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**MANAGEMENT OF KNOWLEDGE IN HIGH-TECHNOLOGY:
BALANCING DELIVERABLES WITH LEARNING IN A PROJECT-
TEAM BASED FIRM**

A Thesis in
Management Studies
by

Jeremy A. Neuringer B. Comm. 1995 - Carleton University

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Management Studies

September 1996

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Thesis Supervisor

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September 1996**

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1. Summary

During the past few decades, high technology industries have moved away from mainly functional or departmental organizational structures towards project-teams and matrix structures (Wheelwright and Clark, 1992; Smith and Remertsen, 1991). The motivations for this trend have been to increase competitiveness with respect to time to market, to improve product quality and reduce the cost of development. The trend toward project-teams has indeed helped many firms develop quality products on time and on budget (Larson and Gobeli, 1988; Craft, 1995). However, the question has been raised whether the drive to improve efficiency and effectiveness of deliverables, through better integration and coordination (Hauptman and Hirji, 1995; Lawrence and Lorsch, 1967), may hinder their ability to develop expertise and specialization (Allen and Hauptman, 1987; Larson and Gobeli, 1988).

The use of information technologies, such as CAD/CAM/CAE and Groupware, is expected to play an important role in the management of product development teams (Allen and Hauptman, 1987). Data are effectively stored, accessed and updated in these information systems and tools, however, procedural and tacit knowledge is accumulated individually (Nonaka and Takeuchi, 1995; Leonard-Barton, 1995). Given that organizations are adopting more team-based structures, individual employees become less effective in terms of knowledge accumulation and retrieval. Therefore, more emphasis on meeting a firm's knowledge needs might be placed on information systems.

Little is known about this topic from previous analysis (Nonaka and Takeuchi 1995). This present study is qualitative with the goal of identifying the relevant factors, problems, hypotheses and generating propositions for further research.

The units of analysis used in this study are the critical incidents of problem solving in product development projects. To collect data, I have followed these incidents, tracing how information and knowledge needs were served in each. Team members, leaders and functional managers from several different teams were interviewed to accomplish this task. The firm utilized for this study was a medium-sized telecommunications manufacturer with a matrix structure.

2. Research Questions

The following are the most relevant and informative questions to be asked about the subject matter at hand, making clear the objectives of this research

Question #1: Given that a shift toward project teams and matrix structures changes the ability of firms to manage knowledge, how are firms currently managing their specialized technical knowledge?

The question is posed under the assumption that high-technology R&D firms are still able to be successful. The answer should shed light on whether the above mentioned shift substantially alters the ability of a firm to manage content-specific knowledge over long periods of time. The answer could be used in identifying how successful the shift has been in the long-run to improve performance.

Question #2: What roles do information technologies play in the management of knowledge?

This question is designed to identify the usefulness of the myriad of new information technologies and communication tools in their role in the management of knowledge.

3. Importance of this Research

During the past several decades, a trend among design and manufacturing firms in high technology and other sectors, has been a move toward project-team or matrix structures. This departure from functional structures has allowed modern organizations to improve their competitiveness both in terms of time and the cost of specific deliverables.

The first research question posed in this study relates to how managers are coping with the possibility that changes in structure may compromise the ability of a firm to capture discipline-specific knowledge (Larson and Gobeli, 1988). I intend to describe current solutions to this problem, which will have implications for future research and practice. Hopefully, one outcome will be a clearer understanding of the structure of knowledge and expertise in a team-based organization.

The second question deals with understanding the role of various information technologies in helping to manage knowledge and expertise. Technologies such as CAD, CAM, CAPP and Groupware are being introduced and implemented in many companies, particularly in the high-technology industries. A second outcome of this research is a better understanding of the role these information technologies are currently playing.

During preliminary discussions with functional managers and team leaders, there was a general concern that underlying issues relating to the management of knowledge are not being sufficiently addressed by industry. This study is designed to address these questions for practitioners, and to raise new questions for researchers in the field.

4. Literature Review

4.1 Organizational Structure: Balancing Deliverables and Knowledge

Companies adopt organizational structures to suit their internal needs and the needs of their surrounding environment (Lawrence and Lorsch, 1967). Functional structures group employees according to their discipline or expertise (Galbraith, 1977).

This type of structure has become the norm for large North American production companies (Lawrence and Lorsch, 1967). Marketing, manufacturing, Research and Development (R&D) are among the traditional functions. Each project the company wishes to undertake usually goes through these functions systematically until completion. Some larger companies have the entire functional structure replicated numerous times where there is a significant division of product-type.

More recently, there has been a need to develop more complex products in shorter periods of time and at lower cost. The functional structure focuses on specializing groups of people to perform specific tasks (Lawrence and Lorsch, 1967). This specialization hinders the company from making rapid changes outside those specific tasks the functions are used to performing, making the functional structure slow in adapting to a changing environment (Lawrence and Lorsch, 1967). Another approach to corporate structure is to form highly integrated groups of functional people. Individuals from each of what were the traditional functions placed into a single group could outperform the older structure on the basis of deliverables (Lawrence and Lorsch, 1967).

A company with a highly integrated structure has the ability to develop and produce products more quickly and less costly, supporting ever growing external environmental demands. Long-term needs, such as the accumulation of discipline-specific technical knowledge may be sacrificed. Lawrence and Lorsch (1967) suggest that a balance between specialization and integration will optimize the tension between internal and external requirements. The balanced structure resulting from this compromise is a matrix. Nonaka and Takeuchi (1995) support the argument that one must include components of both functional structures and project teams in order for a company to be able to perform well in achieving deliverable and learning goals.

Lateral links among functions were the birth of the matrix structure (Galbraith, 1977). Once it was recognized that there is a significant benefit to using these cross-functional teams, managers of development and production firms quickly adopted the matrix structure as a new standard (Wheelwright and Clark, 1992; Smith and Reinersten, 1991; Craft, 1995). The matrix structures vary from mostly functional to mostly project team, with several steps in between (Larson and Gobeli, 1988). Firms more focused on research and new product development tend to choose structures that are closer to the project-team end of the spectrum, while production firms with long-lasting products choose more functional structures. A matrix, by itself, does not imply a specific structure. In fact, there are different levels and loci of control within matrices that create a myriad of corporate structures. Wheelwright and Clark (1992) and Hayes et al (1988) depict some of the most typical variants of the matrix structure (see chart 4.1 next page).

Figure 4.1: Team Structures

Wheelwright and Clark, 1992

The different foci of power and control in the matrix structure yield different performance outcomes. The figure 4.2 on the next page summarizes overall performance on deliverables (Larson and Gobeli 1988).

Figure 4.2: Structure Performance

See Appendix I for breakdown of performance Larson and Gobeli, 1988

One of the key roles of an organizational function is to perform its designated task well, and to accumulate experience about that task over the years, so that it may improve the process and efficiency by which its task is accomplished in the area of its expertise (Allen and Hauptman, 1987; Lawrence and Lorsch, 1967). A project-team, on the other hand, is focused on the deliverable it was assigned to produce (Brown and Van de Ven, 1991). At the same time project-teams typically accumulate technical knowledge required by the project at hand; however, there is little incentive to build that knowledge into a generalizable repertoire of knowledge for future use.

Project teams take advantage of tight coordination and integration, often supported by close proximity (Allen and Hauptman, 1987), for product development. Information, knowledge, resources, ideas and motivation are gathered by members for the

purpose of product development. Inevitably, just after this period of high concentration, a product launch will soon follow (Wheelwright and Clark, 1992).

The figure 4.3 below illustrates the typical innovation funnel of product development in project teams.

Figure 4.3 Innovation Funnel

Modification to Wheelwright and Clark (1992) by Hauptman for class notes

During development, teams are focused on producing the deliverable with the limited resources they have been allocated. Many companies have internal competition among teams so that resources are a scarce commodity. Teams under pressure to maintain their budgets, focus on external goals primarily (Brown and Van de Ven, 1995).

As teams age, on large or long-term projects, developments appear that might erode the efficiencies gained by a project-team approach. The negative relationship between tenure of team members (to the team) and performance (Katz and Allen 1982) is caused by the inward focus of teams, which after a period of time may reduce a team's willingness to seek out and accept advancements in technology external to the team. This "Not Invented Here" syndrome (NIH) is similar to another problem which exists in team groups as they age. That is "Groupthink". The temptation to support the current stage of a deliverable, rather than point out possible flaws, is an inherent problem associated with teams. A possible solution to this problem as Daft (1992) and Wheelwright and Clark (1992) have indicated is to provide outside audits, control and team rotation.

A careful balance between empowerment of teams and external control from functions is required to promote continuous high productivity (Katz and Allen, 1985). The matrix structure implies a shared control between teams and functions.

So far the argument presented here has shown that the structural compromise between integration and specialization is critical for a high level of performance on deliverables by a development firm (Larson and Gobeli, 1988). Most of the literature on the subject focuses on this external goal, rather than examining equally important long-term goal of learning. With a highly project-team based structure, this becomes more difficult (Larson and Gobeli, 1988; Allen and Hauptman, 1987). The figure 4.4 on the following page demonstrates the tenuous balance between performance on these internal and external goals as defined by Lawrence and Lorsch (1967).

Figure 4.4: Accumulating Knowledge vs. Performance

Modification to Allen and Hauptman, 1987

Specific methods, especially the use of information may improve the combined performance of the above trade-off between accumulation of knowledge and performance (Allen and Hauptman 1987; Nonaka and Takeuchi, 1995; Leonard-Barton, 1995). The horizontal dimension shown above is generally accepted, in that there is a great deal of writing and empirical work supporting the idea that greater integration leads to higher deliverable performance (Larson and Gobeli, 1988; see also figure 4.2). Additionally, there is little dispute that the horizontal component of the I/I arrow, the use of information technology can, through improved coordination, increase the productivity of teams on deliverables (e.g. Allen and Hauptman, 1987; Hauptman and Hirji, 1995;

Robertson and Allen, 1992, Smith and Reinersten, 1991). What is not well documented is the ability of information technology to play a role in the management of technical knowledge and the development of organizational capabilities, the vertical dimension of the I/T arrow above.

4.2 The Role of Information Technology

Much work by researchers and practitioners has been done involving the implementation of information technology. However the majority of this work, covers only one of the real corporate requirements described in the previous section, that is Information Technology has a definite role to play in the coordination of team members and functional counterparts throughout organizations. Little is known about how this may help a firm to accumulate discipline-specific technical knowledge, or functional knowledge.

CAD/CAM/CAE play a role in the coordination of production and the development of products. They are tools which form a common reference or language for involved players, and a focus-point for specific projects. Adler and Hellelaid (1987) indicate that the use of CAD/CAM is an effective tool in the development of products, but that there can be problems with the uses of this technology. Having the support and reassurance of high-level management is clearly an advantage in any system. These authors show, however, that the direct involvement of upper management, on a technical level, can impede the ability of the system and its key players to perform their jobs, due to

management's relative ignorance of the technical knowledge involved. This point contradicts Craft (1995) in her prescription for functional management control of teams. The use of such technologies as an inter-functional network can improve performance of development (measured by time and by cost) better than a product champion can (Adler and Hellelaid, 1987).

Robertson and Allen (1992) support the idea that CAD/CAM creates a common reference language for all team players, but that the use of CAD/CAM is more effective to individual users. Larger teams may lead to coordination costs, such as diffused coherence and redundant communication (Hauptman 1986), and may be minimized by better communication technologies. Although information technology, like e-mail and groupware, can reduce much of the coordination costs in larger projects, it does not act necessarily as an agent to communicate or capture expertise. Robertson and Allen (1992) show how CAD is a physical capital, working in conjunction with the knowledge held by its users.

Recently, Leonard-Barton et al (1994) showed how CAD/CAM improves the product development process: high-tech companies such as Kodak and Hewlett-Packard are using CAD/CAM systems to share project specific information among reasonably large groups of various functional team members. The goal of this sharing is less to achieve success on a particular project or product, and more to allow the creation of knowledge relevant to an entire product line (Wheelwright and Clark, 1992). CAD/CAM is used to create shareable libraries and modules that are reused by other teams in subsequent development projects.

In addition to the more traditional tools of CAD/CAM, there are communication tools which exist to reduce the coordination costs involved in larger projects, especially where group members are separated by time and distance. One example, as given by Allen and Hauptman (1987), is groupware. It is a computer application that will manage various aspects of a project and allow many users to share related information regardless of their location.

E-mail also acts as a linkage among group members, connecting their ideas and thoughts about a subject quickly and with little inconvenience. A broader use of e-mail technology, in bulletin boards or more recently internal news-groups, has become a knowledge-building tool. An a priori proposition of this thesis is that communication technologies may improve the ability of managers to keep track of pointers to people who possess specific knowledge units. Through constant interaction with one's co-workers, it is perhaps possible to maintain a map of the knowledge units required to perform a project-related task (Hauptman and Hirji, 1995).

There is a gap in theoretical understanding of the uses of information technologies in the role of management of knowledge. This point is raised by Leonard-Barton (1995) but is not yet addressed.

4.3 Knowledge and Learning

Development firms acquire at least two types of knowledge throughout the process of bringing a product to market. These entail specific technical knowledge related to the product itself, and how to manufacture the product effectively to meet cost, quality and temporal goals. Management scientists and production management specialists teach many techniques which assist companies learning to improve these areas by implementing concepts such as total-quality-management and just-in-time inventory control. While this learning is very important, it focuses on the process side. The recent adaptation of the phrase "the learning organization" focuses on the process side of learning (Goh, 1995) and does not necessarily include discipline-specific technical expertise.

Not surprisingly, the information technology that has been shown to assist companies to coordinate projects through improved communication among its members, also allows for learning at the process level—the use of CAD/CAM to expedite development on product revisions. Few authors (Leonard-Barton, 1995; Nonaka and Takeuchi, 1995) address the subject of using information technology to accumulate tacit or explicit discipline-specific knowledge within matrix companies.

The categorization of technical knowledge into the two headings of "tacit" and "explicit" is important. Due to their different nature, they are accumulated in different ways (Nonaka and Takeuchi, 1995). Explicit knowledge, sometimes called procedural, implies that which experience and detailed learning can teach (other more basic knowledge can be called declarative, or that which can be learned from text books). It

refers to the ability to choose strategy and plan a specific course of action using logic to achieve a task. One can learn this by example, including documented cases or apprenticeship. Tacit knowledge, on the other hand, goes one step further. It is that which is difficult or impossible to express using language alone. It involves feelings and hunches. An example of tacit knowledge is knowing how a batch of cookies should smell when they are done, or how to pitch the perfect fast-ball. Nonaka and Takeuchi (1995) invest considerable time delineating a conversion process between explicit and tacit knowledge. It is possible to document tacit knowledge, after first converting it through a process called "externalization" (Nonaka and Takeuchi, 1995). This process involves expressing chunks of an idea using models, examples and metaphors from within our cultural bounds, such that they are represented by explicit concepts. Not only is it difficult to document tacit knowledge, it is also difficult to communicate this knowledge verbally. Using the example of cookies, the tacit knowledge is knowing the actual smell of "done cookies". There is no word for it, but to say that they are done when you smell "mellow caramel almost going to burn" may help. To complete the process it would be helpful to say that they were done about one minute before the burnt smell occurs. This way, through trial and error and apprenticeship, it is possible to communicate tacit knowledge Nonaka and Takeuchi (1995).

Turban (1995) indicates that there are problems in transferring knowledge from one person to another, and from a person to a technology-tool. Expressing knowledge is done by individuals, groups and machines in a similar manner. Information about a

problem is collected, stored in memory, then operated on by either deductive or inductive logic until a solution is found. Transferring knowledge to a machine is a difficult process because the level of aggregation that humans use, and that which is useful to computers, are different. In order to encode knowledge it must be broken down into its most fundamental building blocks (Turban, 1995). The same is true in reverse. Information that a computer or other communication tool may yield is usually far too granular to be understood by humans as knowledge.

The process of learning within a company, occurs mainly around the core competencies of the firm. Bowen et al (1994) and Leonard-Barton (1995) show that there are several critical success-factors common among companies which learn better than others. These are the following:

- Core capabilities: As mentioned earlier, focus within teams can lead to a dangerous NIH syndrome or inflexibility. There is, however, an advantage in being the best at what you do, and having a concentrated core competency often allows a company to excel. Heavily diverse companies are not the best at each of their competencies. The trend in recent years has been for the liquidation of large conglomerates to reveal their separate core units.
- Corporate vision: It is important for there to be a strong guiding vision for each employee to focus on. Knowing a clear path to the future reduces uncertainty in the minds of team players and helps improve the focus of their work.
- Ownership of work: Team members are more productive if they can enjoy a sense of completion and a sense of being part of a project. The partial ownership of a specific piece of work leads to commitment from functional members.

- **Pushing the envelope:** Team members are more productive when there is a continuous challenge at hand.
- **Organization and leadership:** Flexibility in leadership style is critical. Different project types and team structures require different management styles. Managers must be knowledgeable and enthusiastic about a project, and well-suited to the specific project type. Most companies will require several types of project managers: technical, functional and operational.
- **Prototyping:** This process (modeling) causes critical events on a more regular basis. It is through critical events that team members solve problems, transfer and acquire knowledge from others, and learn.
- **Integration:** This last point requires that there be joint decision-making and control from a wide range of functions. The implications of integration are a cross-functional team-based structure as other authors have prescribed.

The sum of these factors, as laid out by Bowen et al and Leonard-Barton, will improve the environment within an organization for learning technical project knowledge. Prahalad and Hamel (1995) support Leonard-Barton's list of success factors by suggesting that companies should focus on their core competencies to effectively develop new business and core products.

In section 4.2, the idea was raised that most of a team's attention is spent on the actual deliverable, leaving little or no time for the accumulation or documentation of technical knowledge. The innovation funnel (figure 4.3) shows that some of this activity takes place at the latter stages of the process, after the product is released. However, it does not demonstrate how.

Bowen et al (1994) argue that two key factors are important to organizational learning from team work. The first is that companies learn from post-project reviews. During a thorough research project involving nine companies, both successful and unsuccessful in learning from projects, these authors showed that there is a clear advantage to companies who make the effort to review projects after completion. An earlier study (Wheelwright and Clark 1992) showed that learning occurs toward the end of development (see figure 4.3, Innovation Funnel). At the same time, Bowen et al (1994) reveals that most companies do not audit their development projects because of the high financial cost in doing so.

Another aspect of storing and retrieving relates to how the knowledge is encoded. Nonaka and Takeuchi (1995) discuss a spiraling process by which companies may create knowledge. The processes within the spiral include externalization (as discussed earlier about converting procedural to tacit knowledge), and other knowledge-conversion techniques. Although the nature of their model is somewhat bound to Japan's homogenous culture, the concept that learning in teams takes an iterative process, with experience and tenure, is still applicable.

Argyris (1994) and Senge (1994) indicate that learning is best achieved when the double-loop learning process is used. This process goes beyond the simple asking of questions and getting answers (single loop learning), and asks questions about the questions. By studying the foundation of the problems and questions faced by individuals and teams, more can be learned. Argyris (1994) then indicates the unfortunate fact that double-loop learning is seldom used because it points to flaws in its users. This is

important to note so that the researcher may observe the presence of double loop learning where it exists in the field.

To this point, the literature present review has covered how corporate structure have been modified over the years in order to improve deliverable performance in development firms, and how this change has effected the ability of firms to accumulate technical knowledge about the products they develop. Also, the idea that information technology is used to help close the learning gap opened by integrated (project-team) structures, while only covering the coordination and process sides has been raised. This leads to the final dimension of learning - about tacit and procedural knowledge and how they are managed within these companies. It is because so little is written about this subject that these research questions are being put forth. How do the above mentioned firms manage specific technical knowledge? And, what role does information technology play in that process?

By studying the critical incidents within a company, and the problems a team faces throughout the development process, these questions can hopefully be answered.

5. Research Methodology

5.1 Overview

This thesis is divided into two fundamental parts. The first part is the literature review, including the most relevant articles and selected studies on related issues, outlined in the previous section. The second part is the field research, collecting and analyzing data from the industry. The following describes the field research in detail.

This research asks novel questions, which by nature require a qualitative approach. To effectively gather data about the questions with uncertain parameters, face to face interviews will be used. Interviews will be conducted with both functional representatives and team members to get a clear view of the knowledge management practices within a company.

5.2 Validity of qualitative research

This section outlines the advantages and limitations of a qualitative study for this purpose. Consequently this study follows the underlying logic of work such as Dougherty (1994) and Clark and Fujimoto (1991) which are clearly written, well-structured and informative qualitative studies on similar topics. Each of these studies deal with the validity issues.

