

RISK MANAGEMENT IN INFORMATION SYSTEM DEVELOPMENT

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ABSTRACT

The purpose of this study is to facilitate the implementation process of the case corporation's new information system for managing their inventory of bus tires. This study attempts to answer the questions "What were the main IT-risks involved with the development and implementation of the new bus tire inventory management system, what kind of effects did they have and how were they dealt with". The study was carried out with the cooperation of the case corporation, Koiviston Auto, as a part of the development of their Tire Inventory Management system.

The data collection for the study was done through participation in the information system development project, interviews and conversations with the various stakeholders and by studying the circumstances surrounding the system and the work processes of the users. This data was then collected as descriptions of the different aspects of the development process and analyzed using qualitative research methods to find out the biggest risks threatening the implementation of the new system.

The study discovered several possible risks threatening the success of the new system. The discovered risks include risks concerning the data transfer from the old system, user resistance towards the new system, the reliability of the system and personnel risk involving the small size of the project group. These findings were used to mitigate the effect of the risks during the implementation of the new Tire Inventory Management system.

Keywords: Information system development, risk, risk management

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1 INTRODUCTION

Most companies today are so reliant on the continued functionality of their information systems that a disruption in those functionalities might completely prevent them from doing their business. Information technology risk management involves minimizing the damages caused by different problem situations involving the usage of information systems. These situations include, for example, loss of data or service caused by software defects, hardware malfunctions or even human error. They can also include damages caused by viruses, malware and general misappropriation (Stoneburner et al, 2002.)

The motivation for this study is to facilitate the success of the case corporation Koiviston Auto's current and future information system development projects, through the means of risk management. The corporation developed a new information system for managing the functions of their bus maintenance department that replaced several older systems that were used to control the different aspects of the maintenance department functions. One of the older systems replaced by the new integrated solution was the bus tire inventory management system. The study's main focus is on the development of the module of the maintenance department management system that controls and manages the inventory of tires used in the corporation's buses.

The aim of the study is to map out the most likely risk scenarios involving the development project of the tire inventory system, so the development could then be adjusted in order to mitigate or avoid those scenarios. In order to accomplish this, a general list of different risk scenarios involving information systems development was drawn up from literature. After this, a list of specific risks involving the development of the tire inventory management system was compiled, based on interview and discussion with the different system stakeholders, as well as observation and participation in the development.

This thesis will analyse the risks specific to the development of the system based on the list of the generic information technology risks, and describe actions taken to mitigate those risks during the project. The thesis will also discuss the unforeseen risk scenarios that rose up during the development and their consequences.

2 RESEARCH

2.1 Research Problem

The research question for this thesis is: What were the main risks involved with the development and implementation of the new bus tire inventory management system, how were they addressed and what kind of effects did they have?

The key concepts are: Risk, risk management, information system development.

2.2 Research Framework

The central concept of the study is risk management, with all the other concepts stemming from it. Starting from factors outside of the actual information system, this study will limit itself to the issues close to this particular system. Factors like general physical security of the server rooms and workstations are not considered.

Tsui (2004, 108) defines risk as *“A problem that has greater than 0% but less than 100% probability of occurrence”*. He also defines problem as *“An event that has a negative value associated with it”*. Normally the negative value associated with problems and risks is defined as money. However, this study will consider the negative value as the general functionality of the system, due to the nature of the case development project making monetary projections difficult.

Ropponen (1999) defines software risks as “*events, states or actions that endanger achievement of set aspiration levels in a software development initiative*”.

This can be seen as relevant to the entire information system development process.

Risk management means mapping out the possible risks associated with a project and planning out responses for them. Information system development is the act of combining hardware and software together to create a system that will perform the specified functions. The concept of personnel risk is used here to refer the risks involving key personnel of the system like developers and administrators. Data security and loss of data are issues mostly related to the coding of the application used in the system. Loss of service can relate both to physical security and the coding the application but is also related to the hardware of the information system and its configuration.

This study will present a list of possible risk scenarios relating to the discussed concepts as well as the possible responses for them. Using a method similar to Synergistic Contingency Evaluation and Review Technique this study will first describe the situation surrounding the development project of the new Tire Inventory Management System and the different parameters affecting its success, and based on the analysis of these descriptions present a list of the most likely risk scenarios as well as suggestions for further study and actions.

Many articles available on the subject agree about the importance of identifying the risks involved with the development and implementation of new information systems. It is important to consider all the possible risks as early as possible during the development while normally that risk assessment is often left at the end of the development. Traditional risk assessment methods can be useful in determining IT-risks but it would be best incorporate the assessment into the requirements collection phase. If the possible risks are identified during the first phase, they can affect the requirements of the entire system and lead to architectural changes during the development phase. In fact, the best approach would be to incorporate the risk assessment into all of the Systems Development Life Cycle (SDLC) phases (Stoneburner et al, 2002, 4-5; Maguire, 2002, 5.)

3 COMMON RISK SCENARIOS

For finding out common risk scenarios involved with software and information systems development Boehm's top-ten list was selected, due to the recommendation of Ropponen (1999, 71-72).

According to Ropponen the Boehm's list is one the most well known and widely used risk listings in the software development industry. However, he also notes that list represents the views software project managers and may therefore not realistically the views of other stakeholders such as the end-users. For the purposes of this study the list will analyzed to remove the entries that don't apply to the research case.

1. Personnel shortfalls. The lack of qualified personnel can be considered relevant to the case project.
2. Unrealistic schedules and budgets. The amount of resources required by the case project is small enough to disregard budget concerns. Since the schedule of the project lenient enough and can be adjusted according to progress the only possible risk concerning it is the project not getting done at all. However, this was deemed not to be an issue due to the amount of oversight on the project.
3. Developing wrong software functions. Due to the amount of oversight on the project, developing completely wrong functions is unlikely.
4. Developing wrong user interface. The oversight on the project should also be enough to ensure that completely wrong interfaces are not developed. However, the project lead group is comprised mostly of office personnel while the end-users of the system will be mostly repair-shop personnel. This might lead to interfaces that are tuned enough for practical application

5. Gold plating. Adding unnecessary features to the system can be a relevant issue with the case project, due to the nature of the development process.
6. Continuing stream of requirement changes. Very relevant with the case project.
7. Shortfalls on externally furnished components. The case system contains very little externally furnished components.
8. Shortfalls in externally performed tasks. The case project has no externally performed tasks associated with it.
9. Real-time performance shortfalls. Poor performance of the finished system may prove to be an issue
10. Straining computer science capabilities. The planned system is simple enough for this not to be an issue.

