to another.
- Network: It relates two or more computers to share data or resources.

More importantly, choosing, installing and mastering the right combination of Information Technologies (IT) is considerably important for all manufacturing companies wishing to meet their consumer demands. Since every business has their own needs, then each one of them should pay enough attention to construct and utilize an effective IT infrastructure. IT managers should understand the potential benefit of various information technologies available as well as cost/performance relationships. These information technologies can either enhance or impede organizational achievements depending on the way they are combined, and how they are used. In fact, the selection of an organization's IT should consider how well the technology fits together with the organization's culture and structure in addition to its information-processing requirements.

Today, information technology is not limited to computers, software or storage components but must be viewed as a collection of digital devices networked together. Typically, organizations have a vast array of IT options to choose from, but the key information technology decisions should consider the following factors: the appropriateness of the IT for the problem to be addressed; the vendor support of IT services; the efficiency of accessing information; the flexibility in organizing

information; the type of information to be stored and arranged; and the compatibility with the organization's IT model.

1.1.3: Implications of Mass Customization on Information Technology

There is a common agreement in academia that Information Technology (IT) is one of the most critical components of any successful implementation of Mass Customization (MC) (Reichwald, 2000; Blattberg et al., 1994; Andel, 2002). Chandra (2004) identified the primary contributions of IT in the mass customization framework as the following: receiving of customer orders; transformation of customer orders into manufacturing orders; and handling the information flows of inventory and transportation. However, a great number of organizations that are trying to implement the MC techniques are not even close to have the adequate IT system for this new manufacturing model, and the impact of this situation could be catastrophic in terms of the survival of the company (Pine, 1995).

Having the right hardware and software improves the communication means of any organization thus increasing the potential of handling greater levels of information. Furthermore, increments on data management could be very difficult to handle without a specific IT infrastructure to support it (Blecker and Graf, 2004; Winter, 1990). At the same time, MC customers require higher levels of product and service quality that would only be possible with the right IT system.

In MC, the efficient use of information technologies allows customers to take a central role on the design of a product by changing its requirements according to their specific needs. With this in mind, the organization has to be able to quickly adjust the entire manufacturing process for every different product (Matulik, 2004).

1.2: Problem Description

The previous section stated the importance of Mass Customization (MC) on the current Information Technology (IT) infrastructure of any company. In the manufacturing industry, having the best suitable IT could be an important factor for success. However, the problem is that today not every one has the advantage to be using adequate IT in terms of what the organization really needs.

A useful and practical tool to help those organizations to be in a better position to make changes to their IT systems would be a great competitive advantage. And the basic approach to deal with this problem would be to improve the most critical aspects of the IT infrastructure. Furthermore, since every company has different IT requirements, and specific IT issues arise when dealing with such a transformation, then, it is important to use the scientific method in order to establish an empirical guideline.

That is why providing a measuring technique where any company can analyze their current IT situation comes to play a very significant role for the manufacturing world. With something like this, people will be in a much better position to improve their IT, and consequently, it would be easier to implement MC on their production systems.

1.3: Research Objectives and Challenges

The main objective of this thesis is to develop an Information Technology (IT) suitability index that will help to overcome the most difficult IT issues and will have a great positive impact on the performance of a Mass Customized production process. As stated in the previous section of this chapter, the development of such an index requires studying, and analyzing all the correspondent issues regarding the use of IT on the

manufacturing industry. Moreover, the index would have the advantage to provide the following:

1. The most important and critical IT elements of interest in terms of an MC approach,
2. The IT suitability level for the organization,
3. Potential improvement areas on the IT infrastructure.

1.3.1: Methodology for Determining an Information Technology Suitability Index for Mass Customization

In order to develop an IT suitability index for MC it is necessary to perform an extensive analysis of the actual capabilities of the existing IT infrastructure of a specific organization. And one of the most common industrial engineering practices to do this involves the study of performance factors.

The methodology used on the development of this thesis is similar to the one utilized by Gonzalez (1995) and includes the following of steps:

1. Analyze the relationship between IT and MC from an engineering perspective.
2. Define a set of parameters and levels for Information Technology in terms of Mass Customization and their importance on both optimum and worst scenarios.
3. Find a concise and representative combination of scenarios and develop a survey describing such scenarios in terms of the factors and their levels, and distribute the questionnaires to experts for their evaluation.
4. Formulate a mathematical model using linear programming regression that fits the data and provides logical results to compute the relative importance weights that should be assigned to the factors when they take on a given level.

5. Analyze and evaluate the mathematical model in its ability to predict the suitability of IT as indicated in the opinion of experts.

1.4: Organization of the Thesis

This thesis is structured in 5 chapters. The current chapter introduces the background of Information Technology (IT), Mass Customization (MC) and the implications of both working together. This includes the current situation of information technology in mass production, the shift of manufacturing practices from mass production to MC, and the importance of the integration of mass customization to an existing IT infrastructure. Additionally, the problem description, the research objective, and challenges are delineated.

Chapter II summarizes and gives a detailed literature review on existing approaches for the integration of information technologies to the MC concept. It also includes the fundamental ideas of mixed level orthogonal arrays, the basic theories of linear programming regression models, and the primary contributions of several authors on the fuzzy concept.

The next chapter identifies major challenges to integrate IT for MC. Based on the understanding of such challenges and functions of information technology on mass customization, solution mechanisms to construct an IT suitability index for MC.

Chapter IV demonstrates the validation of the model using estimated values and performing an analysis of variance. It also introduces the use of linguistic descriptors as a mean to evaluate the accuracy of the model, and presents a percentage of agreements analysis.

Finally, the last chapter draws a summary of achievements that includes a comprenhensive analysis of the results of this thesis. Furthermore, there are two sections covering contributions and limitations. Lastly, areas of possible future research are discussed.

CHAPTER II

LITERATURE REVIEW

A general overview of the proposed Information Technology (IT) suitability index for Mass Customization (MC) was presented in Chapter I. Now, to show the fundamentals of this thesis, this chapter reviews the current research related to the main subject in question. There are four main sections in this chapter. The first one deals with the details and description of MC. Section number two presents all the relevant aspects of IT. The previous section also shows the importance of IT on a mass customization context as well as their relationships between each other. The third part consists of an explanation of the concept of mixed level orthogonal arrays. Section number four gives an understanding of linear programming regression models.

2.1: Review of Mass Customization

Mass Customization has been recognized as a new paradigm for the manufacturing world (Pine, 1993). It recognizes each customer as an individual and provides each one of them with attractive options that could only be offered in the pre-industrial tailoring system, of course, at an elevated price. At the same time, customers can afford the highly customized products because modern manufacturing and information technologies enable low product cost. Thus with MC, companies can exceed their competitors by gaining new customers and achieving higher margins.

In reality, customers are often willing to pay a premium price for their unique requirements being satisfied thus giving companies bonus profits (Roberts and Meyer, 1991). From an economic perspective, MC enables a better match between producer capabilities and customer needs. This is done through either developing the company's portfolio, including products, services equipment, and skills that the market demands, or leading customers to the total capability of the company so that customers are better served. The end results are conducive to improvements in the use of resources. It also has several significant ramifications in business. It can potentially develop customer loyalty hence propelling company growth and increasing market share by widening the product range (Pine, 1993).

Mass customization research partly covers some topics encompassing customer driven engineering (engineering to order) and manufacturing (Muntslag, 1993). All of this concepts deal with ways to produce unique products for different customer needs. Although the idea of pursuing a customization strategy has many advantages, the current efforts towards MC have only highlighted the end benefits while avoiding the means or requirements to get there (Kotha, 1994 and 1995). As a result, mass customization has drawn the criticism that it has the look and feel of a revolutionary paradigm but lacks of a coherent framework and thus remains a repackaging of pre-existing ideas with only limited synthesis (Kotha, 1994 and 1995 and 1996). Moreover, competitive strategies in the 1990s include diverse and related themes such as manufacturing flexibility, time-based competition, lean production, re-engineering, and continuous improvement. The structure and infrastructure issues are critical to the successful implementation of mass customization so as to be compatible with various strategies and technologies (Lau,

1995). Therefore, it is imperative to develop a coherent framework within which systematic approaches can be taken to enable the realization of MC.

The essence of mass customization lies in the product and service developers being able to perceive and capture latent market niches and subsequently to develop technical capabilities to meet the diverse needs of target customers. Perceiving talent market niches requires the exploration of customer needs. Capturing customer groups means emulating competitors in either: quality; cost; or quick response. Keeping low manufacturing costs involves the appropriate development of production capabilities. Therefore, the requirements of mass customization reside on the following three main aspects:

- Time to market (quick responsiveness)
- Variety (customization)
- Economy of scale (mass efficiency)

In other words, successful mass customization depends on a balance of three elements: features, cost, and schedule. Accordingly, a key player of implementing mass customization is to develop a necessary infrastructure to facilitate the choice of the best design alternative that simultaneously satisfies these requirements.

From an economic point of view, implementing mass customization concepts requests a careful determination of the range in which a product or service can be customized efficiently. The level or the levels of individualization of the offered items seem to be critical for an appropriate definition. Pine (1933 and 1993) e.g. suggests five stages of modular production: customized services (standard products are tailored by people in marketing and delivery before they reach customers), embedded customization

(standard products can be altered by customers during use), point-of-delivery customization (additional custom work can be done at the point of sale), providing quick response (short time delivery of products), and modular production (standard components can be configured in a wide variety of products and services).

2.1.1: Mass Customization Levels

Based on an analysis of existing frameworks to categorize the various levels of customization of a product, Da Silveira et a1. (2001) proposed a set of eight generic levels of mass customization, ranging from pure customization (individually designed products) to pure standardization. Design, as level eight, refers to collaborative product development, manufacturing, and delivery of products according to individual customer preferences. The next level (Level seven: fabrication), refers to manufacturing of customer-tailored products based on predefined designs. Assembly, as level six, deals with the arranging of modular components into different configurations according to customer orders. On levels five and four, mass customization is achieved by simply adding custom work or services to standard products (often at the point of delivery). In level three, mass customization is provided by alternative approaches for distributing or packaging of products (e.g. different labels and/or box sizes according to specific market segments). In level two, mass customization occurs only after delivery, through products that can be adapted to different functions or situations. Finally, level one refers to pure standardization, a strategy that according to Da Silveira et al. (2001) can still be useful in many industrial segments.

2.1.2: Mass Customization of Automobiles

Investigations by Huffman (1998) have shown that selling a customized product can be difficult because the many options and the number of choices can lead to frustration for the customer. In a developed mass customization market, like the automotive there are great regional differences, 90 % of all cars sold on the US market are without customization (Fisher, 1997), compared to the 60 % of the German market (The Economist, 2001). This observation must lead to the conclusion, that there are some imperfection to the way that mass customization is applied. There can be numerous reasons why customers avoid customization, a few are listed here:

- Lead-time: Often customization will result in a longer lead-time since the product will have to be build to order. Therefore, the customer must be willing to wait.
- Cost: There is often a premium connected to the customization process.
- Time consumption: Often, the value added achieved from customization do not match the time invested in the configuration process.
- Uncertainty: Customers often face uncertainty regarding the right configuration of the product, and the effect particular decisions will have on the final performance of the product. They have trouble deciding what they want; and they are overwhelmed or unsure with basic information and/or physical measurements.
- Process flexibility: Multidimensional processing like the one for complex products is difficult to customize.
- Logistics: Information flows with product; distribution channel problems; and business to customer relationships is difficult and different from the one that we are used to manage.

The background for the large difference on the car market might be due to cultural differences. The American consumer sees to a large extend the car as a commodity. Consequently, the American consumer is priced focused and impatient. In contrast, German consumers consider the car of importance and are therefore willing to accept the drawbacks to a customized solution.

2.1.3: Costs of Mass Customization

As stated earlier, mass customization is characterized by the combination of mass production and customization, offering unique products at a low cost. Looking at the market it is clear that in most cases there are some costs generated by the customization process. Pine et al. (1933) claims that mass customization comes at no extra cost, compared to mass production. This can be argued, but looking at customized products today, it is difficult to find products where there is no extra cost. In general, three major cost drivers can be identified:

- the implementation of flexible production equipment,
- availability of individual logistics,
- configuring, designing and selling the customized product.

Flexible manufacturing equipment is typically more expensive than mass production equipment, and the cost of this equipment most be distributed over the products, which thereby becomes more expensive. A flexible system has difficulties to be a match for the efficiency of a dedicated production line.

For products customized at a production facility, individual logistics will generate cost. Customer and product are linked before manufacturing. This is, for instance, the case for automobiles, where the customer creates a pull situation through production by

ordering a unique combination of color, interior, engine etc. This results in reduced capacity utilization or creates waiting time. Some automotive manufactures compensate for this by producing cars to be sold of the lot, whereas more exclusive manufactures will have to accept a lower capacity utilization, or a waiting time, since their customers expects a unique product.

The sales process of a customized product is typically more complicated than a standard product. Since the customer must be supported in the decision making process either by a configurator or a salesperson. Therefore, the process of selling a customized product generates more costs than selling a product off the shelf, which does not demand any interaction with the customer. During the last ten years the cost of customization has fallen. It can be observed that some markets are dominated by customized products. Because of the cost reduction which has been enabled by the application of industrial management methods ensuring cost efficiency.

2.2: Importance of Information Technology on a Mass Customization context

From an implementation viewpoint, a great number of research emphasizes the importance of IT as an instrument for MC (Kallock, 1994; DeRoulet, 1993; Stuart, 1994; Moad, 1995). Quite a lot of literature sets the standpoint on manufacturing management and Advanced Automation Technologies (AAT) (Eastwood, 1996; Moad 1995) in order to implement mass customization. More recently, Lee and Bilington (1994) advocate research into mass customization from a supply chain management perspective. Similarly, Hart (1996) tackles the logistic issues in MC.

In industrialized nations the impact of information technology/information systems (IT/IS) can be observed in virtually all business processes and functions. The impact of IT/IS in manufacturing has been particularly palpable. Computers can be found virtually everywhere in modern manufacturing companies. In many of those companies IT/ IS provides a substantial portion of the infrastructure that moves information. The contribution of IT/IS extends beyond the role of providing an information infrastructure. IT/IS and other technologies comprise Advanced Manufacturing Technologies that directly assist humans in performing tasks or replace them by doing the tasks that they once performed.

The supportive role of IT/IS in moving information is particularly important because nothing else (people, parts, products, machines) moves in manufacturing before information moves. To the extent that the movement of information is faster and more accurate, efficient and reliable, the flow of inputs into, through and out of manufacturing systems is improved. Improvements in the performance of the information infrastructure in manufacturing firms has lead to better quality products, greater flexibility, increased dependability, lower costs and of course, greater speed. Quality, flexibility, dependability, low cost and speed are the primary bases for competition and the very foundation for creating, combating, and sustaining competitive advantage.

In manufacturing, IT/IS can support management decisions (planning and control) at all organizational levels and it can support or replace, staff, technicians and production workers. In a more automated manufacturing systems, such as computer integrated manufacturing (CIM), CAD/ CAM and flexible manufacturing systems (FMS), IT directly guides and controls the processes employed to manufacture products. IT/IS can

play a critical role in supply chain management by expanding the information infrastructure beyond the boundaries of the firm, thereby supporting information flows to and from customers and suppliers.

Where CIM, CAD/CAM, FMS are used, information technology and process technology may be so thoroughly integrated that they are inseparable. In such a setting, manufacturing is clearly IT/IS dependent. Manufacturing planning and control systems are often dependent on IT/IS– MRPII systems are a good example. These systems support managers, staff and production workers as they engage in activities necessary to facilitate the flow of inputs into, through, and out (as finished goods) of a manufacturing system. In other manufacturing environments, IT/IS may play a more supportive role, but there are few modern manufacturing companies in which IT/IS is not important.
New forms of business have emerged in response to the increasing global nature of business commerce. IT/IS advancements that improve inter business communications have contributed to the evolution of some of these new forms of business enterprise. Terms like agile manufacturing, virtual manufacturing and virtual business have been used to describe emerging enterprises that encompass business partners and operations around the globe. A virtual enterprise 2.2.1 Cause and Effect Analysis for Information Technology is comprised of many partners that must interact rapidly to provide products in response to changing markets. The information infrastructure in this type of enterprise must facilitate rapid movement of information around the globe. These firms are highly dependent on IT/IS to provide the necessary information infrastructure to make their operations efficient and effective. In fact, without IT/IS some of these new configurations

would not be practical or possible. If emerging business forms offer a glimpse at the future of the global enterprise, then they portend an increase in the importance of IT/IS.

The role of IT/IS in manufacturing has increased steadily throughout the last half of the 20th century. Although at times the pace of automation has slowed to address problems resulting from increased automation, such as those relating to the ‘‘human factor’’ or difficulties in cost justifying new technologies, the trend towards greater computerization of manufacturing seems certain to continue well into the 21st century. IT/ IS figures prominently in popular visions of the ‘‘factory of the future’’. Improvements in expert systems, vision systems, and neural networks will most certainly result in improvements in the systems that support decision making as well as the systems that direct and control manufacturing processes.

The increased dependence of manufacturing firms on IT/IS has brought new challenges with it, especially when clear organizational and technical system boundaries have become blurred. Change in some manufacturing sectors has been so dramatic that tools and techniques (cost justification and cost accounting are a good examples) that were used for years can no longer be applied in the same manner as in the past. Compounding the problem is a pace of business, social and technological change so rapid, that practitioners and researchers are hard pressed to modify old tools and techniques or develop new ones fast enough to keep pace.

The following objectives can be deduced for the manufacturing industry:

- Reduce the product development lead time in order to deliver the right products satisfying changing customer requirements. This satisfaction of customer demands must be accompanied by lower development cost (entry ticket) and maintaining a

high quality level of the product. Currently, the target is to reach a product development time of less than 24 months.

- Reduce the commercial product delivery time for products which have to be more and more customized.
- Increase the agility of the enterprise, that is to say its capability to introduce quickly product and process innovations to respond to all types of evolution required by the environment market, regulations, enterprise strategies, technological evolutions, etc.
- Increase the innovation at the customer service level in order to compensate for the revenue reduction due to the cost reduction forced by the competition at the car product level cars will cost less and less.

2.3: Design of Experiments

According to Montgomery (2001), the objective of any experiment is to be able to understand and possibly improve the behavior of a process or a system. Depending on the number of factors involved, there are different alternatives of approaching a given problem. It goes from best-guess approaches to complex methodologies using computer algorithms. And, an accepted process for designing experiments was developed by Coleman and Montgomery (1993) and is presented in Table 2.1.

Table 2.1: Guidelines for Designing an Experiment

1	Problem Definition.
2	Choice of factors, levels, and ranges.
3	Selection of the response variable.
4	Choice of experimental design.
5	Performing the experiment.
6	Statistical analysis of the data.
7	Conclusions and recommendations.

The presence of interactions between factors provides a good reason to use full factorial experiments as opposed to testing one factor at a time. Table 2.2 shows a simple example of a 2x2 factorial experiment. However, this method is only recommended when the number of factors is relatively small. By the same token, as the number of factors increases it becomes less efficient to run all possible combinations, and the use of fractional factorials should be considered.

Table 2.2: Example of a 2x2 Factorial Experiment

Factor	**A**	**B**
(1)	-1	-1
a	-1	1
b	1	-1
ab	1	1

One of the conditions to use full factorials and fractional factorials is that all the factors must have the same number of levels (two-level designs are usually recommended whenever quantitative factors are being used). Though, this may not be feasible for experiments where some of the factors are qualitative and require three levels or more.

2.4: Mixed Level Orthogonal Arrays

A special type of factorial experiment with mixed levels is called Mixed-level Orthogonal Array (Montgomery, 2001). The most important characteristic of this design is the orthogonal condition meaning it is able to handle a large number of factors, and it allows an independent evaluation of the desired effects. An example is shown on Table 2.3 where there are 36 runs using 2 factors with two levels, and 8 factors with three levels each.

Table 2.3: A Two 2-level and Eight 3-level Orthogonal Array (L_{36})

	Factors and their correspondent levels									
Run	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
1	1	1	1	1	1	1	1	1	1	1
2	1	1	2	2	2	2	2	2	2	2
3	1	1	3	3	3	3	3	3	3	3
4	1	1	1	1	1	1	2	2	2	2
5	1	1	2	2	2	2	3	3	3	3
6	1	1	3	3	3	3	1	1	1	1
7	1	1	1	1	2	3	1	2	3	3
8	1	1	2	2	3	1	2	3	1	1
9	1	1	3	3	1	2	3	1	2	2
10	1	2	1	1	3	2	1	3	2	3
11	1	2	2	2	1	3	2	1	3	1
12	1	2	3	3	2	1	3	2	1	2
13	1	2	1	2	3	1	3	2	1	3
14	1	2	2	3	1	2	1	3	2	1
15	1	2	3	1	2	3	2	1	3	2
16	1	2	1	2	3	2	1	1	3	2
17	1	2	2	3	1	3	2	2	1	3
18	1	2	3	1	2	1	3	3	2	1
19	2	1	1	2	1	3	3	3	1	2
20	2	1	2	3	2	1	1	1	2	3
21	2	1	3	1	3	2	2	2	3	1
22	2	1	1	2	2	3	3	1	2	1
23	2	1	2	3	3	1	1	2	3	2
24	2	1	3	1	1	2	2	3	1	3
25	2	1	1	3	2	1	2	3	3	1
26	2	1	2	1	3	2	3	1	1	2
27	2	1	3	2	1	3	1	2	2	3
28	2	2	1	3	2	2	2	1	1	3
29	2	2	2	1	3	3	3	2	2	1
30	2	2	3	2	1	1	1	3	3	2
31	2	2	1	3	3	3	2	3	2	2
32	2	2	2	1	1	1	3	1	3	3
33	2	2	3	2	2	2	1	2	1	1
34	2	2	1	3	1	2	3	2	3	1
35	2	2	2	1	2	3	1	3	1	2
36	2	2	3	2	3	1	2	1	2	3

2.5: Linear Programming

Throughout time, human beings have been challenged to find optimum solutions for quantitative problems. With the invention of mathematics and linear algebra, it was possible to answer many of these questions. According to Dantzig (1963), linear programming could be used to maximize or minimize a linear function subject to linear constraints. And with help from computers, several software programs can be used to solve complex equations in a very short time frame compared to older methods.

2.6: Regression Analysis

One of the pioneers of this statistical method comes from Fisher (1992) with the publication of his studies on the goodness of fit of regression formulas. And from here, many engineering problems requiring the forecast or prediction using historic information use a very refined area of statistics called regression analysis. This means that given a sample of a population, one could generate a linear or quadratic function that minimizes the differences between the data and the calculated model. At the same time, these estimated response levels should include some sort of model effectiveness as well as an error factor.

2.7: Goal Programming

The concept dates back to Charnes and Cooper (1961) and followed Ignizio in 1962 with an application for design and placement of aerospace antennas. Goal programming is an optimization system originated from the area of multiobjective optimization and it is very much related to the concept of linear programming with the

special characteristic of using multiple and/or conflicting factors. Then a specific target to be accomplished is chosen, and any deviations from this goal should be minimized using a mathematical function.

2.8: Fuzzy Logic

This way of thinking relates to a special theory that uses approximation values to find solution regions rather than precise points. In other words, specific problems can be optimized using membership values to obtain a range of true values. One of the pioneers of fuzzy logic was Zadeh (1965) and some of its applications include using linguistic variables.

2.9: Linguistic Descriptors

With the invention of numbers, mathematic problems were bounded by the fact that any possible answer had to be an exact value. However, according to extensive research conducted by Zadeh (1996), Ignizio, and Gonzalez, more complex scenarios would be out of consideration without the study of non-numeric linguistic variables. For example, the analysis of water temperature could be set using three possible levels given as HIGH, MEDIUM, or LOW. And from here, one could develop an algebraic function to optimize water temperature on a given scenario.

CHAPTER III

AN INFORMATION TECHNOLOGY SUITABILITY INDEX FOR MASS CUSTOMIZATION

This chapter describes the most important aspects of the development of an Information Technology (IT) suitability index for mass customization. It consists on five sections. The first section presents an introduction to the topic of interest of this thesis. Section number two contains a description of the cause and effect procedure used in the determination of the most important parameters to get an IT suitability index for mass customization. The third section introduces the topic of interest and prepares the ground for further analysis. After this, the fourth section explains the details of the development of the IT suitability index. Finally, the fifth section includes information on the results of the index.

3.1: Introduction to de Development of an Information Technology Suitability Index

Given the complexity of having inappropriate or outdated IT infrastructures operating in the majority of the manufacturing world, it becomes crucial to use the scientific method in order to find a system to rate the different levels of adequacy for a given information technology on any organization.

It is assumed that an organization's purpose for its existence is to maximize profit and be the leader on its industry. And for this reason the quality of the Information Technology is important.

Quality and suitability are two of the factors that are of concern in order to have as a reference an optimum IT. To start with, quality is defined as the totality of features and characteristics of the product, process or service that bear on its ability to satisfy stated or implied needs. In other words, it is said that a quality product is also in general terms fit for use. Then we have the definition of suitability being the following: appropriate to a purpose or an occasion, or the quality of having the properties that are right for a specific purpose.

The best approach to handle the situation described above was utilized by Gonzalez (1995) with the study of quality performance on a restaurant, and later adapted to a mass customization topic by De la torre (2006). According to them, this specific use of capability indexes takes into account different weights for every major parameter depending on their importance. Therefore, the adaptation of a mathematical function for such a suitability of IT index can be described as:

$$Q(x) = \sum_{i=1}^{n} \omega_{ij} x_{ij} \text{ , for j = 1 to } K_i \qquad (3.1)$$

where,

x - A vector of observed variables defining IT suitability,

ω_{ij} - Relative importance weight associated with the ith variable at jth level,

x_{ij} - The value of the ith variable at jth level observed in the performance of the task being evaluated. The value of this variable is 1 if the jth level is observed and 0 otherwise,

K_i - The number of levels that the ith variable can take,

n - The number of parameters used in the definition of the IT suitability,

Q(**x**) - The IT suitability index given the vector of parameter values **x**.

Furthermore, the mathematical formulation for the constrained regression model is as follows:

$$\text{Minimize} \qquad Z = \sum_{i=1}^{n} D_i \,, \tag{3.2}$$

$$\text{Subject to:} \qquad F(x_1, x_2, \ldots, x_m)_i + D_i = O_i \,, \quad i,$$

$$G(x_1, x_2, \ldots, x_m)_j \geq K_j \,, \quad j,$$

$$D_i \text{ is unrestricted in sign,} \quad i,$$

$$x_1, x_2, \ldots, \text{and } x_m \text{ are unrestricted in sign.}$$

where,

$x_1, x_2, \ldots,$ and x_m - Function regression parameters,

$F(x_1, x_2, \ldots, x_m)_i$ - The regression function setting on the ith observation,

O_i - The observed function value for the ith observation,

D_i - The number of levels that the ith variable can take,

$G(x_1, x_2, \ldots, x_m)_j$ - The jth constraint on the regression variables,

K_j - Bound on the jth constraint,

N - Number of observations,

m - Number of regression variables.