The present study begins by outlining the environment, including industries, products and people, in this case these variables were given. The interviews drew an

accurate picture of what actually is the practice of the firms. since I will be able to include the thoughts of many individuals. The questions asked are designed to elicit a clear and concise data set including only that which concerns management of knowledge. Dougherty (1994) has a similar approach.

Dougherty and Clark and Fujimoto (1991) both wrote well recognized and accepted papers using similar methodologies in similar areas of research. These informative papers act as models for this research since experience and insight will be drawn from them.

Yin (1984) provides a checklist for qualitative field research. This list has been consulted to ensure that the questions asked in interviews answer the research questions, satisfy the models in the literature review, and involve the correct units of analysis.

5.3 Research setting and sources of data

The high-technology based product development industries were selected for the study because they are highly knowledge-based industries and are technologically dynamic. They also have the most to gain by knowing what are the ways to manage knowledge. However the questions asked are, in no way industry-specific.

The specific company to study was selected on the basis of its willingness to participate in the and its excellent fit in the category of matrix structured product development firm. Participation in this case requires a commitment of many interviews, totaling as many as 40 or 50 hours within the company; time of key employees is an expensive resource to development firms. Additionally, the company must go through

many critical incidents during its development cycle. This is crucial because these events will be the unit of analysis for this research. A critical incident is defined as being any event, action or problem a team member or the whole team faced that required the input of knowledge or information to be solved.

A mid-sized company in the telecommunication industry, located in the Ottawa region, satisfied the above requirement.

I was provided with office space and full access to the company to facilitate interviews with employees and to minimize coordination costs both to me and to the company.

Specific people interviewed were mutually decided upon by a contact within the company, and myself. A preliminary list of projects available from the company included:

- Project A (401+), a telephone set, a widely used hardware project, basic building block for other projects.
- Project B (USB), hardware design project, has a problematic history in design
- Project C (MC3R), large, software/hardware project involving existing technology
- Project D (ISDN-Gateway), large project that has seen many project managers, supplier interaction, high turnover of team members, and functional members

These projects were studied with a focus on the critical events that took place throughout the project's phases. Team members, team managers, and functional managers were interviewed to follow the path of the information and knowledge requirements of the project.

Prior to the data collection about critical incidents, a technology inventory (snapshot) was taken to determine the set of tools available to all employees in the company. Thus, it is important to be accurate on the specific use of each technology by different types of employees. Functional managers and team leaders were asked to give a complete list of the technologies used in communication, coordination and other daily operations. The list of these technologies was used during interviews as a final checklist of what tools each person uses.

5.4 Data Collection Protocol

The actual interviews were semi-structured, to save time, and to ensure efficiency. A portion of the time was dedicated to asking specific questions, during which the participant was allowed reasonable freedom to answer questions in his or her own way. All technical or specific terms were described before the interview. This was to ensure that we were both communicating about the same meanings for terms that could be ambiguous. Candidates were also informed at this point that the information discussed in meetings was strictly confidential in nature, meaning any project-related technical information would be kept strictly within the company.

In order to build an understanding of the knowledge structure of the target company, it was necessary to design an iterative process that would elicit the linkages to knowledge used by each individual working on a project. The unit of analysis for these iterations were critical incidents. When a team player or functional member encounters a problem, he/she must go somewhere for the answers and solutions. Each stage of a

project entails different types of problems. Earlier stages may involve staffing (who to assign to certain tasks), while others involve determining what tasks should be performed to accomplish the goal. The questions focused on where and how each of these incidents was handled. To make the answer process elicit as much information about the process as possible, without biasing the participant in any way, I started by simply asking "How did you solve the problem"? In order to ensure that the goal was met, the following is a list of more specific questions that were prepared as prompts to be asked if necessary. These questions are:

What was the problem that you were faced with?

- Did you need to ask other individuals for information or knowledge to solve the problem?
- How did you know where to go for a solution?
- What medium did you use to communicate your problem, and to receive the solution?
- Did you use any I/S tools to help you solve the problem? What tools?
- When the problem was solved, did you document it, or disseminate it? How?

This list was repeated with each respondent for each critical incident during the specified projects. The process was applied from top-down, so that I could identify both general and detailed information about the incident. The iterative process was guided by a timeline based on the development cycle of the company. Throughout the product development process, many critical incidents were encountered. Each critical incident

yielded a single question cycle. Snowballing, starting with one person and following the resulting leads was pursued to several levels.

In order to be certain that all of the relevant critical incidents were observed, initial interviews were held with team leaders and functional managers associated with the respective projects. All incidents that participants remembered were considered during analysis, since they were significant enough to be remembered. It is expected that different functional and team employee types will yield different critical incidents. These differences were used to help identify the knowledge roles of each type of leader on a team. Since functional employees are expected to act as the expertise support system to team members, the same iterative critical-incident methodology was used.

What we deem as relevant critical incidents are those that the team leaders, both coordination and content (Hauptman and Hirji, 1995), identify as being important issues to resolve during the process of developing the product. The incidents mentioned by each type of person are so marked to allow conclusions to be made about the true role with respect to knowledge each team member has.

The development process in the selected company has five discrete stages. The following table illustrates these stages and some of the events that take place in each.

The following is a list of questions that apply specifically to each stage of the development process and to some of the key events. Additionally, there are questions about the interactions at certain stages between the team and the functions. They were asked of the team leaders and functional managers more so than of the team members.

- Concept development
 - Has there been work done on this product by other teams already?
 - Why were YOU assigned to this team?
 - How was the core team assembled?
- Planning/requirements
 - How were members assigned to this stage?
 - What communications exist between this team and the functional managers?
How?
 - What communications exist between this team's leader and other team leaders? .
- Development
 - How were the remainder of the team players selected?
 - Was there any redundancy of specific technical knowledge within the team? .
- Testing
 - How were problems associated with the transfer of the technology to manufacturing solved?
- Manufacturing
 - How was the completed design exported (communicated) to the manufacturing function?
 - What is the feedback loop?
- Final questions

- Were any attempts made to reuse parts of this development towards others?
- Is the team still intact?
- Is there a formal document of successful and failed attributes concerning this project and each team member?

5.5 Preliminary Analysis

Each of the data collected from the research pertains to a particular critical event. These events can be categorized into groups (see Dougherty and Heller, 1994). Some groups might be: Events to do with personnel, hiring of people to a team; events pertaining to specific technical knowledge about a product; and events dealing with process of development and manufacturing. Once these data are grouped, it is possible to identify trends about how each type of knowledge is managed.

5.6. Limitations and Assumptions

The key limitation of this study is its generalizability. Since we are dealing with a qualitative study, concerning specific individuals within one team-based organization, the external validity or generalizability may be questionable, however more than 50 people are included in the study, reducing the effects of bias. I feel that it is safe to assume that in this competitive industry (telecommunications), many of the companies will share similar structures.

This research is also limited by being a descriptive study. It will be of interest to readers to have a prescriptive result. This is clearly an area for further work in future, but this project does not attempt to fulfill that goal.

An additional limit is the potential for industry bias. Although it is not likely to be significant, it is possible that the telecommunication industry will, due to its nature, be different from other high-tech industries.

The concerns about bias and exaggeration by individuals in interviews (usually in their favor) is eliminated since many people will be asked about the same problems, and that has been shown to reduce internal validity issues (Hauptman and Hirji, 1995).

6. Analysis and Results

6.1 Introduction

The data from the research for this thesis was collected in two ways: Interviews with individual project team members, who were asked to identify and describe their solutions to critical incidents; and interviews with individual or groups of functional representatives, who were asked to describe inter-functional relationships and various information technologies they use. This data was then analyzed using three steps: First, each of the 101 critical incidents was categorized; next, the categorized incidents, grouped by project, were filtered through several 2X2 matrices to help identify trends in the data and finally,

Figure 6.1: Analysis Schematic

these results along with the functional interview data were used to form a qualitative analysis. Each of these steps is clearly detailed in this chapter. Figure 6.1 above gives an

overview of how the two types of data collected fits into each of the three steps in the analysis. The following three sub-chapters follow the schematic and will also include a detailed description of each project studied with a close look at the team (chapter 6.3) and a snapshot of currently available information technologies (chapter 6.4).

Before continuing an analysis on the data collected, the following are snapshots of both the teams studied and the tools available to them during the development of a product.

PROJECT/TEAMS SNAPSHOT:

ISDN-Gateway Project:

Telephone switching systems have many ways of operating around the world. Until about 20 years ago, almost all phone systems used basic analog switches, which were a complex array of mechanical devices that would connect the appropriate copper lines in a central office, located in each city. The modernization of phones and the increased demand for phone lines, numbers and services, have made the analog switch an obsolete item. Instead, high-speed computer-based digital switches are used. Companies such as AT&T, Nortel, and British Telecom manufacture central-office switches that connect homes and businesses. These switches conform to a new standard of communication (almost everywhere around the world) called ISDN (Integrated Service Digital Network). These new networks allow for computer data, voice, video and many other forms of media to be broadcast along the same lines (both fiber and copper).

Rather than hooking up large businesses with several dozen analog lines called a trunk, as they did in the past, phone companies provide a single high bandwidth line

called a T-1 or E-1 (depending on the country). Each of these lines provides service for 26 or 30 voice lines simultaneously through a single copper pair. The data is transmitted in digital form and must be decoded at each end according to the ISDN specification.

Most PBX systems were designed in the days of the trunk phone system, and are made to accept a multitude of analog lines. The aim of this project was to provide a gateway between the ISDN network and the PBX systems. This will allow existing customers of PBX systems to connect to a newer digital network outside the company. Coincidentally, the PBX systems have used digital (DNIS) communications internally for many years. Now we needed a link between the two digital domains.

The product ISDN-Gateway is mostly software. The hardware required is actually a simple card, which could be purchased from external vendors. The majority of the work is in getting the PBX calls to be processed on the ISDN network.

Over four years ago, the need to perform such a gateway arose in the German market, and this company rushed to fill that need. The project was functional but flawed; however it did stir the realization that there was a need for this product in the main line of PBX options. ISDN Team:

A team was formed to build a more permanent solution to the problem. This team has been working on several versions of the software (now approaching version 5) and alternatives to the hardware card. Many relationships have been made and broken with third-party vendors to supply components of the software and hardware. The problems have been mostly dealing with the fact that there is a difference between the requirements for data and voice ISDN, and some vendors did not specify which they were involved

with before engaging in contract. These ambiguous contracts have caused delays of over 2 years in the project.

The core team consists of approximately twelve people, including a project manager, three group managers and several key members of the engineering team. Also, officially on the team is a product manager, who is responsible for acting as liaison to the marketing and sales people.

The project manager of this team is a young woman who has recently replaced another project manager who left for a year's leave. The role of this manager is to coordinate activities of the rest of the team, budget time, money and other resources, and make sure that the product meets the mandate of the product manager. In this case, the project manager has little knowledge of the actual technical component of the project. The three group managers, however, have highly honed skills in programming and design and delegate the actual core work-load among the remainder of the workers.

This core team meets on a weekly basis to update each other on coordination issues. The project manager acts as facilitator, while the others discuss both matters of coordination and technical issues. During the week, communications among workers is common. The proximity of the groups is such that each of the three sub-teams are kept intact (but not together within the company). The work each sub-team does is facilitated by their close internal proximity. When cross-team efforts are required, members must walk or call the respective area.

This team has been plagued with time and cost overruns during the four years of development. The one-year project is still in development today. This product category is relatively new to the company, thus much of the steering for the project is less focused

than some other current projects. It is no surprise then that this team often prefers to work without close observation, and some participants were less than fully forthcoming during interviews.

MC3R Project:

The MC3R project was born over a year ago mostly as an emergency stop-gap measure to solve a supply and manufacturing problem. The MC series of products is the main controller board for the large and medium PBX systems that this company sells. It processes system requests for a multitude of software that controls how a call is placed, and many other user features to do with the PBX. Essentially it is the brain of the PBX. The MC3 controller is the current product, and is still produced and selling well.

About two years ago, one of the suppliers for a component on this controller (Toshiba, the supplier of the main ASICs, a chip containing large scale logic) announced that it would soon shut down the production line that manufactures these chips because the process is expensive and aging. They offered a one-time buy of any amount of chips that were wanted. The company responded by computing future demand on the MC3 product, based on current and anticipated sales. They added a reasonable number to that amount and placed the order with Toshiba. The order for parts was computed to last long enough so that the new MC4 system would be ready. The MC4 represents a complete departure from the current board concept and would require both new hardware and software designs (a several-year process). Work has begun on the MC4, but about a year ago the company realized that they would not have the MC4 complete before the chips for the MC3 would run out.

A decision was made to "back burner" the MC4 and work on solving the eminent problem. It was not an acceptable situation to run out of main controllers since that would essentially stop a large proportion of the companies' sales. A contingency plan was developed to fix the problem.

MC3R was one of the contingencies, the most likely to actually work, and thus it was executed. The concept behind MC3R was to use as much as possible from the MC3, and redesign what was necessary to get a working card on the market. The ASIC's were the most obvious problem since they could not get more. It was decided to design new ASICs according to the new manufacturing process. Many of the plans and CAD designs for the old chips were either not available or not of use in the new design, so much of the new ASICs is building from the ground-up. Other parts of the board are very similar to the MC3.

In addition to the new chips, many changes were needed in the software since the physical addressing of many components of the processor would be different.

MC3R Team:

A team was built with many engineers from the MC3, and some new additions. The core team includes less than ten people, but there are an additional dozen or so members who work on this project part-time as support to the core group. The project was split into sections: chips, board layout, and software, where each had a few engineers tackling the problem. Team meetings were held every week, some for coordination, some for design, to ensure everyone knew the status of each component.

In this team the project manager is very experienced, both with the company and this type of project. He also has a great deal of technical knowledge, and can coordinate resources and critical incidents within the team. This team does not have the kind of sub-managers found in the ISDN project. Although there are clearly "software" types and "hardware" types, they all act as a team united by the project manager in his dual roles.

The proximity of the workers for this project is in four small clusters. The hardware and software are each in two small groups of two or three people. Much of the work on the project is modular, and therefore communications between the two or three people is often sufficient. When things go wrong, or details outside the module a particular group is working on are required, these people all know exactly where to find each other, and they do. Towards the end of the development, when testing was critical, more people were brought into the close loop (from manufacturing and testing). Meetings were held more frequently and more casually to ensure that all the pieces would fit together.

The team was able to accomplish the task of building a new functioning board before the deadline, and the project as a whole is very close to budget with respect to time and cost. This team was very willing to provide details about the whole story of the development project. There was no feeling of threat present during interviews. Generally, the micro-culture within the team was very friendly and open.

USB Set project:

The USB phone set represents one of the innovative modern hardware projects that this company is undertaking. The initials USB stand for Universal Serial Bus, which

is a standard set by a consortium of companies. The bus is designed to link computers with a variety of peripheral devices, including modems, phones, input devices, cameras and other audio/video hardware. Many companies are designing hardware to work with this bus, and many computer vendors are building system units that comply with the new standard.

The actual USB phone set is a single device that performs two main functions. It plugs into the USB on a PC and acts as a digital modem which can handle fax, voice mail, answering machine and data calls. The set also acts independently as a regular telephone. There are specifications in the design to allow the simultaneous use of voice and data calls (which would be a first for commercial and home use) called DSVD; however, that feature will not be standard on all models.

This project is being developed to sell as an OEM product through several Value Added Resellers. It is possible that after the product is ramped-up, that the company will choose to sell it under its own name.

There are two reasons this project was started: The first was an opportunity, whereby the company was asked to participate in a standard-setting, along with Compaq, Microsoft and others. The main trend for this standard is to move toward computer telephony integration (CTI) which is clearly one of this companies' short and long-term goals. Several steps, including this small one involving a "PC-telephone", are being taken to move towards CTI. The second reason that helped forge a mandate for this project was more of an ultimatum from a business group within the company which declared that, the factory currently manufacturing phone sets is not profitable at present levels. The phone sales that are generated by PBX customers is low volume and cannot prosper without

some sort of expansion. The ultimatum given was "grow the set business or get out of it". The decision was made by the Semiconductor group to support the "grow it" movement, which led to the development of a new group called Desktop Interfaces. This group is the parent to the USB phone, and a strong force for the design of more phones to be manufactured for sale to non-PBX customers.

401+ Set project:

This is an interesting project in that it did not entail a large design or engineering effort. The project was an incremental change from the 401 Set. These are the most basic phones for use with the Mitel PBX systems. They consist of merely a basic handset and cradle with a numeric dialing pad. The 401+ was a response by Mitel to satisfy a market demand to better compete with another company's product which offered a hold button. Additionally, the phone was relatively expensive to make, and thus carried a high selling-price. The other aim of the project was to give more functionality to the customer to justify the high price. The fundamental differences between the 401 and the 401+ are a hold button, some speed-dial buttons and a flip-up stand for the case.

The core team and almost all of the supporting team members for this project were the same as the 401 development team. The phone was designed not too long after the 401 and most of the original people were still involved in the development of other sets. The actual design specifications were used almost exactly from the previous version, and additions or changes were made as necessary. Although it seems rather simple to add one button to a phone, the project did entail a reasonable amount of complexity and effort. In order to add one button, plastic molds must be changed, testing must be redone,

software must be changed or added to include the new feature, and conformance must be measured to be certain that the feature will be compatible with all existing hardware.

This project is unique in that it was so recent, it had the distinct advantage of being the only phone set at this company to fully conform to the relatively new ISDN conformance standards (world wide). The phone was built under guidelines and specifications, and then tested by the ISDN conformance group (a support function within the company that acts independently to maintain objectivity). The 401+ Set is still a current product and holds relatively high sales in the low-end PBX set market.

USB and 401+ Team:

These two projects share largely the same teams, including project manager and core. The reason is that both projects are phone sets, and the team that builds phone sets tends to remain relatively static. These two projects were developed back to back, leaving much of the membership the same.

The project manager of this team is also very experienced within the company, but does not have the kind of technical skills that the manager for the MC3R has. Therefore this project also has a technical leader who provides that type of guidance to all hardware and software issues on the development and design of the product. The core team in this case is much bigger than the other projects, since phone sets are a complex device. The team has about fifteen core members and another several dozen who participate on a regular basis. Like the PBX component division, the phone sets group is old within the company, and there is a lot of historical experience.

Weekly meetings are divided into three main components: hardware, software and coordination. Only people who have responsibilities to a particular meeting need attend. The project manager has a tendency to take advantage of her situation to ensure the fiscal and timely success of the project. In many cases, this means bending or avoiding the classical functional system of rules and procedures (detailed further in the next section, and in Appendix IV). The USB project, like the 401+, were delivered on time and budget. In the case of the USB, the product manager was in a rush to have a working product since the market is new and highly competitive. The whole project was developed under "no rules" to allow fast development.

People on this team are located literally all over the company. Since there are so many disciplines used, the people stay within their respective functional designations' area and communicate as necessary with other workers. The fact that there were usually more than three meetings per week helped this task.

Although the team members for these projects had a clear set of priorities, with their project first, they were very helpful in providing the kind of information needed for this study. The team cooperates as a large finely-tuned instrument. Their experience both in working on phone set development and in working together shows.

TOOLS SNAPSHOT:

During the functional interviews, issues dealing with company-specific tools and terminology often came up. The following descriptions detail each of the important systems used to manage knowledge, building a snapshot of the tools available to most of the employees.

SMS: The SMS system (Software Management System) is likely the most effective and in-depth knowledge management system this company employs. It was created nearly 15 years ago on the DEC VAX computer system, and was more recently ported to the Unix environment. This system consists of several individual data-bases that are connected through searchable indexes. The original intent of the system was to manage versions of the PBX software libraries, ensuring that customers with older hardware would always have the correct software, and so on. In more recent years, the system has been used for all other software applications, and many hardware projects as well. The SMS contains many types of entries, including CAD/CAE source files, actual program code (software), firmware code, and problem reports (DPAR, explained below).

The SMS is used differently by different people. Both because their functional association relies differently upon the system, and because they hold more or less faith or trust in it. One engineer was quoted as saying "The SMS is a write-only system, I never use it to see how something was done, only to say how I just did it". This person does not find that the system does anything but consume his important time resources. On the other extreme, there are people who live by the system, the technical support people for example. In this case, they are able to find solutions to problems within seconds, and disseminate them to customers.