Based on this analysis, the following is proposed as the list concerning this study:

1. Personnel shortfalls.
2. Developing wrong user interface.
3. Gold plating.
4. Continuing stream of requirement changes.
5. Real-time performance shortfalls.

4 RESEARCH

4.1 Research Method

The study was conducted as a case study. The chosen case is the development of the Koiviston Auto Corporation's bus maintenance department management system with special focus in the tire inventory management sub module. The study concerns itself with finding and listing the possible risk-scenarios involved with the new system and is explorative in nature.

The NIST Risk Management Guide discusses the choice between qualitative and quantitative analysis methods for IT-risk assessment. Using qualitative analysis the focus will be on the risks themselves and their prevention while quantitative analysis can be used for direct cost-benefit analysis. Using quantitative research method in risk analysis offers exact measurements of the risk scenario's magnitude, whereas qualitative method prioritizes the risk and the possible solutions for. Considering that the focus of this study is to provide solutions to improve the reliability of the system, rather than just analyzing the economic effects of the possible scenarios, the qualitative research method is more applicable (Stoneburner et al, 2002, 22-23.)

Avison and Fitzgerald (2002, 304) describe the Synergistic Contingency Evaluation and Review Technique (SCERT). It is a risk management technique consisting of four stages, where you first describe the different activities and the possible risks associated with them, list the risks and the possible responses to them, define the parameters by which the severity of the risks will be determined and finally use the information gathered to decide on the best possible course of action.

Avison and Fitzgerald (2002, 304) also write about the problems of extensive risk analysis. It is often impossible to accurately identify all the possible activities and the probabilities of the risks associated with them. Therefore the risk analysis must

always be consciously simplified to a point where it will accurately identify the most pressing risks.

The main data collection for this study was done by action research, through participation in the development of the new system, and also by interviews of the various stakeholders of the system and analyzing both the functions of the different systems that will be replaced by the new integrated solution, as well as the different work processes of the users.

4.2 Action research

Action research differs from most other research methods by having the researcher involve himself with studied subject, therefore actively affecting the results of the study. Järvinen (2005) notes that the action researcher is interested in the utility of system under study, while social and natural scientists might not be.

Action research
Action research emphasizes the utility aspect of the future system from the people's point of view
Action research produces knowledge to guide practise modification
Action research means both action taking and evaluating
Action research is carried out in collaboration between action researcher and the client system
Action research modifies a given reality or develops a new system
The researcher intervenes in the problem setting
Knowledge is generated, used, tested and modified in the course of the action research project

Figure 2: Characteristics of action research (Järvinen 2005)

Applying action research and risk management to information system development involves taking active part in the entire process. You gather data while working on the project objectives and then analyse that data. You then try to identify the areas of the project where problems are most likely to occur, list possible risk scenarios and attempt to draw up solutions to those scenarios.

After you have identified the problems proposed solutions for them, you still need apply the solutions in practise. Sometimes, applying the solution might actually prove unfeasible and you will need to decide between implementing the solution or just acknowledging risk and preparing for mitigating its possible effects.

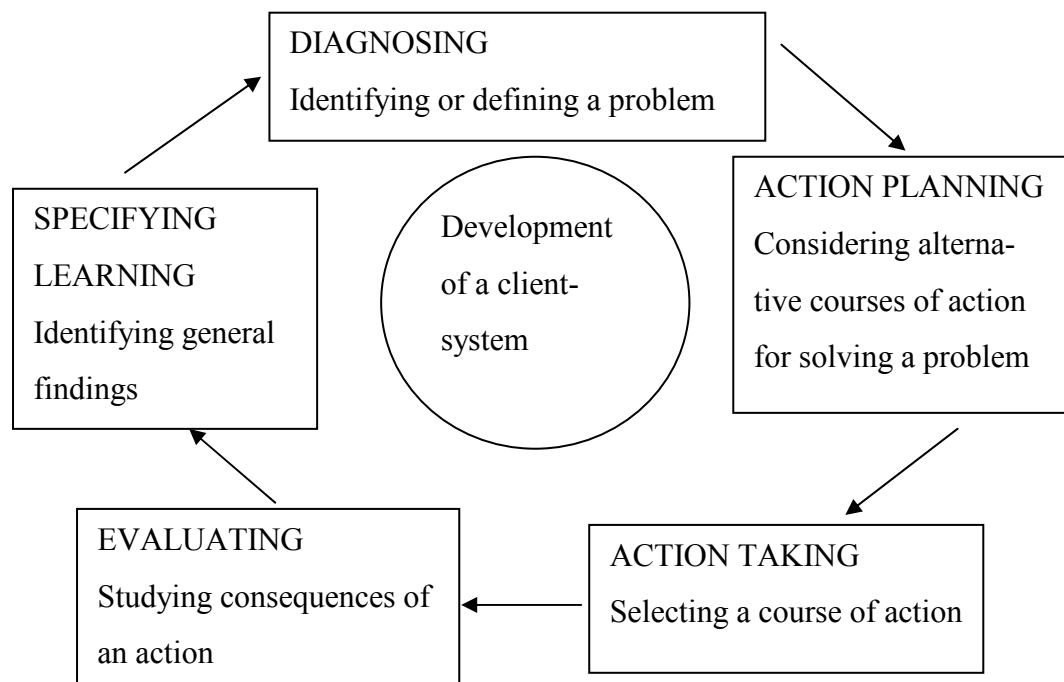


Figure 3: The cyclical process of action research (Susman and Evered 1978 by Järvinen 2005)

Ideally the process of action research is cyclical, as evidenced in the figure (Susman and Evered 1978 by Järvinen 2005), with the aforementioned phases repeating through the entire project. This study however, was limited to a single cycle. We first begin with the Specifying Learning – phase, which is data collection on the implementation process. In the Diagnosing – phase we identify the possible risk scenarios and offer possible solutions for them in the Action Planning – phase. Action Taking is the phase where both the implementation of the system and applying the solutions takes place. Lastly, we move to Evaluating where we analyze the identified risks, the solutions and the consequences. It could also be argued that process repeats in smaller form inside the main cycle, when unforeseen problems are encountered and dealt with.

5 DATA ANALYSIS

The data analysis section of this study is divided into several different parts: Discussion about the current tire inventory management system, work processes of the users of the system and finally the development process of the new system.

5.1 Current system

The current systems for managing the Koiviston Auto bus service department functions and the bus tire inventory are database applications implemented inside Lotus Notes, a corporate communication application. Lotus is a client/server based application that can be used for email, instant messaging, and creating different applications and databases that can be easily shared with the other users in the company (Tamura, et al, 1997.) The databases created in Notes are unstructured, non-relational and save the data as documents. These databases work well if you are storing large amounts of textual information or large documents but can prove problematic for certain applications. The databases in Notes can also grow extremely large, with the largest database in use in the corporation currently weighing several gigabytes in size.