Finally, the series of steps necessary to accomplish the goal of this chapter are revealed as follows:

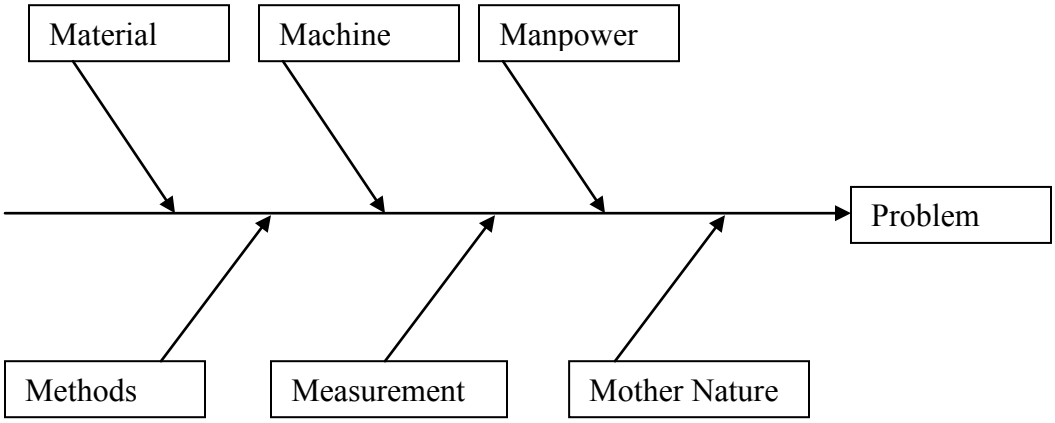
- Investigate important issues when dealing with IT
- Use a fishbone diagram to find out root causes for problems identified previously

- Elaborate on the adaptation of a suitability model for this specific case
- Run the experiment and obtain results

3.2: Cause and Effect Analysis for Information Technology

One of the best techniques to find the root cause of a given problem is the fishbone diagram (Ishikawa, 1960) because it uses team work, brainstorming, and visual representations. And the general model is presented on the following diagram:

Figure 3.1: Cause and Effect (Fishbone) Diagram



The problem solving analysis that needs to be performed has the purpose of finding the most important variables affecting the IT of a company. And the complete results obtained after applying this cause and effect brain storming methodology is described as follows:

Problem: Information Technology is not adequate to handle the requirements of a Mass Customization environment.

Causes:

- Material:
    - N/A.
- Machine/Plant:
    - Systems break down too often hence impeding productivity.
    - Equipment maintenance is too expensive or time consuming.
    - Current technology does not provide updates for growth.
    - Too many resources are needed to run the system making it inefficient.
    - Changes are difficult to implement due to the lack of flexibility.
- Measurement/Policies:
    - N/A.
- Manpower/People:
    - User interface is not friendly.
- Methods/Procedure:
    - Different platforms exist in the same organization and they are not compatible.
    - Older technologies are too slow for information processing.
    - Current procedures allow human error and this affects accuracy.
    - Information only flows to the customer and fails to get specific need from them.
- Mother Nature:
    - N/A.

3.3: An Information Technology Suitability Index for Mass Customization

The following procedure was followed in order to come up with the Suitability Index:

1. Identify the parameters or factors that best describe the characteristics of an IT system suitable for MS and the appropriate descriptors and levels that these factors could take.
2. Setup the best array of scenarios based on the available information.
3. Develop a questionnaire describing the scenarios in terms of the parameters and their levels. And distribute the questionnaires to experts for evaluation.
4. Formulate a regression linear programming model that fits the data and provides logical results to compute the relative importance weights that should be assigned to the factors when they take on a given level.
5. Analyze and evaluate the regression results.

Based on the cause and effect analysis presented on the previous section, the following parameters and linguistic descriptors were developed:

Table 3.1: Main Parameters and correspondent Descriptor Levels

	Parameters	**Descriptors**		
1	Standard Protocols	Yes	No	
2	Bidirectional	Yes	No	
3	Flexibility	High	Med	Low
4	Speed	Good	Fair	Bad
5	Reliability	High	Med	Low
6	Usability	Good	Fair	Bad
7	Accuracy	High	Med	Low
8	Efficiency	Good	Fair	Bad
9	Growth Potential	Good	Fair	Bad
10	Maintenance	Easy	Fair	Complex

Given the information presented on the previous chart including 2 factors with two levels, and 8 factors with 3 levels, it is necessary to use the following Mixed Level Orthogonal array in order to take the optimum and most efficient number of scenarios:

Table 3.2: Mixed Level Orthogonal array

	Parameter									
Scenario	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1	1	1	1	1	1	1	1	1	1
2	1	1	2	2	2	2	2	2	2	2
3	1	1	3	3	3	3	3	3	3	3
4	1	1	1	1	1	1	2	2	2	2
5	1	1	2	2	2	2	3	3	3	3
6	1	1	3	3	3	3	1	1	1	1
7	1	1	1	1	2	3	1	2	3	3
8	1	1	2	2	3	1	2	3	1	1
9	1	1	3	3	1	2	3	1	2	2
10	1	2	1	1	3	2	1	3	2	3
11	1	2	2	2	1	3	2	1	3	1
12	1	2	3	3	2	1	3	2	1	2
13	1	2	1	2	3	1	3	2	1	3
14	1	2	2	3	1	2	1	3	2	1
15	1	2	3	1	2	3	2	1	3	2
16	1	2	1	2	3	2	1	1	3	2
17	1	2	2	3	1	3	2	2	1	3
18	1	2	3	1	2	1	3	3	2	1
19	2	1	1	2	1	3	3	3	1	2
20	2	1	2	3	2	1	1	1	2	3
21	2	1	3	1	3	2	2	2	3	1
22	2	1	1	2	2	3	3	1	2	1
23	2	1	2	3	3	1	1	2	3	2
24	2	1	3	1	1	2	2	3	1	3
25	2	1	1	3	2	1	2	3	3	1
26	2	1	2	1	3	2	3	1	1	2
27	2	1	3	2	1	3	1	2	2	3
28	2	2	1	3	2	2	2	1	1	3
29	2	2	2	1	3	3	3	2	2	1
30	2	2	3	2	1	1	1	3	3	2
31	2	2	1	3	3	3	2	3	2	2
32	2	2	2	1	1	1	3	1	3	3
33	2	2	3	2	2	2	1	2	1	1
34	2	2	1	3	1	2	3	2	3	1
35	2	2	2	1	2	3	1	3	1	2
36	2	2	3	2	3	1	2	1	2	3

After this, a complete survey was developed as shown in Appendix A and it was given to 10 different available experts in the area of Manufacturing Engineering. The results from these questionnaires are the following:

Table 3.3: Expert Results

	Expert									
Scenario	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	140	150	150	145	150	150	150	145	137	150
2	105	123	110	96	100	96	60	110	100	105
3	90	73	115	90	80	45	70	85	90	80
4	120	138	135	120	135	120	80	135	110	130
5	115	103	85	95	103	81	110	95	100	110
6	90	105	120	130	125	78	110	115	65	120
7	110	116	110	80	116	108	95	105	100	105
8	100	120	113	115	120	60	90	115	80	120
9	115	110	130	90	85	135	120	125	130	115
10	65	103	100	70	80	69	65	75	70	85
11	100	108	104	110	108	123	110	105	95	110
12	95	93	110	95	100	87	110	100	110	100
13	75	101	80	70	80	51	75	70	80	75
14	100	110	104	100	95	144	110	95	50	100
15	60	93	75	70	100	99	80	70	60	80
16	50	109	80	65	99	75	90	95	90	70
17	95	99	75	100	109	126	110	100	99	120
18	85	96	97	70	96	84	100	100	45	95
19	110	98	98	107	98	129	100	105	95	100
20	90	108	105	75	108	114	110	100	105	110
21	79	98	92	110	70	63	90	90	75	70
22	120	99	130	125	80	90	60	130	120	130
23	83	100	80	72	83	72	70	95	45	80
24	95	105	98	100	105	117	100	105	60	100
25	70	102	98	93	102	93	100	90	100	120
26	90	102	103	75	115	54	110	105	95	110
27	110	100	94	95	100	147	95	120	105	95
28	50	93	95	85	80	102	90	100	90	70
29	70	76	83	79	76	48	70	85	95	80
30	60	93	75	95	70	141	90	75	70	75
31	60	69	45	55	50	57	50	45	60	45
32	75	95	60	75	70	138	75	70	65	70
33	60	98	95	90	98	111	100	95	100	95
34	65	90	70	65	75	132	65	60	80	50
35	85	88	50	80	85	105	70	65	90	70
36	60	84	80	70	65	66	55	75	70	65

3.4: Development of an Information Technology Suitability Description Model for Mass Customization

According to Gonzalez (1995) and De la torre (2006), the model for the suitability index that provided the best results is:

$$Q(x) = \sum_{i=1}^{n} \omega_{ij} x_{ij} + Q_0 , \qquad \text{for j = 1 to } K_i \qquad (3.3)$$

where

x - A vector of observed variables and levels defining a given scenario,

ω_{ij} - Relative importance weight associated with the ith variable when it takes on the jth level,

x_{ij} - The value of the ith variable at jth level observed in the suitability of the factor being evaluated (the value of this variable is 1 if the jth level is observed and 0 otherwise),

K_i - The number of levels that the ith variable can take,

n - The number of parameters used in the definition of the IT suitability,

Q_0 - Intercept value based on the normal level of suitability from which it could either improve or decline.

Q(**x**) - The IT suitability index given the vector of parameter values **x**.

Now a linear programming regression model was formulated using the previous mathematical method to get the IT suitability index for mass customization. The purpose for this regression model will be to estimate the relative importance weights associated with the IT suitability content variables at their respective levels. Basically, the model seeks to minimize the sum of the absolute deviations and it is subject to two groups of constraints.

The first set of constraints consist of a formulation of the observed scenarios times the regressor weights plus/minus a deviation variable set equal to the observed rating for the scenario of performance given by one of the experts. One different constraint is formulated for each observation in the data set and they take the following form:

$$\sum_{i=1}^{n}\sum_{j=1}^{K_i} \omega_{ij} x_{ijk} + Q_0 + D_{kw} = Q_{kw}, \tag{3.4}$$

where

ω_{ij} - Relative importance weight associated with the ith variable when it takes on the jth level,

x_{ijk} - The value of the ith variable at jth level observed in the suitability of the factor being evaluated on the kth scenario (the value of this variable is 1 if the jth level is observed on the kth observation and 0 otherwise),

K_i - The number of levels that the ith variable can take,

n - The number of parameters used in the definition of the IT suitability,

Q_0 - Intercept value based on the normal level of suitability from which it could either improve or decline.

Q_{kw} - The suitability measure given by the wth expert for the kth scenario presented of the observed parameter level value **x**.

D_{kw} - The absolute deviation obtained from the observed rating for the kth scenario by the wth expert at the optimal solution of the w_{ij} regressors.

The other group of constraints is better represented by logical arguments, and they are described as follows:

1. A constraint on the upper and lower bound on the index values is needed to assure that the weights assigned to the suitability content variables are within the limits of the rating scale used in data collection.
2. A constraint on the value of the intercept normal suitability regressor is required to provide the model with a logical intercept value. In the case of the regression model described in this chapter the value is a rating of 100, which represents normal IT suitability.
3. A set of order constraints is required to set the logical order for the value of the relative importance weights associated with the suitability content variables at their various levels. The difference in the value of the relative importance weight associated with the upper positive level should be at least twice the value in the next level down. For example, the relative importance weight associated with the best descriptor level should be at least twice as important as the weight given to the second best descriptor level. Consequently, the second best descriptor level's relative importance should be twice that of the next level in the sequence.
4. Sign constraints related to the individual suitability content variable levels were established so that the model will reflect logical values for the weights. For example, weights assigned to the best suitability level should be given weights that are positive or zero, and on the other side, the worst descriptor level should be given weights that are negative or zero.

In order to describe these constraints and given that the suitability content variables can take either an upper positive, middle average, or lower negative levels, the

following definitions are in order for the relative importance weights associated with the previously defined variable levels:

ω_{i+} - The relative importance weight associated with the ith suitability content variable and the upper positive level,

ω_{i0} - The relative importance weight associated with the ith suitability content variable and the middle average level,

ω_{i-} - The relative importance weight associated with the ith suitability content variable and the lower negative level,

Given the previous definitions, the constraints could be formally described as follows:

1. An upper and lower bound on the index values are

$$\sum_{i=1}^{n} \omega_{i-} + Q_0 = 45, \tag{3.5}$$

and

$$\sum_{i=1}^{n} \omega_{i+} + Q_0 = 150. \tag{3.6}$$

2. A constraint on the value of the intercept normal IT suitability regressor is

$$Q_0 = 100. \tag{3.7}$$

3. Constraints that set the logical order for the value of the relative importance weights associated with each of the suitability content variables at their various levels are

$$w_{i+} - 2w_{i0} \geq 0, \tag{3.8}$$

and

$$2w_{i0} - w_{i-} \geq 0. \tag{3.9}$$

4. Sign constraints related to the individual performance quality content variable levels are

$$w_{i+} \geq 0, \tag{3.10}$$

$$w_{i0} \text{ - unrestricted in sign,} \tag{3.11}$$

and

$$w_{i-} \leq 0. \tag{3.12}$$

The relative importance weights associated with the IT suitability content variables are obtained using equations (3.4) through (3.12) inside a linear programming formulation as shown next:

Minimize $$\sum_{w=1}^{10}\sum_{k=1}^{36} D_{kw}, \tag{3.13}$$

Subject to: $$\sum_{i=1}^{n}\sum_{j=1}^{K_i} \omega_{ij} x_{ijk} + Q_0 + D_{kw} = Q_{kw}, \qquad \text{k = 1…36 and w = 1…10,}$$

$$\sum_{i=1}^{n} \omega_{i-} + Q_0 = 45,$$

$$\sum_{i=1}^{n} \omega_{i+} + Q_0 = 150,$$

$$Q_0 = 100,$$

$$w_{i+} - 2w_{i0} \geq 0, \qquad \text{i = 1…n,}$$

$$2w_{i0} - w_{i-} \geq 0, \qquad \text{i = 1…n,}$$

$$w_{i+} \geq 0, \qquad \text{i = 1…n,}$$

$$w_{i0} \text{ - unrestricted in sign,} \qquad \text{i = 1…n,}$$

$$w_{i-} \leq 0, \qquad \text{i = 1…n.}$$

where,

ω_{ij} - Relative importance weight associated with the ith variable when it takes on the jth level,

x_{ijk} - The value of the ith variable at jth level observed in the suitability of the factor being evaluated on the kth scenario (the value of this variable is 1 if the jth level is observed on the kth observation and 0 otherwise),

K_i - The number of levels that the ith variable can take,

n - The number of parameters used in the definition of the IT suitability,

Q_0 - Intercept value based on the normal level of suitability from which it could either improve or decline.

Q_{kw} - The suitability measure given by the wth expert for the kth scenario presented of the observed parameter level value **x**.

D_{kw} - The absolute deviation obtained from the observed rating for the kth scenario by the wth expert at the optimal solution of the w_{ij} regressors.

ω_{i+} - The relative importance weight associated with the ith suitability content variable and the upper positive level,

ω_{i0} - The relative importance weight associated with the ith suitability content variable and the middle average level,

ω_{i-} - The relative importance weight associated with the ith suitability content variable and the lower negative level,

3.5: Results

In order to obtain the values for the relative importance weights corresponding to each of the IT suitability content variable levels, the LINDO™ (Linear, Interactive, and Discrete Optimizer) software program was used along the mathematical formulation and the data set presented on the previous section of this chapter (Gonzalez, 1995). The final Linear Programming (LP) model is presented in Appendix B shown at the end of this publication. And its corresponding solution in terms of content variable relative importance weights is shown in the following Table:

Table 3.4: Relative Importance Weights

IT Suitability Content Variable Relative Importance Weights

Variable Description	Upper Positive Level	Middle Average Level	Lower Negative Level
Standard Protocols	13.49	N/A	0.00
Bi-directional	2.27	N/A	-19.23
Flexibility	1.72	0.73	0.00
Speed	1.81	0.00	0.00
Reliability	6.05	0.00	-14.27
Usability	2.77	0.00	0.00
Accuracy	3.72	0.00	-2.16
Efficiency	7.65	0.00	-3.09
Growth Potential	0.00	-7.10	-14.20
Maintenance	10.51	-1.02	-2.04
TOTAL	**50.00**	**-7.39**	**-55.00**

Furthermore, the results of each factor are explained in detail to better understand their meaning:

1. According to the model, the existence of standard protocols has only a positive effect on the overall index

2. A bi-directional IT system has a small positive effect at the upper level but a much higher negative influence when observed at the lower level.
3. The relative importance weight related to the flexibility of the IT system has a very slight positive effect on the overall index when it is observed at the High and Med levels. Both effects are considered non-significant.
4. When taking into account the speed factor, only Good speed had a small effect.
5. Reliability resulted very significant on the Low setting, and somewhat important on the High level.
6. The usability of the IT infrastructure is considered to have only a small positive effect when it is present at the Good level.
7. Accuracy is considered to have low positive and negative effects when it is High and Low respectively.
8. Efficiency has a somewhat positive effect when it is Good, and slightly negative when it is Bad.
9. Growth potential includes a significant negative effect on its Bad setting, and a moderate negative effect on its Fair level.
10. Lastly, maintenance at the Easy level had a strong positive effect on the overall value of the model.

Finally, if we substitute the relative importance weights (Table 3.4) into the original mixed level orthogonal array (Table 3.2), the optimum values obtained from the model can be generated by just adding the quantities on each row, and adding $Q_0 = 100$ to

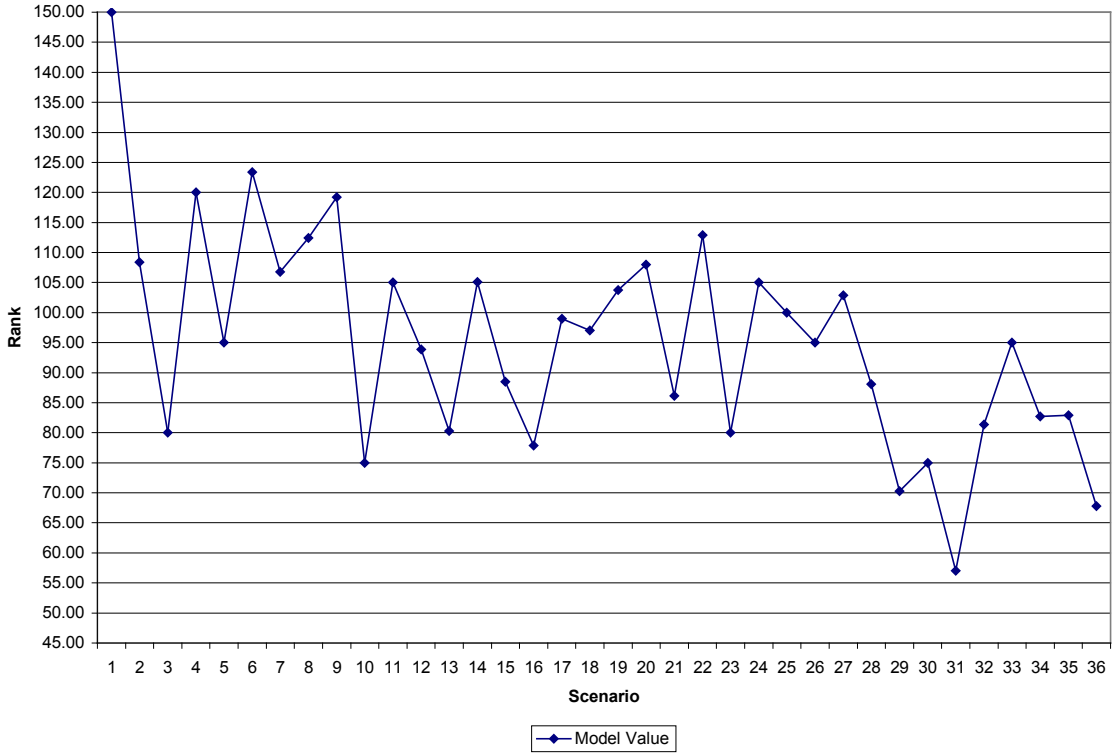
every one of them. Following this calculation, the next table includes the model generated values:

Table 3.5: Model Generated Values

	1	2	3	4	5	6	7	8	9	10	Model Generated Values
1	13.49	2.27	1.72	1.81	6.05	2.77	3.72	7.65	0.00	10.51	150.00
2	13.49	2.27	0.73	0.00	0.00	0.00	0.00	0.00	-7.10	-1.02	108.37
3	13.49	2.27	0.00	0.00	-14.27	0.00	-2.16	-3.09	-14.20	-2.04	80.00
4	13.49	2.27	1.72	1.81	6.05	2.77	0.00	0.00	-7.10	-1.02	120.00
5	13.49	2.27	0.73	0.00	0.00	0.00	-2.16	-3.09	-14.20	-2.04	95.00
6	13.49	2.27	0.00	0.00	-14.27	0.00	3.72	7.65	0.00	10.51	123.37
7	13.49	2.27	1.72	1.81	0.00	0.00	3.72	0.00	-14.20	-2.04	106.77
8	13.49	2.27	0.73	0.00	-14.27	2.77	0.00	-3.09	0.00	10.51	112.41
9	13.49	2.27	0.00	0.00	6.05	0.00	-2.16	7.65	-7.10	-1.02	119.19
10	13.49	-19.23	1.72	1.81	-14.27	0.00	3.72	-3.09	-7.10	-2.04	75.00
11	13.49	-19.23	0.73	0.00	6.05	0.00	0.00	7.65	-14.20	10.51	105.00
12	13.49	-19.23	0.00	0.00	0.00	2.77	-2.16	0.00	0.00	-1.02	93.85
13	13.49	-19.23	1.72	0.00	-14.27	2.77	-2.16	0.00	0.00	-2.04	80.28
14	13.49	-19.23	0.73	0.00	6.05	0.00	3.72	-3.09	-7.10	10.51	105.08
15	13.49	-19.23	0.00	1.81	0.00	0.00	0.00	7.65	-14.20	-1.02	88.49
16	13.49	-19.23	1.72	0.00	-14.27	0.00	3.72	7.65	-14.20	-1.02	77.85
17	13.49	-19.23	0.73	0.00	6.05	0.00	0.00	0.00	0.00	-2.04	99.00
18	13.49	-19.23	0.00	1.81	0.00	2.77	-2.16	-3.09	-7.10	10.51	97.00
19	0.00	2.27	1.72	0.00	6.05	0.00	-2.16	-3.09	0.00	-1.02	103.77
20	0.00	2.27	0.73	0.00	0.00	2.77	3.72	7.65	-7.10	-2.04	108.00
21	0.00	2.27	0.00	1.81	-14.27	0.00	0.00	0.00	-14.20	10.51	86.12
22	0.00	2.27	1.72	0.00	0.00	0.00	-2.16	7.65	-7.10	10.51	112.89
23	0.00	2.27	0.73	0.00	-14.27	2.77	3.72	0.00	-14.20	-1.02	80.00
24	0.00	2.27	0.00	1.81	6.05	0.00	0.00	-3.09	0.00	-2.04	105.00
25	0.00	2.27	1.72	0.00	0.00	2.77	0.00	-3.09	-14.20	10.51	99.99
26	0.00	2.27	0.73	1.81	-14.27	0.00	-2.16	7.65	0.00	-1.02	95.00
27	0.00	2.27	0.00	0.00	6.05	0.00	3.72	0.00	-7.10	-2.04	102.91
28	0.00	-19.23	1.72	0.00	0.00	0.00	0.00	7.65	0.00	-2.04	88.09
29	0.00	-19.23	0.73	1.81	-14.27	0.00	-2.16	0.00	-7.10	10.51	70.28
30	0.00	-19.23	0.00	0.00	6.05	2.77	3.72	-3.09	-14.20	-1.02	75.00
31	0.00	-19.23	1.72	0.00	-14.27	0.00	0.00	-3.09	-7.10	-1.02	57.00
32	0.00	-19.23	0.73	1.81	6.05	2.77	-2.16	7.65	-14.20	-2.04	81.37
33	0.00	-19.23	0.00	0.00	0.00	0.00	3.72	0.00	0.00	10.51	95.00
34	0.00	-19.23	1.72	0.00	6.05	0.00	-2.16	0.00	-14.20	10.51	82.69
35	0.00	-19.23	0.73	1.81	0.00	0.00	3.72	-3.09	0.00	-1.02	82.91
36	0.00	-19.23	0.00	0.00	-14.27	2.77	0.00	7.65	-7.10	-2.04	67.77

The following graph provides a visual representation of the previous solution obtained with the model:

Figure 3.2: Plot of Model Generated Values



3.6: Web based application

Based on the results of the model shown on the previous section and Table 3.1 (Main Parameters and correspondent Descriptor Levels), a web based application interface was created in order to facilitate experience of companies interested on finding out their IT suitability index for Mass Customization. Basically, it asks the user to rate each of the parameters according to their knowledge of the current situation of the company. After completing this, the model automatically interpolates the values using the optimized model in order to find the suitability result. Sample screens of page 1, page 2 and results are shown on Figure 3.3, Figure 3.4, and Figure 3.5 respectively.