To enter a file into the SMS you must submit the file details, including who owns it, who solved it, who else it concerned, the dates that actions were taken, and who to contact for more information, as well as a second part containing the details. In the case of software, these details would be the actual code; for hardware, it would be a technical

drawing, or CAD/CAE file. In many instances, things are documented by the first part only (just the information about the problem, not the solution itself). These instances match perfectly my definition of pointers to knowledge.

To search the system is a cumbersome task. It requires that you have some knowledge of the UNIX operating system, and some command line instructions (GREP). You must also know in which of the several databases the information or knowledge you are looking for resides in. Once you have all of this straight, you can run the search, and the computer will yield all relevant files. From there, you browse through them, looking for solutions, or people who may be able to help.

DPAR: This is one of the file types stored within the SMS. A DPAR is a Design Problem Action Report. This is the result of finding a problem with an existing product, and assigning it to a person for resolution. Once entered into the system (SMS), the responsible person will then perform research to find out how to solve the problem (including assigning parts or all of it to others) and document that in the form. For example, complaints about bugs to the technical support department all result in the creation of a DPAR. There are four examples of DPARs listed at the end of Appendix II.

DAKAN: This is the corporate filing system for the Kanata site of the company. There are other versions used in each of the other worldwide sites. This system contains financial information and coordination information for resources, including labour. Project managers and upper level managers are the main users of this system, both for input and output. Almost none of the Content-R&D critical incidents dealt specifically or exclusively with the DAKAN system (some involved both the SMS and the DAKAN to coordinate the R&D and management functions).

Lotus-Notes: This is one of the first examples of a blanket-knowledge and project management system; is making an appearance in many areas of the company; however, it is by no means commonplace. A few managers are using this system to share project related data, mostly to assist in decision making and planning stages. Other uses of Notes include simple communications such as E-Mail.

Many managers have expressed interest in using Notes in the future for many applications, including the long-term management of knowledge. A topic of discussion for several weeks in a row at a project managers' meeting (weekly with many project managers, I attended) was the eventual introduction of Lotus Notes in this role.

E-Mail: E-mail is the information technology most widely used by this company. Every employee has an account, and almost everyone uses it. It is a means of communication with peers, and superiors, and is very convenient. This company now uses three different mail systems, CC-Mail, Sun-UNIX, and Lotus-Notes. This actually poses a problem to the company, in that the coordination and communication among the three is a weak link. The mail can be slow or get lost between people in the company. There have been several documented instances (approximately 10% of instances dealing with e-mail) where people have used sneaker-net (carry the file in hand on a disk or on paper) because E-Mail failed.

Voice-Mail/Phone: The phone system within this company is both modern and complex. It is possible to identify who is calling before answering the phone, leave mail or call-backs for anyone in the company, or leave personalized messages about where you may be located at a given time. Telephones are used generally as a handshaking procedure, to begin communication about technical knowledge. Once the conversation has begun, it is

more often carried out in person at one of the two persons' desks, or some common meeting place. Phones are also used often in coordination issues. When no content knowledge or information has to be shared, a voice communication is preferred over in person meetings (less time). Since many of the people working in the domain of R&D, are often in meetings dealing with content knowledge with their co-workers, it is difficult to communicate by voice live, over the phone. More often than not, this method of communication requires that a message be left in voice mail.

Cadence/Synopsis: These are two of the more powerful and commonly used CAD/CAE tools in this company. The tools are used by designers in many departments to solve complex design issues, such as board layout, chip design, physical design etc.. Their role in solving the problems is less interesting to this thesis than their role in management of knowledge. Each engineer who uses the system will eventually have an output file that is made public through the SMS and attached to other project related documents. Other designers in the future could then lookup how designs of the past were done to aid in the process of innovation. It is in this way that these tools are able to make a snapshot of a part of the designers knowledge and preserve it for future use. The SMS links that to a searchable database making it even more accessible to other engineers.

6.2 Classification of Critical Incidents

The raw critical incident information located in appendix II was generated as follows: Interviews were conducted with individual team members at their convenience. During each interview one to three critical incidents were identified. Detailed notes were taken by the interviewer, and in some cases a tape recorder was used as backup. The hand-written notes were then transcribed into computer format. Appendix II, with the exception of the "Classification" line, is the result of the transcription process. The classification was done afterwards by filtering each incident through the schematic shown in figure 6.2 on the following page.

During the classification analysis, totals of each main type, solution type and dissemination type were recorded in accordance with figure 6.2. The classification is done in three steps. The first indicates the main classification and functional representation (if applicable), the second shows who solved it and what communication methods were employed, and the third shows where the knowledge can be found, and how public it is. See Appendix III for a summary of the classifications. The information was used in the final analysis to help identify trends in the data.

Figure 6.2: Classification Scheme for Critical Incidents

Base

Classification

Solution Core

Dissemination and

Documentation

Some basic counts of occurrences help paint a picture about the population of data recorded. The following is a list of these counts:

Table 6.3: Main classification breakdown of critical incidents

Content	<u>65</u>	Process	<u>23</u>	Coordination	<u>12</u>
R&D	50	R&D	10	R&D	9
Manuf	10	Manuf	6	Manuf	1
Marketing	1	Mgt.	5	Mgt.	2
Support	3	Support	2		
Testing	1				

This table indicates how many of each basic type of critical incident were recorded, as well as to which main function the incident belonged. The following table shows the basic breakdown by project. There are three named projects, and one category called "other". Other refers to two or three incidents that did not support a specific project, or critical incidents that did not belong to one specific project.

Table 6.4: Critical incident-project breakdown

ISDN Gateway	17	
MC3R	35	
USB	4	Total
Other	25	101

To help identify some trends within the critical incidents, the next analysis will relate solution types and media used in retrieving and disseminating knowledge to a specific team. Before this analysis was done, the data was split into two equal groups. It was purely coincidental that exactly half of the incidents were "content knowledge -

research and development". It is that type of incident that this thesis stresses. The other incidents are all the process knowledge and coordination incidents, as well as content knowledge outside the R&D domain. Figure 6.5 shows the project breakdowns of solutions and mediums, and compares between Content-R&D and other critical incidents.

Table 6.5: Teams and their solution types

Content-R&D	Self	Tool	Outside	E-Mail	F-F/O T.W	Meetings	Other	Total
ISDN	5 (63%)	0	3 (38%)	1 (13%)	5 (63%)	1 (13%)	1 (13%)	8
MC3R	16 (67%)	3 (13%)	5 (21%)	1 (4%)	17 (71%)	2 (8%)	4 (17%)	24
USB	7 (50%)	2 (14%)	5 (36%)	1 (7%)	7 (50%)	5 (36%)	1 (7%)	14
Other	2 (50%)	0	2 (50%)	2 (50%)	1 (25%)	0	1 (25%)	4
Other CIs								
ISDN	2 (22%)	3 (33%)	4 (44%)	2 (22%)	2 (22%)	3 (33%)	2 (22%)	9
MC3R	5 (45%)	3 (27%)	3 (27%)	0	2 (18%)	5 (45%)	4 (36%)	11
USB	8 (80%)	2 (20%)	0	3 (30%)	2 (20%)	1 (10%)	4 (40%)	10
Other	9 (43%)	3 (14%)	9 (43%)	7 (33%)	2 (10%)	3 (14%)	9 (43%)	21

In table 6.5 the bolded number in each cell is the raw number of critical incidents that fits into that category. The second bracketed percentage is the raw number divided by the total number of critical incidents in that project (with the test group, either Content-R&D or Other CIs). The following are definitions for the terms used for each category:

The first three columns are describing the basic solution type as follows: Self: refers to solutions that were principally solved by the owner of the critical incident. Tool: as in figure 6.2 is a critical incident solved by a person assisted by a tool. The tools used in these cases ranged from CAD/CAE tools such as Cadence and Synopsis to MSProject or the Internet. Outside: are solutions that were formulated principally by a person, other than the owner of the critical incident. Possibly a team member, someone else in the company, or someone outside the company.

The second four columns describe the medium used in getting the knowledge required to solve the problem. This should not be confused with the medium used to disseminate the solution, as that was measured separately and will be shown later. E-Mail: When electronic mail exchange was the principal method of acquiring needed information or knowledge to complete the critical incident. F-F/O.T.W.: These refer to Face to Face or Over the Wall communication. Both deal with close proximity within the company. Face to face does not imply that two or more people work or sit near each other. It means that there was a meeting that took place somewhere in person. Over the wall, however, does imply that the proximity between the owner of the critical incident and the person who helped to provide knowledge or information was such that they could literally talk with each other while sitting at their desks. In this company, that could happen either because people work inside the same cubicle area (in which case they can see each other) or in adjacent open office spaces (in which case they can simply hear each other). Meetings: refer to groups of more than three people who find one of many meeting rooms to discuss current problems or incidents. These can be scheduled or unscheduled, and occur very frequently. Other: includes a number of media such as telephone, CAD documents, Lotus Notes, MSProject, the Library or Intranet. Each of these in this context are used strictly as a medium for communication of information pertinent to the solution of a critical incident. This category includes most incidents where people are not close together.

The next part of the analysis deals with the third main identification component (from Figure 6.2), Dissemination and Documentation. The table below, table 6.6,

shows a matrix comparing each project with three levels of public to private. The data is again split in the same way as it was in Figure 6.5, the Content-R&D incidents (50) and the others (51).

Table 6.6: Project-Dissemination Matrix

Content-R&D	Private	Semi	Public	Total
ISDN	2(25%)	2(25%)	4(50%)	8
MC3R	6(25%)	14(58%)	4(8%)	24
USB	2(14%)	9(64%)	3(21%)	14
Other	1(25%)	0	3(75%)	4
Other CIs				
ISDN	1(11%)	3(33%)	5(56%)	9
MC3R	1(9%)	8(73%)	2(18%)	11
USB	2(20%)	4(40%)	4(40%)	10
Other	0	9(43%)	2(21%)	21

Figure 6.6 is in the same numeric format as Figure 6.5, and the top half of the data refers to the 50 Content-R&D critical incidents while the lower set involves the 51 others. The definitions for this data are as follows: Private: refers to knowledge captured during the solution of a critical incident which is only known by the owner of the critical incident. Examples of this include personal notes, computer files, memory and plain experience. Semi: includes semi-private and semi-public from the original classification scheme. Examples of these are where the knowledge was disseminated during a small meeting, or is available to a local number of people via various means (shared computer files system, file cabinet, etc.).

Public: implies that the knowledge gained during a critical incident, including that which was required to solve it are available to all or most employees of the company, if they look for it. Public does not imply that people implicitly know, but simply that they have

access to the knowledge. Examples of these are the corporate filing system DAKAN, and SMS (these and other tools are described in great detail in section 6.4).

Figure 6.5 clearly shows trends that are pertinent to the questions posed in this study. The most basic trend is that each project team has a varied personality with respect to how its members solve critical incidents. ISDN-Gateway for example, uses a lot more external help (including others within the company) than the MC3R team who tend to solve incidents on their own. Detailed descriptions of each project, and the project teams are shown in section 6.3.

The most startling trend is shown on the knowledge acquirement side (right), comparing the Content-R&D incidents with the Other C.I.s. If we look at the inner two columns including F-F/O.T.W. and Meetings (shown by arrows) and contrast them with the outer two, E-Mail and Other, we see that in the upper data set there is a heavy emphasis on the inner, while in the lower the emphasis shifts to the outer pair. The inner pair has one important factor in common. Both deal with direct, in-person contact for information and knowledge exchange. The outer pair, by comparison, only deal with media that are remote, with no in-person contact (the contents of the other category are listed above). The reason this is so important is as follows: When these team members wish to get day to day, non Content-R&D activities done, they will use whatever means of communication is most convenient, such as e-mail or telephone (including voice-mail).

When the same people wish to communicate about Content-R&D type knowledge, or technical details, they do so in-person more than 80% of the time (by comparison the number is about half for the non Content-R&D incidents).

From table 6.6. we can also see a trend. Content-R&D critical incidents tend to be much more private than other types of critical incidents. There are (for an equal number of incidents on each side) more than three times as many private content-R&D incidents than others; also, there are slightly more semi-private incidents for the content-R&D side. This is consistent with the data from table 6.5 which indicates that Content-R&D issues tend to be solved individually. The addition of these two facts leads to the natural conclusion that dissemination either is not a priority, or is ineffective. Section 6.4 will include a more in-depth analysis of this particular observation.

6.3 2x2 Project-Team Analysis

This component of the analysis is designed to outline trends leading to answers to the main research questions by looking at the project teams. In order to identify such trends, I have selected three main ideas that are raised by the two research questions, and have then expanded these three into four dimensions for use as axes on a 2x2 matrix.

The two research questions are: #1: Given that a shift towards project teams and matrix structures changes the ability of firms to manage knowledge, how are firms currently dealing with their knowledge needs? #2: What roles do information technologies play in the management of knowledge? The three main ideas that come from these questions are: 1) project-team performance; 2) successful knowledge management, and 3) use of information technologies.

Rather than measure how successful knowledge management is in #2 (which would require a longitudinal study), I have identified how public, or private, knowledge is, both in its use and in creation. From #3, was the management of knowledge a deliberate part of the process of innovation or purely accidental (coincidental)? These four dimensions will be compared against each other to help define the relationships that exist among them, and outline trends.

Since the dimensions of the 2x2's deal with project level issues, such as performance and long-term management of knowledge, summarized data for each project-team observed qualitatively are used. For the vast majority of cases, there is a

high level of consistency within teams with respect to the underlying parameters of this research (this is supported by the numerical analysis from section 6.2).

Before filtering the project teams through the 2x2 matrices, it is necessary to understand the dynamics of both the project and the team environments. The three main projects studied, as mentioned are the ISDN-Gateway, the MC3R and the USB phone set. The 401+ project is also described, as it represented 6 critical incidents, and was executed by the same team as the USB project. The detailed descriptions for the teams and projects can be found in chapter 6.1.

Each of the teams can now be placed on two by two's to compare relative levels of performance, management of knowledge (as far as how public the knowledge generated by the team is), and use of information technology for the management of knowledge.

Figure 6.7: Public/IT Matrix

Level of Public Access	High	ISD
	Low	MC3
		High
		Use of I/T

The trend identified in this case also seems linear; as information technology is used to manage knowledge, knowledge becomes more public. In the case of the ISDN team, the use of the technology (SMS) is required to manage versions of the software they are writing. It then becomes a simple task for new team members or other people within the company to gain access to the newly developed knowledge. MC3R, on the other hand, although it uses the SMS, does not maintain details about changes to hardware. These details are stored only in the engineer's head, and in some cases are shared at small work-team meetings. Only final revisions, excluding the methodology to get there, are stored in the SMS as a CAD file.

Figure 6.8: Public/Deliberate Matrix

Level of Publicity	High		
		USB/401	ISD
	Low	MC3	
			High
Deliberate Mgt. Of Knowledge			

Although the above relationship seems intuitive, it is important to note the difference between "deliberate" management of knowledge and successful management of knowledge. The MC3R team, for example, does not show high levels of deliberate knowledge management (when observed during individual and team meetings); however, the team members find what they need at their fingertips, through proximity to other workers, and good knowledge of pointers to key people in the company.

Each of the three 2x2 matrices indicate that there may be a relationship between the two dimensions. These relationships will be discussed further in section 6.4 along with the data collected in functional-member interviews.

6.4 Qualitative Analysis

In order to further help the qualitative analysis, it would be useful to go through a few critical incidents in detail. This will put into perspective the usage of the tools in the knowledge management roles, and substantiate the trends mentioned in the previous two chapters.

Content-R&D:

C.I. #: 11

Date: March 26

Project: MC3R

Person: Paul

Functional Assoc.: Hardware designer

Description of incident:

During the development of the larger of the two new ASIC's for the MC3R board, Paul came across a problem with the simulator. It seemed that there was a difference in what the simulator was saying about a particular test vector, and what practice actually yielded in the manufacturing process. Part of Paul's style (cowboy) of engineering allowed this error to occur without any serious implications during most of the chip development. Towards the end, it was apparent that something would have to be changed.

Solution:

The issue was of timing. There was a 10 nanosecond delay between when the simulator said something should occur and when the actual occurrence took place. Paul's solution was to separate the clock from its neighboring lines by 100 nanoseconds, making the 10 ns offset irrelevant. Through his own experience of trial and error, the engineer was confident that this solution would not cause any further problems, yet it would elevate the initial symptom.

Dissemination/Reporting:

This engineering issue is so basic that only engineers were involved in its solution. Paul discussed this problem with two people, his co-worker Yifan and his boss (manager of hardware design) Jacob. Yifan was brought into the loop because he was doing the design for the second chip and they would prevent this problem from occurring in that one by building in the above mentioned delay. Jacob was advised to make sure that the solution was not unorthodox and because he tends to work closely with the small hardware design group. The problem was briefly mentioned at the project coordination

meeting as a line item to inform others including the project manager that there was a problem, and a solution had been found. No technical details were shared at that meeting.

Classification: Content-R&D; Self (experience)-Face to face; semi-private-meetings

The above problem was identified and solved by the same person, and on a product, far before completion. This implies that the DPAR system in SMS would not be used. Instead, a total of three people were told about the problem. First, his co-worker was brought up to speed because the solution to the problem would have direct ramifications to his work. The communication at this level was "over the wall" due to their extremely close proximity. Second, the hardware design manager was told to make sure he did not have any objections to the somewhat informal method for solving the problem. In this particular case, the manager also sits within 3 meters of Paul, meaning that the communication was face to face. Finally, the project manager was told so that he was aware, in case any other team members would need to know (in this case no). Graham was told at the next team meeting about the problem and the solution.

This example is a perfect illustration of solving a content-R&D critical incident with a mostly private solution. There are people who know about the solution other than the solver himself, and they would immediately be able to identify and use him in the future. These pointers are not stored in any mechanical, computer or paper system. Similar problems in the future would likely be referred to the hardware design group, in which case half of them would know who solved the problem. It is likely that Paul would eventually be identified as having this knowledge, although it would take some finding for a new hire into the company or someone from an unrelated department. The collection of critical incidents is full of other examples like this one. This and the other examples

support an argument that Content-R&D critical incidents are solved using in-person contact as a means of communications (often) and are more often private rather than public.

C.I. #: 25

Date: April 18

Project: MC3R

Person:

Gord

Functional Assoc.: Software designer

Description of incident:

During the development of the current project (MC3R) one of Gord's team mates left the company for another company, leaving a hole in the development effort. The next closest person to the set of skills was this engineer. The person who left, was however, a single point skill, in that no one else understood the work he was doing properly. This particular engineer acted as a link between hardware and software engineers in domains such as firmware design and hardware/software addressing.

Solution:

Gord had to fill the hole almost entirely by himself. He began increasing his communications to the hardware designers, using only face to face communication to exchange ideas and negotiate solutions. The loss of the engineer did slow the project down, but by adding small pieces of the puzzle together from many different people, Gord was able to handle the problem.

Dissemination/Reporting

This problem was discussed in many meetings, both at the project level and the upper management level. The decision was made not to fill the position because it would take longer to train a new hire to fulfill their needs than to have the current engineers fill in the hole. There was a reasonably high level of awareness surrounding this loss, however no direct action was taken to prevent future occurrences (not much to do).

Classification: Content-R&D; Self-face to face; semi-private-meetings

One of the most serious problems an R&D firm can face is losing a single-point skill designer or engineer. The most logical solution to the problem would seem to be to hire a replacement as soon as possible; however, in practice this is next to impossible. Single point skills are so, because they require highly specialized knowledge and abilities. Finding an exact match, who also understands company specifics, is rare. The solution

that this company has adopted is to let the closest engineers fill in the missing task. These people are closest to the problem and have the highest understanding about what needs to get done. The above example is one of three that this thesis observed, all solved in this way. The previous example showed that many Content-R&D incidents are solved using personal interaction, and resulted in a mostly private-knowledge repertoire. This one supports that argument by showing that transfer of knowledge in the shortest possible way (using the closest people to the situation) is preferred. In both examples, although the actual incident was not documented, the person who solved it and the specific topic can be found in the SMS as a pointer. Each project is documented at each of three design stages, and would include key team members and their contributions.

Non Content-R&D:

C.I. #: 55 **Date:** May 10th **Project:** USB
Person: Kent **Functional Assoc.:** Product engineer

Description of incident:

Rolf (USB electronic designer) found a bug in the X-tal used on the board. It was running at the wrong frequency. Rolf quickly replaced it with the correct part and told this to Kent who would get the change made into the documentation and the factory.