In order for the maintenance department to switch over to using the new tire inventory system, all the information from the old system has to be transferred over. The new system will direct the mechanics in choosing the right kinds of tires to install, in order to maximize their use age, based on several different parameters like the age of the tire and its total use kilometres. For this reason it is essential that all the relevant information about the tires is transferred over correctly.

The current tire inventory management system is a collection of structured documents comprised of fields containing the tire's information and the different methods to manipulate that data.

Figure 4: Example of a tire information entry in the current system

The information from select fields on each tire's card is displayed in the main index that is divided between the different companies in the corporation.

Numero	Runkonro	Merkki	Pinta	Koko	Auto	Sij	Aspvm	Askm	Pintakm	Runkokm	Pinn.pvm	Pinn.krt
2519 2519		MICHELIN	BDA4	295/80R22.5	KA 313 ICS-789	4 Takavas-sis	21.11.2008	705068			11.07.2008	3
2560 2560		MICHELIN	BT-S	315/80R22.5	KA 320 OSS-6216	Takaoik-ulk	26.06.2009	489007				2
2568 2568		MICHELIN	BDA4	295/80R22.5	KA 311 FAB-346	6 Takaoik-ulk	20.10.2008	615706			15.07.2008	3
2606 2606		MICHELIN	BDA4	295/80R22.5	KA 324 OSS-691	6 Takaoik-ulk	14.10.2008	371192			15.07.2008	3
3073 M 5 Y 330007		BRIDGES	BDA4	285/70R19.5	KA 355 XEY-655	1 Etuvasen	07.12.2009	199248		226599	10.11.2009	2
3076 M 5 Y 330183		BRIDGES	BDA4	285/70R19.5	KA 319 LSI-219	3 Takavas-ulk	14.12.2009	268057		266888	02.12.2009	2
3078 M5Y 329857		BRIDGES	BDA4	285/70R19.5	KA 242 TJY-442	5 Takaoik-sis	30.11.2009	178586		199973	10.11.2009	2
3510 3510		MICHELIN	BDA4	315/80R22.5		Lahti Varasto					28.10.2009	3
3522 3522		MICHELIN	BDA4	295/80R22.5		Lahti Varasto					26.11.2009	2
4281		GOOD YE		295/80R22.5	KA 387 LIB-987	9 Vararengas	06.02.2007	0				1
4500 NLB55824N		MICHELIN	K 217	295/80R22.5	KA 292 GBT-259	9 Vararengas	07.08.2000	658000		537805		1
4513 4513		MICHELIN	BDA4	295/80R22.5	KA 274 HXA-404	5 Takaoik-sis	01.03.2010	750922			09.02.2009	3
4515 4515		MICHELIN	BDA4	295/80R22.5		Odottaa pinnoitua			59619	59619	13.11.2008	3
4516 4516		MICHELIN	BDA4	295/80R22.5	KA 311 FAB-346	5 Takaoik-sis	20.10.2008	615706			15.07.2008	3
4538 4538		MICHELIN	XZE2+	295/80R22.5	KA 324 OSS-691	3 Takavas-ulk	01.03.2010	456222	0		02.07.2009	2
4543 4543		MICHELIN	BDA4	295/80R22.5	KA 357 MKC-952	6 Takaoik-ulk	17.12.2008	511903			13.11.2008	3
4550 4550		MICHELIN	BDA4	295/80R22.5	KA 357 MKC-952	4 Takavas-sis	17.12.2008	511903			13.11.2008	3
4561 4561		MICHELIN	BDA4	295/80R22.5		Lahti Varasto					08.01.2010	2
4562 4562		MICHELIN	BDA4	295/80R22.5	KA 375 KHV-965	3 Takavas-ulk	27.02.2009	534323			14.01.2009	2
4591 4591		MICHELIN	BDA4	295/80R22.5	KA 353 ZAS-213	4 Takavas-sis	19.02.2009	600576			13.01.2009	3
4592 4592		MICHELIN	BDA4	295/80R22.5		Odottaa pinnoitua			51963	51963	14.01.2009	3
5535		MICHELIN	BDA4	315/80R22.5	KA 320 OSS-621	1 Etuvasen	14.01.2009	440155				2
5551 5551		MICHELIN	BDA4	295/80R22.5	KA 388 LIB-713	6 Takaoik-ulk	11.01.2010	231915			24.11.2009	1
5553 5553		MICHELIN	BDA4	295/80R22.5	KA 324 OSS-691	4 Takavas-sis	01.03.2010	456222	0		09.02.2009	2
5554 5554		MICHELIN	BDA4	295/80R22.5	KA 375 KHV-965	6 Takaoik-ulk	03.02.2009	524071			14.01.2009	2
5578 5578		MICHELIN	BDA4	295/80R22.5	KA 273 HXA-403	3 Takavas-ulk	02.02.2010	76084			09.02.2009	2
5914 TDA05914A		MICHELIN	BDA4	12R22.5	KA 499 BBN-70	1 Etuvasen	21.12.2007	18871				2
6551 6551		MICHELIN	BDA4	315/80R22.5		Lahti Varasto					04.11.2009	1
6577 6577		MICHELIN	BDA4	295/80R22.5	KA 293 GBY-451	6 Takaoik-ulk	19.01.2010	457480			24.11.2009	1
6606 6606		MICHELIN	BDA4	295/80R22.5	KA 378 KHS-802	4 Takavas-sis	06.05.2009	23070				2
7517 7517		MICHELIN	BDA4	295/80R22.5	KA 313 ICS-789	1 Etuvasen	16.12.2008	800077			13.11.2008	1