Figure 3.3: Web Based Application – Screen 1

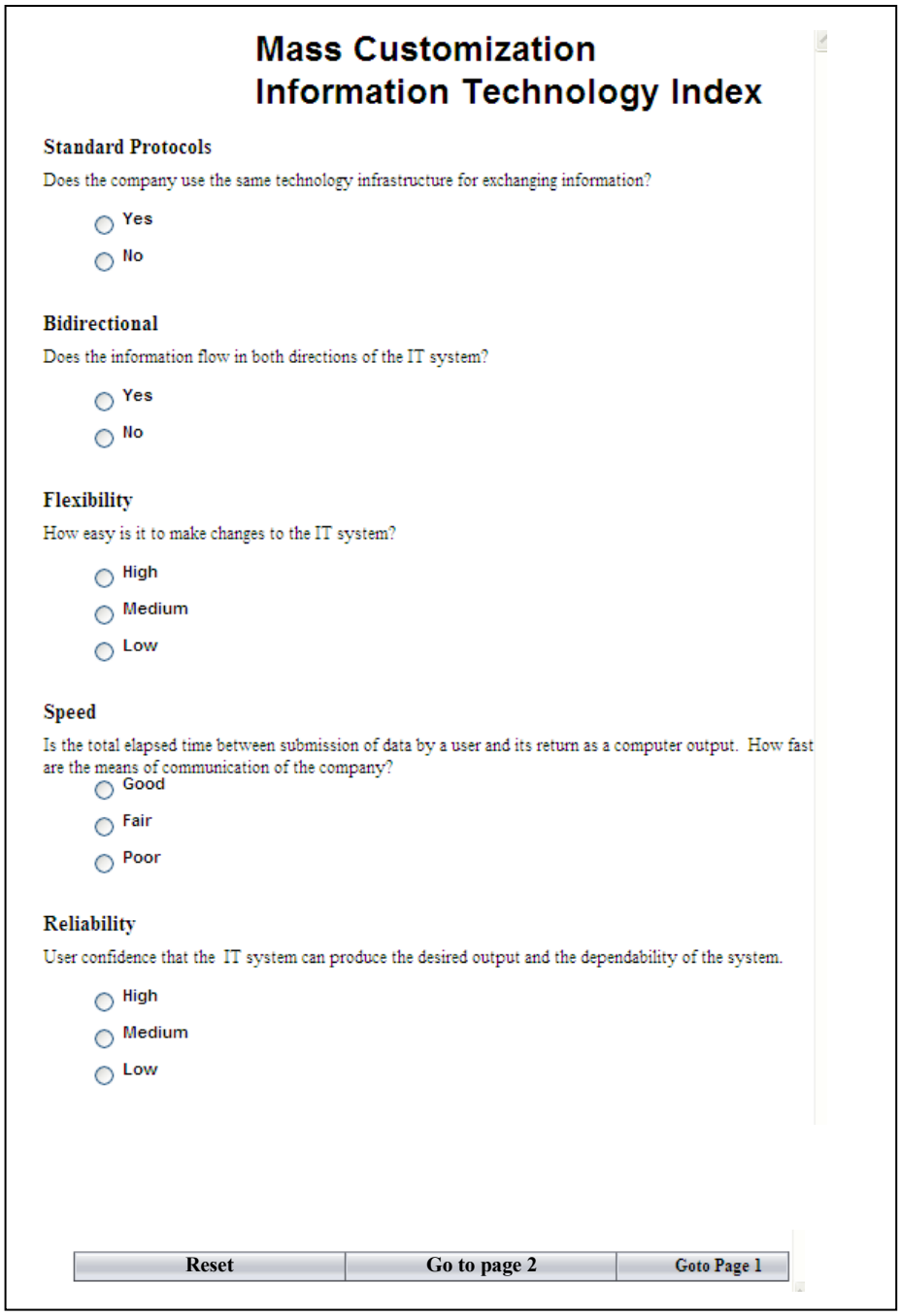


Figure 3.4: Web Based Application – Screen 2

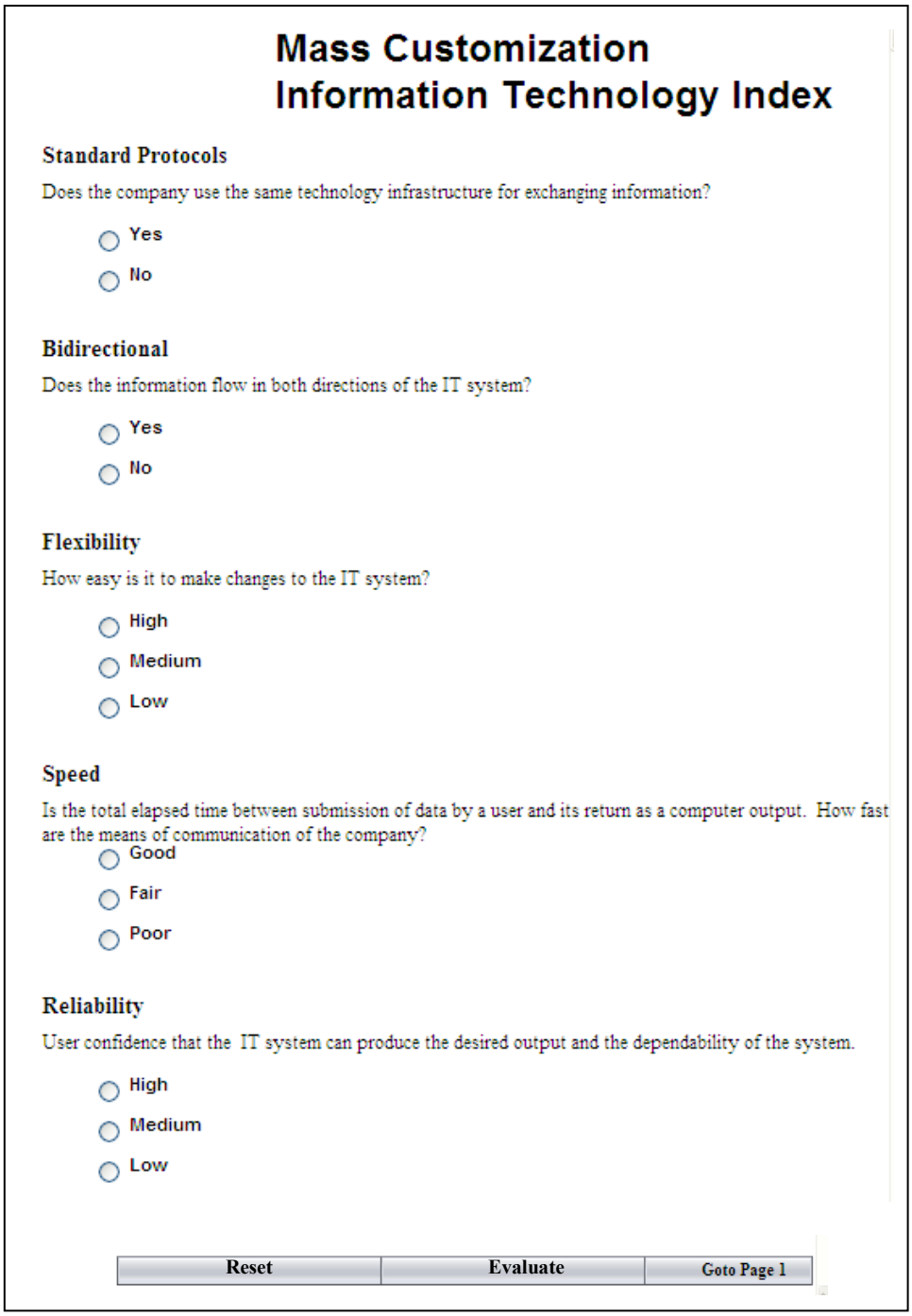
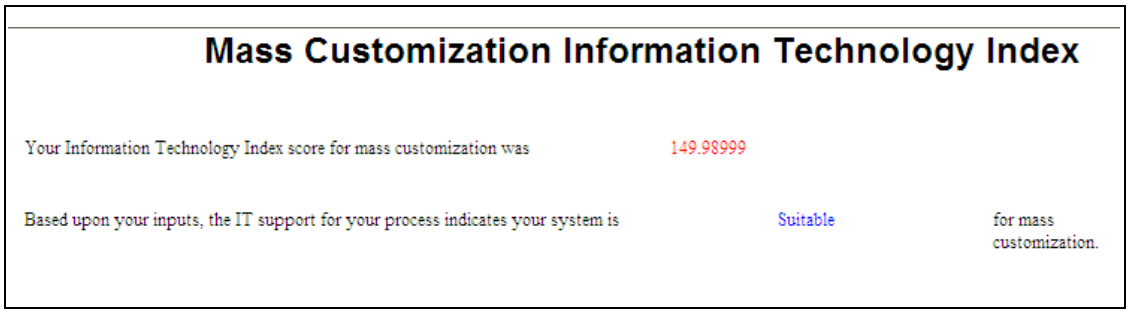


Figure 3.5: Web Based Application – Suitability Index Result



In order to facilitate the use of the model, the web based application has been stored on a local server of the university and it is available to anyone interested. The potential user need to have basic computer requirements including: a computer; an internet connection; and a web browser software. The following is the internet address: http://quality.engr.utpa.edu/MassCustomizationInformationTechnology/

CHAPTER IV

EVALUATION OF RESULTS

In this chapter, the validity of the results is challenged to illustrate the veracity of the suitability index. The first section presents an introduction to the evaluation methodology used on this thesis. The second section shows the estimated values generated using the linear programming model. The next section deals with an analysis of variance of the obtained data in order to prove that the responses came from the same population. The forth section introduces a membership function for fuzzy linguistic descriptors. The fifth section exhibits a percentage of agreement study. And the last section gives a brief summary of the chapter

4.1: Introduction

The results of the relative importance weights obtained from the model were presented on the previous chapter. Moreover, based on this information, the credibility of the data has to be evaluated in order to say that the results are consistent with the theory.

Gonzalez (1995) used a practical standpoint to evaluate the results of his model. This evaluation method is adequate as opposed to the common method of goodness of fit statistics which cannot be used for this particular linear programming model. Another reason for this model evaluation is that it is imperative to prove that the results obtained from the model are similar to those observed in the original data.

The approach taken for the overall evaluation of the results is better explained using the following approach:

1. Calculate a set of different linguistic descriptor ranges for the values obtained from the suitability index model.
2. Determine the estimated value of the IT suitability index for each of the 36 scenarios using the linear programming regression model.
3. Develop a membership function for fuzzy linguistic descriptors to be used with the IT suitability index.
4. Analyze the results of the previously calculated linguistic descriptor ranges by determining the number of scenarios in the data set that were correctly identified by the model as compared to the identification made in the data observation..
5. Determine: the percentage of agreements; a relative frequency distribution of the number of experts that agree with the model description for the set of scenarios; and the average number of linguistic variable levels of difference between the model and the expert ratings over the entire date set and on the scenarios in which the model does not agree with the experts.

4.2: Linguistic Descriptor Range

The use of fuzzy linguistic descriptors provides the advantage of creating ranges of suitability for a given subject. In this case, the objective will be to find several boundaries where the index classification for Information Technology would be feasible. The work performed by Gonzalez (1995) was taken as a guideline in order to conclude that it was possible to divide three main areas for the descriptors in question. And after

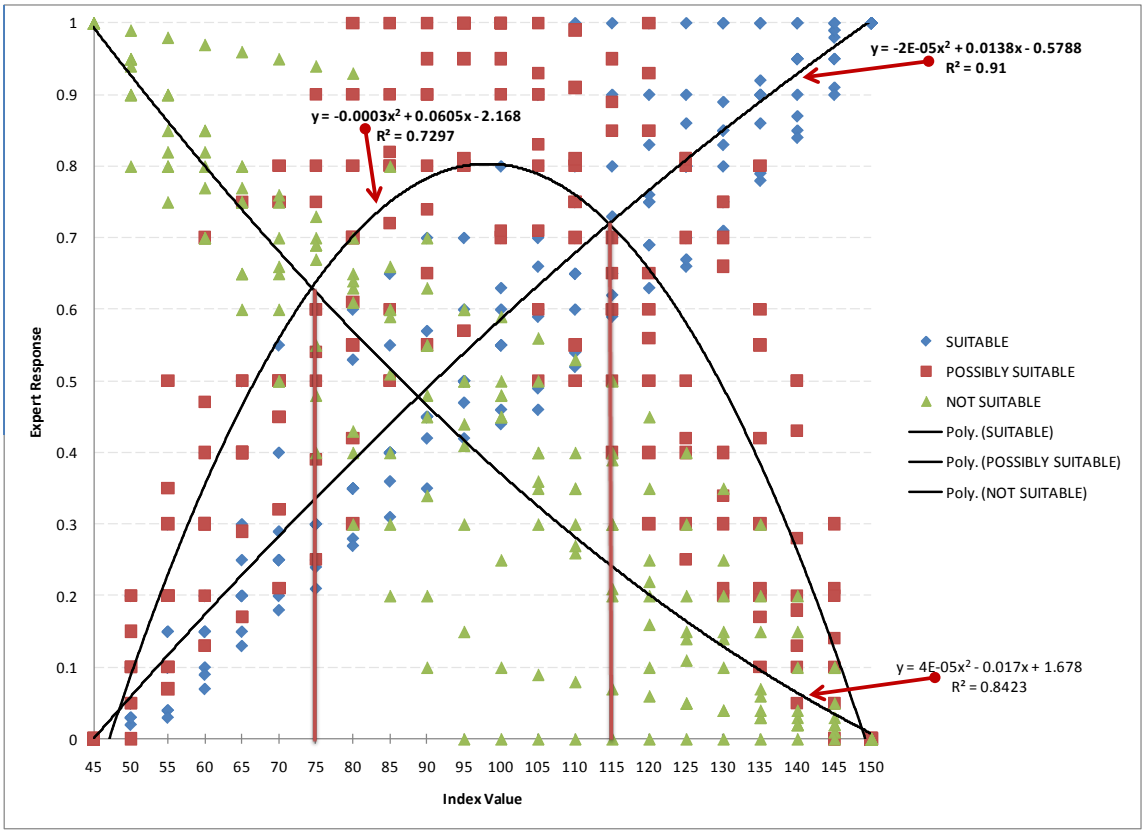
obtaining consensus with a group of experts, three major categories were identified as follows: Suitable; Possibly Suitable; and Not Suitable.

A supplementary interview was conducted to obtain the membership function for these descriptors based on the work by Gonzalez and Chen (1996). Twenty two equally located scenario scores that ranged from the lowest possible index value (45) to the highest possible index value (150) were used; to avoid bias, the interviews were given at random order to 9 experts in Information Technology for Mass Customization (MC). These interviews requested the following information; the truthfulness from 0 to 1 that a person with a certain scenario is suitable for MC; the truthfulness from 0 to 1 that a person with a certain scenario is possible suitable for MC; and the truthfulness from 0 to 1 that a person with a certain scenario is not suitable for MC. The questionnaires are shown in Appendix C.

Furthermore, the results from the Suitability index survey confirm several different patterns that the experts decided to utilize in order to come up with their answers. These patterns can easily be identified after creating one graph per expert, shown on Appendix D, containing the particular three responses from each survey.

Once all data points were consolidated on one single chart, the process to find limits for the previously established linguistic descriptors consists on calculating and superimposing a quadratic regression line that best represents the behavior of each descriptor. And this analysis can be found on the following figure including each correspondent quadratic equation and R-squared values:

Figure 4.1: Suitability Index Analysis



Lastly, the final step to find each boundary consisted on drawing a straight line from the intersection points of two pairs of regression lines as shown on the previous chart. And this will constitute the boundaries of interest gathered on the following table:

Table 4.1: Suitability Index Range Values and Associated Linguistic Variables

Suitability Index Range	**Corresponding Linguistic Descriptor (Nomenclature)**
Greater than 115 and lower than or equal to 150	Suitable = S
Greater than 75 and lower than 115	Possibly Suitable = P
Greater than or equal to 45 and lower than 75	Not Suitable = NS

4.3: Suitability Model Validation

Using the information presented on the previous chapter which included the procedure to calculate estimated values based on the results from the linear programming optimization model, now it is possible to generate a validation table (Table 4.2) for the purpose of creating 10 different plots (presented inside Appendix E). The procedure consisted in that every expert response will be graphed along its correspondent model values in order to visualize any potential issues such as outliers. On top of that, the values of the ranges of the suitability index obtained in Table 4.1 are included in every graph as horizontal lines in order to serve as a visual reference for the model suitability.

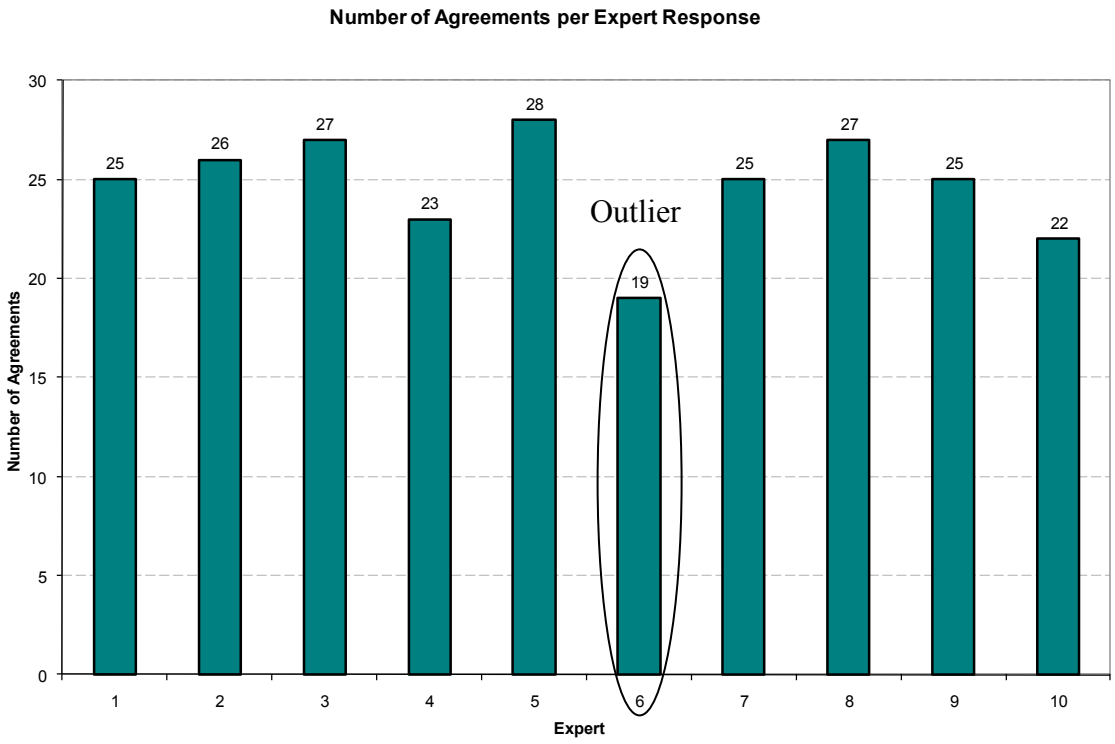
Table 4.2: Model Generated Values and Expert Response Validation

Scenario	Model Generated Index Value	Response from 10 different experts									
		1	2	3	4	5	6	7	8	9	10
1	150.00	140	150	150	145	150	150	150	145	137	150
2	108.37	105	123	110	96	100	96	60	110	100	105
3	80.00	90	73	115	90	80	45	70	85	90	80
4	120.00	120	138	135	120	135	120	80	135	110	130
5	95.00	115	103	85	95	103	81	110	95	100	110
6	123.37	90	105	120	130	125	78	110	115	65	120
7	106.77	110	116	110	80	116	108	95	105	100	105
8	112.41	100	120	113	115	120	60	90	115	80	120
9	119.19	115	110	130	90	85	135	120	125	130	115
10	75.00	65	103	100	70	80	69	65	75	70	85
11	105.00	100	108	104	110	108	123	110	105	95	110
12	93.85	95	93	110	95	100	87	110	100	110	100
13	80.28	75	101	80	70	80	51	75	70	80	75
14	105.08	100	110	104	100	95	144	110	95	50	100
15	88.49	60	93	75	70	100	99	80	70	60	80
16	77.85	50	109	80	65	99	75	90	95	90	70
17	99.00	95	99	75	100	109	126	110	100	99	120
18	97.00	85	96	97	70	96	84	100	100	45	95
19	103.77	110	98	98	107	98	129	100	105	95	100
20	108.00	90	108	105	75	108	114	110	100	105	110
21	86.12	79	98	92	110	70	63	90	90	75	70

22	112.89	120	99	130	125	80	90	60	130	120	130
23	80.00	83	100	80	72	83	72	70	95	45	80
24	105.00	95	105	98	100	105	117	100	105	60	100
25	99.99	70	102	98	93	102	93	100	90	100	120
26	95.00	90	102	103	75	115	54	110	105	95	110
27	102.91	110	100	94	95	100	147	95	120	105	95
28	88.09	50	93	95	85	80	102	90	100	90	70
29	70.28	70	76	83	79	76	48	70	85	95	80
30	75.00	60	93	75	95	70	141	90	75	70	75
31	57.00	60	69	45	55	50	57	50	45	60	45
32	81.37	75	95	60	75	70	138	75	70	65	70
33	95.00	60	98	95	90	98	111	100	95	100	95
34	82.69	65	90	70	65	75	132	65	60	80	50
35	82.91	85	88	50	80	85	105	70	65	90	70
36	67.77	60	84	80	70	65	66	55	75	70	65

After an initial visual analysis of every single plot on Appendix E, expert number 6 was identified as an outlier because it had a significant number of responses that were not in the same region of the graph. And this was further corroborated Figure 4.2 where it is shown that this expert had only 19 agreements out of a total of 36 possible scenarios. Therefore, with only 53% of agreements, it was decided to remove the expert from the model because in order to improve the accuracy of the model.

Figure 4.2: Number of Agreements per Expert Response



Using the responses from the remaining 9 experts, the LINDO™ optimization code was adjusted as shown in Appendix F, and the model was recalculated. As a consequence Table 3.4, Table 3.5, and Table 4.2, were modified as follows:

Table 4.3: Final Relative Importance Weights

IT Suitability Content Variable Relative Importance Weights

Variable Description	Upper Positive Level	Middle Average Level	Lower Negative Level
Standard Protocols	0.00	N/A	-13.88
Bi-directional	13.75	N/A	-8.08
Flexibility	0.71	0.35	-0.88
Speed	3.52	1.12	0.00
Reliability	0.00	-3.83	-15.78
Usability	4.12	0.00	0.00
Accuracy	3.86	0.00	-0.44
Efficiency	12.60	5.25	0.00
Growth Potential	0.00	-6.71	-13.43
Maintenance	11.43	-1.26	-2.52
TOTAL	**50.00**	**-5.08**	**-55.00**

To better understand the meaning of the numeric results obtained on the previous table, a detailed explanation is presented as follows:

11. According to the expert model, the absence of standard protocols has a strong negative effect on the overall index.
12. A bi-directional IT system has a significant positive effect at the upper level and a moderate negative influence when observed at the lower level.
13. The relative importance weight related to the flexibility of the IT system has a slight effect on the overall index when it is observed at the High, Med, and Low levels. For their small magnitude, these effects are considered non-significant.
14. When taking into account the speed factor, either a Good or a Fair value has a low positive effect. A Bad value has absolutely no effect at all.
15. Reliability resulted very significant on the Low setting. Also, there is a slight negative effect at the Middle value, and zero effect when it is High.
16. The usability of the IT infrastructure is considered to have only a medium positive effect when it i at the Good level. And no effect otherwise.
17. Accuracy is considered to have low positive when it is High, and an insignificant negative effect when Low. No effect was found at the Middle value.
18. Efficiency has a strong positive effect when it is Good, a medium positive effect when it is Fair, and no effect when it is Bad.
19. Growth potential includes a significant negative effect on its Bad setting, and a moderate negative effect on its Fair level. And no effect when it is Good.
20. Lastly, maintenance at the Easy level had a strong positive effect on the overall value of the model, and low negative effects on both Fair and Complex levels.