Solution:

This problem is about formalization. Kent had to generate the necessary documents to change the product technical description and the BOM (bill of materials) for the manufacturing process. There is a detailed template to follow (which he did).

Dissemination/Reporting

The new documents (ECO and BOM) were submitted to the team managers to be signed off, then sent to their respective functions for further processing, IE manufacturing. The ECO is the document that makes changes to the product description. These are maintained in the SMS as are the complete detailed and technical descriptions.

Classification: Process-R&D; Self-e-mail; public-SMS

The above critical incident is a perfect example of what I have classified as non-Content-R&D. The majority of coordination and process knowledge incidents observed resulted in communications other than in-person, and at much higher levels of public dissemination. In conjunction with the previous two examples, this helps outline the trend seen in the data from section 6.2, that content-R&D incidents are more often solved in person, yielding a mostly private unit of knowledge, while other incidents are solved using information technologies to communicate, and have more public solutions. From the three examples in this section, and the trends seen in the previous two sections the following statements can be made:

Content-R&D critical incidents more often use personal contact as the means for exchange of information and knowledge, whereas other critical incidents use more convenient E-Mail, voice-mail or other information technologies. This statement is supported by the frequency distribution of observations made in section 6.2 and by qualitative observations made by the researcher while at the company. At first this seems to counter the idea set forth in Figure 4.4, that IT helps push the effectiveness of project-team structures by improving their ability to learn. However, Figure 4.4 is still valid since some of the more advanced technologies, such as SMS, provide excellent help in management of pointers to specific knowledge units, and therefore management of knowledge itself.

Content-R&D incidents also tend to have mostly private solutions. The knowledge units acquired or developed during this type of incident is often known only to the engineer who developed it, with pointers to this knowledge held by team members.

managers, and very often in the SMS. It is important to note that the SMS does a good job at managing the pointers, and in keeping track of versions of software and hardware, but not the actual content knowledge itself. Coordination and process knowledge incidents are more often public, using the corporate filing system and SMS to maintain vast repertoires of information, transactions and knowledge. This statement is supported also by the data in section 6.2, and by closely observing several critical incidents that use tools such as MS-Project (with output stored in DaKAN) to solve coordination problems.

It is surprising to this researcher that some concepts were not observed in the critical incidents. The most likely is the post-project review. At present there is a process for the creation and use of such a tool in the company; however, managers choose either not to write them, or if they do write them, they are often careful not to share them publicly. The result is the frequent "reinvention of the wheel". At a project managers' meeting this was discussed as the key topic for three weeks. The result of these discussions was the creation of a new formal system for use by managers to create and share these post-project reviews. The system is designed to leave individual names out of the document, but through context it is possible to figure them out. Additionally, the new process is not yet widely accepted, and likely will only be effective a few years down the road. None of the managers knew of literature on the subject such as Leonard Barton(1995). The problem that Senge(1994) and Argyris(1994) described when talking about the drawbacks of double-loop learning clearly exist, in that managers are not willing to implicate themselves for the benefit of the team or company. At present there is no specific attention paid to these concepts in the reward structure of the company.

Figure 6.9 shows the ways that project members obtain knowledge. It shows the clear existence of a true matrix structure since knowledge is shared in teams, inter-team, and functionally. Notice how with inter-team knowledge management, which represents the majority of cases at the company studied, only pointers to specific knowledge units are maintained in the corporate data-bases. Actual knowledge units are communicated using conventional means such as meetings, and other forms of face to face contact.

Figure 6.9: Content Knowledge Management

7. Implications and Recommendation for further research

7.1 Theoretical Implications

The findings of this thesis begin to fill a gap that exists in the literature about knowledge management. We know there is respectable literature on the management of knowledge in the functionally structured organization (Larson and Gobeli, 1988), and we also know the positive effects that team structure has on product development (Clark and Fujimoto 1991 and others). We do not yet have any knowledge about longitudinal effects of new company structures on the long-term management of knowledge, and hence the long-term performance of development in project teams.

Ideas raised by this thesis that are already supported by popular literature are: Information technology tools are used well in the role of communication and coordination, but do not yet have the ability to manage content knowledge itself. Recent developments from the tool industry have been to attempt to do so, and the demand for such a product exists in management. It is simply a matter of time before the correct tools are developed.

This thesis helps outline the need for a longitudinal study into the same subject and acts as a starting point for other possible critical incident studies.

7.2 Practical Implications

The concept of management of knowledge in R&D is becoming important to upper-level managers in recent years. During the several months that this researcher spent on sight, there was an observable change in the system used to perform that function. Steps are being taken that are conceptually new and based on literature and experimental practice. The most prominent examples are the use of post-project reviews and tools such as Lotus-Notes. Neither is a new idea, but both are being used in more modern ways than ever before to help capture and manage content and tacit knowledge.

The results from this thesis cannot prescribe what direction to take, in the changes that so many managers wish to make; however, it can confirm that change may improve long-term performance, since that is the end to the means of successful management of knowledge.

7.3 Methodological Implications and Limitations

This thesis has used a critical incidents methodology as the main source of data collection and observations in meetings with functional representatives as a secondary method. Individually, these methods would show portions of the way that high technology development companies manage their content R&D knowledge, but together they help to build a concise analysis that paints a wide-brushed picture about management of knowledge.

By performing a qualitative numerical analysis on the classified critical incidents, clear trends were identified. An alternative to this method would have been to use statistical analysis. This would require that a larger sample of critical incidents would be collected, and that specific numbers of each classification gathered. Statistical analysis would better support more vague trends found in the data. Additionally, the analysis would have greater generalizability if critical incidents were collected from more than one corporate culture within the industry. Notwithstanding these limitations, the methodology used, both the qualitative numerical analysis and the 2x2 matrices, have performed excellently in identifying the keys to answering the research questions.

Issues such as differences among the team dynamics and individual bias as alternative explanations to some of the results were looked at and found to be insignificant. In the former, the major concern was that the interactions between teams and other parts of the company may be different, and therefore focus on one method of communication more than another. Since the teams are mostly self sufficient, at least to the same degree, these external communications are infrequent, and similar. For the latter, more than one individual was interviewed about nearly every problem. Multiple respondents reduce this internal validity issue.

7.4 Recommendations for Future Research

In accordance with the previous section and section 7.2. "Implications in Practice" two main branches of further research are identified: Further confirmation of the results found in this thesis could be found by increasing the number of critical incidents, the number of companies studied, and by using a statistical method for analysis. The possibilities that company-specific tools that help in the knowledge management process in this company, either by managing pointers to knowledge or specific knowledge units, existing elsewhere, would prove to be a very interesting addition. Research in other companies would also confirm or disprove that corporate culture plays a significant role in the way that knowledge is managed.

The second main thrust for further research would be to design a prescriptive conclusion to the results. After confirming the results found here with others in the industry, comparisons could be made among the larger data-set, identifying the most successful components from each company. A single content knowledge management scheme could be developed using the insight from the critical incident and statistical analyses. Applications to develop a more effective overall method for management of content knowledge in the domain of R&D could be a new large and highly lucrative industry.

8. Conclusion

The first research question, in summary, is answered by the numerical analysis in section 6.2, and was confirmed by further qualitative analysis in section 6.4. There is a dichotomy relating to how knowledge is managed based on what basic category it falls into. Issues dealing mainly with content-specific knowledge in the R&D domain were solved by individuals interacting in person with other individuals. The solutions to problems and newly created knowledge units are generally kept private to their owners. Pointers to this knowledge are held by close co-workers and managers as well as in some of the information systems.

Other types of critical incidents such as coordination issues and process knowledge problems are addressed using various tools. E-Mail, voice-mail, telephone, the SMS and CAD/CAE systems are used as communication tools to find, retrieve and share information relevant to the solution of these problems. Since these systems are used in the information gathering stage of problem solving it is easier for the solutions to be public to a larger audience than for the content-R&D incidents.

A possible hypothesis concerning this dichotomy is that it is still very difficult to communicate tacit or technical content knowledge (Nonaka and Takeuchi, 1995) through information technology. When this type of problem needs to be solved, humans feel more comfortable using communication which closest resembles apprenticeship. This is best achieved in person.

The second research question, asking what role does information technology play in the management of knowledge, is derived from the first. One of the a-priori ideas of

this author was that some advanced information technologies could capture and manage knowledge in a organized fashion. In fact, what was discovered is that very little content knowledge is captured by these systems (some is in detailed CAD/CAE drawings; however, the drawings do not include the strategies used to develop the final product). Process knowledge and coordination issues are frequently captured and managed in the "system", but mostly pointers to content knowledge are managed in the information technology. The company studied uses a sophisticated database system that manages these pointers and makes accessing them relatively simple (the user interface is showing its age). The relative success of the company, and its ability to manage knowledge, rely heavily on the above conclusion that management of knowledge is done in systems such as the SMS by maintaining a complex database of pointers to who (not what) possesses specific knowledge units.

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Appendix I

Breakdown of Deliverable performance

Meeting Deliverable Schedule

Cost performance

Technical, Quality Performance

Appendix II Critical Incidents.

C.I. #: 1 **Date:** March 13th **Project:** ISDN-Gateway
Person: Melinda **Functional** **Assoc.:** Project Manager
(Coordination)

Description of incident:

Original ISDN project delayed multiple years by frequent design changes in supplier hardware cards from Intel. The hardware platform for this project was purchased rather than designed in house, since expertise to do this task were not readily available at that time (subsequently they are). Each time hardware was changed by supplier, the existing version including recent modifications of Mitel software were made obsolete.

Solution:

Design change to use standardized hardware components (slightly customized by Mitel) and switch to a standard operating system for software. Originally to be Unix, then changed twice to OS/2, and finally Windows NT. The result of these changes allowed the Mitel designs to remain valid through many minor and major changes to the standardized platforms because by definition, they support backward compatibility to the "standard". Project manager indicates that had Mitel chosen to build from scratch in the first place, the final time to market and cost would have been reduced.

Dissemination/Reporting:

This incident is project wide, and is widely documented in corporate databases such as SMS, and Dacan. The information and decisions made as a result of this incident were available to most team members at team meetings.

Classification: Process-R&D+Management; decision made in team-face to face; semi private-meetings

C.I. #: 2 **Date:** March 13th **Project:** ISDN-Gateway
Person: Melinda **Functional** **Assoc.:** Project Manager
(Coordination)

Description of incident:

Due to budgetary reasons, and availability of internal intellectual resources, the decision was made to outsource a component of the ISDN software libraries that perform line testing and standardization. (It could have been built internally, but the people required were working on other projects, and were very limited in capacity (time to market would be slower)).

Solution:

Misunderstandings to poor communication and contractual ambiguities lead to the eventual abandonment of the outsourced product and the scratch building by Mitel. The Mitel product was able to solve the problem, yet cost more than the original and required a long development time to produce.

At this point software developers were added to the team to complete the design requirements.

Dissemination/Reporting:

This project component required formal documentation to acquire resources from other Mitel functions (software, hardware etc.). Corporate database files are updated with software versions of this project (in SMS) and hardware versions (including libraries and hardware schematics). The corporate financial database also contains product specifications and all financial data.

Classification: Coordination-R&D; team decision- meetings; Public-SMS, DaKAN

C.I. #: 3 Date: March 15th Project: ISDN-Gateway
Person: ISDN team Functional Assoc.: Core team

Description of incident:

A change in a hardware component delayed the completion of a Mitel designed software component within the ISDN project. The router software for the ISDN digital traffic was affected by a change in the hardware design, resulting in a more than two week delay in the software. This component is now on the critical path, and holding up the release 4 of the project.

Solution:

It was decided to move the changes to the release five of the project rather than continue holding up the existing version (Melinda in conjunction with the project managers and rest of team). The problem is not critical enough to warrant the "stop ship" on the current release. The solution to the actual problem just required more time and resource allocation, available to the release 5.

Dissemination/Reporting:

This problem was documented as a "DPA" (Design Problem Action Report) and made available to the engineers required to solve the problem. Additional copies are kept on file both hard and soft copies for anyone to see.

Classification: Content-R&D; team decision in person; Public-SMS, meeting

C.I. #: 4 Date: March 15 Project: ISDN-Gateway
Person: ISDN team meeting Functional Assoc.: Core team

Description of incident:

Conformance problems in software with traffic present. The conformance testing group (K. Steeden) detected a failure in the software when asked to handle various traffic loads. These conformance tests are the only way that Mitel has to insure that the boxes they build conform to the standards used by telephone companies. The ISDN gateway project links the modern digital networks to both digital and analogue PBX systems. Failure to conform with the ISDN standards could bring down a network. Changes made to systems by OTHER Mitel functions caused new problems to occur, implying that there was a failure to conform somewhere.

Solution:

Eventually hardware changes were made to correct the problems even the software ones, which were responsible for the "lack of conformance"

Dissemination/Reporting:

These changes were recorded in the SMS, both hardware and software versions were documented in the databases, and classified under a DPAR "ISDN Traffic Conformance"

Classification: Content-Testing; team effort; public-SMS

C.I. #: 5

Date: March 15th

Project: MC3R

Person:

Graham

Functional Assoc.: Project Manager (Coord. And Technical)

Description of incident:

MC3 main board to be replaced by delayed MC4, however, the 2 main ASIC chips used on the MC3 were limited in supply and no longer available to be ordered. Sales of the MC3 (demand) was under estimated when the "last time buy" of the ASICS were made. Since then, sales have continued to increase, leaving Mitel in a awkward position. They will soon run out of main controllers for their "big" PBX line, a major part of the business. The MC4 will NOT be finished before the MC3 runs out.

Solution:

Upper management decided to "hold" the MC4 project and spend the designer resources on building a new MC3, to replace the old one. The new product would be called MC3R, functionally the same as the old, with small increases in features, such as higher SCSI throughput, and built in Ethernet networking. Additionally, the new controller is slightly higher in performance than the old. A team of engineers were assigned to build the two NEW ASICs (the main design effort for the board) and other software and hardware people were added to the team to complete the new software build and support electronics on the PCB.

Dissemination/Reporting:

This project is a typical Mitel project in that it was fully documented in the SMS system as for all software versions and hardware designs. The Chip layouts are shared by engineers electronically through CAD tools and version numbers referenced in the SMS. Several minor and major problems encountered by this project and its team members were documented as DPARs. (Many of these are other critical incidents documented below).

Classification: Process-management; self-face to face; decision was documented in SMS and document vault

C.I. #: 6 **Date:** March 18 **Project:** Functional
Person: Richard **Functional Assoc.:** Project Mgr. Coordination

Description of incident:

A particular member of Richard's team (undisclosed) was recruited by another firm, and left for financial reasons. This person was the only person possessing a particular skill in Mitel (working with a specific CAD design tool). At the point that the person left, Mitel no longer had the ability to perform that specific task, required by this project.

Solution:

The project manager was forced to hire other resources from within the company to relearn the lost skill. The result was a delay in project delivery and increase in development cost. Richard mentioned that it is difficult to protect these "single point skills" because they are valuable to Mitel and other companies, and are often recruited. Having many people with the same skill can be very expensive because the training required is lengthy and the skill is so precise that it is not often used.

Dissemination/Reporting:

The fact that the single point skill is no longer in the company is known publicly to all those who would interact with him, through personal interaction (or lack thereof), but the newly learned techniques are documented in the software management system in a very primitive form. The actual skills are not recorded, but actions taken for the specific project are.

Classification: coordination-management; self assisted by tool-networks, postings; semi-private-meetings

C.I. #: 7 **Date:** March 18 **Project:** MC3R
Person: Graham **Functional Assoc.:** Project Mgr. Coord.

Description of incident:

Sales of the MC3 increased even after more recent forecasts were updated, pushing the deadline to complete the MC3R even closer. If they run out of main controllers, sales for PBX lines stop completely. This is a problem of beating the clock. The critical path of the project had to be shortened by about 2 weeks to allow a buffer for expected production problems of the prototype boards.

Solution:

The critical path of the project had several areas that could be shortened. It was decided by the project manager to reduce some of the time used to do "product verification", a process of making it the best it can be, in order to save time. (see also C1 #9). Some small problems were encountered in the design stage, like an Ethernet controller that does not have functional software yet, and some SCSI timing problems were scheduled to be fixed after the board goes into production.

Dissemination/Reporting:

This issue was dealt with through the project managers "MS-Project" system. Versions of the documentation for the project schedule are made available to all team members, as well as functional parents (those paying for the project) through e-mail and hard copy. These documents show the history and progression of the critical path for the entire project, and indicates what has and has not been completed to date. In project meetings, the MS-Project charts are brought up on a large overhead screen to show all attending. Discussions are focused around finding the best solution with the least "downstream" repercussions.

Classification: coordination-R&D; self assisted by tool-Msproject; Public-MSPProject

C.I. #: 8

Date: March 18

Project: MC3R

Person: Paul

Functional Assoc.: Hardware Designer

Description of incident:

The MC3R has both hardware and software components to it. Paul is strictly a hardware designer, although he is familiar with the software development techniques, and often helps with software development. In this case, small software code developed by a software designer to perform a test on the MC3R board did not function under Paul's design. The software was in fact built to "spec" but the hardware design, due to a rush in the development cycle was not. The hardware did however perform as expected.

Solution:

The software component in this case was very small, so Paul built a workaround to do the same function without using the "broken" software. This process slowed him (Paul) by about a day on the project, but the result was a working test bed for the board and the chips.

Dissemination/Reporting:

This particular problem was between two people only. It did not have consequences outside the project or these individuals (other than potentially delaying the project). There was no formal documentation done for this problem, and all communications were done face to face between those involved. It was mentioned at a product design meeting that the original software component would not be used, and that Paul had made a work around for the problem. The technical knowledge for this problem was Paul's experience.

Classification: Content-R&D; Self-Face to Face; private-memory

C.I. #: 9

Date: March 18

Project: MC3R

Person:

Paul

Functional Assoc.: Hardware designer

Description of incident:

During the final stages of the design of the main ASIC for the MC3R board, the simulator program (for ASIC's) determined that the test vectors that the engineers had generated would fail some good chips. This basically means that during the manufacturing process at Toshiba, the system would reject a portion of parts that should not be rejected.

Solution:

The solution to this problem was to perform a secondary test to produce a more accurate test vector. The second test (called a dither test) is more of a kludge than a standard practice. According to the engineer, "There will still be a problem, but it will work". A more ideal solution would take considerably longer, and since time was not a resource of abundance on this project, that route was rejected by the team (at the meeting).

Dissemination/Reporting:

This problem was brought up at a weekly project meeting, however, it was really solved before hand. Paul, and one of the software engineers working closely with Paul (Gordon) discussed the ramifications of performing a dither test to overcome the problem, and tried it out (experiment) before the project meeting. The communication was then a matter of reporting the problem and solution to the rest of the team and the project manager at the project meeting. This problem was documented in the DPARs list of the SMS for the project.

Classification: Content-R&D; Self assisted by tool (CAD/CAE)-Face to Face; SMS (DPAR) Public

C.I. #: 10

Date: March 18

Project: MC3R

Person:

Radovan

Functional Assoc.: Software designer

Description of incident:

While designing a new software driver for SCSI disk drives to work with the new main controller card, this engineer discovered that there was a lack of conformance to the SCSI specification, leading to some serious problems with some existing SCSI hardware. The drive Mitel was currently shipping would not suffer any problems, however, some of the drives used already in the field would be effected (if they were to use the new main controller). The problem as it turned out was the fault of the third party vendor, but they were long since out of manufacturing that product, and would not be able to fix the problem, so a work around would be needed for Mitel to use with any upgraded field systems.

Solution:

A contingency plan was developed between Radovan and Paul, the project manager to have three solutions. One would be to rewrite the software to allow for the firmware deficiency to be ignored, the second called for a hardware workaround with a small time delay in the SCSI bus, removing the problem, and the third which was to customize cards specifically for the few field sights who would want to upgrade (essentially not doing anything to the design of the card to solve the fundamental problem).

Eventually, the solution was found to be simplest (through experimentation with all three plans by Radovan) to make a small change to the software. The engineer used trial and error experimentation, based on a hunch to tweak the software to ultimately solve the problem.

Dissemination/Reporting:

The problem was reported as an action item at the weekly project meetings by the engineers and the manager. It was documented in the managers project file that Radovan would take this item further (as he did). Eventual changes made to the SCSI driver were posted in the SMS and notes about the problem were included in the code (although these are very brief). Other members of the team, having to do with software design were aware of the problem and the solution at the meetings.