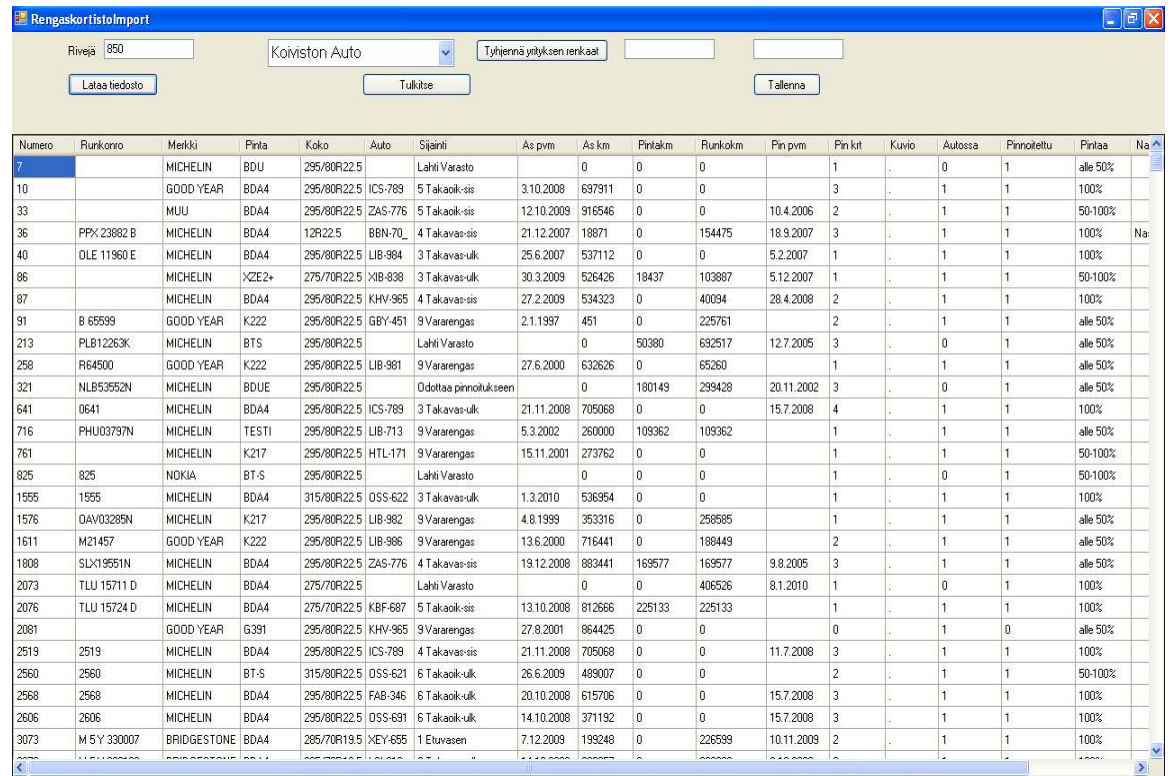
Figure 5: Example of the list view of the current tire inventory system

The current tire inventory management system was deployed in 2001 as part of the current maintenance department management system. The maintenance department management system also functions under Lotus Notes and will be completely phased out in favour of the new system. The current system was created by the Chief Information Officer of the corporation. He was interviewed for the purposes of this study and has also been a part of the development project of the new system from the start.

Before the current tire inventory system the tires were kept track of using Microsoft Excel. This was of course quite labour intensive and the system was prone to errors. The development of the current system therefore arose from user need, and was therefore met with very little user resistance during the changeover. The amount of data that had to be transferred was about the same as now, around 7000-9000 individual tire records and the transfer went smoothly.

Due to the textual nature of the database in the current tire inventory management system, transferring the data into the SQL-database used in the new system is quite problematic. There are some commercial software applications available for transferring Notes databases into SQL-form but they cannot convert the information into the relational database form utilized by the new application. Therefore transferring the information requires the creation of an extra application to handle the conversion.

The version of Notes in use in the corporation supports exporting the data-views of the tire inventory system into structured text files. These files can then be opened in Microsoft Excel and converted into an Excel data tables that are then read into the conversion application. It would also be possible to create an application that would read the structured text files, but converting them into Excel-files makes it possible to utilize a previously created Excel-import component.



The screenshot shows the 'RengaskortistoImport' application window. At the top, there is a search bar with 'Rivejä 850' and a dropdown menu showing 'Koiviston Auto'. Below the search bar are buttons for 'Lataa tiedosto', 'Tulkitse', and 'Tallenna'. The main area contains a table with the following columns: Numero, Runkonro, Merkki, Pinta, Koko, Auto, Sijainti, As pvm, As km, Pintakm, Runkokm, Pin pvm, Pin krt, Kuvio, Autossa, Pinnoletu, Pinta, and Na. The table lists various tire records with details like manufacturer (e.g., MICHELIN, GOOD YEAR), size (e.g., BDA4, BDA4), and location (e.g., Lahti Varasto).

Numero	Runkonro	Merkki	Pinta	Koko	Auto	Sijainti	As pvm	As km	Pintakm	Runkokm	Pin pvm	Pin krt	Kuvio	Autossa	Pinnoletu	Pinta	Na
7		MICHELIN	BDA4	295/80R22.5		Lahti Varasto		0	0	0		1		0	1		
10		GOOD YEAR	BDA4	295/80R22.5	ICS-789	5 Takaoik-sis	3.10.2008	697911	0	0		3		1	1	100%	
33		MIU	BDA4	295/80R22.5	ZAS-776	5 Takaoik-sis	12.10.2009	916546	0	0	10.4.2006	2		1	1	50-100%	
36	PPX 23882 B	MICHELIN	BDA4	12R22.5	BBN-70	4 Takavas-sis	21.12.2007	18871	0	154475	18.9.2007	3		1	1	100%	Na
40	OLE 11960 E	MICHELIN	BDA4	295/80R22.5	LIB-984	3 Takavas-ulk	25.6.2007	537112	0	0	5.2.2007	1		1	1	100%	
86		MICHELIN	XZE2+	275/70R22.5	XIB-838	3 Takavas-ulk	30.3.2009	526426	18437	103887	5.12.2007	1		1	1	50-100%	
87		MICHELIN	BDA4	295/80R22.5	KHV-965	4 Takavas-sis	27.2.2009	534323	0	40094	28.4.2008	2		1	1	100%	
91	B 65599	GOOD YEAR	K222	295/80R22.5	GBY-451	9 Vararengas	2.1.1997	451	0	225761		2		1	1	alle 50%	
213	PLB12263K	MICHELIN	BTS	295/80R22.5		Lahti Varasto		0	50380	692517	12.7.2005	3		0	1	alle 50%	
258	R64500	GOOD YEAR	K222	295/80R22.5	LIB-981	9 Vararengas	27.6.2000	632626	0	65260		1		1	1	alle 50%	
321	NLB53552N	MICHELIN	BDA4	295/80R22.5		Odottaa pinnoletuksen		0	180149	299428	20.11.2002	3		0	1	alle 50%	
641	0641	MICHELIN	BDA4	295/80R22.5	ICS-789	3 Takavas-ulk	21.11.2008	705068	0	0	15.7.2008	4		1	1	100%	
716	PHU03797N	MICHELIN	TESTI	295/80R22.5	LIB-713	9 Vararengas	5.3.2002	260000	109362	109362		1		1	1	alle 50%	
761		MICHELIN	K217	295/80R22.5	HTL-171	9 Vararengas	15.11.2001	273762	0	0		1		1	1	50-100%	
825	825	NOKIA	BT-S	295/80R22.5		Lahti Varasto		0	0	0		1		0	1	50-100%	
1555	1555	MICHELIN	BDA4	315/80R22.5	DSS-622	3 Takavas-ulk	1.3.2010	536954	0	0		1		1	1	100%	
1576	DAV03285N	MICHELIN	K217	295/80R22.5	LIB-982	9 Vararengas	4.8.1999	353316	0	258585		1		1	1	alle 50%	
1611	M21457	GOOD YEAR	K222	295/80R22.5	LIB-986	9 Vararengas	13.6.2000	716441	0	188449		2		1	1	alle 50%	
1808	SLX19551N	MICHELIN	BDA4	295/80R22.5	ZAS-776	4 Takavas-sis	19.12.2008	883441	169577	169577	9.8.2005	3		1	1	alle 50%	
2073	TLU 15711 D	MICHELIN	BDA4	275/70R22.5		Lahti Varasto		0	0	406526	8.1.2010	1		0	1	100%	
2076	TLU 15724 D	MICHELIN	BDA4	275/70R22.5	KBF-687	5 Takaoik-sis	13.10.2008	812666	225133	225133		1		1	1	100%	
2081		GOOD YEAR	G391	295/80R22.5	KHV-965	9 Vararengas	27.8.2001	864425	0	0		0		1	0	alle 50%	
2519	2519	MICHELIN	BDA4	295/80R22.5	ICS-789	4 Takavas-sis	21.11.2008	705068	0	0	11.7.2008	3		1	1	100%	
2560	2560	MICHELIN	BT-S	315/80R22.5	DSS-621	6 Takaoik-ulk	26.6.2009	489007	0	0		2		1	1	50-100%	
2568	2568	MICHELIN	BDA4	295/80R22.5	FAB-346	6 Takaoik-ulk	20.10.2008	615706	0	0	15.7.2008	3		1	1	100%	
2606	2606	MICHELIN	BDA4	295/80R22.5	DSS-691	6 Takaoik-ulk	14.10.2008	371192	0	0	15.7.2008	3		1	1	100%	
3073	M 5 Y 330007	BRIDGESTONE	BDA4	285/70R19.5	XEY-655	1 Etuvasen	7.12.2009	199248	0	226599	10.11.2009	2		1	1	100%	