Table 4.4: Final Model Generated Values

	1	2	3	4	5	6	7	8	9	10	Model Generated Values
1	0.00	13.75	0.71	3.52	0.00	4.12	3.86	12.60	0.00	11.43	150.00
2	0.00	13.75	0.35	1.12	-3.83	0.00	0.00	5.25	-6.71	-1.26	108.67
3	0.00	13.75	-0.88	0.00	-15.78	0.00	-0.44	0.00	-13.43	-2.52	80.71
4	0.00	13.75	0.71	3.52	0.00	4.12	0.00	5.25	-6.71	-1.26	119.37
5	0.00	13.75	0.35	1.12	-3.83	0.00	-0.44	0.00	-13.43	-2.52	95.00
6	0.00	13.75	-0.88	0.00	-15.78	0.00	3.86	12.60	0.00	11.43	125.00
7	0.00	13.75	0.71	3.52	-3.83	0.00	3.86	5.25	-13.43	-2.52	107.31
8	0.00	13.75	0.35	1.12	-15.78	4.12	0.00	0.00	0.00	11.43	115.00
9	0.00	13.75	-0.88	0.00	0.00	0.00	-0.44	12.60	-6.71	-1.26	117.06
10	0.00	-8.08	0.71	3.52	-15.78	0.00	3.86	0.00	-6.71	-2.52	75.00
11	0.00	-8.08	0.35	1.12	0.00	0.00	0.00	12.60	-13.43	11.43	104.00
12	0.00	-8.08	-0.88	0.00	-3.83	4.12	-0.44	5.25	0.00	-1.26	94.88
13	0.00	-8.08	0.71	1.12	-15.78	4.12	-0.44	5.25	0.00	-2.52	84.38
14	0.00	-8.08	0.35	0.00	0.00	0.00	3.86	0.00	-6.71	11.43	100.85
15	0.00	-8.08	-0.88	3.52	-3.83	0.00	0.00	12.60	-13.43	-1.26	88.65
16	0.00	-8.08	0.71	1.12	-15.78	0.00	3.86	12.60	-13.43	-1.26	79.75
17	0.00	-8.08	0.35	0.00	0.00	0.00	0.00	5.25	0.00	-2.52	95.00
18	0.00	-8.08	-0.88	3.52	-3.83	4.12	-0.44	0.00	-6.71	11.43	99.13
19	-13.88	13.75	0.71	1.12	0.00	0.00	-0.44	0.00	0.00	-1.26	100.00
20	-13.88	13.75	0.35	0.00	-3.83	4.12	3.86	12.60	-6.71	-2.52	107.75
21	-13.88	13.75	-0.88	3.52	-15.78	0.00	0.00	5.25	-13.43	11.43	90.00
22	-13.88	13.75	0.71	1.12	-3.83	0.00	-0.44	12.60	-6.71	11.43	114.75
23	-13.88	13.75	0.35	0.00	-15.78	4.12	3.86	5.25	-13.43	-1.26	83.00
24	-13.88	13.75	-0.88	3.52	0.00	0.00	0.00	0.00	0.00	-2.52	100.00
25	-13.88	13.75	0.71	0.00	-3.83	4.12	0.00	0.00	-13.43	11.43	98.88
26	-13.88	13.75	0.35	3.52	-15.78	0.00	-0.44	12.60	0.00	-1.26	98.88
27	-13.88	13.75	-0.88	1.12	0.00	0.00	3.86	5.25	-6.71	-2.52	100.00
28	-13.88	-8.08	0.71	0.00	-3.83	0.00	0.00	12.60	0.00	-2.52	85.00
29	-13.88	-8.08	0.35	3.52	-15.78	0.00	-0.44	5.25	-6.71	11.43	75.67
30	-13.88	-8.08	-0.88	1.12	0.00	4.12	3.86	0.00	-13.43	-1.26	71.58
31	-13.88	-8.08	0.71	0.00	-15.78	0.00	0.00	0.00	-6.71	-1.26	55.00
32	-13.88	-8.08	0.35	3.52	0.00	4.12	-0.44	12.60	-13.43	-2.52	82.25
33	-13.88	-8.08	-0.88	1.12	-3.83	0.00	3.86	5.25	0.00	11.43	95.00
34	-13.88	-8.08	0.71	0.00	0.00	0.00	-0.44	5.25	-13.43	11.43	81.56
35	-13.88	-8.08	0.35	3.52	-3.83	0.00	3.86	0.00	0.00	-1.26	80.69
36	-13.88	-8.08	-0.88	1.12	-15.78	4.12	0.00	12.60	-6.71	-2.52	70.00

Table 4.5: Final Model Generated Values and Expert Response Comparison

Scenario	Model Generated Index Value	Response from 9 different experts									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	150.00	140	150	150	145	150	-	150	145	137	150
2	108.67	105	123	110	96	100	-	60	110	100	105
3	80.71	90	73	115	90	80	-	70	85	90	80
4	119.37	120	138	135	120	135	-	80	135	110	130

5	95.00	115	103	85	95	103	-	110	95	100	110
6	125.00	90	105	120	130	125	-	110	115	65	120
7	107.31	110	116	110	80	116	-	95	105	100	105
8	115.00	100	120	113	115	120	-	90	115	80	120
9	117.06	115	110	130	90	85	-	120	125	130	115
10	75.00	65	103	100	70	80	-	65	75	70	85
11	104.00	100	108	104	110	108	-	110	105	95	110
12	94.88	95	93	110	95	100	-	110	100	110	100
13	84.38	75	101	80	70	80	-	75	70	80	75
14	100.85	100	110	104	100	95	-	110	95	50	100
15	88.65	60	93	75	70	100	-	80	70	60	80
16	79.75	50	109	80	65	99	-	90	95	90	70
17	95.00	95	99	75	100	109	-	110	100	99	120
18	99.13	85	96	97	70	96	-	100	100	45	95
19	100.00	110	98	98	107	98	-	100	105	95	100
20	107.75	90	108	105	75	108	-	110	100	105	110
21	90.00	79	98	92	110	70	-	90	90	75	70
22	114.75	120	99	130	125	80	-	60	130	120	130
23	83.00	83	100	80	72	83	-	70	95	45	80
24	100.00	95	105	98	100	105	-	100	105	60	100
25	98.88	70	102	98	93	102	-	100	90	100	120
26	98.88	90	102	103	75	115	-	110	105	95	110
27	100.00	110	100	94	95	100	-	95	120	105	95
28	85.00	50	93	95	85	80	-	90	100	90	70
29	75.67	70	76	83	79	76	-	70	85	95	80
30	75.00	60	93	75	95	70	-	90	75	70	75
31	57.00	60	69	45	55	50	-	50	45	60	45
32	81.37	75	95	60	75	70	-	75	70	65	70
33	95.00	60	98	95	90	98	-	100	95	100	95
34	82.69	65	90	70	65	75	-	65	60	80	50
35	82.91	85	88	50	80	85	-	70	65	90	70
36	67.77	60	84	80	70	65	-	55	75	70	65

From the previous tables it can be concluded that the model is significantly sensitive to changes on the information provided by the experts. However, this could prove to benefit the model especially on the values close to the descriptor boundaries.

4.4: Membership Function for Fuzzy Linguistic Descriptors

After making sure that the model significantly represents the opinion of all experts, the next step would be to obtain a membership function for a linguistic descriptor of the reliability for each scenario based on the information presented in section 4.1. Based in the work of De la Torre (2006) it was decided that there would be three such descriptors that an IT infrastructure could belong to depending on their index value. Each scenario score belongs to a certain fuzzy linguistic descriptor set according to Table 4.1. And as a reference the three descriptors are:

1. The IT is suitable for Mass Customization;
2. The IT is possible suitable for Mass Customization;
3. The IT is not suitable for Mass Customization.

Taking these three main descriptors and their corresponding numeric range presented in Table 4.1, it is now possible to translate the results from the model and the experts into coded information that will be of great importance to further validate the outcome of this thesis. This coded data is presented in the following table:

Table 4.6: Linguistic descriptors for the expert generated data and model computed IT suitability index values.

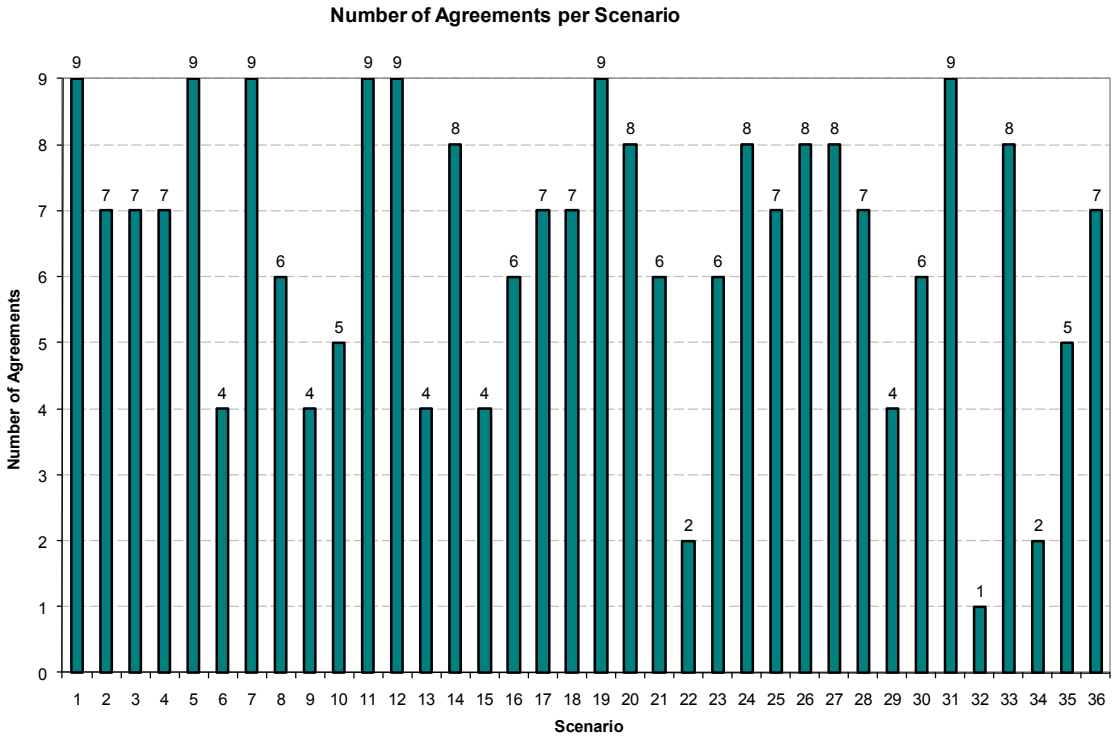
Scenario	Model Value	Response from Expert									
		1	2	3	4	5	6	7	8	9	10
1	S	S	S	S	S	S	-	S	S	S	S
2	P	P	S	P	P	P	-	NS	P	P	P
3	P	P	NS	P	P	P	-	NS	P	P	P
4	S	S	S	S	S	S	-	P	S	P	S
5	P	P	P	P	P	P	-	P	P	P	P
6	S	P	P	S	S	S	-	P	P	NS	S
7	P	P	P	P	P	P	-	P	P	P	P
8	P	P	S	P	P	S	-	P	P	P	S
9	S	P	P	S	P	P	-	S	S	S	P

10	NS	NS	P	P	NS	P	-	NS	NS	NS	P
11	P	P	P	P	P	P	-	P	P	P	P
12	P	P	P	P	P	P	-	P	P	P	P
13	P	NS	P	P	NS	P	-	NS	NS	P	NS
14	P	P	P	P	P	P	-	P	P	NS	P
15	P	NS	P	NS	NS	P	-	P	NS	NS	P
16	P	NS	P	P	NS	P	-	P	P	P	NS
17	P	P	P	NS	P	P	-	P	P	P	S
18	P	P	P	P	NS	P	-	P	P	NS	P
19	P	P	P	P	P	P	-	P	P	P	P
20	P	P	P	P	NS	P	-	P	P	P	P
21	P	P	P	P	P	NS	-	P	P	NS	NS
22	P	S	P	S	S	P	-	NS	S	S	S
23	P	P	P	P	NS	P	-	NS	P	NS	P
24	P	P	P	P	P	P	-	P	P	NS	P
25	P	NS	P	P	P	P	-	P	P	P	S
26	P	P	P	P	NS	P	-	P	P	P	P
27	P	P	P	P	P	P	-	P	S	P	P
28	P	NS	P	P	P	P	-	P	P	P	NS
29	NS	NS	NS	P	P	NS	-	NS	P	P	P
30	NS	NS	P	NS	P	NS	-	P	NS	NS	NS
31	NS	NS	NS	NS	NS	NS	-	NS	NS	NS	NS
32	P	NS	P	NS	NS	NS	-	NS	NS	NS	NS
33	P	NS	P	P	P	P	-	P	P	P	P
34	P	NS	P	NS	NS	NS	-	NS	NS	P	NS
35	P	P	P	NS	P	P	-	NS	NS	P	NS
36	NS	NS	P	P	NS	NS	-	NS	NS	NS	NS

4.5: Percentage of Agreements

From the conclusion of the previous section and after a simple statistical analysis, Figure 4.3 was developed in order to show a visual representation of the number of agreements between each of the experts and the model generated values. Which in turn represent a 71.6 % of agreements meaning that the predictor model is significantly representative for the data in question. It can also be observed that nearly 20% of the scenarios reached the maximum of nine agreements.

Figure 4.3: Percentage of Agreements



Furthermore, as shown in Figure 4.4, scenarios 22 and 32 deserve special attention for having the lowest level of agreements. With the reasoning behind the first one would be having a model value (114.75) too close to the boundary of 115, and the majority of the experts giving it a higher value. And the second one in question was the opposite with the model being higher than most of the experts.

Figure 4.4: Plot of Suitability Index Values

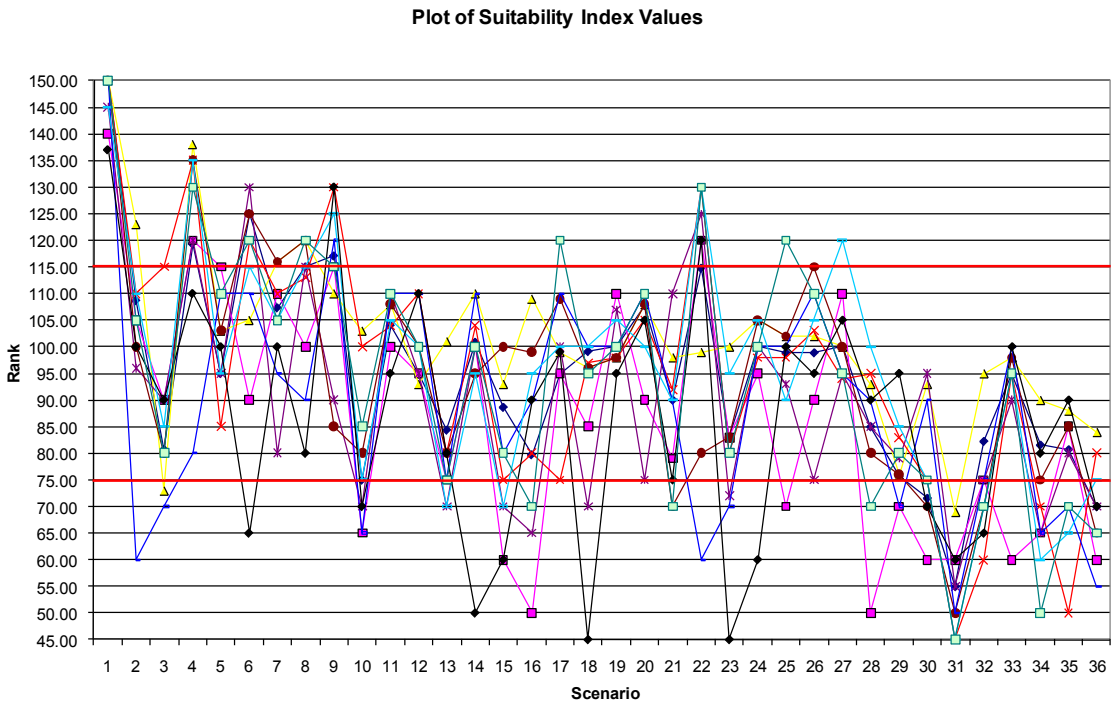
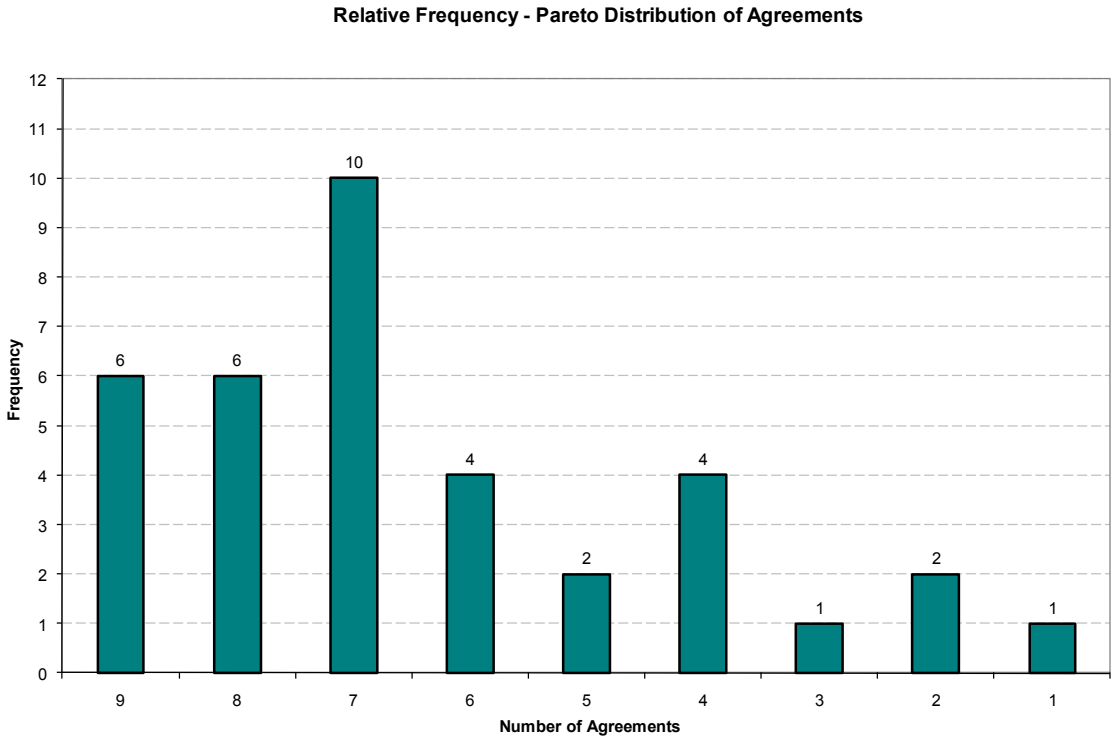


Figure 4.5: Relative Frequency Distribution of Agreements



Finally, another way to support the results of the model is to construct a Pareto analysis using the relative frequency of agreements as shown in Figure 4.5. This chart visually presents a higher correlation on the left side suggesting again an above average probability of the model being representative of the information collected from the experts.

CHAPTER V

CONCLUSIONS

One of the most important concerns in today's manufacturing world is to be able to provide exactly what the customer requires at the right time and cost, but still remain competitive in the marketplace by improving profits and market share. That is why the theories of Mass Customization have been lately a major area of interest around the glove. However, the problem is such that little research has been found to focus on the adequate guidelines to successfully implement those theories in a new or an existing manufacturing facility.

One of most critical aspects of Mass Customization is the use of IT to connect the production line with orders, design, and purchasing and to manipulate production machines. If successful, the consequence of this is a flexible and efficient manufacturing facility that is able to produce different single units of goods according to each one of the customer requirements without compromising quality, cost or time.

The model presented in this thesis can be a valuable tool at the first stages of trying to assess the position of an existing Information Technology infrastructure when the company is thinking about approaching Mass Customization. And without such a tool, many economic implications could arise if certain aspects of the IT system are not up to the requirements of a super flexible environment to produce large volumes of completely unique items.

It is also necessary to state that not all products will benefit from the pure concept of Mass Customization, and therefore other options should be taken into consideration. Customers are often more interested in getting the right product for their needs, as opposed to a unique product that does not perform as expected, or requires too much involvement from their side. Therefore, special importance should be pointed to modular or pre-configured products that are able to be slightly tailored for a great variety of customers.

And to conclude, with Mass Customization being a relatively recent way of gaining competitive advantage, the challenge for today's experimentation in this topic increases dramatically. However, as more experts would become available in different parts of the world, and as universities invest great amounts of time and effort on this advanced manufacturing processes, then a more robust and reliable expert model would be feasible to construct.

The business structure will change because of the increased competition. All parts for the fabrication must be efficient to ensure the overall competitiveness of the product. As a result of this, manufactures will focus, at the same on the time customers demand for more and more complex products, which increases competencies demands on manufactures, and as a result of this companies will change, new skills must be build. Managing customization and supplier network can become the core competence of companies.

Finally, any conclusion that someone could find about the diverse approaches of IT and Mass Customization has yet to be validated with the appropriate experimentation process that is required for any specific product. Most of the time it is difficult to come

up with a universal solution to any given problem, but eventually our society will get there sooner than what we think.

5.1: Summary of Achievements

A reliable expert predictor model for identifying different levels of suitability for information technology was constructed with success. Using the latest software was of a great advantage in order to speed up the process of computing all linear programming models. Furthermore, the web based application presents a fast and simple way to use the results of this thesis on real life situations.

5.2: Contributions

Information Technology is rarely taken in consideration as one of the main factor for a manufacturing organization to become agile and flexible to capture specifications from customers and translate them to an individual product. Therefore, the results of this thesis could be used to keep polishing the details of getting to a true mass customization approach. The most recent publication regarding this topic was presented at the 2006 IIE Annual Conference & Exposition (Gonzalez, Barrenechea, Timmer, and Li, 2006).

5.3: Limitations

Given the difficulty of finding mass customization experts, only a limited number of responses were obtained. Also, the level of expertise that every one of them has could play a major role on the results of this manuscript.

5.4: Future Research

As Mass Customization (MC) evolves from being a highly desirable option to being a must have option, and the results from this thesis could be extended to other important elements in the supply chain of goods. Areas like manufacturing processes or

even the service industry would be highly benefited from the suitability index studied on this research. Also, as more manufacturing companies adopt mass customization methodologies, it would be necessary to apply the model on real life situations in order to further validate the results presented in this thesis.

One area that can be further explored is the possibility of utilizing a different approach to the optimization model in order to find out if there is any significant change on the results. The least squares method is one of the alternatives that may prove to either reduce or increase the sensitivity of the model.

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APPENDIX A

APPENDIX A

SURVEY: INFORMATION TECHNOLOGY

SUITABILITY INDEX FOR MASS CUSTOMIZATION

The Manufacturing Engineering Department of the University of Texas Pan American is conducting a survey in order to better understand the actual requirements for an Information Technology (IT) infrastructure to be able to support Mass Customization (MC).

First of all, MC refers to the production system where the main focus is to provide the required goods so the specific need of every possible individual is satisfied at a price low enough to remain competitive. However, the resulting increment on the exchange of information throughout the whole supply chain has become a major obstacle to implement MC due to the fact that some manufacturing companies still don't possess the required IT infrastructure.

Therefore, the information obtained from this survey will be used to develop a model that will provide an IT suitability index for MC that could be used to allow any manufacturing company to identify and overcome their critical IT issues.

Instructions

The suitability of an existing IT infrastructure for Mass Customization can be defined using a precise number of parameters. However, for the purpose of this study, the parameters used to describe the suitability of IT and their correspondent descriptors are explained as shown on the following table:

	Parameters	Descriptors
1	Standard Protocols: • Does the company use the same technology infrastructure for exchanging information?	Yes No
2	Bidirectional: • Does the information flow on both directions (back and forward) of the IT system?	Yes No
3	Flexibility: • How easy is to make changes to the IT system.	High Med Low
4	Speed: • Is the total elapsed time between submission of data by a user and its return as a computer output. How fast are the means of communication of the company?	Good Fair Bad
5	Reliability: • It refers to the confidence that the IT system can produce the desired output cycle after cycle. How dependable is the IT of the company in terms of times that communication was interrupted due to weak points in the system, or in equipment?	High Med Low
6	Usability: • Is the worth of a system as evaluated by the people who must use it. It is a measure of the user friendliness of the system, and it is the final measure of its acceptance.	Good Fair Bad
7	Accuracy: • Relates to the steps involved in getting source data into the system and the steps that are taken to keep the data as error free as possible. How good is the IT infrastructure in terms of times that there was a mistake on the information?	High Med Low
8	Efficiency: • How much money does it cost to keep the IT system running on a normal basis?	Good Fair Bad
9	Growth Potential: • Is a measure of how much the system can continue to grow without extensive modification to the IT system.	Good Fair Bad
10	Maintenance: • How complex or difficult is to take care of the IT system?	Easy Fair Complex

Based on the information presented on the previous table, rank each of the 36 scenarios based on your knowledge of the role of Information Technology on the Mass Customization context. Please, use an index number ranging from 45 to 150; with 45 being the lowest and 150 being the highest.

Information Technology Suitability Parameters for Mass Customization Based on the information of each scenario											
Scenario	**Std. Protocols**	**Bi-directional**	**Flexibility**	**Speed**	**Reliability**	**Usability**	**Accuracy**	**Efficiency**	**Growth Potential**	**Maintenance**	**Rank**
1	Yes	Yes	High	Good	High	Good	High	Good	Good	Easy	
2	Yes	Yes	Med	Fair	Med	Fair	Med	Fair	Fair	Fair	
3	Yes	Yes	Low	Bad	Low	Bad	Low	Bad	Bad	Complex	
4	Yes	Yes	High	Good	High	Good	Med	Fair	Fair	Fair	
5	Yes	Yes	Med	Fair	Med	Fair	Low	Bad	Bad	Complex	
6	Yes	Yes	Low	Bad	Low	Bad	High	Good	Good	Easy	
7	Yes	Yes	High	Good	Med	Bad	High	Fair	Bad	Complex	
8	Yes	Yes	Med	Fair	Low	Good	Med	Bad	Good	Easy	
9	Yes	Yes	Low	Bad	High	Fair	Low	Good	Fair	Fair	
10	Yes	No	High	Good	Low	Fair	High	Bad	Fair	Complex	
11	Yes	No	Med	Fair	High	Bad	Med	Good	Bad	Easy	
12	Yes	No	Low	Bad	Med	Good	Low	Fair	Good	Fair	
13	Yes	No	High	Fair	Low	Good	Low	Fair	Good	Complex	
14	Yes	No	Med	Bad	High	Fair	High	Bad	Fair	Easy	
15	Yes	No	Low	Good	Med	Bad	Med	Good	Bad	Fair	
16	Yes	No	High	Fair	Low	Fair	High	Good	Bad	Fair	
17	Yes	No	Med	Bad	High	Bad	Med	Fair	Good	Complex	
18	Yes	No	Low	Good	Med	Good	Low	Bad	Fair	Easy	
19	No	Yes	High	Fair	High	Bad	Low	Bad	Good	Fair	
20	No	Yes	Med	Bad	Med	Good	High	Good	Fair	Complex	
21	No	Yes	Low	Good	Low	Fair	Med	Fair	Bad	Easy	
22	No	Yes	High	Fair	Med	Bad	Low	Good	Fair	Easy	
23	No	Yes	Med	Bad	Low	Good	High	Fair	Bad	Fair	
24	No	Yes	Low	Good	High	Fair	Med	Bad	Good	Complex	
25	No	Yes	High	Bad	Med	Good	Med	Bad	Bad	Easy	
26	No	Yes	Med	Good	Low	Fair	Low	Good	Good	Fair	
27	No	Yes	Low	Fair	High	Bad	High	Fair	Fair	Complex	
28	No	No	High	Bad	Med	Fair	Med	Good	Good	Complex	
29	No	No	Med	Good	Low	Bad	Low	Fair	Fair	Easy	
30	No	No	Low	Fair	High	Good	High	Bad	Bad	Fair	
31	No	No	High	Bad	Low	Bad	Med	Bad	Fair	Fair	
32	No	No	Med	Good	High	Good	Low	Good	Bad	Complex	
33	No	No	Low	Fair	Med	Fair	High	Fair	Good	Easy	
34	No	No	High	Bad	High	Fair	Low	Fair	Bad	Easy	
35	No	No	Med	Good	Med	Bad	High	Bad	Good	Fair	
36	No	No	Low	Fair	Low	Good	Med	Good	Fair	Complex	