Classification: Content-R&D; Self-Face to Face; SMS-public

C.I. #: 11

Date: March 26

Project: MC3R

Person: Paul

Functional Assoc.: Hardware designer

Description of incident:

During the development of the larger of the two new ASIC's for the MC3R board, Paul came across a problem with the simulator. It seemed that there was a difference in what the simulator was saying about a particular test vector, and what practice actually yielded in the manufacturing process. Part of Paul's style (cowboy) of engineering allowed this error to occur without any serious implications during most of the chip

development. Towards the end, it was apparent that something would have to be changed.

Solution:

The issue was of timing. There was a 10 nanosecond delay between when the simulator said something should occur and when the actual occurrence took place. Paul's solution was to separate the clock from its neighboring lines by 100 nanoseconds, making the 10 ns offset irrelevant. Through his own experience of trial and error, the engineer was confident that this solution would not cause any further problems, yet it would elevate the initial symptom.

Dissemination/Reporting:

This engineering issue is so basic that only engineers were involved in its solution. Paul discussed this problem with two people, his co-worker Yifan and his boss (manager of hardware design) Jacob. Yifan was brought into the loop because he was doing the design for the second chip and they would prevent this problem from occurring in that one by building in the above mentioned delay. Jacob was advised to make sure that the solution was not unorthodox and because he tends to work closely with the small hardware design group. The problem was briefly mentioned at the project coordination meeting as a line item to inform others including the project manager that there was a problem, and a solution had been found. No technical details were shared at that meeting.

Classification: Content-R&D; Self (experience)-Face to face; semi-private-meetings

C.I. #: 12

Date: March 26

Project: MC3R

Person: Paul

Functional Assoc.: Hardware designer

Description of incident:

During one of the final debugs of the large ASIC chip, Paul found that there was an I.7 interrupt not being clear by the software (this is a very high level interrupt which could cause the main controller to come to a crashing halt). The cause of the problem was simply a lack of agreement and coordination between software and hardware engineers. The solution could have been implemented either in software or hardware, or it could be ignored and cleared by additional software.

Solution:

Paul talked face to face with the software engineer responsible for that part of the code (another team member) and decided to fix the problem himself. The solution was easier done in software, so Paul wrote a small patch to perform a "Ram-S move" instruction that would cause the controller to ignore the bus error and not be affected by the interrupt. Paul remembered that something very similar to this happened in the previous version of the software and the board, so he was quite sure it would work. The information about the previous solution was not written down anywhere, or in the version documentation in the SMS, it was only by his memory that this knowledge was available.

Dissemination/Reporting:

This problem never made it off of Paul's and the software engineers' (Gordon) desk. It was not mentioned at the meetings, and was not documented yet again. It is now part of the knowledge repertoire of Paul, and since he is the only one in the company who would ever design such an ASIC, it is likely that if the problem reoccurs in a future version that he will have to fix it.

Classification: Content-R&D; Self-face to face; private-memory

C.I. #: 13

Date: March 26

Project: MC3R

Person:

Paul

Functional Assoc.: Hardware designer

Description of incident:

In order to develop an ASIC (a super scalar micro controller) Mitel uses a CAD/CAE tool called Synopsis. This is a highly complex and specific tool for building electronic layouts of micro-components and logic. The tool is expensive, requires tremendous computer resources to run, and has a very small world wide distribution. As a result, it is no surprise that there are, from time to time, bugs in the software. Paul received an update to the Synopsis software (version 3.4a) and found that it caused a serious problem with the development of the large ASIC. This problem would not be apparent in all applications of Synopsis, and the software vendor cannot test for all cases (would require too many resources and delay product release). As a result, companies like Mitel become test sights (and customers at the same time).

Solution:

Paul placed a call to the Synopsis people and explained the bug to a high level software designer there. They understood the problem, and were able to reproduce it. Once the problem was isolated, Synopsis announced that they would be able to fix it in the next release of the software (which would not be available until after the MC3R was complete). Paul reverted back to an older version of the CAE tool, lost some functionality, but at least it did not cause the problem as did the new version.

Dissemination/Reporting:

Mitel used to have a specific person who was responsible as a support person for the Synopsis tool. That person was recruited by another company over one year ago, leaving Mitel with virtually no support. Normally this sort of problem would have been documented by that support person, however, in his absence, Jacob (Paul's boss) and Yifan were notified by face to face interaction. The software vendor has a record of the complaint in e-mail form, and a reply was received by Mitel in E-mail form (Paul). There is no log of progress on this particular tool. The problem was also mentioned at the weekly project meeting (notifying about 8 others of the version problem) since it caused Paul's component to be delayed by several days (the project manager needs to know when there is a delay on the critical path).

Classification: Content-R&D; Paul and other people outside-telephone; semi private-meetings

C.I. #: 14 **Date:** March 26 **Project:** MC3R
Person: Radovan **Functional Assoc.:** Software designer/tester

Description of incident:

This engineer, while debugging the new driver for the SCSI controller on the MC3R discovered a bug that he could not figure out. He was not certain if it was a problem with the test tool, or with the actual code, and could not devise a way to determine which. He also did not (at that point, since he was new to Mitel) know who to ask.

Solution:

The large part of the solution was finding the right person to talk with in the company. He started out by looking at the organization chart of his department (software design) to see who was responsible for SCSI in the past. This chart was of little help. The next step he took was look (using a grep search) in the SMS for problems (DPAR's) about SCSI. He found a few, and asked the people who owned those problems, (who were from a different department). They pointed Radovan to the right person, who was actually within his own department and section. It turned out that there was a problem with the debugger tool, and there was a simple solution to it.

Dissemination/Reporting:

Radovan was still unfamiliar with many of the reporting procedures at the time, and did mention the problem in the source code that he wrote (mostly for his own future use) but other people who came across the code could see the notes. This problem never made it to a project level meeting.

Classification: Content-R&D; self assisted by tools-e-mail; private-memory

C.I. #: 15 **Date:** March 26 **Project:** MC3R
Person: Radovan **Functional Assoc.:** Software designer/tester

Description of incident:

Radovan was asked to work on an interface with the PBX system, one that he had no experience with. At this point he was in the company for many months and began to know many of the people around him. He had no idea of the "big picture" of this system works, and needed to learn it fast.

Solution:

This engineer decided to ask the person in product support, responsible for this line, about the working details of the system. In fact, he bugged him quite a lot until he had the information he needed about the machine. It was almost an apprenticeship where Radovan would learn about the large PBX by watching the support person do his job. Once Radovan had a good idea about the system, he was able to do his job and found many bugs in the software. During this debugging process, he was learning highly detailed knowledge about the basic and complex operations of the PBX line. This process took two months and was highly experimental for Radovan.

Dissemination/Reporting:

Since this process was a learning experience for an engineer, the knowledge being built went specifically into one person's head. His superiors and co-workers, as well as a few people in product support have a very good idea about what new knowledge Radovan has, and conversely, Radovan now knows exactly who to ask about each type of problems in the PBX line. During project meetings for the MC3R Radovan mentioned his learning and was assigned new tasks based on that.

Classification: Content-R&D; Self (experiment)-private; semi-private-meetings

C.I. #: 16 Date: April 4 Project: MC3R
Person: Yifan Functional Assoc.: Hardware designer

Description of incident:

The timing skew issue that was first started on the larger ASIC chip by Paul Gresham in another critical incident of course had a serious impact on the design of the second, smaller ASIC. The timing from both chips must match perfectly for them to work with each other. Paul told Yifan exactly what he had done and said to repeat this process for the second chip.

As far as Yifan was concerned, he was a new employee who did not know the ropes of Mitel very well. He took what Paul had to say for gold and made the necessary changes to the chip. This required Yifan to learn some simple content specific knowledge that he never had before, and he was able to do that from Paul.

Solution:

Due to their very close proximity in the company (geographically) Paul and Yifan have a high level of face to face interaction whereby Yifan learns by example. This type of apprenticeship is how many of the junior engineers tend to learn at Mitel. It only took Yifan a very short time to adapt the timing skew of 100 ns in the second chip.

Dissemination/Reporting:

This incident was reported in conjunction with the main ASIC timing issue with Paul. It was really a secondary issue, and piggybacked along with the first (even though it involved a different person). There was no formal documentation made for this incident, however, there is no one more person in the hardware design department fully aware of the problem and solution

Classification: Content-R&D; self-face to face; semi-private-meeting

C.I. #: 17 **Date:** April 4 **Project:** MC3R
Person: Yifan **Functional Assoc.:** Hardware designer

Description of incident:

Yifan had to get the information about how to manufacture the ASIC chip to Toshiba, and Toshiba had to supply a file format for the information so that the machines could understand the content. There was a problem in the file exchange format that Toshiba sent to Mitel, in that it would not interface with the CAD/CAE tool that they were using. The result was that the information that Mitel sent to Toshiba was useless in the manufacturing process.

Solution:

Yifan took it upon himself to write a script to convert the files from the Mitel format to the Toshiba format. Although these formats were very similar, it was necessary to write this script to allow a transparent transfer of data between the two companies. Yifan experimented with many variations of his script before it worked perfectly, but the knowledge he got from doing it was purely experimental, and experienced based.

Dissemination/Reporting:

This problem never made it out of the local area of the hardware designers (about 5 people). These people did know about it from face to face communication, and the script itself lives in the software directory of the product release. In other words, if someone were to look at that particular version several years from now, they would also find that conversion script.

Classification: Process-R&D; Self(experimental); semi private-personal files, libraries

C.I. #: 18 **Date:** April 15 **Project:** MC3R
Person: Graham **Functional Assoc.:** Project manager (coord. and technical)

Description of incident:

As project manager Graham was made aware of a serious problem in the development of the large ASIC chip. He was asked for input to guide the solution, and

for his influence if outside help was needed. The basic problem fell in the lap of Paul (senior hardware designer), however the problem was serious enough that it could cause significant problems in production, so the manager was brought in.

The test vector generator component of the development tool Synopsis was providing false data, and would cause an eventual nightmare in the manufacturing process, as it would fail many components which in fact were good. The problem was a result of testing the whole chip as a single unit rather than the individual components (which tested fine separately).

Solution:

Graham realized himself that the problem was in the tool rather than the design when he found out that each part of the chip tested fine by itself, and caused a problem only when tested together. His solution was to move forward with the design progress, and debug the tool by placing a call to the tool vendor. Graham instructed Paul to make that call because only he could communicate the precise problem to the vendor, and understand the solution. Two calls and follow-up e-mails were made to the vendor before the problem was solved. During this solution, the project manager had Yifan (the designer of the other ASIC) brought into the problem so as to be made aware of the details, hopefully avoiding a similar problem with the second ASIC.

Dissemination/Reporting:

This problem was documented by title only in the MS-project file used by the project manager in meetings. The content was made public to other team members at the weekly design meetings but very little details were disseminated outside of Paul and Yifan. There are however approximately a dozen people who know that the problem existed and that the solution was found.

Classification: Content-R&D; outside person-phone; semi-private-meetings

C.I. #: 19

Date: April 15

Project: MC3R

Person: Graham
Technical)

Functional Assoc.: Project manager (Coord and

Description of incident:

The MC3R board was the first in the line of Mitel main controllers to use and "off the shelf" SCSI controller rather than a Mitel custom one. This caused a problem of compatibility with some older Mitel labled equipment. This particular problem was a SCSI bus timing/lockup issue that would cause certain tape drives to hang the card

Solution:

Radovan was already working on some other SCSI problems with this same card, in fact a similar problem. Graham suggested that a contingency plan be built for this problem, since it was unexpected and not budgeted for. Radovan did comply, and came up with three possible solutions. One of those solutions was developed in conjunction

with Graham, who came up with the idea of placing a small resistor pack (hardware change) on the board to increase a delay in the timing loop. This fix actually took the board away from the SCSI specification, but did not cause any new problems, while still solving the old one.

The other two solutions were to fix it in software, which would be very time consuming, and therefore expensive, or not to fix it at all, and notify all users of the old Mitel tape drive that, if they would upgrade the main controller to MC3R they would also have to upgrade the drive to the current one.

The ultimate solution was the first mentioned, being both inexpensive and good to customers.

Dissemination/Reporting:

This problem was also mentioned at the weekly project design meeting so that other members would be aware that the problem exists. The actual hardware design changes were made and updated in the board layout design and stored in the CAD system and referenced in the SMS. People looking for this problem in the future would be able to find the design changes and why they were made in a report in the SMS by using a search for "SCSI timing problems" on the MC3R project.

Classification: Content-R&D; self (experimentation); semi public - SMS

C.I. #: 20

Date: April 15

Project: Many

Person:

Bob

Functional Assoc.: Mgr. Tool support

Description of incident:

The tool support group at Mitel is a reasonably large and very important support function. These people provide first line support for all of the design project with respect to the hardware and software tools that they use. These include all of the CAD/CAM/CAE systems, operating systems including Unix, Solaris, Windows and others, and many other applications used for design. The group is separated into smaller groups by specific tool. For example, there is a group (two people) who look after all Unix problem, and there is a single person who looks after the Cadence tool (a high level CAD/CAE for developing board and chip layout). There was a person responsible for the Synopsis tool. A single point skill, which no one else really could do effectively. That person was recruited out of Mitel by the competition over a year ago, and the hole has still not been filled.

Solution:

At present, the solution is to have the customers of the support (usually designers) transfer their first line questions to the second line (which has always been and still is), the vendor of the tool itself. This is padded by the designers having to debug and maintain the tools themselves. This generally works because no one knows how to use the tools better than the designers, however, it does take away from their design time, meaning longer times for development of most projects.

To date, there is no replacement for the Synopsis support person because there are so few of these people around in North America. Even the vendor does not have a person who knows the tool AND the context it is used in better than the former support person. As time progresses, the support person for Cadence and the designers themselves develop a better sense on how to support the tool and gradually fill the hole of the missing person.

Dissemination/Reporting:

This problem was quite substantial in the design and support departments, and as a result, a large number of people were informed about it in various meetings. Ideas about how to fill the hole were floated, but unfortunately, not much can be done to bring back the single point skill that left the company. Only measures to prevent it from happening again could be done. In general, Mitel has limited resources and cannot make the single point skill that they have redundant.

Classification: Coordination-R&D; self-phone; semi-private-meetings

C.I. #: 21

Date: April 15

Project: Many

Person:

Managers meeting

Functional Assoc.: Project manager

Description of incident:

One manager struggled over decision whether to perform a post project review (also called post mortum at Mitel), since the process clearly says that it should be done, but in practice it is rarely done (at present) for a number of reasons. Resources are scarce, and finger pointing is not desirable. Additionally the manager did not see who the customer of the report would be, since at present there is no system for allowing other managers to see the results from a PPR.

Solution:

In this case, it was discussed among nearly 10 project managers and a brainstorming session yielded ideas about how to constructively share information about PPRs without implicating individuals who were at the problem points of a project. The idea was to make the PPRs non project specific, and therefore not point a finger at a single project or person (in some cases, it may still be obvious). It was decided that other managers could benefit by looking at PPRs by preventing the repetition of old mistakes, or old development efforts.

Information about the PPRS will be made available to project managers on the INTRAnet at Mitel. Other employees will be able to gain access to portions of the information that do not clearly mention names (other than project managers). The proposed system for this is Lotus Notes.

Dissemination/Reporting:

At present, the members of the meeting are the only ones who are in on the solution, however, this idea is being formalized by informing upper level managers about the intent (through other meetings) and by making modifications to the formal Mitel

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process (about PPR). These notes eventually will be made available to all project managers, who will be expected to participate.

Classification: Process-management; group meeting-face to face, e-mails; semi-public-official action orders

C.I. #: 22 **Date:** April 15 **Project:** Many
Person: Managers meeting **Functional Assoc.:** Project managers

Description of incident:

Terminology has been and still is a problem at Mitel (and other companies). This issue came up in a meeting when an ambiguous term came up and people took it to have different meanings. Terms such as "Function, Manager, Leader, Development, Thrust, Focus, Program" and others were words that depending on the functional association of the person would mean something different. The inability to communicate concisely in meetings costs Mitel a fortune in human resource dollars (and potentially research dollars wasted on redevelopment after a miscommunication).

Solution:

Mitel actually has a dictionary of terms such as those and a myriad of acronyms (both industry and company specific). The group decided to stick to the dictionary, and add words that were missing (such as some of the above). This solution is a difficult one to have everybody stick to because there are different backgrounds to all the people, leading them to use words in alternate ways. Eventually, this manager group refrained from using most of the ambiguous words and replaced them with more easily discernible ones.

Dissemination/Reporting:

This solution was used solely for the project managers meeting, however, since there were several people present, it is likely that the results be carried to their respective projects. No formal attempt was made to have people avoid the use of ambiguous words (such as manager and function) however, in subsequent meetings, this solution did stick.

Classification: Process-Management; tool assisted-intranet; public-intranet

C.I. #: 23 **Date:** April 18 **Project:** ISDN-Gateway
Person: Dave **Functional Assoc.:** Software builds

Description of incident:

This particular individual is the owner of literally hundreds of DPARS (or critical incidents) because he is the manager of a particular component of the SMS. His example to me was a fault in the build of the 4.0 version of the ISDN software library. It turned

out to be a documentation problem that was identified by Ed. The problem was that the correct file include versions did not match the new release, and cause the build to fail.

Solution:

This problem was solved by Dave communicating with the few software designers (by e-mail) to find out the correct versions and includes required for this release 4.0. Part of the result was the design of a new tool which matched versions of software with file requirements, hopefully preventing this problem again in the future. Ed would be one of the people who would use the new tool. Dave pioneered the construction of the new tool, which is simply an addition to the procedures of the SMS.

Dissemination/Reporting

This incident was documented fully in the SMS since it was first identified through that system. It went through the full DPAR stages: DPAR raised, designed, submitted, tested and closed. The results of this incident are public to all, but were specifically aimed at software designers working on multi-version applications (almost all software has more than one version).

Classification: Content-R&D; Self-e-mails; public-SMS

C.I. #: 24

Date: April 18

Project: MC3R

Person:

Gord

Functional Assoc.: Software designer

Description of incident:

Gord was handed a DPAR from the support people, identifying a problem in the field. He was given a paper printout of the symptomatic data from the customer sight as well as the electronic DPAR form. The problem was an intermittent communication link between the redundant processors in a large PBX system. Normally the communication should be continuous. The printout indicated the connection opening and closing far too often, which reduces the effectiveness of the redundant system.

Solution:

First this engineer tried to reproduce the problem in the lab by simulating the exact system configuration and environment as the customers. Failing that, he did a grep search in the code for the text outputted in the error message in the customers' printout. This error message turned out to be common for many errors, so he changed the code so that each error was yielding a unique message and sent that software to the customer to find out which error in fact he was getting. He spent a week fumbling around like this without major success before he went to colleagues who had more experience with this type of error detection. He found these people from a sheet of expert given him by his supervisor. These people informed Gord as to what the problem was NOT, and narrowed the search pattern. Gord spent another week trying again with little success. Then he heard about one more engineer at Mitel who worked on the original code, who was also no longer working on this project. It took some serious negotiation to get an appointment

with him since this other engineers' supervisor did not want him diverted from his work. Gord eventually walk straight to the engineers desk and spent an hour talking about the problem. After that, the solution came within a day.

Dissemination/Reporting

This problem was initiated as a DPAR, and thus it was documented with its solution in the SMS. The case includes the name of the engineer who gave the ultimate help, but does not include the long involved process about how Gord actually found where the knowledge was.

Classification: Content-R&D; self (experimentation)-face to face; Public-SMS

C.I. #: 25

Date: April 18

Project: MC3R

Person: Gord

Functional Assoc.: Software designer

Description of incident:

During the development of the current project (MC3R) one of Gord's team mates left Mitel for another company, leaving a hole in the development effort. The next closest person to the set of skills was this engineer. The person who left, was however, a single point skill, in that no one else understood the work he was doing properly. This particular engineer acted as a link between hardware and software engineers in domains such as firmware design and hardware/software addressing.

Solution:

Gord had to fill the hole almost entirely by himself. He began increasing his communications to the hardware designers, using only face to face communication to exchange ideas and negotiate solutions. The loss of the engineer did slow the project down, but by adding small pieces of the puzzle together from many different people, Gord was able to handle the problem.

Dissemination/Reporting

This problem was discussed in many meetings, both at the project level, and the upper management level. The decision was made not to fill the position because it would take longer to train a new hire to fulfill their needs than to have the current engineers fill in the hole. There was a reasonably high level of awareness surrounding this loss, however no direct action was taken to prevent future occurrences (not much to do).