Figure 6: The data transfer application

After the information is read into the import application it has to be converted into a format that can be written into the database of the new system. The application compares the textual fields like the tire manufacturer name against the list of manufacturers already present in the database and then converts the field into an identity key value that the be inserted into the tire's database table. The date values can be converted straight into the corresponding date time values but the source data contains many missing or erroneous date values that can cause problems during the process. Similarly the numerical km-values of the tires' can be easily converted into 32-bit integer format used in the database but they also contain a lot of bad data. For example, a numerical value of 1.122222222123E+17 will cause an exception during the conversion process due to being too large to fit into a 32-bit integer variable.

Although the current tire inventory system is mostly used through drop-down lists and menus it is still possible to accidentally save false information like menu headings and even type in some of the fields that aren't meant to type into. This

can lead to entries like “Choose” in place of the tire surface texture description or Notes error-messages in place of tire identification numbers.

Another information field that can cause trouble is the current location of the tire. The system by which the ownership of the tires is decided was changed two years ago. Before, each sub company bought their own tires and even though the tires were shipped to and from the Central Warehouse their ownership never changed, only their marked location in the tire inventory. Two years ago the system was changed so that the majority of tire purchases are done by the Central Warehouse and then sold to different sub companies. When a worn-out tire is shipped back to the Central Warehouse for maintenance purposes it becomes the property of the parent company of the corporation. The refurbished tires are then sold back to the sub companies at the price of the maintenance operations. The current inventory system still contains unclear entries where the tire is marked as the property of a sub company but stored at the Central Warehouse. Determining the actual owner and the location of these tires can prove problematic.

The tires marked as installed in vehicles also pose some problems. The car-field in the tires information contains the abbreviation of the company that owns the vehicle, identification number and registration number. The identification number is not constant so the most reliable way of locating the vehicle is by the registration number. The list of all the corporations' vehicles was transferred to an SQL-database earlier on, and the tire inventory import application links the installed tires with cars with matching registration numbers. However, test runs with the import application came up with several instances where a tire is marked as installed in a vehicle that cannot be located in the database. The most likely explanation for these instances is that the vehicle in question has been scrapped but the problem lies in determining whether the tires have been scrapped as well or if they've just been marked wrong in the system.

In addition to the information displayed in the index view of the tire inventory system, each tire's card also contains a section devoted for its history. The history section lists all the instances where the tire was either installed in or removed from a vehicle, transferred from one location to another, the repairs done on it and the

times it has undergone a surface replacement operation. This data cannot be listed in the index view and has to be exported from the system separately from the tires' general information. The data can be exported in a form of list where each row contains information about several actions done on a single tire, identified by the tires identification code. The history entries can be connected to their prospective tires through the code but translating them into a format compatible with new database will require a different kind of algorithm than the one designed for transferring the basic tire information.

5.2 Work Processes of the Users

The Koiviston Auto Corporation's process for handling bus tires is centred on the corporation's department called the Central Warehouse. Most of the new tires that come into the system are purchased by the Central Warehouse, where they are then given an identification number and entered into the inventory system. The maintenance departments of the corporation's sub companies then place orders to the Central Warehouse, which supplies them with new tires and bills the sub company for the price of the tire. The individual bus repair shops receive the tires sent from the Central Warehouse put them in storage to wait for install in vehicles. In each repair shop there is storage of at least a couple of extra tires per vehicle working inside the shops service range.

New tires can also enter system through vehicle purchases, in which case their information is entered into the inventory system by the mechanics of the sub company that receives the vehicle.

When a tire is installed in a bus, the reading of the vehicles odometer is entered into the tire management system. When the tire is removed from the vehicle the new odometer reading is entered in order to determine the total usage kilometres of the tire. In the new system the odometer reading is drawn automatically from the vehicle information database that is, in turn, updated from the information entered by drivers during gas refills. This will reduce the amount repetitive data

entry done by the mechanics. However there have been considerable amounts faulty data entries into the refill system. Most common entry error contains extra, or too few, digits and can cause discrepancies of thousands of kilometres in the final calculations of the tires usage kilometres.

After a tire has been removed from a vehicle, due to being damaged somehow, in one of the repair shops, it is usually shipped back to Central Warehouse. At this point the tire becomes the property of the parent company of the corporation. At the Central Warehouse the tire is inspected and is either scrapped or sent for repairs. After a tire has been repaired it is sent to a sub company that has a need for it. The sub company is billed for the price of the repairs on the tire.