APPENDIX B

APPENDIX B

INITIAL LINDO GOAL PROGRAMMING FORMULATION

Minimize:

n1 + p1 + n2 + p2 + n3 + p3 + n4 + p4 + n5 + p5 + n6 + p6 + n7 + p7 + n8 + p8 + n9 + p9 + n10 + p10 + n11 + p11 + n12 + p12 + n13 + p13 + n14 + p14 + n15 + p15 + n16 + p16 + n17 + p17 + n18 + p18 + n19 + p19 + n20 + p20 + n21 + p21 + n22 + p22 + n23 + p23 + n24 + p24 + n25 + p25 + n26 + p26 + n27 + p27 + n28 + p28 + n29 + p29 + n30 + p30 + n31 + p31 + n32 + p32 + n33 + p33 + n34 + p34 + n35 + p35 + n36 + p36 + n37 + p37 + n38 + p38 + n39 + p39 + n40 + p40 + n41 + p41 + n42 + p42 + n43 + p43 + n44 + p44 + n45 + p45 + n46 + p46 + n47 + p47 + n48 + p48 + n49 + p49 + n50 + p50 + n51 + p51 + n52 + p52 + n53 + p53 + n54 + p54 + n55 + p55 + n56 + p56 + n57 + p57 + n58 + p58 + n59 + p59 + n60 + p60 + n61 + p61 + n62 + p62 + n63 + p63 + n64 + p64 + n65 + p65 + n66 + p66 + n67 + p67 + n68 + p68 + n69 + p69 + n70 + p70 + n71 + p71 + n72 + p72 + n73 + p73 + n74 + p74 + n75 + p75 + n76 + p76 + n77 + p77 + n78 + p78 + n79 + p79 + n80 + p80 + n81 + p81 + n82 + p82 + n83 + p83 + n84 + p84 + n85 + p85 + n86 + p86 + n87 + p87 + n88 + p88 + n89 + p89 + n90 + p90 + n91 + p91 + n92 + p92 + n93 + p93 + n94 + p94 + n95 + p95 + n96 + p96 + n97 + p97 + n98 + p98 + n99 + p99 + n100 + p100 + n101 + p101 + n102 + p102 + n103 + p103 + n104 + p104 + n105 + p105 + n106 + p106 + n107 + p107 + n108 + p108 + n109 + p109 + n110 + p110 + n111 + p111 + n112 + p112 + n113 + p113 + n114 + p114 + n115 + p115 + n116 + p116 + n117 + p117 + n118 + p118 + n119 + p119 + n120 + p120 + n121 + p121 + n122 + p122 + n123 + p123 + n124 + p124 + n125 + p125 + n126 + p126 + n127 + p127 + n128 + p128 + n129 + p129 + n130 + p130 + n131 + p131 + n132 + p132 + n133 + p133 + n134 + p134 + n135 + p135 + n136 + p136 + n137 + p137 + n138 + p138 + n139 + p139 + n140 + p140 + n141 + p141 + n142 + p142 + n143 + p143 + n144 + p144 + n145 + p145 + n146 + p146 + n147 + p147 + n148 + p148 + n149 + p149 + n150 + p150 + n151 + p151 + n152 + p152 + n153 + p153 + n154 + p154 + n155 + p155 + n156 + p156 + n157 + p157 + n158 + p158 + n159 + p159 + n160 + p160 + n161 + p161 + n162 + p162 + n163 + p163 + n164 + p164 + n165 + p165 + n166 + p166 + n167 + p167 + n168 + p168 + n169 + p169 + n170 + p170 + n171 + p171 + n172 + p172 + n173 + p173 + n174 + p174 + n175 + p175 + n176 + p176 + n177 + p177 + n178 + p178 + n179 + p179 + n180 + p180 + n181 + p181 + n182 + p182 + n183 + p183 + n184 + p184 + n185 + p185 + n186 + p186 + n187 + p187 + n188 + p188 + n189 + p189 + n190 + p190 + n191 + p191 + n192 + p192 + n193 + p193 + n194 + p194 + n195 + p195 + n196 + p196 + n197 + p197 + n198 + p198 + n199 + p199 + n200 + p200 + n201 + p201 + n202 + p202 + n203 + p203 + n204 + p204 + n205 + p205 + n206 + p206 + n207 + p207 + n208 + p208 + n209 + p209 + n210 + p210 + n211 + p211 + n212 + p212 + n213 + p213 + n214 + p214 + n215

+ p215 + n216 + p216 + n217 + p217 + n218 + p218 + n219 + p219 + n220 + p220 + n221 + p221 + n222 + p222 + n223 + p223 + n224 + p224 + n225 + p225 + n226 + p226 + n227 + p227 + n228 + p228 + n229 + p229 + n230 + p230 + n231 + p231 + n232 + p232 + n233 + p233 + n234 + p234 + n235 + p235 + n236 + p236 + n237 + p237 + n238 + p238 + n239 + p239 + n240 + p240 + n241 + p241 + n242 + p242 + n243 + p243 + n244 + p244 + n245 + p245 + n246 + p246 + n247 + p247 + n248 + p248 + n249 + p249 + n250 + p250 + n251 + p251 + n252 + p252 + n253 + p253 + n254 + p254 + n255 + p255 + n256 + p256 + n257 + p257 + n258 + p258 + n259 + p259 + n260 + p260 + n261 + p261 + n262 + p262 + n263 + p263 + n264 + p264 + n265 + p265 + n266 + p266 + n267 + p267 + n268 + p268 + n269 + p269 + n270 + p270 + n271 + p271 + n272 + p272 + n273 + p273 + n274 + p274 + n275 + p275 + n276 + p276 + n277 + p277 + n278 + p278 + n279 + p279 + n280 + p280 + n281 + p281 + n282 + p282 + n283 + p283 + n284 + p284 + n285 + p285 + n286 + p286 + n287 + p287 + n288 + p288 + n289 + p289 + n290 + p290 + n291 + p291 + n292 + p292 + n293 + p293 + n294 + p294 + n295 + p295 + n296 + p296 + n297 + p297 + n298 + p298 + n299 + p299 + n300 + p300 + n301 + p301 + n302 + p302 + n303 + p303 + n304 + p304 + n305 + p305 + n306 + p306 + n307 + p307 + n308 + p308 + n309 + p309 + n310 + p310 + n311 + p311 + n312 + p312 + n313 + p313 + n314 + p314 + n315 + p315 + n316 + p316 + n317 + p317 + n318 + p318 + n319 + p319 + n320 + p320 + n321 + p321 + n322 + p322 + n323 + p323 + n324 + p324 + n325 + p325 + n326 + p326 + n327 + p327 + n328 + p328 + n329 + p329 + n330 + p330 + n331 + p331 + n332 + p332 + n333 + p333 + n334 + p334 + n335 + p335 + n336 + p336 + n337 + p337 + n338 + p338 + n339 + p339 + n340 + p340 + n341 + p341 + n342 + p342 + n343 + p343 + n344 + p344 + n345 + p345 + n346 + p346 + n347 + p347 + n348 + p348 + n349 + p349 + n350 + p350 + n351 + p351 + n352 + p352 + n353 + p353 + n354 + p354 + n355 + p355 + n356 + p356 + n357 + p357 + n358 + p358 + n359 + p359 + n360 + p360

Subject to the following model constraints:

stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n1 + p1 + lbound = 140

stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n2 + p2 + lbound = 105

stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n3 + p3 + lbound = 90

stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n4 + p4 + lbound = 120

stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n5 + p5 + lbound = 115

stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n6 + p6 + lbound = 90

stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n7 + p7 + lbound = 110

stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n8 + p8 + lbound = 100

stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n9 + p9 + lbound = 115
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n10 + p10 + lbound = 65
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n11 + p11 + lbound = 100
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n12 + p12 + lbound = 95
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n13 + p13 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n14 + p14 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n15 + p15 + lbound = 60
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n16 + p16 + lbound = 50
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n17 + p17 + lbound = 95
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n18 + p18 + lbound = 85
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n19 + p19 + lbound = 110
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n20 + p20 + lbound = 90
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n21 + p21 + lbound = 79
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n22 + p22 + lbound = 120
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n23 + p23 + lbound = 83
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n24 + p24 + lbound = 95
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n25 + p25 + lbound = 70
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n26 + p26 + lbound = 90
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n27 + p27 + lbound = 110
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n28 + p28 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n29 + p29 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n30 + p30 + lbound = 60
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n31 + p31 + lbound = 60

- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n32 + p32 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n33 + p33 + lbound = 60
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n34 + p34 + lbound = 65
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n35 + p35 + lbound = 85
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n36 + p36 + lbound = 60
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n37 + p37 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n38 + p38 + lbound = 123
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n39 + p39 + lbound = 73
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n40 + p40 + lbound = 138
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n41 + p41 + lbound = 103
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n42 + p42 + lbound = 105
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n43 + p43 + lbound = 116
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n44 + p44 + lbound = 120
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n45 + p45 + lbound = 110
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n46 + p46 + lbound = 103
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n47 + p47 + lbound = 108
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n48 + p48 + lbound = 93
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n49 + p49 + lbound = 101
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n50 + p50 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n51 + p51 + lbound = 93
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n52 + p52 + lbound = 109
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n53 + p53 + lbound = 99

stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n54 + p54 + lbound = 96
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n55 + p55 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n56 + p56 + lbound = 108
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n57 + p57 + lbound = 98
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n58 + p58 + lbound = 99
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n59 + p59 + lbound = 100
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n60 + p60 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n61 + p61 + lbound = 102
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n62 + p62 + lbound = 102
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n63 + p63 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n64 + p64 + lbound = 93
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n65 + p65 + lbound = 76
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n66 + p66 + lbound = 93
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n67 + p67 + lbound = 69
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n68 + p68 + lbound = 95
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n69 + p69 + lbound = 98
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n70 + p70 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n71 + p71 + lbound = 88
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n72 + p72 + lbound = 84
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n73 + p73 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n74 + p74 + lbound = 110
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n75 + p75 + lbound = 115

stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n76 + p76 + lbound = 135
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n77 + p77 + lbound = 85
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n78 + p78 + lbound = 120
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n79 + p79 + lbound = 110
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n80 + p80 + lbound = 113
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n81 + p81 + lbound = 130
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n82 + p82 + lbound = 100
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n83 + p83 + lbound = 104
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n84 + p84 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n85 + p85 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n86 + p86 + lbound = 104
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n87 + p87 + lbound = 75
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n88 + p88 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n89 + p89 + lbound = 75
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n90 + p90 + lbound = 97
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n91 + p91 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n92 + p92 + lbound = 105
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n93 + p93 + lbound = 92
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n94 + p94 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n95 + p95 + lbound = 80
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n96 + p96 + lbound = 98
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n97 + p97 + lbound = 98
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n98 + p98 + lbound = 103

- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n99 + p99 + lbound = 94
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n100 + p100 + lbound = 95
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n101 + p101 + lbound = 83
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n102 + p102 + lbound = 75
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n103 + p103 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n104 + p104 + lbound = 60
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n105 + p105 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n106 + p106 + lbound = 70
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n107 + p107 + lbound = 50
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n108 + p108 + lbound = 80
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n109 + p109 + lbound = 145
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n110 + p110 + lbound = 96
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n111 + p111 + lbound = 90
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n112 + p112 + lbound = 120
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n113 + p113 + lbound = 95
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n114 + p114 + lbound = 130
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n115 + p115 + lbound = 80
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n116 + p116 + lbound = 115
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n117 + p117 + lbound = 90
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n118 + p118 + lbound = 70
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n119 + p119 + lbound = 110
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n120 + p120 + lbound = 95

stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n121 + p121 + lbound = 70
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n122 + p122 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n123 + p123 + lbound = 70
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n124 + p124 + lbound = 65
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n125 + p125 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n126 + p126 + lbound = 70
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n127 + p127 + lbound = 107
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n128 + p128 + lbound = 75
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n129 + p129 + lbound = 110
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n130 + p130 + lbound = 125
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n131 + p131 + lbound = 72
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n132 + p132 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n133 + p133 + lbound = 93
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n134 + p134 + lbound = 75
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n135 + p135 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n136 + p136 + lbound = 85
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n137 + p137 + lbound = 79
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n138 + p138 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n139 + p139 + lbound = 55
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n140 + p140 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n141 + p141 + lbound = 90
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n142 + p142 + lbound = 65
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n143 + p143 + lbound = 80

- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n144 + p144 + lbound = 70
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n145 + p145 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n146 + p146 + lbound = 100
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n147 + p147 + lbound = 80
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n148 + p148 + lbound = 135
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n149 + p149 + lbound = 103
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n150 + p150 + lbound = 125
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n151 + p151 + lbound = 116
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n152 + p152 + lbound = 120
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n153 + p153 + lbound = 85
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n154 + p154 + lbound = 80
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n155 + p155 + lbound = 108
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n156 + p156 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n157 + p157 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n158 + p158 + lbound = 95
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n159 + p159 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n160 + p160 + lbound = 99
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n161 + p161 + lbound = 109
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n162 + p162 + lbound = 96
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n163 + p163 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n164 + p164 + lbound = 108
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n165 + p165 + lbound = 70

- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n166 + p166 + lbound = 80
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n167 + p167 + lbound = 83
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n168 + p168 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n169 + p169 + lbound = 102
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n170 + p170 + lbound = 115
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n171 + p171 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n172 + p172 + lbound = 80
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n173 + p173 + lbound = 76
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n174 + p174 + lbound = 70
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n175 + p175 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n176 + p176 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n177 + p177 + lbound = 98
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n178 + p178 + lbound = 75
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n179 + p179 + lbound = 85
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n180 + p180 + lbound = 65
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n181 + p181 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n182 + p182 + lbound = 96
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n183 + p183 + lbound = 45
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n184 + p184 + lbound = 120
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n185 + p185 + lbound = 81
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n186 + p186 + lbound = 78
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n187 + p187 + lbound = 108

stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n188 + p188 + lbound = 60
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n189 + p189 + lbound = 135
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n190 + p190 + lbound = 69
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n191 + p191 + lbound = 123
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n192 + p192 + lbound = 87
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n193 + p193 + lbound = 51
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n194 + p194 + lbound = 144
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n195 + p195 + lbound = 99
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n196 + p196 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n197 + p197 + lbound = 126
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n198 + p198 + lbound = 84
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n199 + p199 + lbound = 129
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n200 + p200 + lbound = 114
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n201 + p201 + lbound = 63
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n202 + p202 + lbound = 90
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n203 + p203 + lbound = 72
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n204 + p204 + lbound = 117
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n205 + p205 + lbound = 93
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n206 + p206 + lbound = 54
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n207 + p207 + lbound = 147
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n208 + p208 + lbound = 102
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n209 + p209 + lbound = 48
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n210 + p210 + lbound = 141

- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n211 + p211 + lbound = 57
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n212 + p212 + lbound = 138
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n213 + p213 + lbound = 111
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n214 + p214 + lbound = 132
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n215 + p215 + lbound = 105
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n216 + p216 + lbound = 66
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n217 + p217 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n218 + p218 + lbound = 60
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n219 + p219 + lbound = 70
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n220 + p220 + lbound = 80
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n221 + p221 + lbound = 110
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n222 + p222 + lbound = 110
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n223 + p223 + lbound = 95
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n224 + p224 + lbound = 90
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n225 + p225 + lbound = 120
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n226 + p226 + lbound = 65
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n227 + p227 + lbound = 110
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n228 + p228 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n229 + p229 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n230 + p230 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n231 + p231 + lbound = 80
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n232 + p232 + lbound = 90

stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n233 + p233 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n234 + p234 + lbound = 100
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n235 + p235 + lbound = 100
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n236 + p236 + lbound = 110
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n237 + p237 + lbound = 90
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n238 + p238 + lbound = 60
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n239 + p239 + lbound = 70
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n240 + p240 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n241 + p241 + lbound = 100
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n242 + p242 + lbound = 110
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n243 + p243 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n244 + p244 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n245 + p245 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n246 + p246 + lbound = 90
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n247 + p247 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n248 + p248 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n249 + p249 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n250 + p250 + lbound = 65
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n251 + p251 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n252 + p252 + lbound = 55
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n253 + p253 + lbound = 145
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n254 + p254 + lbound = 110

stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n255 + p255 + lbound = 85
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n256 + p256 + lbound = 135
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n257 + p257 + lbound = 95
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n258 + p258 + lbound = 115
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n259 + p259 + lbound = 105
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n260 + p260 + lbound = 115
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n261 + p261 + lbound = 125
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n262 + p262 + lbound = 75
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n263 + p263 + lbound = 105
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n264 + p264 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n265 + p265 + lbound = 70
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n266 + p266 + lbound = 95
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n267 + p267 + lbound = 70
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n268 + p268 + lbound = 95
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n269 + p269 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n270 + p270 + lbound = 100
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n271 + p271 + lbound = 105
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n272 + p272 + lbound = 100
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n273 + p273 + lbound = 90
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n274 + p274 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n275 + p275 + lbound = 95
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n276 + p276 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n277 + p277 + lbound = 90

- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n278 + p278 + lbound = 105
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n279 + p279 + lbound = 120
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n280 + p280 + lbound = 100
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n281 + p281 + lbound = 85
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n282 + p282 + lbound = 75
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n283 + p283 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n284 + p284 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n285 + p285 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n286 + p286 + lbound = 60
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n287 + p287 + lbound = 65
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n288 + p288 + lbound = 75
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n289 + p289 + lbound = 137
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n290 + p290 + lbound = 100
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n291 + p291 + lbound = 90
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n292 + p292 + lbound = 110
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n293 + p293 + lbound = 100
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n294 + p294 + lbound = 65
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n295 + p295 + lbound = 100
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n296 + p296 + lbound = 80
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n297 + p297 + lbound = 130
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n298 + p298 + lbound = 70
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n299 + p299 + lbound = 95

stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n300 + p300 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n301 + p301 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n302 + p302 + lbound = 50
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n303 + p303 + lbound = 60
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n304 + p304 + lbound = 90
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n305 + p305 + lbound = 99
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n306 + p306 + lbound = 45
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n307 + p307 + lbound = 95
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n308 + p308 + lbound = 105
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n309 + p309 + lbound = 75
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n310 + p310 + lbound = 120
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n311 + p311 + lbound = 45
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n312 + p312 + lbound = 60
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n313 + p313 + lbound = 100
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n314 + p314 + lbound = 95
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n315 + p315 + lbound = 105
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n316 + p316 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n317 + p317 + lbound = 95
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n318 + p318 + lbound = 70
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n319 + p319 + lbound = 60
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n320 + p320 + lbound = 65
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n321 + p321 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n322 + p322 + lbound = 80

- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n323 + p323 + lbound = 90
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n324 + p324 + lbound = 70
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n325 + p325 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n326 + p326 + lbound = 105
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n327 + p327 + lbound = 80
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n328 + p328 + lbound = 130
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n329 + p329 + lbound = 110
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n330 + p330 + lbound = 120
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n331 + p331 + lbound = 105
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n332 + p332 + lbound = 120
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n333 + p333 + lbound = 115
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n334 + p334 + lbound = 85
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n335 + p335 + lbound = 110
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n336 + p336 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n337 + p337 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n338 + p338 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n339 + p339 + lbound = 80
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n340 + p340 + lbound = 70
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n341 + p341 + lbound = 120
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n342 + p342 + lbound = 95
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n343 + p343 + lbound = 100
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n344 + p344 + lbound = 110

- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n345 + p345 + lbound = 70
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n346 + p346 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n347 + p347 + lbound = 80
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n348 + p348 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n349 + p349 + lbound = 120
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n350 + p350 + lbound = 110
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n351 + p351 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n352 + p352 + lbound = 70
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n353 + p353 + lbound = 80
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n354 + p354 + lbound = 75
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n355 + p355 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n356 + p356 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n357 + p357 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n358 + p358 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n359 + p359 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n360 + p360 + lbound = 65

Subject to the following boudary constraints:
- nstpron - nbidirn - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc + lbound = 45
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig - gpotg + mainte + lbound = 150
lbound = 100

Subject to the following sign constraints:
flexih - 2flexim + 2nflexim > 0
2flexim - 2nflexim + nflexil > 0
speedg - 2speedf + 2nspeedf > 0
2speedf - 2nspeedf + nspeedb > 0
reliah - 2reliam + 2nreliam > 0

2reliam - 2nreliam + nrelial > 0
usag - 2usaf + 2nusaf > 0
2usaf - 2nusaf + nusab > 0
accurah - 2accuram + 2naccuram > 0
2accuram - 2naccuram + naccural > 0
effig - 2effif + 2neffif > 0
2effif - 2neffif + neffib > 0
gpotg - 2gpotf + 2ngpotf > 0
2gpotf - 2ngpotf + ngpotb > 0
mainte - 2maintf + 2nmaintf > 0
2maintf - 2nmaintf + nmaintc > 0

end

APPENDIX C

APPENDIX C

SUITABILITY INDEX SURVEY

From a scale of 45-150; an IT has an index of:	**From 0-1; How true is this statement: This IT <u>is suitable</u> for MC.**
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	
105	
110	
115	
120	
125	
130	
135	
140	
145	
150	

From a scale of 45-150; an IT has an index of:	**From 0-1; How true is this statement: This IT <u>is possibly suitable</u> for MC.**
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	
105	
110	
115	
120	
125	
130	
135	
140	
145	
150	

From a scale of 45-150; an IT has an index of:	**From 0-1; How true is this statement: This IT <u>is not suitable</u> for MC.**
45	
50	
55	
60	
65	
70	
75	
80	
85	
90	
95	
100	
105	
110	
115	
120	
125	
130	
135	
140	
145	
150	

Suitability Survey - Answers

From 0.00 to 1.00, how true is the following statement: This index value is definitely SUITABLE for MC.									
From a scale of 45-150;	**Opinion from 9 different experts.**								
the IT has an index of:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.05	0.05	0.02	0.05	0.10	0.10	0.20	0.03	0.03
55	0.10	0.10	0.04	0.10	0.15	0.15	0.30	0.04	0.03
60	0.15	0.15	0.10	0.15	0.20	0.20	0.40	0.07	0.09
65	0.20	0.20	0.15	0.20	0.30	0.25	0.50	0.13	0.20
70	0.25	0.25	0.20	0.25	0.40	0.29	0.55	0.18	0.21
75	0.30	0.30	0.25	0.30	0.50	0.30	0.60	0.21	0.24
80	0.35	0.35	0.30	0.35	0.53	0.35	0.60	0.28	0.27
85	0.40	0.40	0.40	0.40	0.55	0.40	0.65	0.36	0.31
90	0.45	0.45	0.45	0.45	0.57	0.45	0.70	0.42	0.35
95	0.50	0.50	0.50	0.50	0.60	0.50	0.70	0.47	0.42
100	0.55	0.70	0.60	0.55	0.63	0.55	0.80	0.44	0.46
105	0.60	0.90	0.70	0.60	0.66	0.59	0.80	0.46	0.49
110	0.65	1.00	0.75	0.65	0.70	0.60	0.80	0.54	0.52
115	0.70	1.00	0.80	0.70	0.73	0.65	0.90	0.59	0.62
120	0.75	1.00	0.83	0.75	0.76	0.69	0.90	0.69	0.63
125	0.80	1.00	0.86	0.80	0.80	0.70	0.90	0.66	0.67
130	0.85	1.00	0.89	0.85	0.83	0.75	1.00	0.71	0.80
135	0.90	1.00	0.92	0.90	0.86	0.80	1.00	0.78	0.79
140	0.95	1.00	0.95	0.95	0.90	0.85	1.00	0.84	0.87
145	0.99	1.00	0.98	0.99	0.95	0.95	1.00	0.91	0.90
150	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

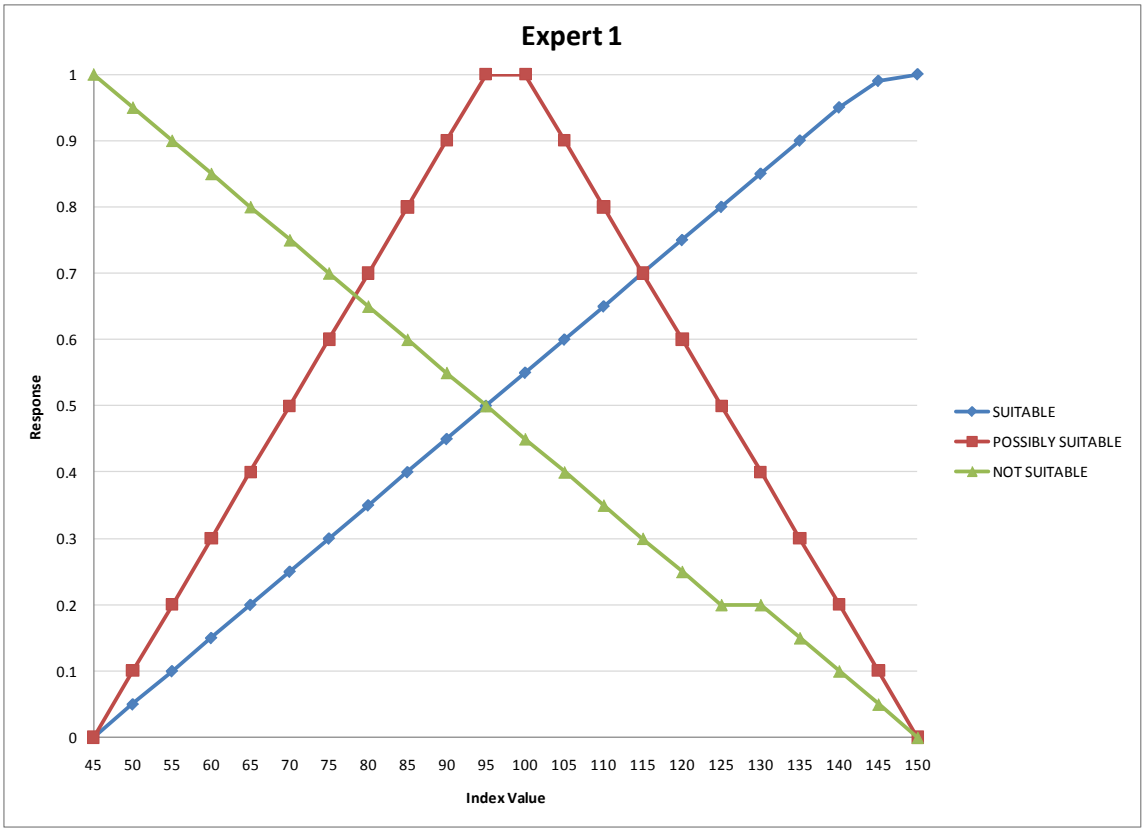
From 0.00 to 1.00, how true is the following statement: This index value is POSSIBLY SUITABLE for MC.									
From a scale of 45-150; the IT has an index of:	Opinion from 9 different experts.								
	1	2	3	4	5	6	7	8	9
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.10	0.20	0.15	0.05	0.10	0.10	0.20	0.00	0.05
55	0.20	0.30	0.35	0.10	0.20	0.20	0.50	0.07	0.10
60	0.30	0.40	0.47	0.13	0.30	0.30	0.70	0.13	0.20
65	0.40	0.50	0.50	0.17	0.40	0.40	0.75	0.17	0.29
70	0.50	0.75	0.50	0.21	0.45	0.50	0.80	0.32	0.45
75	0.60	0.90	0.75	0.25	0.50	0.60	0.80	0.39	0.54
80	0.70	1.00	0.80	0.30	0.55	0.70	0.90	0.42	0.61
85	0.80	1.00	0.82	0.50	0.60	0.80	0.90	0.50	0.72
90	0.90	1.00	0.90	0.65	0.80	0.90	0.95	0.55	0.74
95	1.00	1.00	0.95	0.80	1.00	1.00	1.00	0.57	0.81
100	1.00	1.00	1.00	1.00	0.70	0.90	0.95	0.71	1.00
105	0.90	0.90	1.00	0.60	0.50	0.80	0.93	0.71	0.83
110	0.80	0.75	0.99	0.50	0.55	0.70	0.91	0.81	0.75
115	0.70	0.50	0.95	0.40	0.60	0.60	0.89	0.85	0.65
120	0.60	0.40	0.93	0.30	0.65	0.50	0.85	1.00	0.56
125	0.50	0.30	0.81	0.25	0.70	0.40	0.80	0.81	0.42
130	0.40	0.20	0.75	0.21	0.75	0.30	0.70	0.66	0.34
135	0.30	0.10	0.55	0.17	0.80	0.20	0.60	0.42	0.21
140	0.20	0.05	0.43	0.13	0.50	0.10	0.50	0.28	0.18
145	0.10	0.00	0.21	0.05	0.30	0.00	0.20	0.14	0.05
150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