Classification: Content-R&D; Self-face to face; semi-private-meetings

C.I. #: 26

Date: April 18th

Project: Mc3R

Person: Gord

Functional Assoc.: Software designer

Description of incident:

Gord needed to know how the new ethernet adapter would be addressed on the MC3R product, and the only people that could provide that information was the supplier of the chip, National Semiconductor. The communication channel with them was slow and inconsistent, leading to delays in the design of the code corresponding to that chip. It seemed that the chip did not follow the specification sheet, and caused an error when initialized normally.

Solution:

After two months of faxes and e-mails, the answer was still not clear to Mitel, and the engineers responsible for this code were beginning to hold up many downstream parts of the project. Finally, Mitel hosted an engineer to come onsite from National. Once the face to face interaction was started, it was a matter of hours to determine that there was a typo in the spec sheet, and that there were two address lines reversed. The problem was immediately resolve and the downstream components then moved along. The total delay to the project was about two months, however, the final delivery was not effected because of built in anticipated delays at the onset.

Dissemination/Reporting

This problem was a highly visible one to many engineers and the project managers (both coordination and technical). The incident was documented in the SMS in designers notes, and the project schedule (MS Project). It would be easy to find references to it in online systems, however, it would require personal conversation with either Gord or Paul to completely understand it.

Classification: Content-R&D; Outside people- face to face; public-SMS, meetings

C.I. #: 27

Date: April 18th

Project: MC3R

Person:

Tom

Functional Assoc.: CAD support (Cadence)

Description of incident:

All logic boards require some sort of test points so that during the manufacturing process, they may be tested in various levels. Normally, the most simple kind of test points are boundary scan point (those that test only the input and output of a circuit. It is not an easy task to generate these points by hand, so it was requested that a program (under Cadence) be written that would allow the CAD tool to automatically generate a boundary scan.

Solution:

During a three day process, this engineer communicated with the supplier of the tool (Allegro) and the Mitel designers who used it to create a new application that would generate test vectors. Since this project was driven by a requirement from the designers themselves, the design stage of the new software came almost entirely from those engineers. It was for technical details that Tom communicated with the supplier, to make

sure that the requirements and new code matched, and were in fact a possible task for this CAD software to perform.

Dissemination/Reporting

There were three types of communication in this project. Firstly, the design requirements came from the Mitel designers. This can in the form of face to face conversation between Tom (tool support) and two or three design engineers. The second form of communication was between Tom and the software supplier. This took place through e-mail and voice communication. There were several calls placed. The final stage involved the dissemination of the solution to everyone who required it. The three who originally asked for it were very well informed about it, but the new software was documented in the tools support library for public access, and for easier use on the Intra-Net. Users could use Netscape to get detailed descriptions about what the software does, and how it works (also who to talk to for further information).

Classification: Process-R&D; Outside person-telephone; semi-public-intranet, meetings

C.I. #: 28 **Date:** April 18th **Project:** MC3R
Person: Tom **Functional Assoc.:** CAD support (Cadence)

Description of incident:

During the early stages of the MC3R development, Tom noticed that there was a problem in the CAD tool files that Paul was working on. The problem was a confusion in the working directory in the computer system, meaning that Paul was working on old files, rather than the most recent. Fragments of work were being done on two instances of the same project, meaning that progress was at a standstill.

Solution:

Paul and Tom realized the problem at about the same time. Tom was able to overlay the recent changes made to the older file on top of the newer file, creating a complete version including all the work done. This process did take over a day to do, and was wasteful. The cause of the original problem was determined to be a flaw in the file transfer/copy process. It was a timing issue of when to insert a disk, and when not to.

Dissemination/Reporting

This problem was not documented in any way, or made public to anyone other than Tom, Paul and the two people working closest to Paul (they also have access to the same files, in fact, it was one of them who was involved with the copy timing error). No attempt was made to prevent this from happening in the future other than this experience will cause the users to think before they copy.

Classification: Process-R&D; Self-face to face; private-memory, personal notes

C.I. #: 29 **Date:** April 18th **Project:** MC3R
Person: Tom **Functional Assoc.:** CAD tool support (Cadence)

Description of incident:

Recently the versions of the CAD tool that Tom supports changed versions, and added a lot of functionality. Since then, the designers have not used it. In fact, there is often a span of a year between when designers will use a particular tool, depending on where in the design of a project they are. Since so much changes between uses of the tools, there is often a great deal of learning curve when the engineers pick up the tool again. Tom would like to see training on a regular basis to prevent this. The effect is similar when a designer with a single point skill leaves. Training is required and is seldom performed.

Solution:

Tom discussed with many of the designers, the possibility of training sessions on a regular basis. The idea went over well, but the problem of limited resources (of time) always prevented from the actual execution of such training. To date this training is done using the "band-aide" method, fixing problems as they crop up rather than preventing them.

Dissemination/Reporting

Numerous documents are available about the changes made to tools, however these documents are used as a reference during design rather than a tutorial in advance. Little can be done about this specific problem with such limited human resources.

Classification: Process-R&D; self-meetings; semi-public-meetings, physical documents

C.I. #: 30 **Date:** April 18th **Project:** MC3R
Person: Tom **Functional Assoc.:** CAD tool support (Cadence)

Description of incident:

At the end of a board layout design, there is a process called ground copper balancing. This involves making everything that is not used in a circuit into a ground so that there is electrical and noise shielding. Normally this is done at the click of a mouse button in a CAD tool. The software should automatically find the grounds and fill them in. The latest version of Cadence however, rather than making all the grounds balanced, would cause an error field for each ground area. This created several days of work and delay to the MC3R project. The designers spoke closely with Tom in getting the instance of the problem fixed, and the future problem prevented.

Solution:

The solution in this case would not come from the CAD tool. In fact, they ended up switching to an older version of the tool which did this function correctly. The action to prevent it from happening in the future was to initiate a product change request to the

supplier of the tool. This supplier (Allegro) immediately acknowledged the problem and promised a fix for the next version (too late for this project).

Dissemination/Reporting

All individuals working with the tool were informed of the problem with this version and told wither to live with it until the new version comes in the fall, or use the older version until then. This information was disseminated by face to face interaction and by e-mails to all involved.

Classification: Content-R&D; tool assisted- face to face; semi-private-meetings

C.I. #: 31 **Date:** April 18th **Project:** MC3R
Person: Paul **Functional Assoc.:** Hardware designer

Description of incident:

Synopsis CAD tool has a routine which performs an automatic fault test and analysis. This allows designers to test the functionality and integrity of their design as they go, in simulation. The component of the simulation in the latest version of the tool was not performing the fault check correctly, causing delays in the design of the main control ASIC and board layout (downstream operations).

Solution:

Paul placed two calls by voice to the supplier of the Synopsis tool. That was not able to solve the problem. The next step was to look at the code in the tool itself to try to debug it in-house (Paul). In fact, he did come up with a solution that appeared to work, and sent it to Synopsis. At this point, he got a quick reply from the vendor saying that the "fix is wrong, try this". The new patch (second attempt to debug) was successful in fixing the problem.

Dissemination/Reporting

This problem was not publicly documented, however Paul is developing a rapport with the supplier of the tool (similar to the one that he had with the old tool support person before he left). Calls and communication between the chief engineer at Synopsis and Paul are frequent and commonplace. This is becoming another single point skill.

Classification: Content-R&D; outside person-telephone; private-personal notes

C.I. #: 32 **Date:** April 23rd **Project:** MC3R
Person: John **Functional Assoc.:** Software designer

Description of incident:

This engineer was responsible for writing the code that converts the software code into a firmware ROM for use as the main software for the MC3R controller board. This process involves downloading the code onto a programmable chip (PROM) and then testing it using a checksum. This test adds the total number of bits used on the chip and compares that with a predetermined number. The problem here is that the new design includes a serial numbered (address) ethernet interface. The result is that every chip would yield a different checksum, and fail the test.

Solution:

The problem here was with the tool that performs the test. It was one generation of technology behind the current design. The engineer rewrote the tool to perform a checksum excluding the ethernet component, and a second part that would include only the ethernet, adjusted for the address number (causing it not to fail if it was a good chip).

Dissemination/Reporting

This problem is a fair bit out of John's domain, however, it is not out of his capability. He wrote the new code and communicated (before and after) with the person that normally maintains the test tools for firmware (Richard). Richard both approved and documented the update. This new tool is visible from the SMS and the intranet.

Classification: Content-R&D; Self-face to face; semi-public-SMS, tools manager, intranet

C.I. #: 33

Date: April 24th

Project: MC3R

Person: John

Functional Assoc.: Software designer

Description of incident:

On the original MC3 controller card, there is a flash ROM chip made by Motorola which uses a 24 bit addressing scheme to get data in and out of the chip. That product is no longer made, and the replacement uses a 32 bit addressing scheme. The result is that the software designed for use with the old chip will not work. (These formats are called s2 and s3 respectively by Motorola)

Solution:

During a chat with Richard, the tools support person for John, this subject was brought up. Richard thought it would be simple to write a new tool that would strip the 24 bit data and convert it into the newer 32 bit code. This in fact was done in a very short iterative process between John and Richard (Richard doing the coding in the most part for this). The new script was designed and tested within a few days of the problem, and put into practice shortly after.

Dissemination/Reporting

Since John is the only person who will be working with the new 32 bit flash, very few others were brought online to this problem. Other people in the future may encounter a similar problem however. This incident is mentioned in the SMS under the flash ROM component of the MC3R project. It would be possible for other engineers to find it (if they looked).

Classification: Content-R&D; self-face to face, e-mails, semi-private-mentioned in SMS, tools support

C.I. #: 34 **Date:** April 23rd **Project:** MC3R
Person: Gord **Functional Assoc.:** Software designer

Description of incident:

During a design meeting of the MC3R group, Graham (the project manager) was looking for some answers about dates to completion. It was determined that the critical path at some point in the near future would no longer be a hardware bottleneck, but rather software. He asked Gord (senior software engineer on the project) what the hold was. Gord explained it was simply a resource problem, not enough people to do the job. He stated that it would be done in three weeks, however that there was a chance that something would go wrong in that time, and to reduce that risk (this project is extremely important to get done on time) that some other action should be taken.

Solution:

Gord suggested that the design effort could not be farmed out to other engineers because the learning curve would be too great and little to no help would be gained. However, he thought that parachuting some engineers in to do some of the mundane tasks could divert all of the more critical issues to the existing designers, reducing the first try design time by about a week (giving that extra week for debugging and fixing). The idea was accepted.

Dissemination/Reporting

E-mails were sent to managers of several other software designers who were working on less critical projects, asking if they could be borrowed for two weeks for the crucial stages of a potentially company stopping project. At least one engineer was reassigned to the task temporarily.

Classification: Coordination-R&D; others (meeting) face to face; semi-private-personelle files

C.I. #: 35 **Date:** April 23rd **Project:** ISDN-gateway
Person: Nancy **Functional Assoc.:** Software designer/mgr

Description of incident:

Just over a year ago, the ISDN team (software component, managed by Nancy) came to the conclusion that the operating system that they supported was going nowhere. The implication was that the product they were putting out was being designed for an obsolete market. The current O/S was IRMX, and Intel specific code which very few vendors supported. It was decided to change the operating system for a more competitive one.

Solution:

The team held a brainstorming meeting to determine the possible alternatives to a new operating system. There was already an existing preference towards OS/2 from IBM so the ideas were skewed around that. Several versions of windows and Unix were also mentioned. During the following weeks Nancy did some research in the company library and several trade journals to see where the industry was going. She determined that Unix was out because although it was well supported, the clients that the Mitel products were going to were generally using PC platforms. OS/2 although it had some good features was no longer under development from IBM, and had a limited future (even at that time). She made the decision that Windows NT would be the most fitting OS for development under the ISDN project.

Dissemination/Reporting

During a team meeting she told the group that the decision was made to use WinNT, and explained the reasons behind it. It took a bit of convincing to get all the engineers online (because some of them had little experience with the OS). However, in hindsight, it was the best decision, since the product is now fully functional in WinNT and is available to more customers than ever. The decision about the OS selection is briefly documented in the team meeting minutes, and in more detail in Nancy's notes.

Classification: Content-R&D; Self (group)-face to face; semi-private-meetings, personal notes

C.I. #: 36

Date: April 23rd

Project: ISDN-gateway

Person:

Nancy

Functional Assoc.: Software designer/mgr

Description of incident:

Another design decision had to be made with respect to the mode of programming using in the ISDN project. Two basic models could be used, the first being a PROCESS model and the second being a THREAD model. The differences in performance, functionality and ease of maintenance are huge, but there is no clear better method (at least at that point there wasn't). Before too many more resources were spent on the existing process model.

Solution:

Nancy assigned another senior engineer to build a model program for each of the programming types and build a scheme of weights of what issues were more importance

or critical to this project. That engineer then took responsibility for the research and eventually came back with the desired information. A benefit analysis was then performed (by both Nancy and the senior engineer) to determine if there was a clear advantage to using one method over the other. It was then decided that in fact they had been using the inferior method, and that the switch should be made.

Dissemination/Reporting

The first action was to inform the project manager (Melinda) and schedule a project meeting. During the next project design meeting, Nancy brought it to the attention of the others involved on the team. There was some "humming and hawing" because there was a significant redesign effort in front of them all, but the benefits could be seen even through all the new work. The decision and information about the decision were recorded both in a FAD document and in the team meeting minutes.

Classification: Content-R&D; Other person - face to face; semi-private-meetings, notes

C.I. #: 37 **Date:** April 23rd **Project:** ISDN-gateway
Person: Nancy **Functional Assoc.:** Software designer-mgr

Description of incident:

In addition to being the manager of the software component of the project, Nancy also manages the interface to hardware. Since the hardware is now being outsourced, she has to deal with other companies on a regular basis. The main supplier of the ISDN DSP card was having delivery problems with the card Mitel was interested in. This meant that the software design team didn't have anything to test the software with, ultimately creating delays in Mitel's delivery date.

Solution:

The solution here was to change the downstream schedule to absorb about one month of time. In other words, they would be taking a more risky design path in the future to keep the project on schedule. Melinda agreed that this route was better than leaving things as is, and took responsibility for making the changes.

Dissemination/Reporting

Melinda then made changes to the MS-Project schedule and sent via e-mail to all concerned (both on and off the project). She also went over the ramifications of the changes in the next project meeting.

Classification: coordination-R&D; self assisted by tool- face to face; semi-private MS-Project

C.I. #: 38 **Date:** April 23rd **Project:** ISDN-gateway
Person: Ed **Functional Assoc.:** Software designer

Description of incident:

On past versions of the ISDN gateway as well as many other projects at Mitel, most of the components are designed and built in house (at least during the design stage). The ISDN gateway project recently decided to outsource the hardware component of the product, which is in fact a very small part of the design. The problem arose when the supplier was late in producing samples to do testing with. In this case, this designer had to talk directly with the supplier to get details about what the product would be like.

Solution:

The solution to this instance of this problem was solved by rescheduling the downstream activities as mentioned in the previous critical incident. The prevention of the same problem in the future however, was done by forming a strict contract protocol for dealing with outside suppliers. In future, very tight dates will be used, and they (this team) will never rely on a single supplier (this is difficult in the R&D industry, where a newer technology is being acquired. This project's hardware component is not too cutting edge to prevent a multi-supplier arrangement).

Dissemination/Reporting

This incident (instance) was documented in the project meeting minutes and in FAD's, however this engineers point of view, where he had to contact the vendor directly was not.

Classification: Process-R&D; person assisted by tool-DAKAN; public-DAKAN (fad)

C.I. #: 39

Date: April 23rd

Project: ISDN-gateway

Person: Ed

Functional Assoc.: Software designer

Description of incident:

Ed is responsible for creating the human-machine interface for the ISDN project. This is a software component which talks to the actual ISDN software and gets/gives information to the user. During the design of this software, Ed became very far behind in the documentation as set out by the company process (FAD's), and in addition he had to build a test interface that would test the interaction of his software with the hardware.

Solution:

To solve the latter problem, Ed contacted the OEM support people within Mitel to find out how this type of testing was done before. There was a significant amount of work already done on that, so Ed took that and made small modifications to accomplish his goal. For the former part, he simply had to recall the important issues and document them as prescribed. To date, these documents are still behind, but the work on the project takes priority.

Dissemination/Reporting

This incident should be documented, however it is not. The normal process would have the incident indicated in a FAD and in the engineers notes, however, time resources prevent either. It may in the future be written down.

Classification: Content-R&D; self-face to face; private-memory

C.I. #: 40 **Date:** April 23rd **Project:** ISDN-gateway
Person: Ed **Functional Assoc.:** Software designer

Description of incident:

Ed was given a BELA copy of the IMAT testing forms to test and work with. The group that designed this software is located next to Ed's and is functionally similar. While testing, Ed found a general protection fault error (very serious). The error is caused by something which the designer would have normally not thought of in his white box testing and was found during Ed's black box boundary testing.

Solution:

Since this was a BELA test, there was no documentation done for it, and all progress made on it OUTSIDE of the original designer was strictly off the record. As a result the communication was done face to face (simple because these engineers are within 25 feet of each other) and a iterative process was followed until the errors were eliminated.

Dissemination/Reporting

As discussed above, this problem was solved outside the formal Mitel process because it would have taken too long to do within the normal boundaries. No reporting or dissemination took place with the exception of face to face interaction between engineers. This whole process is a form of cross-checking that occurs frequently at Mitel.

Classification: Content-R&D; self (experimentation) - over the wall; private-memory

C.I. #: 41 **Date:** April 23rd **Project:** MC3R
Person: Jacob **Functional Assoc.:** Hardware Design Manager

Description of incident:

During the first stages of the design of the MC3R project, there was a major failure of the Synopsis design tool which effected all of the designers (hardware, and software in a downstream sense) on the project. The failure was so major that the software would not even load on the network.

Solution:

In this case, there was no time to be wasted or spared by having engineers contact the vendor. Jacob stepped in and took action by contacting the vendor and stated that this

was a critical design phase. The vendor was willing to provide immediate help. Jacob then acted as facilitator between the designers and the Synopsis support people (to reduce the amount of time to get the system working). After one full day, the system was working properly.

Dissemination/Reporting

This problem was in the domain of the hardware design group only since they are the only ones who use this particular tool. The problem was mentioned by Jacob at higher level meetings. No formal documentation was created as this is not in the domain of Mitel specific products (it's a tool and thus the Mitel process does not include it).

Classification: Process-R&D; self-meetings; semi-private-meetings

C.I. #: 42

Date: April 24th

Project: USB

Person:

Philippe

Functional Assoc.: Acoustics

Description of incident:

The US government has created a standard called the American Disabilities Act which affects the manufacture of many devices including phone sets. By 1997 all phones being made must comply, and to comply each phone must have on it an adjustable volume control as well as a passive magnetic loop for hearing aides. The former is already included in every Mitel phone set, and many of the phones include a volume control, but the new USB phone was designed in a unique way. It consists of both a digital component and an analog component. The result is that it was more simple to allow the analog part control the handset and thus difficult to include a volume control. Normally, the volume is adjusted digitally, based on a number of environment variable, including the line signal strength (this works well on PBX phones) but in this case, the phone is a standalone unit, and has no such luxury.

Solution:

The solution was tried in many stages: At first, Philippe thought it would be a good idea to try to get the US government to change the code to allow certain phones not to have the volume control since the passive loop almost always makes it obsolete. While the US government did actually make a change due to Mitel lobbying, this was not it, and there would have to be some other solution.

The ultimate solution requires a large sized design change to the phone set itself (which is about to make its first appearance in production). At present, the change has not been made, but meetings including Philippe and Rolf (the electrical designer) and Doug Oddy (manager) have begun to plan strategies to solve the problem.

Dissemination/Reporting

The input part of the problem is in the form of government documents, and is well known by a few people at Mitel (the ones responsible for the eventual changes). The actual solution is only discussed in verbal terms at informal meetings so far. Eventually it will be made into an ECO where all the details are documented and made public (internally).

Classification: Content-R&D; Others-telephone, face to face, meetings: semi-public-ECO (SMS)

C.I. #: 43 **Date:** April 24th **Project:** USB
Person: Project team **Functional Assoc.:** all

Description of incident:

The USB project is almost at completion (with respect to the design stages and test manufacturing) but it did not have a name. They needed to have a name for the certification process, one for the marketing people and one for the OEM market that they would be selling the phones in.