The Process for Buying, Retreading or Disposing Tires					
Acquisition	Measure	Bookkeeping	Storing	Delivery	Bookkeeping
New tire to the Central Warehouse (Bridgestone, Michelin)	Numbering	Tire inventory, Purchase (Accounting system)		By company truck, bus transport, outside transporting company	Tire inventory , builling the subcompany (Accounting system)
Used tire returned to the Central Warehouse(from subcompany, scrapyard)	Grooving	Tire inventory			
	Retreading/repair (Rengas-Vekka Oy, Hämeenlinna)	Tire inventory, ordering (Internet, rengas-veikka.fi)	Inspection, tire inventory, buy-in(accounting system)		
	Disposal (Rengas-Vekka Oy, Hämeenlinna)	Tire inventory			

Figure 7: Diagram of the tire handling process

5.3 Development of the New System

The development of the new Maintenance Department Management system was started at the fall of 2009. The development has been carried out internally by the corporations IT-department. The corporation has long traditions in using internally developed applications due to the flexibility it offers. Earlier, most of the development was done by the corporations' IT-manager and the main IT-designer, who are these days busy with managing the ever-growing IT usage in the corporation.

Due to this the corporation now employs another IT-designer doing full-time development of new applications for internal use. For the new management system he has been doing the development of the main system with the development of the Tire Inventory system sub module being handled by another new IT-designer. The system is planned to be implemented at the beginning of June 2010 with a trial period lasting through the summer, in preparation for the busier period of the year starting at fall.

The development of the system has been done following a general Rapid Application Development style. Features have been implemented one at a time with the development controlled by meetings with the project lead group, approximately once every two weeks. The project lead group is comprised of the Director, Chief Information Officer and the Technical Director of the Koiviston Auto Corporation as well as the Central Warehouse Manager. During the meetings the lead group inspected any changes done to the system and requested new features.

The main architecture of the management system is based on the architecture of the ERP-system controlling the production of the corporations' bus factory. The system was developed in part by the IT-designer in charge of the Maintenance Department Management system development.

The system consists of individual applications, running on workstations in the repair shops, which get their data from a server machine running a Microsoft SQL-server. The server machine is located in the main server room in the corporations' headquarters in Lahti.

The development of the software of the system has been done on Microsoft Visual Studio 2005, using C#, Windows Forms and .NET 3.5.

6 RISK ANALYSIS

6.1 Identified risks

The descriptions of the circumstances surrounding the development of the Tire Inventory Management system pointed out many of the problems faced during the development so far and ones that are yet to be dealt with. Of course the problems aren't the risks that this study is aiming at revealing but critical areas of the implementation that have a lot difficult problems are the main source of the risks threatening the success of the project.

This study focuses on the aspects surrounding the implementation of the new system and system it is replacing. The aspects regarding the software architecture of the new system were left out from this study.

After analyzing the data gathered, the following issues were identified as the main risks threatening the implementation of the Tire Inventory Management system. The parameters by which the identified risks are prioritized were determined based on the risk's effect on the reliability of the system and the success of the implementation process.

Firstly the issue of transferring the data over from the current system still has several problematic areas and there is a clear risk that some of the errors will transfer over and cause problems in the functions of the new system. The structure of the new system is flexible enough to allow small deviations from expected values but nevertheless the data should be cleaned up before the final changeover.

Secondly there is the risk of user resistance. Throughout the development process there has been very little input from the actual end-users of the system, the maintenance department personnel, and the decisions regarding the user-interface have

been done exclusively by the management. The maintenance department personnel have traditionally been quite doubtful regarding any new IT-developments and there is the added factor that the current system has been working well enough for them to see no clear benefit from having to learn the usage a new system. Also the new system can be seen as more constrictive with the feature that instructs the mechanics in the selection of tire to be installed. The user resistance should be lessened by the fact that each of the repair shop managers has a direct line of communication with the system developers and they can suggest smaller adjustments to the user interface once the trial period has begun. Also, the users will be personally trained in the use of both the new Management system and the Tire Inventory system by the developers, which will give an opportunity for more personal feedback and reassurance.

Thirdly there is risk involving the general reliability of the new Tire Inventory system itself. Since there is no separate testing or QA teams involved in the project, most of the testing of the new system will be done by users during the trial period. This combined with the general lack of experience of the developer can lead to possible loss of data or service on the system. This risk is mitigated by the in-house development of the system, which allows for fast response times on any problem situations and quick fixes for possible bugs, since maintenance of the system is done by the original creators. It also allows for more personal communications between the user experiencing the problem and the creator of the system since there are no extra levels of tech support organization to pass through.

Lastly there is the personnel risk involving the system developers. Since the development team is so small, they are the only people who know the structure of the system well enough to maintain or fix it. In order to decrease the risks related to this the systems code must well documented to allow others to easily interpret the different functions. The current state of the documentation of the Tire Inventory Management system is quite inadequate, and is therefore one of the areas where immediate corrective actions are necessary.

6.2 Categorising the risks

For categorising the identified risk scenarios the list discussed in chapter 3 is used.

1. Personnel shortfalls.
2. Developing wrong user interface.
3. Gold plating.
4. Continuing stream of requirement changes.
5. Real-time performance shortfalls.

The risk involved with transferring the data from the old system is quite difficult to categorize based on the list. The only possibility is to group it under item number 5, since it directly affects the reliability and function of the new system. Categorising the risk of user resistance is even harder. In fact, the Boehm's (1989) list that was used as the basis of this categorising used makes very little mention to the attitudes of the users. The closest possible category for the risk would most likely be number 2, developing the wrong user interface. The risk involved with the general reliability of the system most clearly belong under number 5 category as well, although the some issues affecting it could be categorised under list items 3 and 4 as well. The personnel risk involving the system developers belongs in category 1, personnel shortfalls.

7 REALIZED RISKS

The development of the Tire Inventory Management System begun in the fall of 2009 and was finished in the fall of 2010. The system was deployed in limited form during the summer of 2010, for testing and training purposes. The old system was still in use until a specific cut-off date. At that time, the old system was locked so that no new data entries could be made and all the information it contained was transferred over to the new system.

The trial period gave an opportunity for finding and fixing several smaller problems and bugs in the system, but as development was still underway with some parts of the system, it cannot be classified as a proper testing period.

This section will discuss the consequences of the risk scenarios identified in section 6, as well as any problems that didn't come up during the earlier risk analysis.