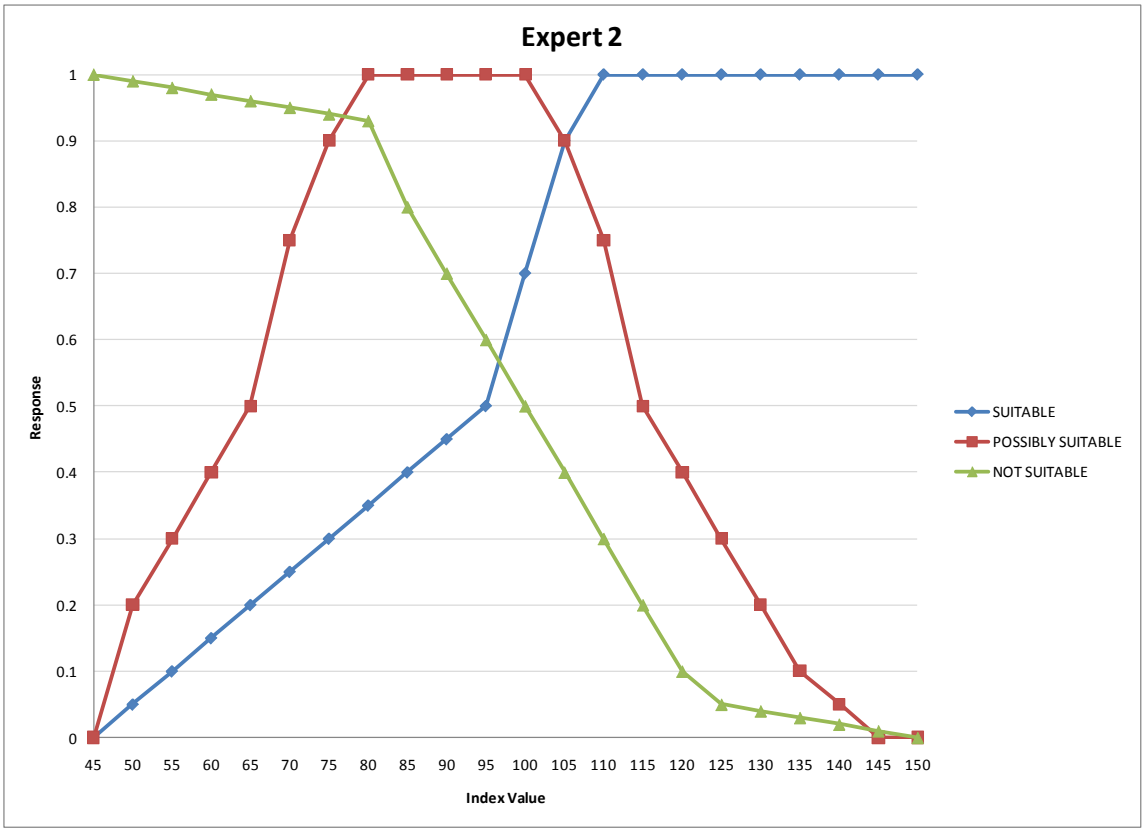
From 0.00 to 1.00, how true is the following statement: This index value is definitely NOT SUITABLE for MC.									
From a scale of 45-150;	**Opinion from 9 different experts.**								
the IT has an index of:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	0.95	0.99	0.90	0.80	0.95	0.95	0.90	0.90	0.94
55	0.90	0.98	0.80	0.75	0.90	0.85	0.80	0.82	0.90
60	0.85	0.97	0.70	0.70	0.85	0.80	0.70	0.82	0.77
65	0.80	0.96	0.65	0.65	0.80	0.75	0.60	0.75	0.77
70	0.75	0.95	0.60	0.50	0.76	0.70	0.50	0.66	0.65
75	0.70	0.94	0.55	0.48	0.73	0.69	0.40	0.69	0.67
80	0.65	0.93	0.40	0.43	0.70	0.63	0.30	0.64	0.61
85	0.60	0.80	0.30	0.40	0.66	0.60	0.20	0.59	0.51
90	0.55	0.70	0.20	0.34	0.63	0.55	0.10	0.45	0.48
95	0.50	0.60	0.15	0.30	0.60	0.50	0.00	0.44	0.41
100	0.45	0.50	0.10	0.25	0.59	0.48	0.00	0.45	0.48
105	0.40	0.40	0.09	0.30	0.56	0.50	0.00	0.36	0.35
110	0.35	0.30	0.08	0.35	0.53	0.40	0.00	0.26	0.27
115	0.30	0.20	0.07	0.40	0.50	0.39	0.00	0.30	0.21
120	0.25	0.10	0.06	0.20	0.45	0.35	0.00	0.16	0.22
125	0.20	0.05	0.05	0.15	0.40	0.30	0.00	0.11	0.14
130	0.20	0.04	0.04	0.10	0.35	0.25	0.00	0.15	0.14
135	0.15	0.03	0.03	0.07	0.30	0.20	0.00	0.04	0.06
140	0.10	0.02	0.02	0.03	0.20	0.15	0.00	0.04	0.02
145	0.05	0.01	0.01	0.02	0.10	0.10	0.00	0.03	0.02
150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