Solution:

During the meeting, there were many opinions as to what the name of the phone should be, but two prominent statements were made: the name for certification must always be on the phone, and that Mitel has no marketing plan for selling the phone under their own name (yet). The name USB1 was chosen by the certification people and that name stuck. There were some objections at the meeting, which were eventually overruled. The Mitel part number was generated as #9117

Dissemination/Reporting

This solution was documented in the large corporate data system (Dakan) and in the product description documents. Additionally, many people from the meeting brought back the name to other functional members (respectively).

Classification: Content-Marketing; self-e-mails, face to face; Public-DAKan

C.I. #: 44 **Date: April 29th** **Project: MC3R**
Person: Graham **Functional Assoc.: Project manager**

Description of incident:

Projects managers, including Graham, would like a way to share knowledge gained from post project reviews. This is currently badly done by hallway talking, casually.

Solution:

It was decided at a project managers' meeting to have Lotus Notes installed on each of the project managers systems so that such information and knowledge could be shared in a scheme that is cued to projects, people and larger systems (above projects, or could be called functions).

The process of getting Notes installed in each of the managers' computers is a slow one due to limited resources in the systems department.

Dissemination/Reporting

This was made into an action item at the managers meeting, whereby certain parts of the task were assigned to various people. It was sent in multi-copies through e-mail to all those concerned as well as the document control department.

Classification: Process-Management; self assisted by tools-NOTES; semi-public-action order, Lotus Notes

C.I. #: 45 **Date: May 6th** **Project: USB**
Person: Bill **Functional Assoc.: Manufacturing service group**

Description of incident:

Bill was asked to find out what components would be used on the USB phone that were not used before. They need to know what ones will work with the manufacturing process, and what the costs of all the new parts are. The problem with this process is that the list may change every day during the design of the board.

Solution:

He started by e-mailing the designer of the board for a parts list. That designer did not know what the procedure for submitting a list was, so Bill sent a copy of the Mitel "BOM" bill of materials documents guideline. Rolf (the designer) then complied with an incomplete list. This process was iterative for a few weeks before it became a stable list. It was at that point that Bill subtracted the known parts from the list and was left with a list of new components. This list then went to component engineering and purchasing.

Dissemination/Reporting

The communication between Rolf and Bill was mostly e-mail, not because it was more convenient, but because there were detailed lists which were better communicated

in visual form. The communication to the component engineering mostly took place in the form of small meetings. Decisions about what products and suppliers to use were made here. Purchasing was brought online via meetings and e-mail when the time came. They simply acted on the decisions already made, unless there were exceptions found.

Classification: Process-Manufacturing; self-e-mails; semi-public meetings; CAD/CAE files

C.I. #: 46

Date: May 6th

Project: USB

Person: Bill

Functional Assoc.: Manufacturing service group

Description of incident:

During the final design stages of the USB phone, it was becoming more time sensitive to get the product complete. A decision was made to build the phone before all the parts were available (there was a supply problem with a ram chip and a questionable problem with the main CPU). One way or the other they needed boards to test, and the hurried manufacturing process would require the use of more through hole parts (which would eventually be surface mount) this change would require the temporary change and careful monitoring of different board versions.

Solution:

The solution to this problem was to go as if there were not parts missing, and that all the parts that were known were working. The assumption was made (Bill) that it takes far longer to make the boards (due to a relatively long lead time process) than it would to cut and strap them later to make them work. Boards were built with whatever was available, and close contact was kept between Bill and Rolf (the designer of the board) to keep track of any changes (so that they could be made as soon as possible). When missing parts arrived, they were immediately mounted on to the boards by available engineers (Kent).

The result was that by the time the design of the phone was finalized, there was a working model already built in test quantity (20). This closely resembles the prototyping methodology, however, at the same time, the manufacturing process for the phone was being developed, rather than after, additionally, the manufacture of the first phones was in the domain of the factory, not the designers.

Dissemination/Reporting

Detailed CAD plans were the main data exchange between designers and factory people. These were supplemented by SMS entries and face to face contact. Printed copies of the CAD output were carried back and forth, rather than sharing a common library (which is possible).

Classification: Process-Manufacturing; self-face to face; Public-CAD/CAE, SMS

C.I. #: 47 **Date: May 6th** **Project: Many**
Person: Kelvin **Functional Assoc.: Conformance testing**

Description of incident:

ISDN conformance is a mandatory feature of European phone equipment. It must comply to be sold within the union, however, in North America, the rules are less strict. Companies compete with phone systems that are not compatible with each other, and conform to any of several standards. It would be a clear advantage if a product would comply with the main phone system standard and many others. Several of the PBX companies have begun building in ISDN conformance into their phone sets, and Mitel was one of the pioneers. This move however, was not accepted by all equally (within the company). Kelvin heads up the ISDN conformance testing group which was originally designed to make the phones comply for European markets. This group is now used to test all systems made by Mitel. The critical incident that faced Kelvin was to get all the necessary players in Mitel to cooperate and accept the new standards testing.

Solution:

At first, designers thought of the test group as a hindrance and a nuisance. Kelvin showed them how this kind of conformance testing could identify bugs and problems that would normally never be discovered (and could cause worse problems later). He also showed by example how this could detect deviations in the specifications of products and standards. The end result would be higher awareness of possible problems, and reduced development time (contrary to what designer first thought).

Dissemination/Reporting

The approach taken was a proactive one. Any possible time Kelvin could show how a test could pinpoint the problem he would talk with the designer, in person and volunteer the service. Conformance standards are done formally with government and ISO certified documents. Engineers use these to help future revisions of products. More recently, the designers come to the conformance group for help, rather than the other way around.

Classification: Process-R&D; Self-Meetings; Public-Meetings, physical documentation

C.I. #: 48 **Date: May 10th** **Project: USB/others**
Person: Bryan **Functional Assoc.: Testing (manufacturing)**

Description of incident:

Before a phone can be sold it must undergo strict testing to insure that every unit is working. This group is responsible for constructing test equipment to include in the manufacturing process. The USB phone is a complex analog device (that means it is not the same as the normal DNIC interface phones, for which there exists a test unit) requiring a new test system.

Solution:

At first the test group as a whole decided to try to buy an off the shelf system that would test the USB phone, but found that there was not such a device. The second attempt to solve the problem was to build one in house. The following were the issues: There was no experience with a phone/modem combination, which would involve a large learning curve; There was no experience with analog devices of this type, causing new categories of problems to test for; This method would require an estimated year of research and design to develop a good test system.

The real solution came by talking with some of the USB phone designers, who mentioned that they had used a modem tester in the past, which was simply a "Central Office Simulator" with special software. Bryan looked at this idea and contacted one of the vendors of such a system and asked for an evaluation model. He got it and was able to use it for the test. With some small modifications to the software and hardware, the off the shelf unit performs a comprehensive series of tests on the phone and does it very effectively.

Dissemination/Reporting

When asked the question about documentation, I was told "That's a good point, we don't do it." The actual process of researching the market for a system, and all the communications with the designers and vendors, and how the actual decision were not in any way documented. The decision was made locally within the test group, and approximately 4 people know the outcome and reasoning. The end result of the completed test system, including a detailed document about how to build one and how to use one are available in the SMS and the document library.

Classification: Content-R&D; Others (group)-meetings; semi-private-meetings

C.I. #: 49 **Date:** May 10th **Project:** USB/others
Person: Bryan **Functional Assoc.:** Testing (manufacturing)

Description of incident:

The USB phone project required this person to acquire knowledge about modems. This is an area that he had no previous experience about and since he would have to test advanced systems, including modems, he would need to have these skills.

Solution:

To get a general knowledge of the subject he first went to the internet using Netscape. He searched the modem vendor sights for FAQs (frequently asked questions) to get a feel for the terminology used. Second he looked through the Mitel library for publications and trade journals that had articles relating to modem technology. Finally he purchased (through purchasing) some modems to use with the newly acquired modem testers and experimented with them in detail to discover how this equipment operates. At this point he discussed with the USB phone designer about the future implementation of DSVD (Digital simultaneous voice and data) a feature of the USB phone.

Dissemination/Reporting

Although there is no formal documentation of this persons new knowledge, there are several people who know he has it. The designers know, as well as his supervisor (during performance evaluations (bi-annual)).

Classification: Content-Manufacturing; Self assisted by tools-Internet; Private-memory

C.I. #: 50

Date: May 10th

Project: USB/others

Person: Bryan

Functional Assoc.: Testing (manufacturing)

Description of incident:

Designing test equipment for use in the manufacturing process is the core of this persons work. Each phone needs to be tested in a number of ways (as mentioned above) including acoustically. This means actually building a device that listens to how the loudspeakers, microphones, and handset speakers perform in their plastic housings. To design a test-bed that fits each phone is a long and complex process, meaning that these engineers would have to learn and use the design tools used by the phone set designers to build a "mirror" mold to fit.

Solution:

In the past this methodology was used, but in a recent trial, Bryan asked the designers to invert the 3D image within the original design of the phone. This step produced a 3D model of the "Mirror" which could be build by the CAM division. Only small modifications were required to ad test sensors. The new process of building a test bed required less than half the time of the original one, and most of that work was done by the experienced designers instead of the test engineer. This solution came up as an idea when Bryan and one of the designers were talking face to face.

Dissemination/Reporting

The knowledge about how to effectively build a test bed, including the addition of the test sensors is held by the small test engineering group. The skills are in fact single point, as there is no documentation, formal or informal about the procedures and who to talk with in the design groups. The design details of a specific tester are included in the format documentation pertaining to each phone model and it's test bed. Details include how to build a new one, so someone looking through these documents could indeed contact the correct people and reproduce the process. More recently however, Bryan has been doing more informal (non company mandated) documentation (done in Unix based Frame) so that lesser skilled workers within the group can handle some of his increasing workload.

Classification: Content-Manufacturing; Self assisted by tool-CAD/CAE; Semi-private-Meetings, personal notes

C.I. #: 51 **Date:** May 10th **Project:** USB
Person: Rob **Functional Assoc.:** Hardware designer

Description of incident:

The design of the USB phone did not include any RAM memory on it because the CPU chip from INTEL had a certain amount on it that would do. Unfortunately, at the time of this writing, the CPU ram was non-functional, and being "work on" by Intel. As a contingency plan, in the case that CPU's are still non-functional by the time the product ships, the designer decided (with the knowledge of the team and management) to add a small RAM chip to the design. This would obviously have cost and downstream design issues, but it is considered a temporary solution.

Solution:

The addition of the RAM chip was not a difficult task for Rob, but the coordination of the other engineers to incorporate the change to their components (plastics, board layout, parts acquisition, etc. would be the most difficult part.

Dissemination/Reporting

This issue was really strictly in the domain of the designers so the project managers (coordination) and many of the service groups did not need to participate. The meeting was called with only the key component designers involved (about 5) at this meeting it was discussed what RAM chip would be used, where it would be located on the card (real estate was VERY tight already, so this was a big issue. In fact, they had to substitute another chip for a smaller version to make room for the RAM.) and how much they would cost. Each person went back to their groups and made the necessary changes. This solution was well disseminated to ONLY the correct and pertinent people. The change was documented in the final design drawings of the device, including the fact that there was a change, but no mention was made to how the change was made and any of the details about how it was implemented.

Classification: Content-R&D; Self assisted by tools-CAD/CAE; Public-SMS

C.I. #: 52 **Date:** May 10th **Project:** USB
Person: Rob **Functional Assoc.:** Hardware designer

Description of incident:

The details for C.I. #51 are as follows. Rob had to devise a multi-art plan to help him decide how to add RAM to the board. He came up with three options: A) Shoe-horn the RAM chip on the top of the circuit board, where the real estate is extremely tight (could require a large amount of layout effort). B) surface mount chip on the bottom of the board (definitely causes a manufacturability issue). C) Fix the flash ram, ultimately removing the whole contingency plan all together (see CI 51).

Solution:

Rob knew that each of the choices would effect other top level people on the project in a rather large way. A) would cost himself time, B) would cost manufacturing and C) would cost management by exposing the project to undue risk. He quickly removed choice C) and work with the others. Choice be would increase the phone (in addition to the cost of the new RAM part) possibly placing it out of the market. so, he eventually chose A. He would find a place for the part on the top of the board (C.I. 51 tells how during a small designer meeting they discovered how a smaller replacement for an existing ship could free up space for the RAM).

Dissemination/Reporting

Normally this kind of problem is not documented in the product technical description, but in this case it was. The reason is that the case was done under such great time pressure that they wanted to cover themselves (engineers) from possible future problems. The technical description has details about the changes made to the phone about this RAM chip. Additionally the designers note book contains many details about how the decision was made (contingency charts, cost/benefit analysis...).

Classification: Content-R&D; Self-meetings; semi-public-SMS, personal notes

C.I. #: 53

Date: May 10th

Project: USB

Person: Rob

Functional Assoc.: Hardware designer

Description of incident:

A DPAR was entered into the system about customers having problems with the 430 series phone sets having low volume levels on some calls. No one could really understand why it was happening since these phones are equipped with digital volume controls that allow very high levels. Even with full volume there was still low signal going to the handset.

Solution:

Rob started with the basics. He first checked the hardware, and tried to duplicate the problem in the lab. With the help of the acoustics people, he performed a series of tests and could not duplicate the same problem. He then had the conformance people (after obtaining, with difficulty, permission from the product manager) test for problems, and found nothing. Finally, on a hunch he traced the problem to some software which is designed to compensate for noise and signal loss within the actual PBX switch. This is called the loss-plan software. It tries to guarantee a consistent signal to each phone, based on the quality of the incoming line and several other environmental variables. As it turned out, this software was getting hung in a loop with the use of the 430 in a rare case. Rob WAS able to reproduce this problem. He promptly searched for the original designer of the loss-plan code (This he found in the SMS)!!! Once this engineer was found, he forwarded the DPAR to him and got the problem solved.

Dissemination/Reporting

This DPAR was eventually repossessed by the software engineer who wrote the code, and therefore Rob did not document anything about it's solution. He did however tell the software designer the steps he had taken (through a phone conversation). The Software engineer corrected the problem and closed the DPAR in the SMS system, including the details about the solution.

Classification: Content-R&D; Other person-assisted by tool (SMS); Public-SMS

C.I. #: 54

Date: May 10th

Project: USB

Person:

Kent

Functional Assoc.: Product engineer

Description of incident:

This hardware project is one that shows clear concurrent engineering. In the history of Mitel, this is not unusual, but in cases where there is firmware on a ROM or a flash RAM, that code is generally done before the board goes to be built. In this case, the software for the flash ram was not finished by the time the board went to the factory. This meant that the code would have to be programmed onto chips, then tested and installed by hand onto the first run boards. Kent was given this task.

Solution:

At first Kent went to the factory to procure the equipment necessary to program, test and install the chips. He has a close relationship with all the factory people since his job is as interface between designers and the factory. He then waited for the code to be available from the software designers, and carried out the process of installing it onto the boards.

Dissemination/Reporting

This task was very much out of the normal for Mitel procedures, and therefore the formal documentation system had no requirement for it to take place. One designer did record the fact that the software was added later to the hardware in the product technical specification document. This problem was solved strictly through meetings and face to face contact.

Classification: Process-Manufacturing; Self-face to face; semi-private-meetings, personal notes

C.I. #: 55

Date: May 10th

Project: USB

Person:

Kent

Functional Assoc.: Product engineer

Description of incident:

Rolf (USB electronic designer) found a bug in the X-tal used on the board. It was running at the wrong frequency. Rolf quickly replaced it with the correct part and told this to Kent who would get the change made into the documentation and the factory.

Solution:

This problem is about formalization. Kent had to generate the necessary documents to change the product technical description and the BOM (bill of materials) for the manufacturing process. There is a detailed template to follow (which he did).

Dissemination/Reporting

The new documents (ECO and BOM) were submitted to the team managers to be signed off, then sent to their respective functions for further processing. IE manufacturing. The ECO is the document that makes changes to the product description. These are maintained in the SMS as are the complete detailed and technical descriptions.

Classification: Process-R&D; Self-e-mail; public-SMS

C.I. #: 56

Date: May 10th

Project: SS-7000

Person:

Robin

Functional Assoc.: Software verification

Description of incident:

The superset 7000 is a PC interface card and software that allow a computer based phone system to perform many receptionist type functions. During the final stages of getting this product to market it was discovered by the approvals group that it would fail the U.K. standards. This problem was caused by electrical traces on the logic board being too close together (electrical hazard in a SPIKE situation). This problem was immediately red flagged because it would result in a stop ship.

Solution:

Robin used his experience to recall all the members of the design team to a meeting (hardware) and discuss the problem. It would be a reasonably minor board layout change to fix the problem, but many different types of engineers needed to work on it to get it done quickly. They built a game plan as a group and went to work. Within several days, the change was made, and the only thing to wait for was the manufacturing lead time (the actual PCB is done outside Mitel, and takes several more days). They managed to ship the product only a few weeks later.

Dissemination/Reporting

All those involved with this problem were kept abreast of the situation via milestone reports generated by Robin. These were distributed through e-mail. The final design changes were logged in the SMS system as an ECO.

Classification: Content-R&D; Others-telephone; Public-SMS, DaKan, personal notes

C.I. #: 57 **Date:** May 10th **Project:** Many
Person: Robin **Functional Assoc.:** Software verification

Description of incident:

Mitel is testing a new SCSI device for use as a primary storage system for the SX-2000 PBX line. The reason for this is to allow users to have high speed access to their data, and faster software loads in general. Currently they are using tape drives, which are very slow. The proposed new drive is an Avatar 170 meg removable hard drive. This system is new to the marketplace, and still somewhat under development, but the company promises to support it for many years, which is a feature Mitel needs. The problem arose when during a test, Robin noticed that it took 25 minutes for the system to format a disk, an operation that should take just a few minutes.

Solution:

He first called the product support people at Avatar, who could not tell him anything because they did not know the nature of the problem. Then Robin asked Radovan, the chief software engineer working with SCSI to test the drive on his test system. The results showed that there was a slight deviation from the SCSI specification that would cause the drive to hang on the format command. Since the Mitel SX-2000 controller uses the SCSI spec, it would be necessary to have drives that do the same. Now that Robin knew exactly what was the problem, he relayed the information to Avatar who quickly changed the drive firmware to correct it.

Dissemination/Reporting

This problem was not documented. The only people who know about it in Mitel are Robin and Radovan, however, Radovan is becoming the resident expert on SCSI and will likely remember this issue for a long time.

Classification: Content-R&D; Others- telephone, face to face; Private-personal notes, memory

C.I. #: 58 **Date:** May 14th **Project:** Many
Person: Anthony **Functional Assoc.:** Product support group

Description of incident:

Anthony is in the position of first line technical support for many of the FBX products Mitel sells. This means that when a new bug is reported, he is the first person to hear about it. In this case, there was a growing number of DPARs being added to the same problem, a new version of an existing product (designed for cost reductions) was

causing the PBX's to hang. Old versions of software were being shipped out to fire fight the situation, but the problem persisted.

Solution:

The solution here was for Anthony to make an important decision. He thought the best way of getting the designers attention would be to cause a stop ship. He cleared it with his boss, and got the stop order authorized. As of that moment, Mitel was no longer shipping the product, which of course caused serious concern and pressure from the sales department. They aimed that pressure at the designers who quickly got on the case.

Dissemination/Reporting

This problem is a classic example of the use of the SMS system. From start to finish there is a clear history of the problem and all actions taken to get it solved stored as DPARS in the SMS. Each DPAR has the name of the person who opened it, and the name of the person who closed it (solved the problem usually) and each person who worked on it in between. These records are there for good, and are public to the whole company.

Classification: Content-Support; Self-e-mails; Public-SMS

C.I. #: 59

Date: May 14th

Project: Many

Person:

Anthony

Functional Assoc.: Product support group

Description of incident:

A new bug was reported that no one had heard of before. A customer complained that after picking up the phone in certain circumstances, there would be a silent delay of up to 10 seconds before being able to speak. At first people thought this was impossible until a second sight called with the same problem.

Solution:

Although both instances of the problem were reported to two different agents, they both met in the SMS. Here a DPAR was ordered and assigned to engineers who would try to reproduce the problem at Mitel. At present, there is no answer for this problem as it can't be reproduced. When it is solved, the designers will close the DPAR and inform Anthony who will in turn update the customer. In this case, the customer will be sent a fix to solve the problem at no charge.