7.1 Identified Risks

7.1.1 Problems with the data transfer from the old system

As was explained before, transferring the data from the previous tire inventory system was considered one of the key areas where problems might occur. In addition it was also one of the areas most crucial to the success of the new system, since re-entering the data about the existing tires by hand was not feasible while having the data in the system was required to actually use the system.

After the issues with the transfer were brought up by the study, it was decided that the system change-over period would be extended to two days. It was also decided that the data would be transferred one sub-company at a time. Having two days to complete the procedure gave enough time to properly verify the transferred

information and doing one company at a time made it easier to organise the procedure.

During transfer it was found that slightly larger number of tires had incorrect vehicle identification information than was previously estimated. This was found to be caused by the fact that while the tire inventory database had still been updated during the summer, the Lotus Notes vehicle database, which was transferred to new system earlier as a part of the larger Maintenance Department Management System project, had been not. This would not have been problem, if not for the fact that new vehicles had been entered into system during the summer and they were assigned identification numbers that corresponded with older vehicles found in the un-updated Notes database. This database in turn was linked to old tire inventory system and when tires were installed to the new vehicles, the system assigned them registration numbers from the old vehicles.

During the data transfer to the new system, the import application could not connect the registration numbers to any of the vehicles in the new database and classified the tires associated with them into the unknown –category, which created for this purpose after the study's findings concerning the transfer procedure. Because of the extra time allotted for transfer, it was possible to modify the import application to enter the vehicle's identification number into the freeform info-field for each of the tires classified into the unknown-category. Because the amount of afflicted tires was only around 50, it was possible to use this information to manually allocate them into their correct vehicles. To solve the issues concerning the history entries on the older tires, it was decided that the transfer of that information wasn't necessary since the old system can be kept around in read-only form until all the older tires have been disposed of.

As a whole, the transfer process clearly benefitted from the steps taken in response of the issues uncovered by study, as most problems were either avoided or sufficiently mitigated thanks to the extra time allotted for the change-over.

7.1.2 User Resistance

One of the main worries with implementation of the new Tire Inventory Management system was the user resistance by the maintenance department personnel. Traditionally it has been fairly difficult to explain the need for new systems and the new practises involved with them to repairmen, who generally aren't too interested or are busy enough with their work, to spend a lot of time with data entry.

As a part of the implementation process of the new Maintenance Department Management System, a series of training sessions were held at all of the major offices of Koiviston Auto Corporation around Finland. The sessions were usually attended by the repair shop supervisors and in some other repair shop and office personnel. During these sessions the developers of the new system, in addition to giving training on the use of the Management System and Tire Inventory, held lengthy discussions with users about the systems in general and the new practises required. The sessions were very informal in nature and the users were encouraged to give as much feedback as possible. This helped to ease any doubts the users might have had about the new system. It also resulted in some new ideas about the user interfaces which, when implemented, further helped to assure the users that their opinions are actually listened.

Concerning the Tire Inventory Management System, the main thing that was emphasized during the training sessions was ease-of-use of the new system compared to the old one. In the old system the users had to work with a list based interface, entering data one tire at a time. The new system allows them to easily manage all the tires of the each vehicle they are working on and features a simplified interface with drag-and-drop functions as well as requiring far less manual data entry. Pointing out the benefits of the new system in keeping tire storages of the repair shop in good order helped with the acceptance of the more constricting features like the automatic tire selection and the fact that the users have less change to interact with the storages of other offices.

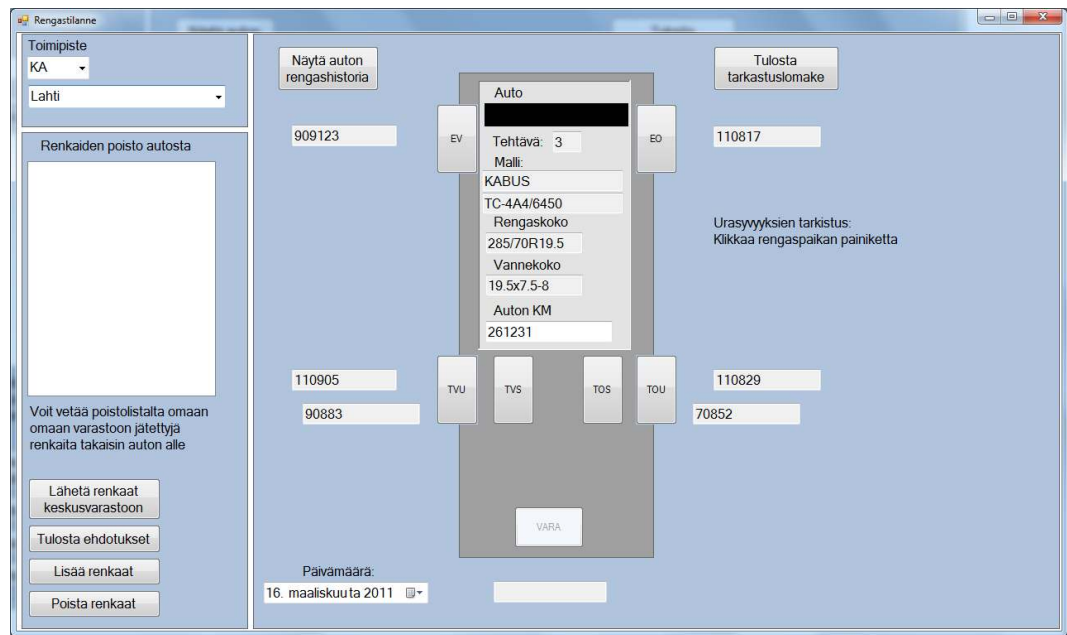


Figure 8: The user-interface for manipulating the tires in a vehicle in the new system

Listening to the user feedback continued after the training sessions, with implementing new features suggested by the users and fixing bugs reported by them.

In all, the user resistance encountered during the implementation of the Tire Inventory Management system was less than expected. In some cases, the users wanted additional training sessions held after the main sessions, but this was more of a fault with the implementation of the original sessions. While planning for the main training sessions, it was decided that to save and time effort, the repair shop managers would be trained in the use of the system and they in turn would instruct the other personnel. This approach worked in some cases but in others it turned out that the managers either hadn't sufficiently learned the system themselves or simply lacked the time to properly instruct the repairmen in its use. These problems were sufficiently addressed during the incremental training sessions.

7.1.3 Reliability of the System

As was mentioned earlier, the general reliability of the new Tire Inventory System can be called into question due to the main developer being fairly inexperienced in larger software projects.