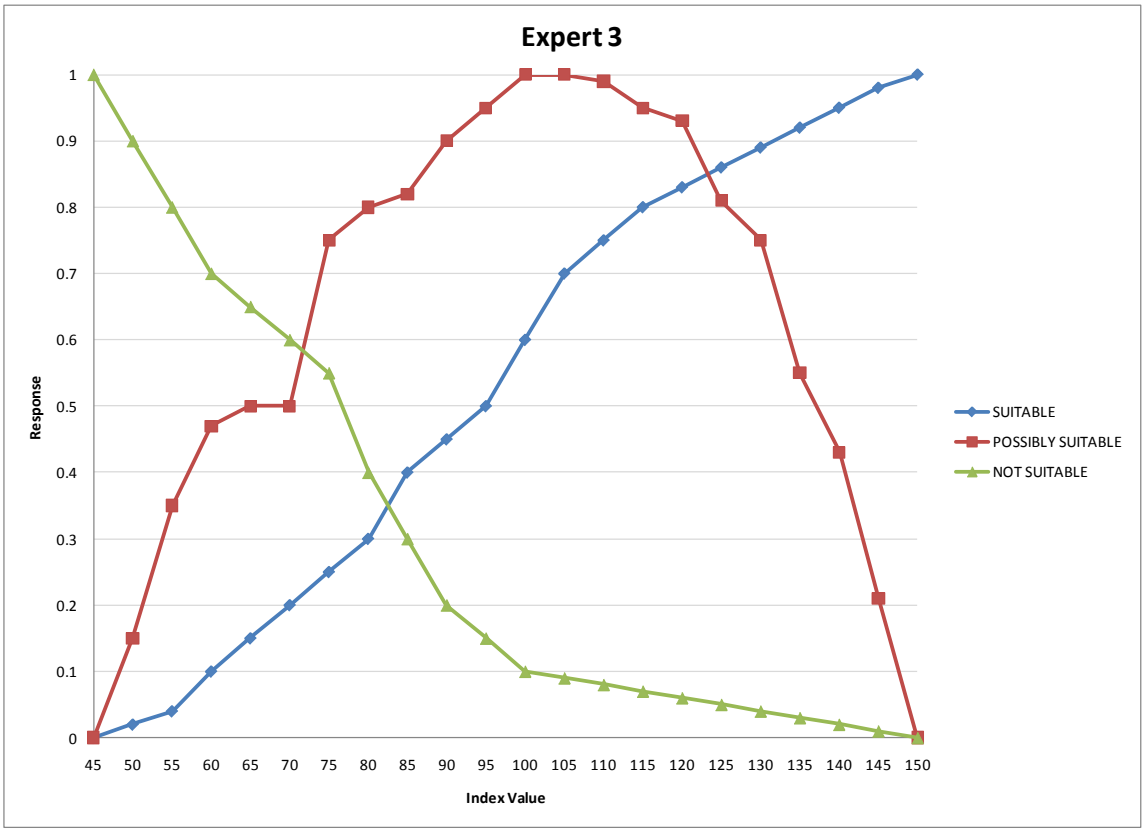
APPENDIX D

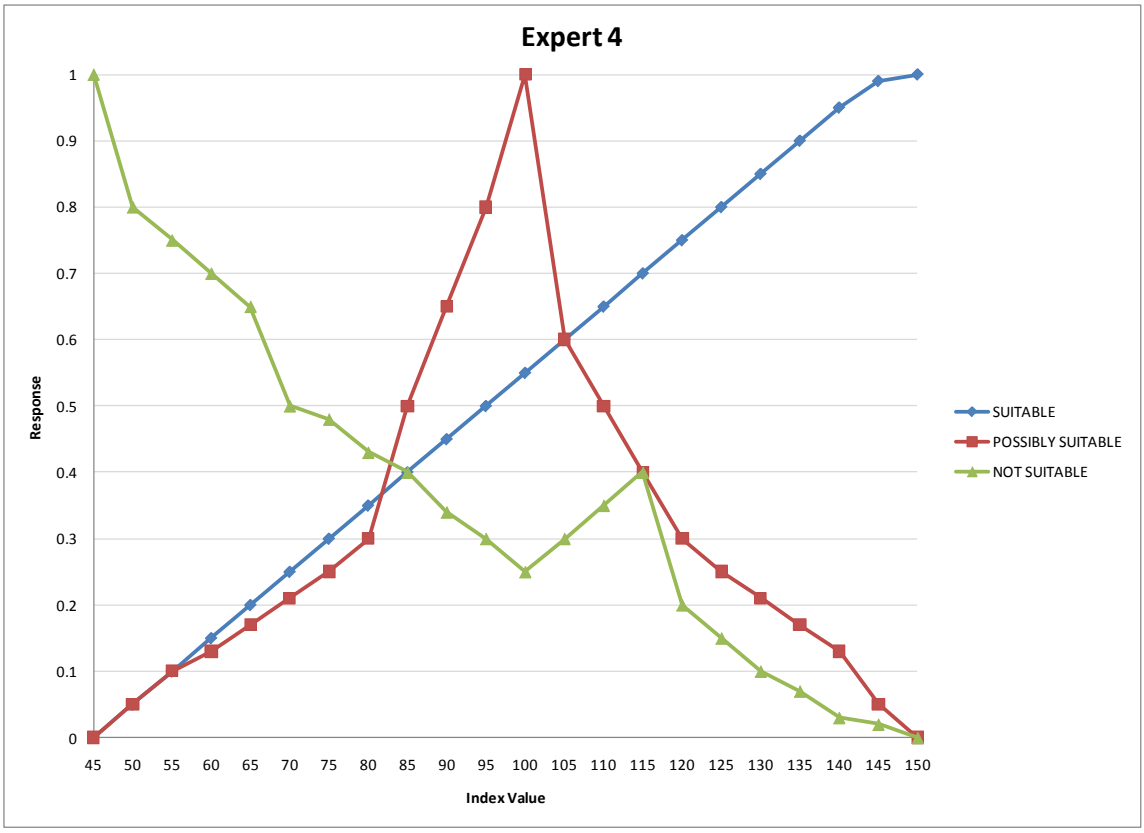
APPENDIX D

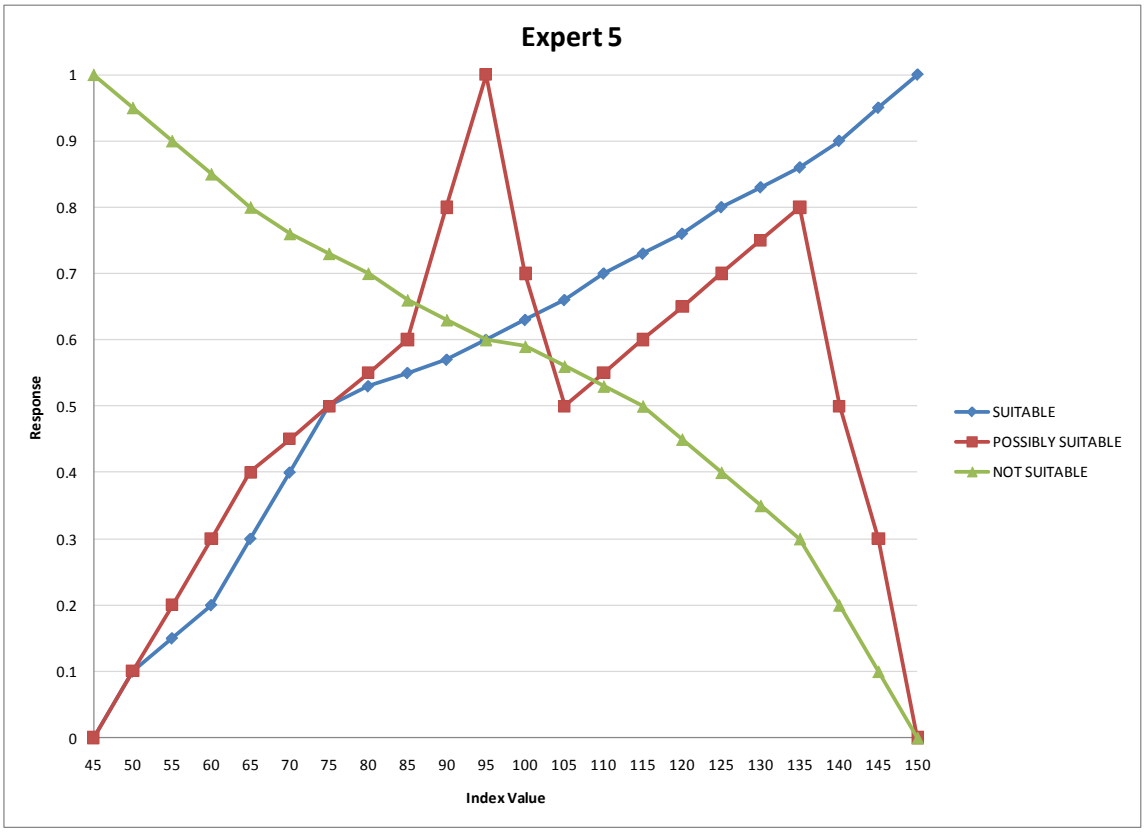
SUITABILITY ANALYSIS CHARTS

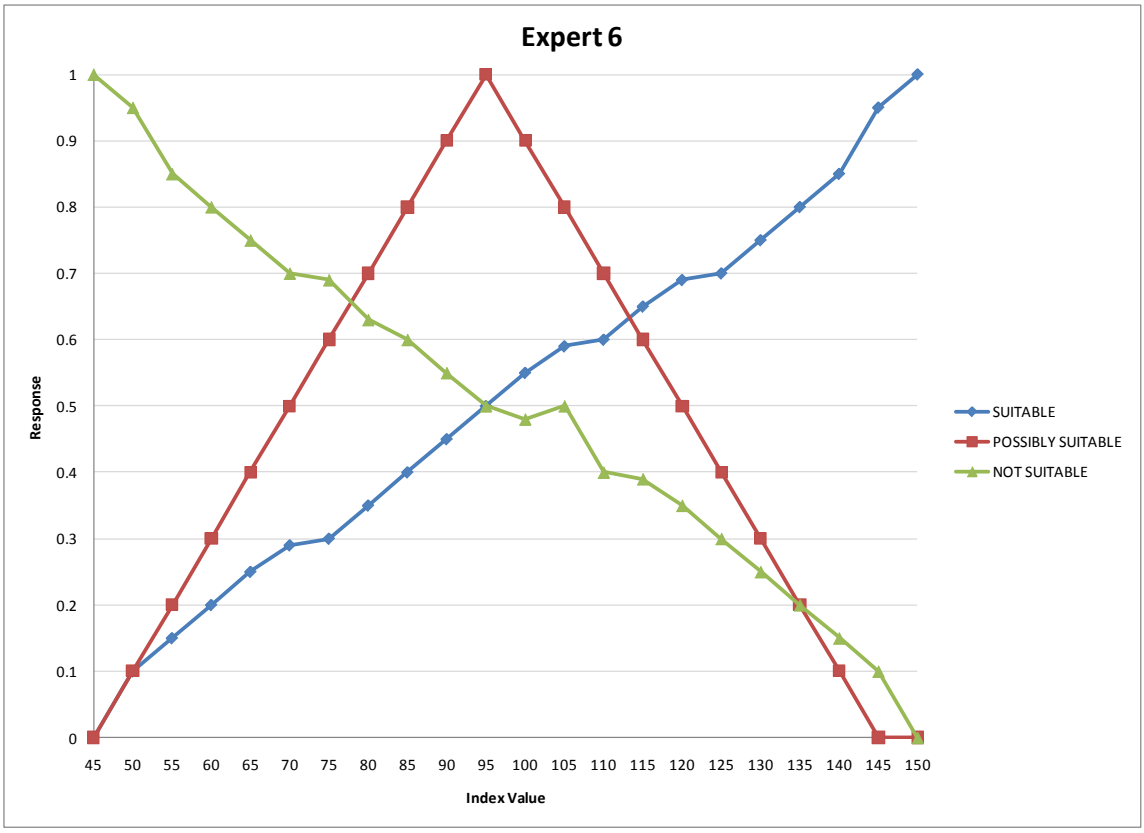


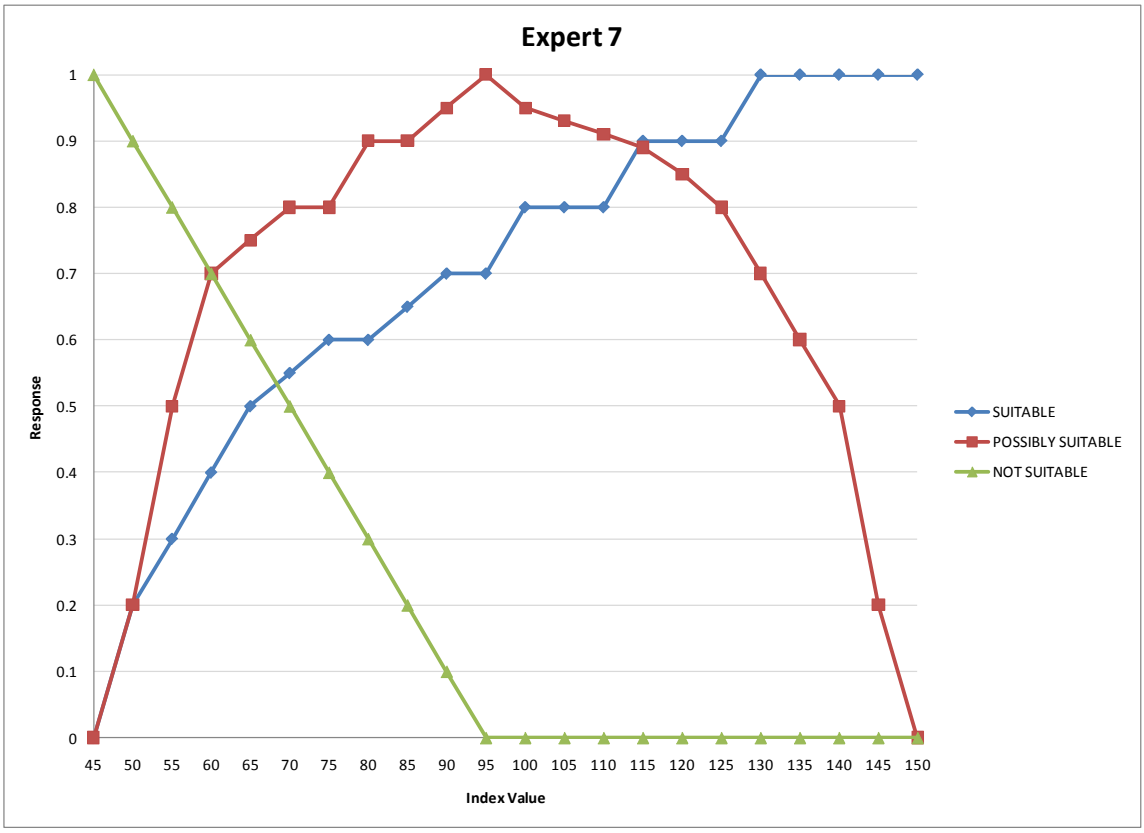

Expert 2
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE

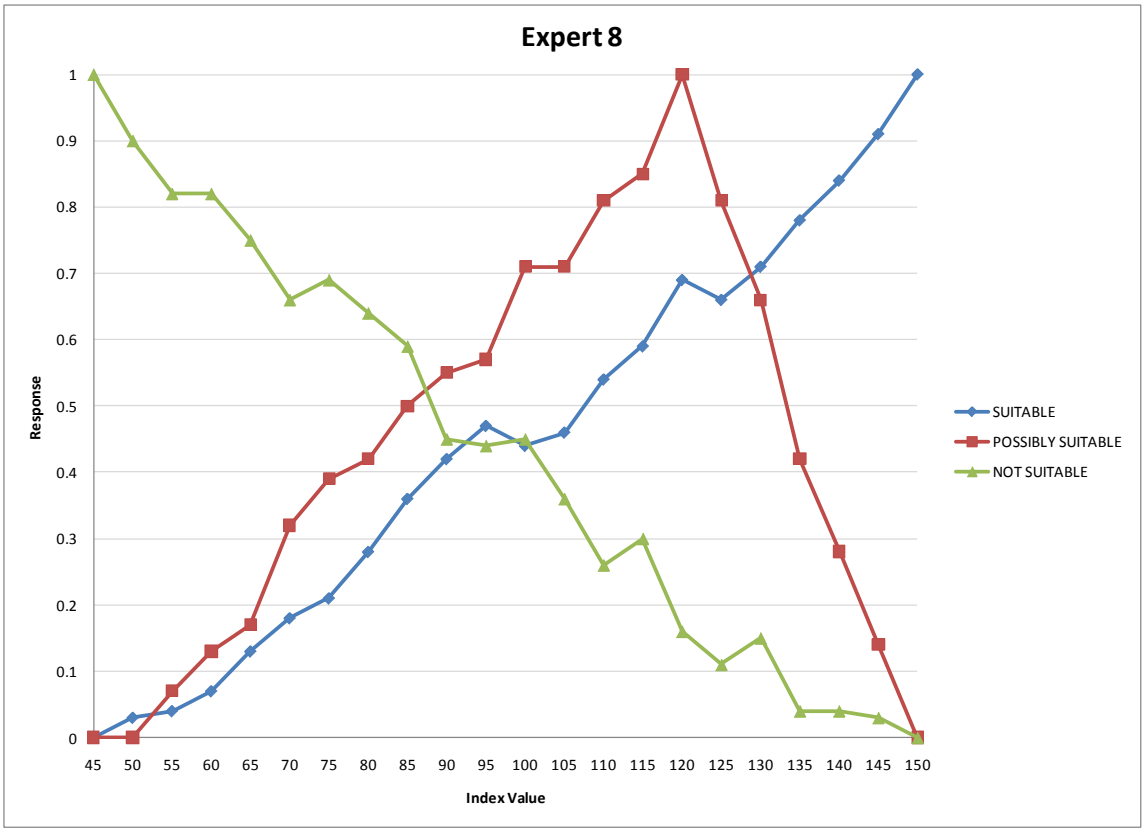

Expert 3
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE

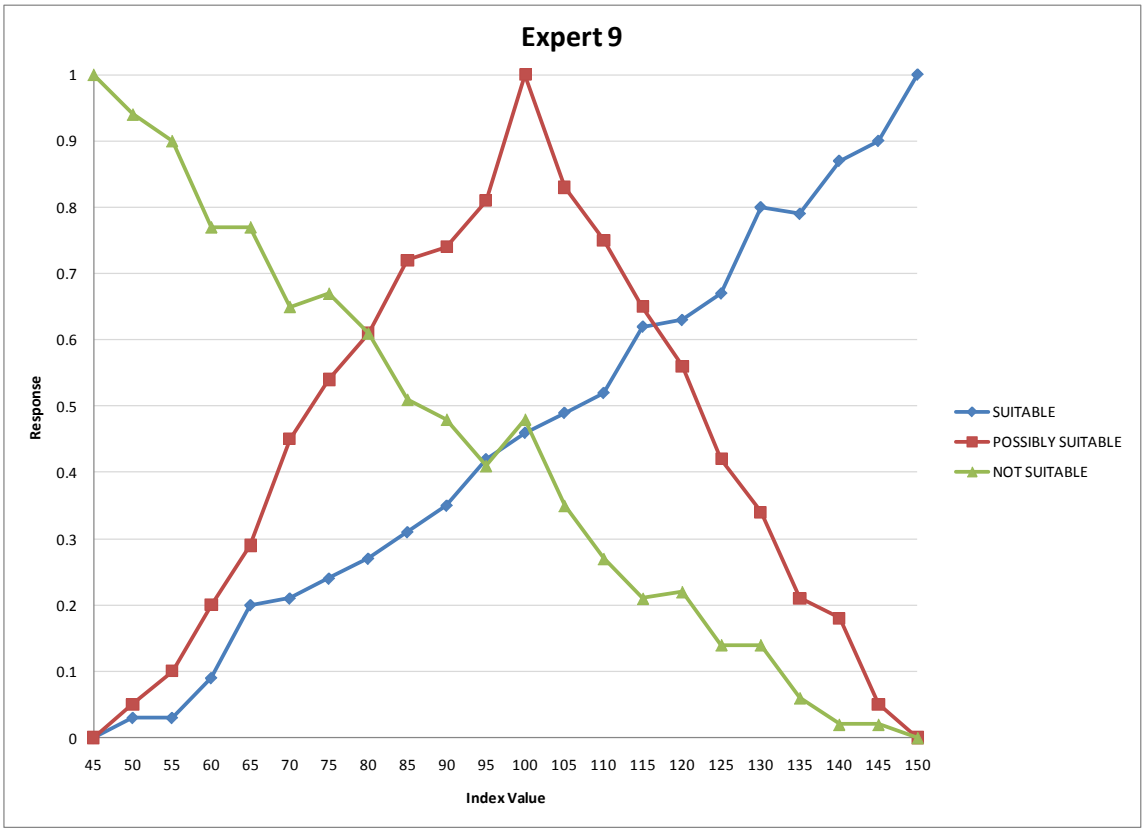

Expert 4
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE


Expert 5
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE


Expert 6
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE


Expert 7
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE

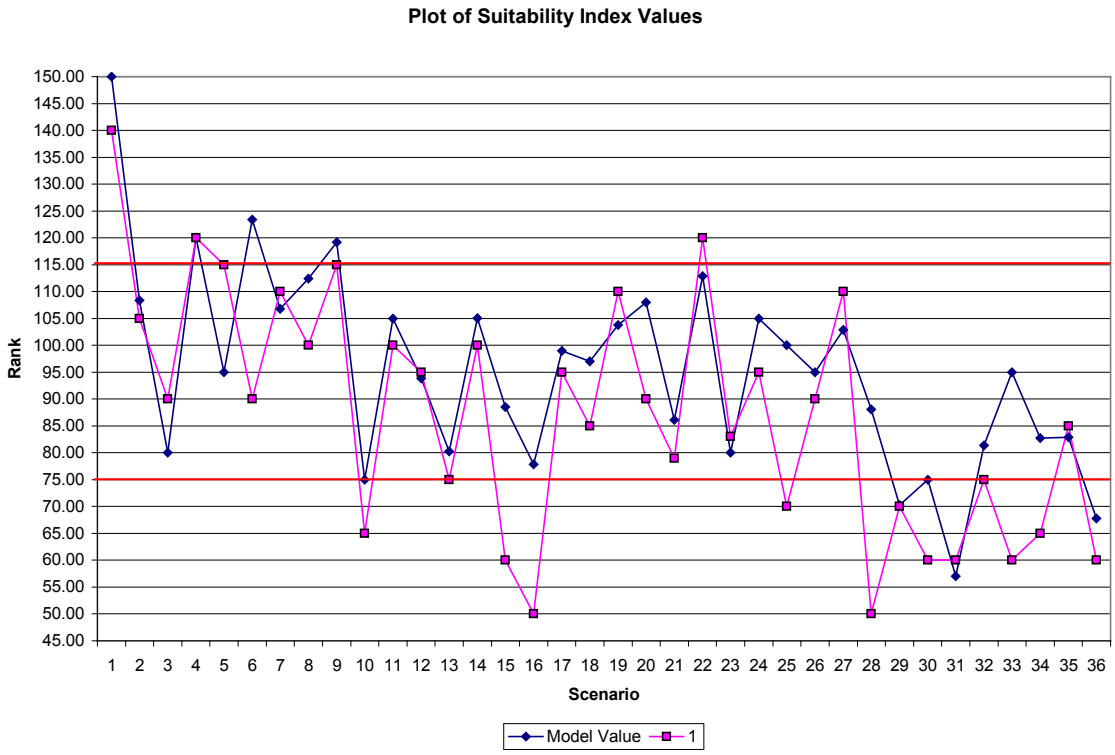

Expert 8
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE

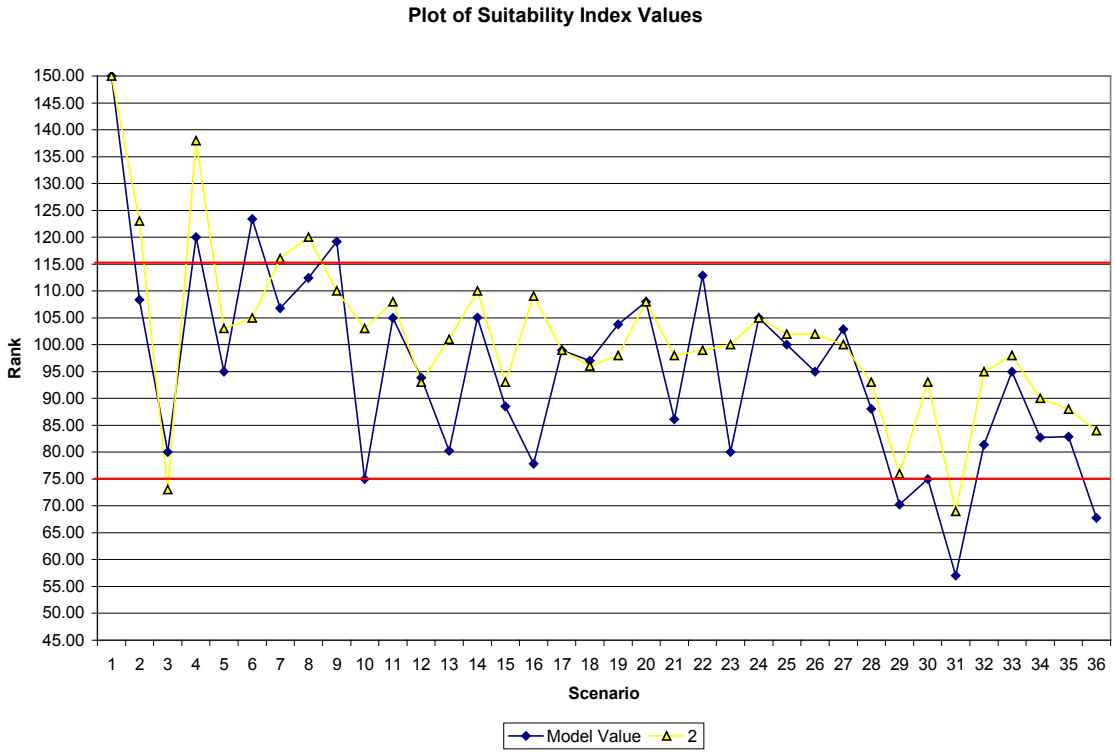

Expert 9
Response
Index Value
SUITABLE
POSSIBLY SUITABLE
NOT SUITABLE

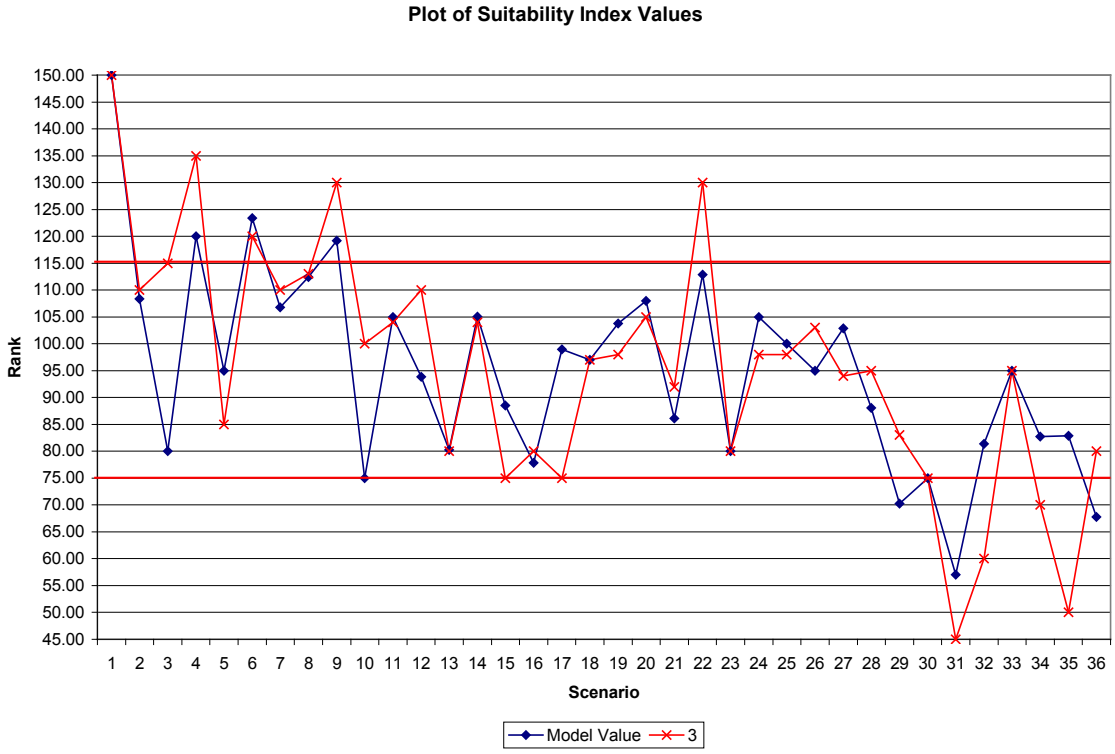
APPENDIX E

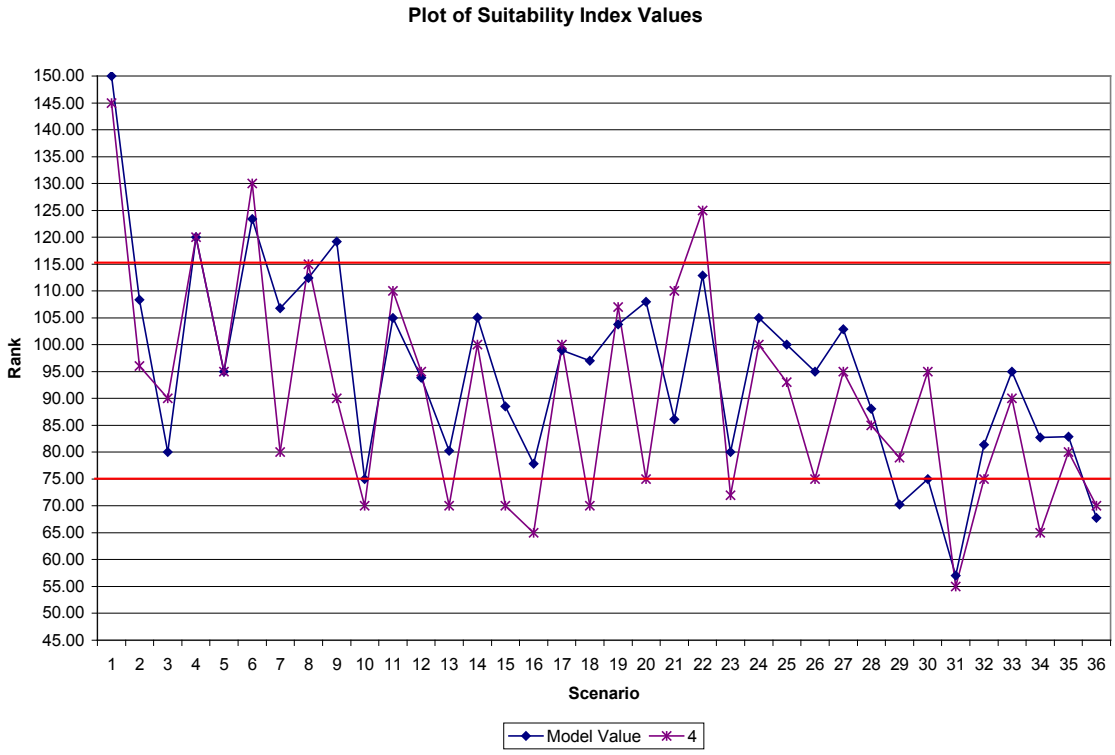
APPENDIX E

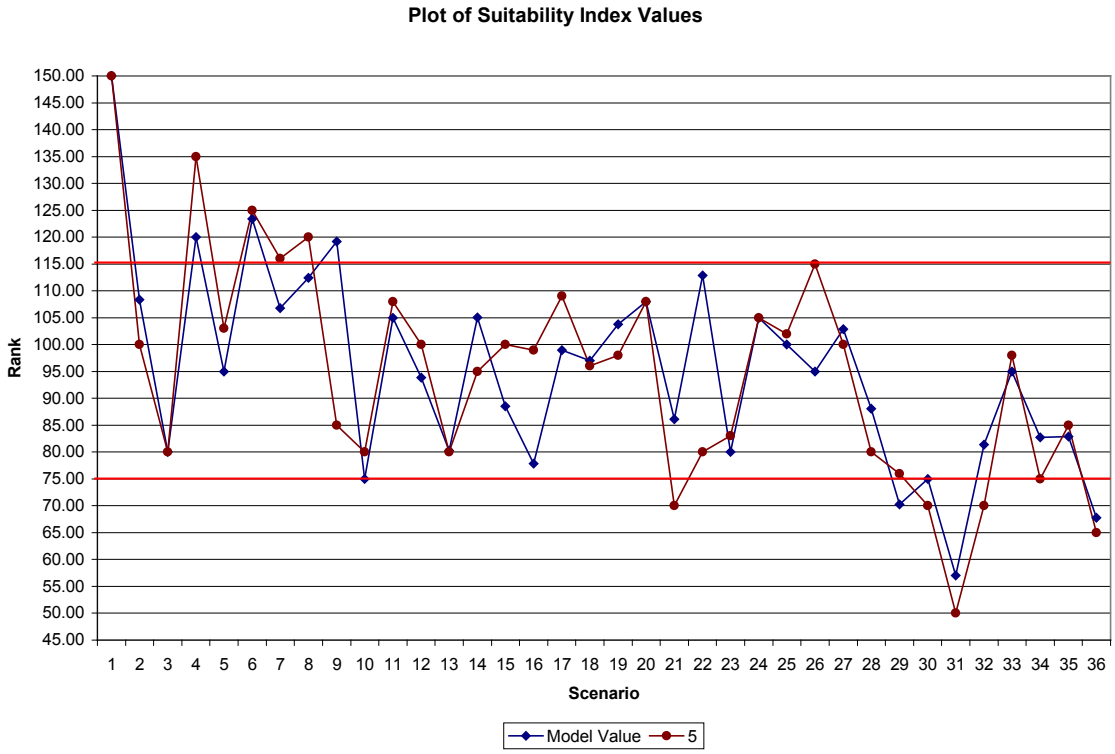
SUITABILITY VALIDATION

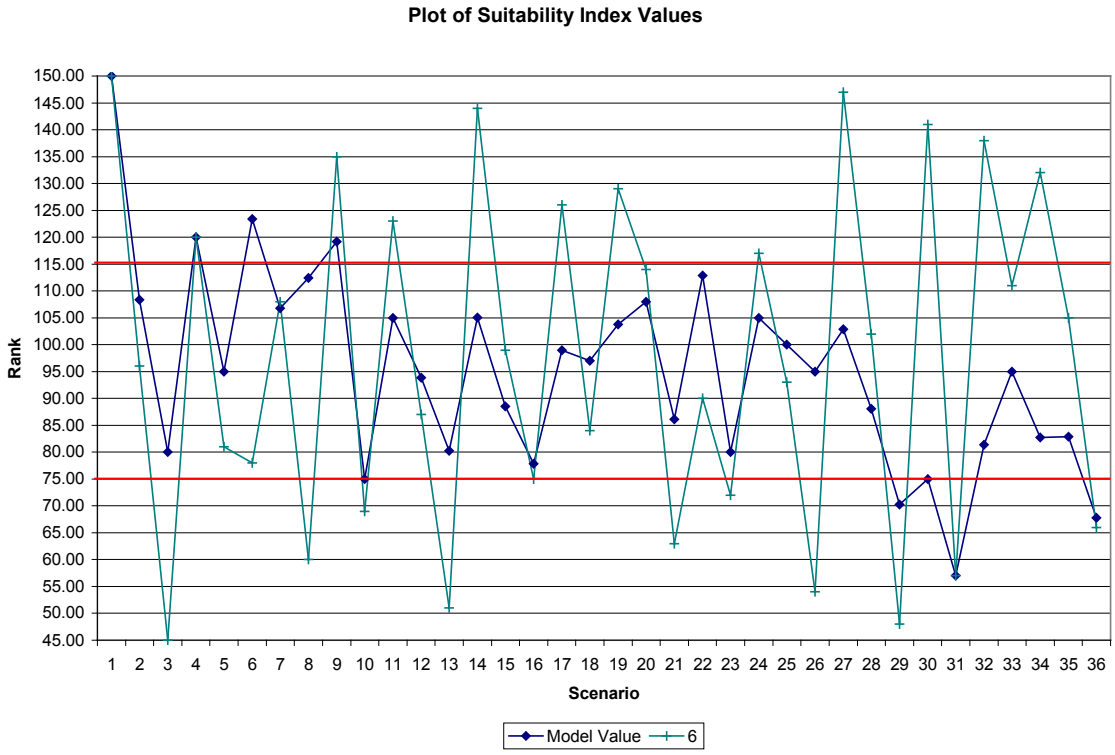


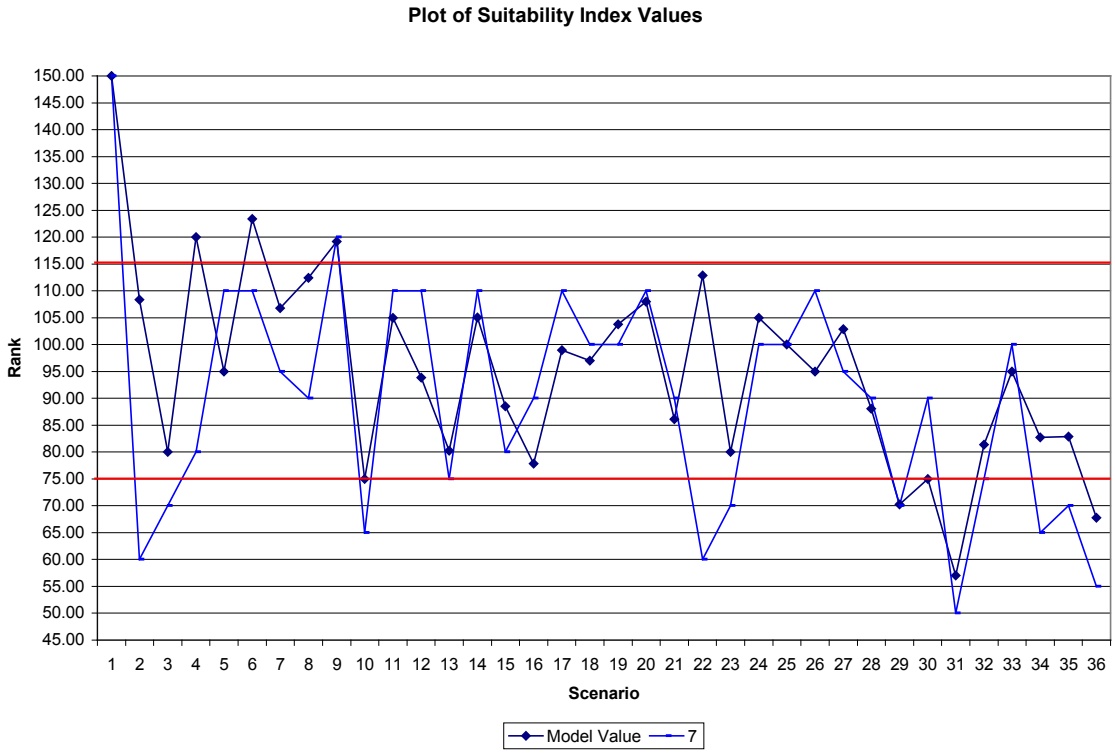

Plot of Suitability Index Values
Rank
Scenario
Model Value
2

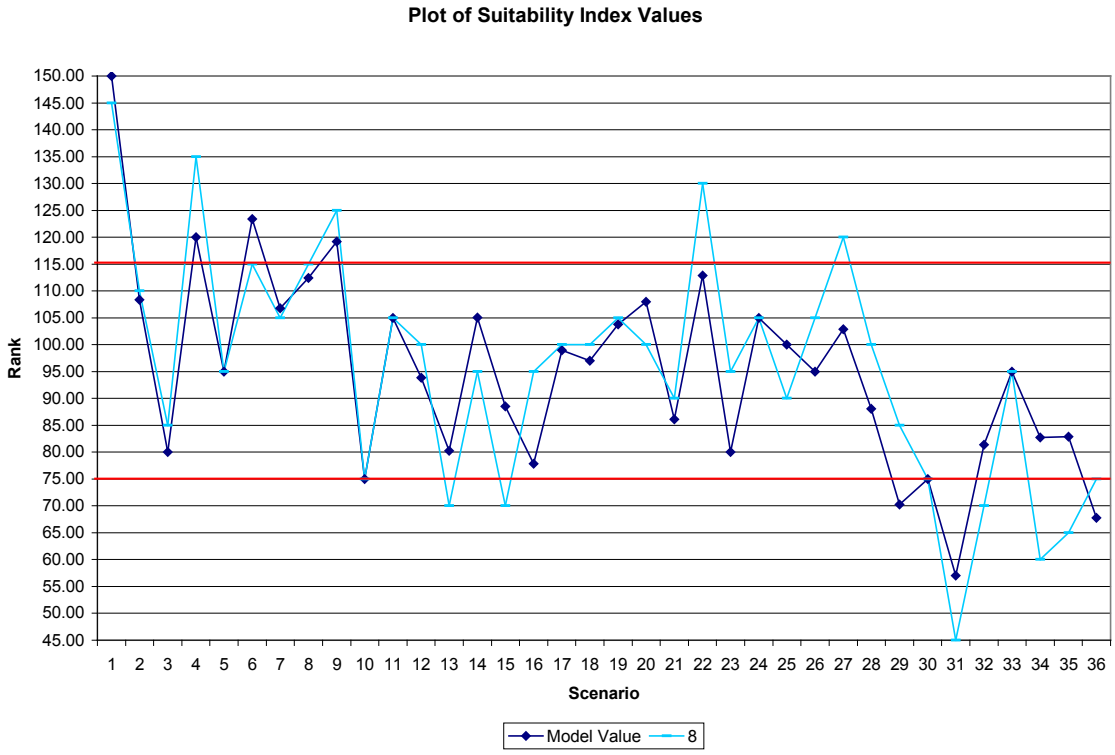

Plot of Suitability Index Values
Rank
Scenario
Model Value
3

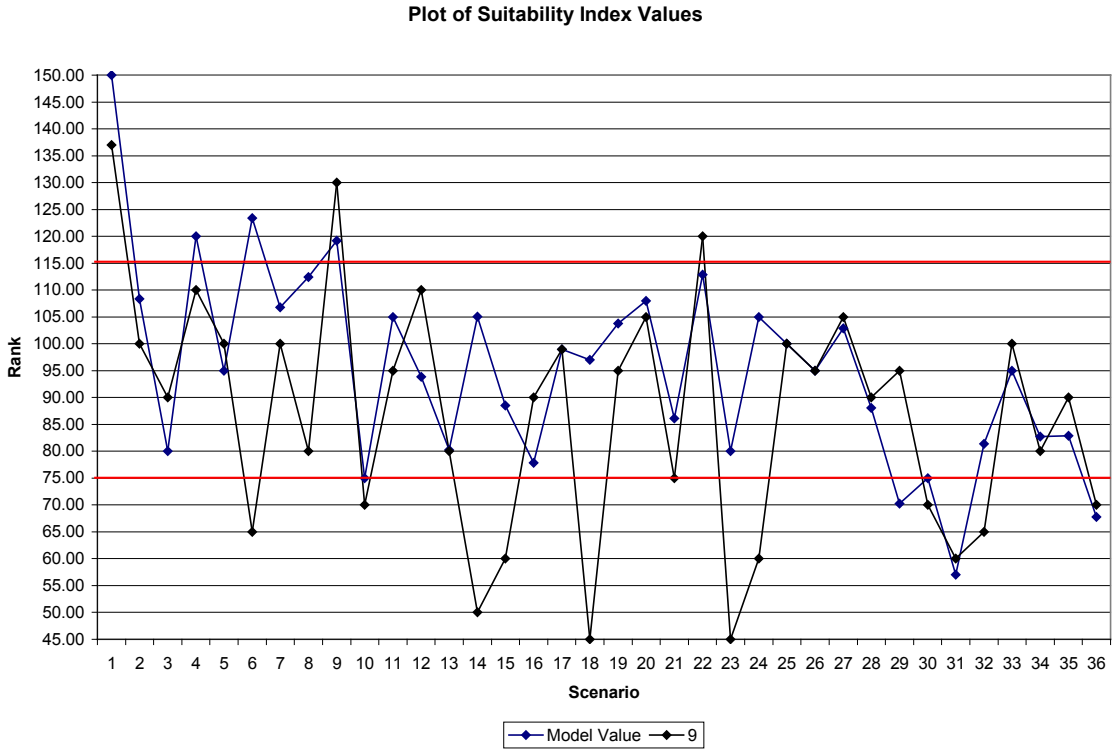

Plot of Suitability Index Values
Rank
Scenario
Model Value
4

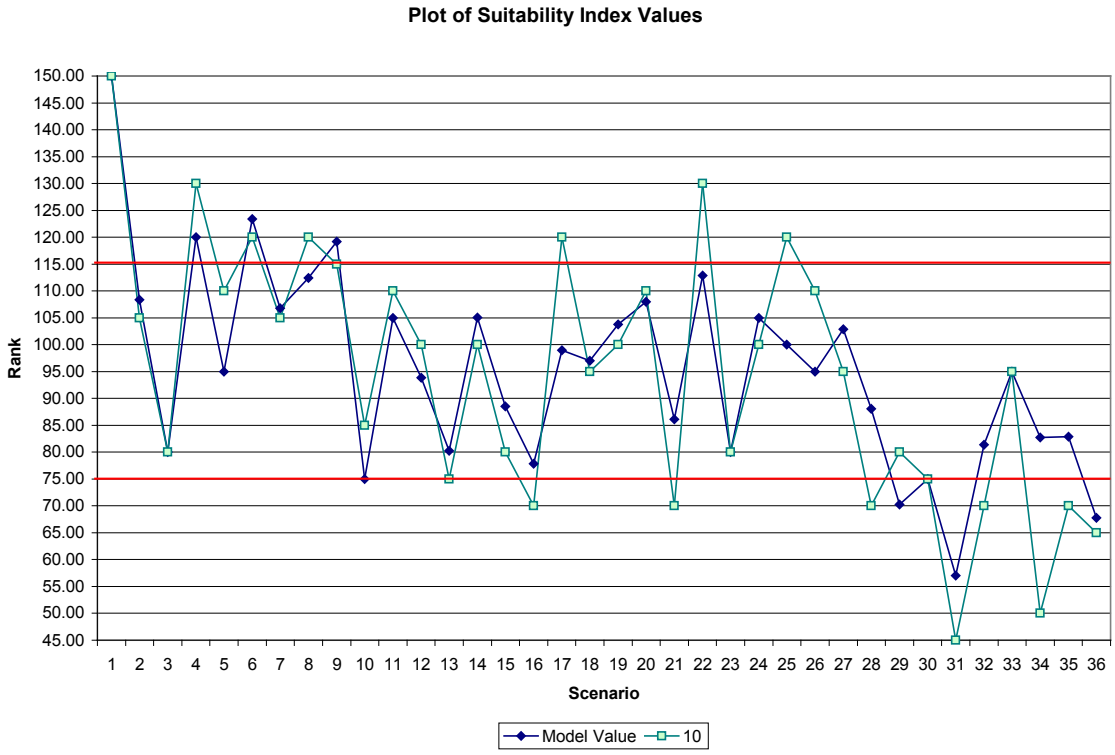

Plot of Suitability Index Values
Rank
Scenario
Model Value
5


Plot of Suitability Index Values
Rank
Scenario
Model Value
6


Plot of Suitability Index Values
Rank
Scenario
Model Value
7


Plot of Suitability Index Values
Rank
Scenario
Model Value
8


Plot of Suitability Index Values
Rank
Scenario
Model Value
9


Plot of Suitability Index Values
Rank
150.00
145.00
140.00
135.00
130.00
125.00
120.00
115.00
110.00
105.00
100.00
95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
55.00
50.00
45.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Scenario
Model Value
10

APPENDIX F

APPENDIX F

FINAL LINDO GOAL PROGRAMMING FORMULATION

Minimize:

n1 + p1 + n2 + p2 + n3 + p3 + n4 + p4 + n5 + p5 + n6 + p6 + n7 + p7 + n8 + p8 + n9 + p9 + n10 + p10 + n11 + p11 + n12 + p12 + n13 + p13 + n14 + p14 + n15 + p15 + n16 + p16 + n17 + p17 + n18 + p18 + n19 + p19 + n20 + p20 + n21 + p21 + n22 + p22 + n23 + p23 + n24 + p24 + n25 + p25 + n26 + p26 + n27 + p27 + n28 + p28 + n29 + p29 + n30 + p30 + n31 + p31 + n32 + p32 + n33 + p33 + n34 + p34 + n35 + p35 + n36 + p36 + n37 + p37 + n38 + p38 + n39 + p39 + n40 + p40 + n41 + p41 + n42 + p42 + n43 + p43 + n44 + p44 + n45 + p45 + n46 + p46 + n47 + p47 + n48 + p48 + n49 + p49 + n50 + p50 + n51 + p51 + n52 + p52 + n53 + p53 + n54 + p54 + n55 + p55 + n56 + p56 + n57 + p57 + n58 + p58 + n59 + p59 + n60 + p60 + n61 + p61 + n62 + p62 + n63 + p63 + n64 + p64 + n65 + p65 + n66 + p66 + n67 + p67 + n68 + p68 + n69 + p69 + n70 + p70 + n71 + p71 + n72 + p72 + n73 + p73 + n74 + p74 + n75 + p75 + n76 + p76 + n77 + p77 + n78 + p78 + n79 + p79 + n80 + p80 + n81 + p81 + n82 + p82 + n83 + p83 + n84 + p84 + n85 + p85 + n86 + p86 + n87 + p87 + n88 + p88 + n89 + p89 + n90 + p90 + n91 + p91 + n92 + p92 + n93 + p93 + n94 + p94 + n95 + p95 + n96 + p96 + n97 + p97 + n98 + p98 + n99 + p99 + n100 + p100 + n101 + p101 + n102 + p102 + n103 + p103 + n104 + p104 + n105 + p105 + n106 + p106 + n107 + p107 + n108 + p108 + n109 + p109 + n110 + p110 + n111 + p111 + n112 + p112 + n113 + p113 + n114 + p114 + n115 + p115 + n116 + p116 + n117 + p117 + n118 + p118 + n119 + p119 + n120 + p120 + n121 + p121 + n122 + p122 + n123 + p123 + n124 + p124 + n125 + p125 + n126 + p126 + n127 + p127 + n128 + p128 + n129 + p129 + n130 + p130 + n131 + p131 + n132 + p132 + n133 + p133 + n134 + p134 + n135 + p135 + n136 + p136 + n137 + p137 + n138 + p138 + n139 + p139 + n140 + p140 + n141 + p141 + n142 + p142 + n143 + p143 + n144 + p144 + n145 + p145 + n146 + p146 + n147 + p147 + n148 + p148 + n149 + p149 + n150 + p150 + n151 + p151 + n152 + p152 + n153 + p153 + n154 + p154 + n155 + p155 + n156 + p156 + n157 + p157 + n158 + p158 + n159 + p159 + n160 + p160 + n161 + p161 + n162 + p162 + n163 + p163 + n164 + p164 + n165 + p165 + n166 + p166 + n167 + p167 + n168 + p168 + n169 + p169 + n170 + p170 + n171 + p171 + n172 + p172 + n173 + p173 + n174 + p174 + n175 + p175 + n176 + p176 + n177 + p177 + n178 + p178 + n179 + p179 + n180 + p180 + n181 + p181 + n182 + p182 + n183 + p183 + n184 + p184 + n185 + p185 + n186 + p186 + n187 + p187 + n188 + p188 + n189 + p189 + n190 + p190 + n191 + p191 + n192 + p192 + n193 + p193 + n194 + p194 + n195 + p195 + n196 + p196 + n197 + p197 + n198 + p198 + n199 + p199 + n200 + p200 + n201 + p201 + n202 + p202 + n203 + p203 + n204 + p204 + n205 + p205 + n206 + p206 + n207 + p207 + n208 + p208 + n209 + p209 + n210 + p210 + n211 + p211 + n212 + p212 + n213 + p213 + n214 + p214 + n215

+ p215 + n216 + p216 + n217 + p217 + n218 + p218 + n219 + p219 + n220 + p220 + n221 + p221 + n222 + p222 + n223 + p223 + n224 + p224 + n225 + p225 + n226 + p226 + n227 + p227 + n228 + p228 + n229 + p229 + n230 + p230 + n231 + p231 + n232 + p232 + n233 + p233 + n234 + p234 + n235 + p235 + n236 + p236 + n237 + p237 + n238 + p238 + n239 + p239 + n240 + p240 + n241 + p241 + n242 + p242 + n243 + p243 + n244 + p244 + n245 + p245 + n246 + p246 + n247 + p247 + n248 + p248 + n249 + p249 + n250 + p250 + n251 + p251 + n252 + p252 + n253 + p253 + n254 + p254 + n255 + p255 + n256 + p256 + n257 + p257 + n258 + p258 + n259 + p259 + n260 + p260 + n261 + p261 + n262 + p262 + n263 + p263 + n264 + p264 + n265 + p265 + n266 + p266 + n267 + p267 + n268 + p268 + n269 + p269 + n270 + p270 + n271 + p271 + n272 + p272 + n273 + p273 + n274 + p274 + n275 + p275 + n276 + p276 + n277 + p277 + n278 + p278 + n279 + p279 + n280 + p280 + n281 + p281 + n282 + p282 + n283 + p283 + n284 + p284 + n285 + p285 + n286 + p286 + n287 + p287 + n288 + p288 + n289 + p289 + n290 + p290 + n291 + p291 + n292 + p292 + n293 + p293 + n294 + p294 + n295 + p295 + n296 + p296 + n297 + p297 + n298 + p298 + n299 + p299 + n300 + p300 + n301 + p301 + n302 + p302 + n303 + p303 + n304 + p304 + n305 + p305 + n306 + p306 + n307 + p307 + n308 + p308 + n309 + p309 + n310 + p310 + n311 + p311 + n312 + p312 + n313 + p313 + n314 + p314 + n315 + p315 + n316 + p316 + n317 + p317 + n318 + p318 + n319 + p319 + n320 + p320 + n321 + p321 + n322 + p322 + n323 + p323 + n324 + p324

Subject to the following model constraints:

stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n1 + p1 + lbound = 140

stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n2 + p2 + lbound = 105

stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n3 + p3 + lbound = 90

stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n4 + p4 + lbound = 120

stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n5 + p5 + lbound = 115

stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n6 + p6 + lbound = 90

stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n7 + p7 + lbound = 110

stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n8 + p8 + lbound = 100

stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n9 + p9 + lbound = 115

stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n10 + p10 + lbound = 65

stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n11 + p11 + lbound = 100

stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n12 + p12 + lbound = 95

stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n13 + p13 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n14 + p14 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n15 + p15 + lbound = 60
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n16 + p16 + lbound = 50
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n17 + p17 + lbound = 95
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n18 + p18 + lbound = 85
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n19 + p19 + lbound = 110
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n20 + p20 + lbound = 90
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n21 + p21 + lbound = 79
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n22 + p22 + lbound = 120
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n23 + p23 + lbound = 83
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n24 + p24 + lbound = 95
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n25 + p25 + lbound = 70
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n26 + p26 + lbound = 90
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n27 + p27 + lbound = 110
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n28 + p28 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n29 + p29 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n30 + p30 + lbound = 60
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n31 + p31 + lbound = 60
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n32 + p32 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n33 + p33 + lbound = 60
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n34 + p34 + lbound = 65
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n35 + p35 + lbound = 85

- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n36 + p36 + lbound = 60
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n37 + p37 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n38 + p38 + lbound = 123
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n39 + p39 + lbound = 73
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n40 + p40 + lbound = 138
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n41 + p41 + lbound = 103
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n42 + p42 + lbound = 105
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n43 + p43 + lbound = 116
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n44 + p44 + lbound = 120
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n45 + p45 + lbound = 110
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n46 + p46 + lbound = 103
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n47 + p47 + lbound = 108
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n48 + p48 + lbound = 93
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n49 + p49 + lbound = 101
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n50 + p50 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n51 + p51 + lbound = 93
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n52 + p52 + lbound = 109
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n53 + p53 + lbound = 99
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n54 + p54 + lbound = 96
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n55 + p55 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n56 + p56 + lbound = 108
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n57 + p57 + lbound = 98

- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n58 + p58 + lbound = 99
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n59 + p59 + lbound = 100
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n60 + p60 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n61 + p61 + lbound = 102
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n62 + p62 + lbound = 102
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n63 + p63 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n64 + p64 + lbound = 93
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n65 + p65 + lbound = 76
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n66 + p66 + lbound = 93
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n67 + p67 + lbound = 69
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n68 + p68 + lbound = 95
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n69 + p69 + lbound = 98
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n70 + p70 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n71 + p71 + lbound = 88
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n72 + p72 + lbound = 84
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n73 + p73 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n74 + p74 + lbound = 110
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n75 + p75 + lbound = 115
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n76 + p76 + lbound = 135
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n77 + p77 + lbound = 85
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n78 + p78 + lbound = 120
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n79 + p79 + lbound = 110

stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n80 + p80 + lbound = 113
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n81 + p81 + lbound = 130
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n82 + p82 + lbound = 100
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n83 + p83 + lbound = 104
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n84 + p84 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n85 + p85 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n86 + p86 + lbound = 104
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n87 + p87 + lbound = 75
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n88 + p88 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n89 + p89 + lbound = 75
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n90 + p90 + lbound = 97
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n91 + p91 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n92 + p92 + lbound = 105
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n93 + p93 + lbound = 92
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n94 + p94 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n95 + p95 + lbound = 80
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n96 + p96 + lbound = 98
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n97 + p97 + lbound = 98
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n98 + p98 + lbound = 103
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n99 + p99 + lbound = 94
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n100 + p100 + lbound = 95
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n101 + p101 + lbound = 83
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n102 + p102 + lbound = 75

- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n103 + p103 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n104 + p104 + lbound = 60
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n105 + p105 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n106 + p106 + lbound = 70
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n107 + p107 + lbound = 50
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n108 + p108 + lbound = 80
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n109 + p109 + lbound = 145
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n110 + p110 + lbound = 96
stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n111 + p111 + lbound = 90
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n112 + p112 + lbound = 120
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n113 + p113 + lbound = 95
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n114 + p114 + lbound = 130
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n115 + p115 + lbound = 80
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n116 + p116 + lbound = 115
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n117 + p117 + lbound = 90
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n118 + p118 + lbound = 70
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n119 + p119 + lbound = 110
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n120 + p120 + lbound = 95
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n121 + p121 + lbound = 70
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n122 + p122 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n123 + p123 + lbound = 70
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n124 + p124 + lbound = 65

stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n125 + p125 + lbound = 100
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n126 + p126 + lbound = 70
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n127 + p127 + lbound = 107
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n128 + p128 + lbound = 75
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n129 + p129 + lbound = 110
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n130 + p130 + lbound = 125
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n131 + p131 + lbound = 72
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n132 + p132 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n133 + p133 + lbound = 93
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n134 + p134 + lbound = 75
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n135 + p135 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n136 + p136 + lbound = 85
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n137 + p137 + lbound = 79
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n138 + p138 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n139 + p139 + lbound = 55
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n140 + p140 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n141 + p141 + lbound = 90
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n142 + p142 + lbound = 65
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n143 + p143 + lbound = 80
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n144 + p144 + lbound = 70
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n145 + p145 + lbound = 150
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n146 + p146 + lbound = 100

stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n147 + p147 + lbound = 80
stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n148 + p148 + lbound = 135
stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n149 + p149 + lbound = 103
stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n150 + p150 + lbound = 125
stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n151 + p151 + lbound = 116
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n152 + p152 + lbound = 120
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n153 + p153 + lbound = 85
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n154 + p154 + lbound = 80
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n155 + p155 + lbound = 108
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n156 + p156 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n157 + p157 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n158 + p158 + lbound = 95
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n159 + p159 + lbound = 100
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n160 + p160 + lbound = 99
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n161 + p161 + lbound = 109
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n162 + p162 + lbound = 96
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n163 + p163 + lbound = 98
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n164 + p164 + lbound = 108
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n165 + p165 + lbound = 70
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n166 + p166 + lbound = 80
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n167 + p167 + lbound = 83
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n168 + p168 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n169 + p169 + lbound = 102

- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n170 + p170 + lbound = 115
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n171 + p171 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n172 + p172 + lbound = 80
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n173 + p173 + lbound = 76
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n174 + p174 + lbound = 70
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n175 + p175 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n176 + p176 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n177 + p177 + lbound = 98
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n178 + p178 + lbound = 75
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n179 + p179 + lbound = 85
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n180 + p180 + lbound = 65
stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n181 + p181 + lbound = 150
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n182 + p182 + lbound = 60
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n183 + p183 + lbound = 70
 stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n184 + p184 + lbound = 80
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n185 + p185 + lbound = 110
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n186 + p186 + lbound = 110
 stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n187 + p187 + lbound = 95
 stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n188 + p188 + lbound = 90
 stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n189 + p189 + lbound = 120
 stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n190 + p190 + lbound = 65
 stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n191 + p191 + lbound = 110

stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n192 + p192 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n193 + p193 + lbound = 75
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n194 + p194 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n195 + p195 + lbound = 80
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n196 + p196 + lbound = 90
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n197 + p197 + lbound = 110
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n198 + p198 + lbound = 100
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n199 + p199 + lbound = 100
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n200 + p200 + lbound = 110
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n201 + p201 + lbound = 90
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n202 + p202 + lbound = 60
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n203 + p203 + lbound = 70
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n204 + p204 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n205 + p205 + lbound = 100
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n206 + p206 + lbound = 110
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n207 + p207 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n208 + p208 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n209 + p209 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n210 + p210 + lbound = 90
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n211 + p211 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n212 + p212 + lbound = 75
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n213 + p213 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n214 + p214 + lbound = 65

- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n215 + p215 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n216 + p216 + lbound = 55
 stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n217 + p217 + lbound = 145
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n218 + p218 + lbound = 110
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n219 + p219 + lbound = 85
 stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n220 + p220 + lbound = 135
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n221 + p221 + lbound = 95
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n222 + p222 + lbound = 115
 stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n223 + p223 + lbound = 105
 stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n224 + p224 + lbound = 115
 stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n225 + p225 + lbound = 125
 stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n226 + p226 + lbound = 75
 stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n227 + p227 + lbound = 105
 stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n228 + p228 + lbound = 100
 stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n229 + p229 + lbound = 70
 stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n230 + p230 + lbound = 95
 stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n231 + p231 + lbound = 70
 stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n232 + p232 + lbound = 95
 stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n233 + p233 + lbound = 100
 stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n234 + p234 + lbound = 100
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n235 + p235 + lbound = 105
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n236 + p236 + lbound = 100

- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n237 + p237 + lbound = 90
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n238 + p238 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n239 + p239 + lbound = 95
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n240 + p240 + lbound = 105
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n241 + p241 + lbound = 90
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n242 + p242 + lbound = 105
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n243 + p243 + lbound = 120
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n244 + p244 + lbound = 100
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n245 + p245 + lbound = 85
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n246 + p246 + lbound = 75
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n247 + p247 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n248 + p248 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n249 + p249 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n250 + p250 + lbound = 60
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n251 + p251 + lbound = 65
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n252 + p252 + lbound = 75
 stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n253 + p253 + lbound = 137
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n254 + p254 + lbound = 100
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n255 + p255 + lbound = 90
 stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n256 + p256 + lbound = 110
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n257 + p257 + lbound = 100
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n258 + p258 + lbound = 65

stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n259 + p259 + lbound = 100
stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n260 + p260 + lbound = 80
stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n261 + p261 + lbound = 130
stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n262 + p262 + lbound = 70
stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n263 + p263 + lbound = 95
stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n264 + p264 + lbound = 110
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n265 + p265 + lbound = 80
stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n266 + p266 + lbound = 50
stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n267 + p267 + lbound = 60
stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n268 + p268 + lbound = 90
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n269 + p269 + lbound = 99
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n270 + p270 + lbound = 45
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n271 + p271 + lbound = 95
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n272 + p272 + lbound = 105
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n273 + p273 + lbound = 75
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n274 + p274 + lbound = 120
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n275 + p275 + lbound = 45
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n276 + p276 + lbound = 60
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n277 + p277 + lbound = 100
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n278 + p278 + lbound = 95
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n279 + p279 + lbound = 105
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n280 + p280 + lbound = 90
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n281 + p281 + lbound = 95

- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n282 + p282 + lbound = 70
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n283 + p283 + lbound = 60
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n284 + p284 + lbound = 65
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n285 + p285 + lbound = 100
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n286 + p286 + lbound = 80
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n287 + p287 + lbound = 90
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n288 + p288 + lbound = 70
 stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig + gpotg + mainte - n289 + p289 + lbound = 150
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accuram - naccuram + effif - neffif + gpotf + maintf - nmaintf - n290 + p290 + lbound = 105
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc - n291 + p291 + lbound = 80
 stproy + bidiry + flexih + speedg + reliah + usag + accuram - naccuram + effif - neffif + gpotf - ngpotf + maintf - nmaintf - n292 + p292 + lbound = 130
 stproy + bidiry + flexim - nflexim + speedf - nspeedf + reliam - nreliam + usaf - nusaf - naccural - neffib - ngpotb - nmaintc - n293 + p293 + lbound = 110
 stproy + bidiry - nflexil - nspeedb - nrelial - nusab + accurah + effig + gpotg + mainte - n294 + p294 + lbound = 120
 stproy + bidiry + flexih + speedg + reliam - nreliam - nusab + accurah + effif - neffif - ngpotb - nmaintc - n295 + p295 + lbound = 105
 stproy + bidiry + flexim - nflexim + speedf - nspeedf - nrelial + usag + accuram - naccuram - neffib + gpotg + mainte - n296 + p296 + lbound = 120
 stproy + bidiry - nflexil - nspeedb + reliah + usaf - nusaf - naccural + effig + gpotf - ngpotf + maintf - nmaintf - n297 + p297 + lbound = 115
 stproy - nbidirn + flexih + speedg - nrelial + usaf - nusaf + accurah - neffib + gpotf - ngpotf - nmaintc - n298 + p298 + lbound = 85
 stproy - nbidirn + flexim - nflexim + speedf - nspeedf + reliah - nusab + accuram - naccuram + effig - ngpotb + mainte - n299 + p299 + lbound = 110
 stproy - nbidirn - nflexil - nspeedb + reliam - nreliam + usag - naccural + effif - neffif + gpotg + maintf - nmaintf - n300 + p300 + lbound = 100
 stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usag - naccural + effif - neffif + gpotg - nmaintc - n301 + p301 + lbound = 75
 stproy - nbidirn + flexim - nflexim - nspeedb + reliah + usaf - nusaf + accurah - neffib + gpotf - ngpotf + mainte - n302 + p302 + lbound = 100
 stproy - nbidirn - nflexil + speedg + reliam - nreliam - nusab + accuram - naccuram + effig - ngpotb + maintf - nmaintf - n303 + p303 + lbound = 80

stproy - nbidirn + flexih + speedf - nspeedf - nrelial + usaf - nusaf + accurah + effig - ngpotb + maintf - nmaintf - n304 + p304 + lbound = 70
stproy - nbidirn + flexim - nflexim - nspeedb + reliah - nusab + accuram - naccuram + effif - neffif + gpotg - nmaintc - n305 + p305 + lbound = 120
stproy - nbidirn - nflexil + speedg + reliam - nreliam + usag - naccural - neffib + gpotf - ngpotf + mainte - n306 + p306 + lbound = 95
- nstpron + bidiry + flexih + speedf - nspeedf + reliah - nusab - naccural - neffib + gpotg + maintf - nmaintf - n307 + p307 + lbound = 100
- nstpron + bidiry + flexim - nflexim - nspeedb + reliam - nreliam + usag + accurah + effig + gpotf - ngpotf - nmaintc - n308 + p308 + lbound = 110
- nstpron + bidiry - nflexil + speedg - nrelial + usaf - nusaf + accuram - naccuram + effif - neffif - ngpotb + mainte - n309 + p309 + lbound = 70
- nstpron + bidiry + flexih + speedf - nspeedf + reliam - nreliam - nusab - naccural + effig + gpotf - ngpotf + mainte - n310 + p310 + lbound = 130
- nstpron + bidiry + flexim - nflexim - nspeedb - nrelial + usag + accurah + effif - neffif - ngpotb + maintf - nmaintf - n311 + p311 + lbound = 80
- nstpron + bidiry - nflexil + speedg + reliah + usaf - nusaf + accuram - naccuram - neffib + gpotg - nmaintc - n312 + p312 + lbound = 100
- nstpron + bidiry + flexih - nspeedb + reliam - nreliam + usag + accuram - naccuram - neffib - ngpotb + mainte - n313 + p313 + lbound = 120
- nstpron + bidiry + flexim - nflexim + speedg - nrelial + usaf - nusaf - naccural + effig + gpotg + maintf - nmaintf - n314 + p314 + lbound = 110
- nstpron + bidiry - nflexil + speedf - nspeedf + reliah - nusab + accurah + effif - neffif + gpotf - ngpotf - nmaintc - n315 + p315 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliam - nreliam + usaf - nusaf + accuram - naccuram + effig + gpotg - nmaintc - n316 + p316 + lbound = 70
- nstpron - nbidirn + flexim - nflexim + speedg - nrelial - nusab - naccural + effif - neffif + gpotf - ngpotf + mainte - n317 + p317 + lbound = 80
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliah + usag + accurah - neffib - ngpotb + maintf - nmaintf - n318 + p318 + lbound = 75
- nstpron - nbidirn + flexih - nspeedb - nrelial - nusab + accuram - naccuram - neffib + gpotf - ngpotf + maintf - nmaintf - n319 + p319 + lbound = 45
- nstpron - nbidirn + flexim - nflexim + speedg + reliah + usag - naccural + effig - ngpotb - nmaintc - n320 + p320 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf + reliam - nreliam + usaf - nusaf + accurah + effif - neffif + gpotg + mainte - n321 + p321 + lbound = 95
- nstpron - nbidirn + flexih - nspeedb + reliah + usaf - nusaf - naccural + effif - neffif - ngpotb + mainte - n322 + p322 + lbound = 50
- nstpron - nbidirn + flexim - nflexim + speedg + reliam - nreliam - nusab + accurah - neffib + gpotg + maintf - nmaintf - n323 + p323 + lbound = 70
- nstpron - nbidirn - nflexil + speedf - nspeedf - nrelial + usag + accuram - naccuram + effig + gpotf - ngpotf - nmaintc - n324 + p324 + lbound = 65

Subject to the following boudary constraints:
- nstpron - nbidirn - nflexil - nspeedb - nrelial - nusab - naccural - neffib - ngpotb - nmaintc + lbound = 45

stproy + bidiry + flexih + speedg + reliah + usag + accurah + effig - gpotg + mainte +
lbound = 150
lbound = 100

Subject to the following sign constraints:
flexih - 2flexim + 2nflexim > 0
2flexim - 2nflexim + nflexil > 0
speedg - 2speedf + 2nspeedf > 0
2speedf - 2nspeedf + nspeedb > 0
reliah - 2reliam + 2nreliam > 0
2reliam - 2nreliam + nrelial > 0
usag - 2usaf + 2nusaf > 0
2usaf - 2nusaf + nusab > 0
accurah - 2accuram + 2naccuram > 0
2accuram - 2naccuram + naccural > 0
effig - 2effif + 2neffif > 0
2effif - 2neffif + neffib > 0
gpotg - 2gpotf + 2ngpotf > 0
2gpotf - 2ngpotf + ngpotb > 0
mainte - 2maintf + 2nmaintf > 0
2maintf - 2nmaintf + nmaintc > 0

end

BIOGRAPHICAL SKETCH

Oscar Leonardo Barrenechea was born on March 17, 1979 in Panuco, Veracruz, Mexico where he has the following address: 5 de Mayo #2, Col. Zona Centro, 93990. In December 2002 he earned his bachelor's degree in Industrial and Systems Engineering from the Monterrey Institute of Technology campus Tampico. By January 2003, he was already enrolled in the Master's Degree in Manufacturing Engineering program from the University of Texas Pan-American (UTPA) in Edinburg, TX where he also worked as Research Assistant and later on as Teaching Assistant. And, shortly after that, he had the opportunity to become an Engineering Student Intern for the Texas Manufacturing Assistance Center (TMAC) department.

On 2004 Mr. Barrenechea started working as an engineer for the Advanced Mfg. Engineering department of Alps Automotive, Inc in McAllen, TX. Then in 2006 he was hired as a Mfg. Engineer for the Solid Surface Division of Woodcrafters Home Products, LLC in Weslaco, TX. Afterward, at the beginning of 2008, he was offered to come back to take a full time position as a Mfg. Specialist I for UTPA-TMAC where he has been working to this date, and has gained experience as a training facilitator for more than 30 different companies located along the South Texas USA-Mexico border. His certifications include Lean Mfg., Six Sigma Black Belt, APICS CPIM review modules, Leadership and Team Building. Furthermore, he is a member of the Golden Key International Honour Society.