Other issue that can factor into the unreliability of the system is the list of the requirements of the system, which was constantly changed during the development. The consulting company PM Solutions recently found (PM Solutions, 2011), that problems with requirements was the most common reason for failures with IT-Projects, so obviously it presented a great challenge for the success of the implementation project.

The system was developed using a Rapid Application Development methodology. The process involved lots of prototyping and new features were presented to the control group in bi-monthly meetings. This helped to ensure that system was shaping up as wanted but it also meant that new features were added and existing ones were scrapped in the middle of development, sometimes in a quite uncontrolled manner. It also led to the documentation of the system to be quite inadequate due to limited resources and the features of the finished system being different than at the planning state.

As of six months after the implementation of the new system, it has been working reliably enough that the old system was removed from as scheduled. During this period some bugs have cropped up, but they have been dealt with rapidly.

As expected, the in-house nature of the development has allowed the debugging of the system to proceed smoothly and the response time in fixing problems has generally been hours.

7.1.4 Personnel Risk

The continued maintenance of the new system was determined to be at risk, due to small number of people who are familiar with its architecture. While the architecture is straightforward enough, effective maintenance of an information system always requires either a good understanding of system or extremely good documentation. As it stands, only two people in the company are capable of maintaining the system without any specific orientation or education on it. This fault is also shared by the main maintenance department management system, but that system is documented better.

Improving the documentation of the tire inventory system was offered as a solution for mitigating the possible effects of this particular risk, but that was hindered by lack of resources. As a result, the personnel risk involving the tire inventory system is still present and continues to be a threat beyond the implementation process. After analysing the circumstances of the identified it is clear that the personnel risk should've been prioritized higher in the initial estimates, considering the effects it may have on the future reliability of the system. However, it is still quite possible to mitigate the risk, mainly by improving the documentation of system.

7.2 Unforeseen Problems

Analysis of the outcome of the Tire Inventory Management system development project showed that most of the problems encountered during the project could be classified into the risk categories found earlier in the study. After the analysis outlined in chapter 7.1, only one issue remained uncategorized.

As described earlier, the system was implemented alongside the new Maintenance Department Management system during the summer of 2010. While the tire inven-

tory system was deployed in test capacity, the other system was ready for production use at this point. There were several factors affecting this.

Firstly the Maintenance Department Management system had already undergone a testing period of several months during the spring of 2010, and had therefore had the most critical bugs affecting it identified and fixed. The second factor involved the time required for the user training of both systems. The Koiviston Auto Corporation has offices in 9 major cities around Finland, as well as couple of smaller depots containing repair shops and garages. Getting all the relevant personnel to a single location for one training session was simply not feasible. Therefore the developers of the new systems had to personally travel to each location for the training sessions, which took practically the entire summer. Due to the nature of the Maintenance Department Management system, it was possible for each office to transition over to using the new system immediately after the training session. This was not possible with the Tire Inventory system; due to the fact that it contains a lot of interaction among the different offices, causing a staggered deployment to complete throw the inventories off balance. Because of these factors, it was decided that while the exact date of transferring over to the new Maintenance Department Management System was left up to each office to decide by themselves, the Tire Inventory Management system would have to be deployed at the same time everywhere. During the training sessions, the repair shop personnel were instructed to test out and acquaint themselves with the new system and continue making all the relevant operations using the old system, so that the system database would be up to date during the transfer.

Approximately two weeks before the Tire Inventory Management System deployment date, it was found that the repair shop personnel in three different offices had misunderstood the instructions given during the training and had moved to exclusively using the new system by themselves. Due to this, the tire transfers to and from the central warehouse had not been logged properly in the old system and many installations into cars had not been recorded in either system because the tires had not been entered into the new system yet.

Since the database entries that presented actual installations and other activities done by the repair shops that had moved to using the new system were impossible to discern from the training entries done by the other repair shops during the data transfer, the only solution was to recreate all the correct entries in the old system and follow with the original plan of wiping the test database of the new system and transferring the data over.

The operation history function of the new system could be used to get a list of the activities done during the erroneous period but actually separating the actual entries from the training entries proved difficult, since the function that separates the entries based on the user's office wasn't finished until late in the development. In the end, the correct entries were found by cross-referencing the tire-identification numbers and the offices of the vehicles they had been installed or removed from. The data was then manually entered into the old system.

This scenario was not predicted during the risk assessment phase. The main reason for the oversight is that during that phase the user training and testing phase had not been properly planned out yet and the necessity of the simultaneous deployment only became apparent later in the development. The incident clearly demonstrates the need for continual risk assessment during all the phases of the project.

Had this problem been accurately predicted earlier during the development, its classification based on the Boehm's list would have been quite difficult. It obviously belongs in the same category with user resistance risk discussed earlier but it cannot be classified under "developing wrong user interface". The only possible option would be "real-time performance shortfalls", due to the fact that the system failed to cope with the given situation. The easiest mitigation strategy for this scenario would have been increased oversight during the test-period.

8 CONCLUSION

This study set out to find out what were the main risks involved with the development and implementation process of the new Tire Inventory Management System. Based upon recommendations from literature, qualitative research methods were found to be the best approach for the purpose. A description of the circumstances surrounding the development of the system was compiled based on the interviews and discussions of the stakeholders, analysis on the work processes of the users, analysis of the system being replaced and information collected through participation in the development process. The main research method used in this process was action research.

Based on the Synergistic Contingency Evaluation and Review Technique the description was analysed to find out the greatest risks threatening the project. These were determined to be problems involving the data transfer from the old system, user resistance towards the new system, general reliability of the new system and personnel risk involving the developer of the new system. These risks were compared to the list of software development risks presented by Boehm (Figure 1) and were found to partially match the common risks.

The found risks were used to draw up mitigation strategies to ensure that the implementation of the system would proceed smoothly. The risks were either avoided completely or sufficiently mitigated, so that they didn't actually become problems. The one exception to this was the problem of users switching over to the system too early, which wasn't identified as a risk during the assessment stage, due to the fact that the circumstances that affected it hadn't completely revealed themselves at that point.

The study demonstrated that a proper risk management process can make the implementation of an information system go much smoother by giving the developers an early warning on problems and forcing to plan and take action on their ac-

count. Many of the risks identified in this study had the potential to become major problems that could have threatened the success of the whole system, had they not been accounted for.

Analysing the findings of this study, it is clear that they are closely tied to the circumstances of this particular case and their usefulness for other application might therefore be limited. However, many of the observations made can be considered relevant to other small-scale in-house information systems development projects. Examining the case corporation's history with other internally developed systems, it was noted that many of them share problems of poor documentation of overt reliance on few key people for maintenance and improvements. One possible avenue of further research would be to find out if this is the case in other companies employing a lot of in-house development for their information systems.

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