Dissemination/Reporting

This example also uses the SMS to act as a messaging system between the front line and the engineers who are working to solve the problem. In the process of this communication, they are building a repertoire of bugs and fixes for future use by other engineers. Generally these DPARs are well maintained and well keyed.

Classification: Content-Support; Others assisted by tool-SMS; Public-SMS

C.I. #: 60 **Date:** May 15th **Project:** USB
Person: Clair **Functional Assoc.:** Product Line Manager

Description of incident:

The choice for colour of the USB phone set was the problem that Clair had to solve. She had pressures from technical representatives from many departments. There are valid technical issues involved in selecting a colour such as cost, matching other existing appliances, matching itself, and being pleasing enough to sell. Additionally some colours of plastics are available in stronger types.

Solution:

Clair took all the inputs and started with the most important, technically. This was industrial design. Then tried to satisfy as many of the other needs as possible. In so doing she came up with a Gray called Dove. It is a darker than normal Gray, but it matches most of the existing hardware, and is relatively easy to implement.

Dissemination/Reporting

This decision was extremely public. Just about everyone wanted to have their say. The communication input side was mostly face to face conversations, done informally. There were no large meetings to help make the decision, just a few one on ones. The ultimate choice and its justification were noted in the POD (Product Objective Document). This does not contain how she came to the decision.

Classification: Content-Management; self-meetings; public-DaKan (pod)

C.I. #: 61 **Date:** May 15th **Project:** USB
Person: Doug **Functional Assoc.:** HW design, Technical leader

Description of incident:

During the very early stages of the USB project, before even the core design team was on-line, Doug had to decide what type of resources would be required, and which specific ones to use.

Solution:

He started by identifying each of the categories of design that would be required by the project, mechanical, software, hardware, acoustics, etc.. He made a list of 8 positions that would have to be filled with full time people. Mitel then has a process to fill those positions, by submitting a request to each of the functional managers, who would then assign people. This process does not always yield a well tuned team, and since Doug has 19 years of experience at the Company, and know many of the engineers personally, he identified the people that he wanted to work with. Having done that, it was simply a matter of convincing the managers to allow those employees to go to the project.

Dissemination/Reporting

The formal process takes place on a Resources Request document. This is then fulfilled by managers using the Organization diagram (outlining all the people and their functions). In this case, the process was assisted by Doug's preferences.

Classification: Coordination-Management; Self-telephone; Semi-private-meetings

C.I. #: 62

Date: May 15th

Project: USB

Person:

Doug

Functional Assoc.: HW design, Technical leader

Description of incident:

The hardware component of the USB consists of a complex PCB, on which there is a single component cost almost half the value of the phone. There are at least four vendors of such a part in the industry, and the decision about which to choose was very critical to the success of the phone (it is the Modem chip which does many DSP functions at 28.8kbps).

Solution:

Although Doug was ultimately responsible for this decision, as technical leader, he did not think that it would be wise for him to do it. He chose instead the board designer to make it. He asked Rolf (the board designer) to research the four chips out there devise a cost benefit analysis plan for each. Rolf did this for several days, and came to the conclusion that the Rockwell chipset would be the most advantageous for reasons of cost, functionality, power consumption/heat generation and several other features. Doug agreed, and the decision was made.

Dissemination/Reporting

This decision had a wide effect on many people. Software people had to know what drivers to use and write, hardware designers had to know how to layout the board, and purchasing needed to know what parts to order. The ultimate decision was disseminated in a meeting with all these people (project meeting) and through e-mails. Ultimately the design documentation will include the details about the chip and why it was selected. The decision partially noted in Lotus Notes by Rolf.

Classification: Content-R&D; Other person-Face to face; Semi private-meeting, personal notes

C.I. #: 63

Date: May 15th

Project: 400 series

Person:

Doug

Functional Assoc.: HW design, Technical leader

Description of incident:

The 400 series of phone sets all uses a Mitel custom chip to perform many of the phones functions. There was a complex problem with these chips that had a statistical nature, meaning that a specific number of the m failed, and that number was known. Doug was asked to devise a solution for this problem.

Solution:

This solution was done in two steps. The first was a fire fighting method to stop the problem from happening in the field, yet it did not address the core of the real trouble. The second more time consuming method was to redesign the chip and completely solve the problem.

At first Doug assigned software engineers to write a piece of code that would look for the problem, and run around it when necessary. This solution was messy, and not a good way to ship phones, so as mentioned above, the chip was eventually fixed by the Semi group at Mitel. The software solution was coordinated by Doug, a hardware type, and performed by software types.

Dissemination/Reporting

There are DPARs listed against this problem that detail the problem and who took responsibility to solve it (Doug). These mention the solution in their closure, but are not detailed. Doug has a personal file (physical) that has an extremely high level of detail about each step and issue taken to solve this problem. These files are included with the original development documents of the 400 series chip set (which Doug was working on many years ago). These notes however, are private to Doug.

Classification: Content-R&D; others-meetings, e-mails; public-SMS, personal notes

C.I. #: 64

Date: May 23rd

Project: Many

Person: John

Functional Assoc.: Manufacturing

Description of incident:

As new phone designs were making it to the factory, John needed to identify what were the causes of set failures. Normally there would be a specific person to do this task. (please see functional discussion in thesis about apprenticeship at Mitel)

Solution:

John posted a company wide request for someone to take that job, but found little success. Timing was a serious issue, in that he could not wait for Mitel to hire someone before starting the problem identification. What he ended up doing, was performing the task himself, and spending his management time doing line work. This ultimately reduced his performance at his mandated job.

Dissemination/Reporting

This problem is identified in the HRM files as a request for resources. The request is posted inside the company and out. Generally, there is a lead time before a

position so narrowly defined can be filled, and the resulting inefficiencies cannot be avoided.

Classification: Coordination-Manufacturing; tool assisted-intranet, posting; Public-DAKan

C.I. #: 65 **Date:** May 23rd **Project:** Many
Person: John **Functional Assoc.:** Manufacturing

Description of incident:

A single point skill at Mitel is the operation of the Wave solder equipment. There was at the time this problem came up only one person who was qualified and skilled to use the equipment. That person was hired by another group within Mitel to perform a different equally important task. This left John with a non-functional solder system, meaning that there was no way to complete the manufacture of any products.

Solution:

At first the task of running the machine was done by himself, for a day, to keep the lines running, although this was terribly inefficient since he did not have the skills to do the job just right. He asked one of his Jr. workers to take over. She asked the former wave solder person to help her for a couple of days, which he did. After several days she became reasonably proficient at operating the machine. Within two months, she even began to develop some new processes that improved throughput and safety on that part of the line. At present, the wave solder system is running at full capacity.

Dissemination/Reporting

This problem was not documented in any formal way. The experience of the new worker is still a single point skill, meaning if she left there would be a severe hole in the production line again. The main reason for that is there are thin resources, and no room for redundancy in the line. The fact that there are new people working in this area is documented however in something called a flash report. This is a weekly or biweekly update about what's going on in the factory. It does not detail how and why the new person was added or who to talk to if the problem arises again. The solution to this problem came from personal networking.

Classification: Content-Manufacturing; self-apprenticeship; semi-private-meetings, apprenticeship

C.I. #: 66

Date: May 23rd

Project: Many

Person: John

Functional Assoc.: Manufacturing

Description of incident:

As mentioned in earlier C.I.'s there has sometimes been a problem of finding enough real estate on a given board. In fact, this has been a common problem as the PBX systems have grown more complex, and the board sizes remained the same. There needed to be some way of getting more onto the board without the extra cost of printing on two sides (which is a very difficult and expensive process).

Solution:

During lunch times, and social interactions in the company, designers mention to manufacturers how they need to get more into the same space. John was one of the people who had that mentioned to him, so he replied by saying that there are possibilities that the company could buy a new pick and place machine that could support "603" parts (this is the size of the SMT components, 603 is about half the size of the 804 that they were currently using). This would free up plenty of space to put more than twice as much on as before. The designers liked the idea and made calls to several people in the company. At this point it became less of a social process and more formal. A meeting of designers and factory people determined that the move would be made. First samples were brought in and tested then the equipment was bought, and now new Mitel designs incorporate the new smaller components, allowing much more complex boards.

Dissemination/Reporting

This process took place almost entirely outside the framework of Mitel operations. The decision was already made before the purchasing people and upper management were brought online. It was so crucial to the success that those were not actual issues until the actual purchase needed to be made. There is no documentation process available to such acquisitions other than a purchase request. This process took place through an old boys friendship network. The people interacted socially to resolve a business issue.

Classification: Content-Manufacturing; others (group) face to face; semi-public-meetings

C.I. #: 67

Date: May 23rd

Project: ISDN-Gateway

Person: Ed

Functional Assoc.: Software Builds

Description of incident:

This person is responsible for putting together the final software build of a large product, the ISDN-gateway. He compiles files from many engineers to make one complete package. During the last build (and many others) there were files missing, or files with the wrong version of code. Before moving further, all these issues must be resolved, and each file must be verified.

Solution:

Ed first has to find out who the missing files belong to. That requires looking up in the SMS who owns the file. Once he find all the people who are responsible for missing or out of date items, he e-mails them all to send a correct copy. In very urgent cases he will go see them face to face to show how important the file is. In every case the project manager and the functional supervisor of the employee are CC'd.

Dissemination/Reporting

The process of CC'ing all of the relevant people gets the word out quite well. Managers keep track of who is losing files more often and can try to improve upon that. Functional supervisors (who are directly responsible for the designers) have disciplinary responsibility (come review time). The SMS keeps a very good record of who works on what files.

Classification: Process-R&D; Self-e-mails; Public-SMS**C.I. #: 68****Date:** May 23rd**Project:** ISDN-Gateway**Person:**

Ed

Functional Assoc.: Software Builds**Description of incident::**

The software design group recently adopted a new process which causes a lot of confusion in versioning for the build group. The problem is that Ed could not understand what versions of each software were current in the working version. The new system allowed designers more flexibility, but prevented Ed from being as effective.

Solution:

Ed implemented a new versioning format called IMAT to load all the DLL files (the ones the were causing a problem). Formerly, you could have three "current" versions of a file and all would be different. The new standard allowed for only one to be marked current. To force this, he wrote a kludge in the SMS that only allowed one open version at a time. This first attempt actually caused more problems than it was worth, but a second attempt worked very well.

Dissemination/Reporting

Obviously he needed to get the word out to all the designers who were working under him. He sent a message out in the SMS through the "Perap" library (where all the tools are kept). He also used face to face to inform people that the new system was running, and worked well.

Classification: Process-R&D; Self-meetings; public-SMS**C.I. #: 69****Date:** May 23rd**Project:** ISDN-Gateway**Person:**

Ed

Functional Assoc.: Software Builds

Description of incident:

The newest version of ISDN gateway (as mentioned in an earlier C.I.) uses the PC platform under WinNT. In order to make builds for this platform, Ed really needed to have one of the PC's. The problem was that there were none available in the company, and purchasing was not providing one fast enough.

Solution:

This is an issue where an employee did not understand the process outside his own domain. Purchasing has a strict set of rules that they follow in the acquisition of new equipment. It is designed to save money and reduce obsolescence. Eventually Ed asked someone in that department how it was that he could get a machine very quickly. It took several phone calls and favours before he got in touch with the right person. Once he did, the reception was not great, but eventually he did get his machine. (About 2 weeks later).

Dissemination/Reporting

This is an example where the problem was out of the domain of the person effected. Ed now has the experience to deal with purchasing in the future, but this problem was not documented other than in his private notes.

Classification: Process-support; others-telephone; private-memory

C.I. #: 70

Date: May 24th

Project: USB

Person: Rolf

Functional Assoc.: Hardware Designer

Description of incident:

After a meeting with the design team of the USB product, Rolf realized that he had to incorporate a new analog circuit onto the board. It was a fairly simply line voltage monitoring circuit, but there were many ways to do it. He had three choices, try it on a bread board, try it in a simulator or build one directly onto the board without testing.

Solution:

The answer to the choice has typically depended on the level of engineering confidence he had in the design of the new component. In this case, it was fairly high since Rolf is accustomed to doing line voltage work, and it was quite simple. He chose choice 2, to simulate it in software, then add it to the design. This method worked out well, it predicted the possible bugs, and allowed him to eliminate them before any electronics were wasted.

Dissemination/Reporting

Before committing the new part to the board, Rolf showed it to Doug why looked it over. It seemed logical (although it was analog) and made sense. The design change was captured in an amendment to the product technical description and the final drawings. The fact that there was this addition was also mentioned there, but the

reasoning process about the three choices is not shown anywhere public (it is in Rolf's notes).

Classification: Content-R&D; Self assisted by tools (CAD/CAE); semi-private-personal notes

C.I. #: 71 **Date:** May 24th **Project:** USB
Person: Rolf **Functional Assoc.:** Hardware Designer

Description of incident:

During the last two months, Mitel has been beginning an upgrade process of the operating system that people use on their PC computers. They are switching from Windows 3.1 to Windows 95 and NT. The decision is a wise one for future purposes, but it is plagued with problems at the present. Rolf's machine takes in some cases 3 times longer to perform the same functions.

Solution:

At first he made a call to the tech support group for PC's. They had no answers for him. He had to fix many bugs in the system himself, by copying parts of his old operating system back onto the computer. This took over a day of design time away. To date his system is not working the way it should, but he has neither the time to fix it himself nor to get it fixed.

Dissemination/Reporting

This problem would be recorded in the complaint logs of the computer support people. Also, there is a certain amount of experience being built by Rolf as he desperately tries to get it to work. That is however, private knowledge.

Classification: Process-support; self-library; private-memory

C.I. #: 72 **Date:** May 24th **Project:** 401+, USB
Person: Peter **Functional Assoc.:** Physical design

Description of incident:

The redesign of the 401 into the 401+ included the addition of several new buttons. Buttons are a simple task for Mitel to do, but some of these new ones were using a new type of material that had never before been used for a button at Mitel. It was elastomere, a rubbery substance that eliminates the need for a "key cap". Several issues were, would the rubber collapse under use, or would it make contact to close the circuit.

Solution:

In this case, Peter used his hunch about what the material would do under normal use and exaggerated what potential problems could occur. He then designed the plastic housing to suite those exaggerated circumstances. These included adding more taper to the plastic near the rubber, and more clearance to prevent chafing. This was purely an experimental process, which yielded a working system.

Dissemination/Reporting

Only final designs are ever committed to the SMS. The rest, about the experimental process is stored only in the designers mind. When resources were much more plentiful at Mitel, there would be a mentoring process which would allow more junior people to be included in the experimentation, however, that has not existed for a few years.

Classification: Content-R&D; self (experimentation); Semi-public-SMS, memory

C.I. #: 73

Date: May 24th

Project: 401+, USB

Person: Peter

Functional Assoc.: Physical design

Description of incident:

The new lens on the 401+ was designed to hold a piece of paper under it, and that had to cover the elastomere buttons and let the plastic ones through. Part of the problem was the people would be writing on the paper and that could effect the program buttons hiding below.

Solution:

This also required experimentation. The trick as it turned out was in the latch the held the lens down. By making it catch with more force then previous models, it would prevent the above mentioned problem. The trick was how hard. Peter experimented a few times with different thicknesses of plastics for the latch, until after a short number of iteration he had the perfect shape.

Dissemination/Reporting

Like #72, this one was added to Peter's experience, and other than the final solution, not documented anywhere.

Classification: Content-R&D; self (experimentation); Semi-public-SMS, memory

C.I. #: 74

Date: May 24th

Project: 401+, USB

Person: Peter

Functional Assoc.: Physical design

Description of incident

The 401+ had a new snap down leg that was quite long and unsupported. The problem was how long to make it to both lift the phone to the right angle, and yet not to "skip" across the desk when moved. The skipping action could cause a number of other products.

Solution:

Peter knew in advance that this would be solved only by experimentation, but the turnaround time and cost of making new molds for the plastic leg are long and expensive. He decided to start with a short leg, and grow it until the right height. The reason for this is that the metal mold can be "cut" back to make the leg longer, but never added to, to make the leg shorter.

Dissemination/Reporting

In this case some private notes were made while working in the lab experimenting on the plastics mold. He originally learned these skills by mentoring, however there are very few junior engineers to mentor from the senior ones.

Classification: Content-R&D; self-experience; semi-private-personal notes, memory, meetings

C.I. #: 75

Date: May 24th

Project: MC3R

Person: Manwai

Functional Assoc.: HW design tool support

Description of incident:

The MC3 board is an old design plagued with parts that are becoming obsolete. This happened to a small chip that is used for support logic, and would still be required on the MC3R. Manwai had to come up with a replacement solution before the board made it to production.

Solution:

The first and most obvious solution was to find a direct replacement from another manufacturer. She started doing research by looking up in the databooks about similar kinds of chips. She actually found something that would work, but after further looking into it (with that supplier) she found that the book was out of date, and that the chip was also no longer made. The next route took her to the online parts CD-ROM. This allowed her to perform a global search of all the manufacturers for similar parts. The CD-ROM yielded nothing, and thus Manwai decided she would have to build a part.

Before starting to build, she inquired at the Mitel Semiconductor group about how difficult it would be to do in silicon. She found out that there was already an engineer working on a chip that would perform the very function she needed. The only trouble was that it was not an official project, and the engineer would not tell how long it would be until it was ready (for his own protection). The timeliness of this parts sourcing would be critical to the completion of the MC3R, so she decided to build the chip in FPGA (freely programmable gate array). This solution was very simple to implement, in that

there is little development to do, but the unit cost is almost double that of the silicon cousins.

Dissemination/Reporting

Manwai has a engineering log book, which she claims is the property of Mitel. This book contains very detailed information about what, why and how she dose her daily engineering. It even includes things like decision processes, and who and how she gets her information. This document is however private, but can be accessed through her. There were no other documents made about this problem. People knew about it from the project meeting where it was raised by another engineer. It was even placed as a scheduled task in the MS-Project chart, but that does not include any details. Most of the communications took place face to face.

Classification: Content-R&D; self-over the wall; semi-private-meetings

C.I. #: 76

Date: May 24th

Project: MC3R

Person:

Manwai

Functional Assoc.: HW design tool support

Description of incident:

Each controller card uses a real time clock to establish when calls are made for the computer log. When building the real time clock it must be tested in the simulator for a certain period of time, to insure its accuracy. Manwai was given this task, as well as making the clock easily updated by the user.

Solution:

She remembered that once in the past she worked with the real time clock. It was a similar instance, but several years back. She could not remember the exact code she used for the simulator. This is an example where she was able to go into her engineering notebooks and extract the information. It took about an hour to find because there was no index to her system. Once she did find it, she made a small modification to compensate for a newer simulation tool and ran the program. It worked well.

Dissemination/Reporting

The solution to this problem was documented in her notes as before. This particular issue was never brought up in meetings because it is simply a routine part of the board design. It would be a non-issue for everyone else, unless for some reason it did not work. An interesting point is when this incident occurred, and Manwai had to spend over an hour just looking for the answers in her notes, she changed her system to include an index. Each book would have a table of contents reserved in the front with all the pages numbered (before she uses the book). In more recent times she has been able to access her notes very quickly. On two occasions, people have come to her where she has looked up things for them.

Classification: Content-R&D; self-her notes; private-personal notes

C.I. #: 77 **Date: May 24th** **Project: MC3R**
Person: Manwai **Functional Assoc.: HW design tool support**

Description of incident:

As mentioned in the C.I. #76, this is an occasion where someone asked Manwai a question that she could not possibly remember on her own, but her indexed notes contained the answer. The question was "Where to find a particular license file for a program they were using" (on the network).

Solution:

At first Manwai looked in her computer, using a search routine, to see if she had a copy of the file. Failing that, she remembered roughly when it was that she last dealt with that file and looked in the notebook for that month. Within 5 minutes she had found the answer, and replied in e-mail to the other engineer the location and date of the file.

Dissemination/Reporting

E-mail and face to face contact were used with the other person.

Classification: Content-R&D; self-her notes; private-personal notes

C.I. #: 78 **Date: May 24th** **Project: MC3R**
Person: Manwai **Functional Assoc.: HW design tool support**

Description of incident:

The use of design tools such as CAD systems are a regular part of most designers jobs at Mitel. When they do not work properly it is very costly both to the productivity of the engineer and to the company. Manwai has recently been using Netscape a lot to retrieve information from the internet and intranet. When the Netscap program is run at the same time as the Cadence CAD tool, there is a conflict of screen colours making it difficult or impossible to see her work.

Solution:

The first step was to ask over the wall to her partner if he was having the same trouble. He said no, but he didn't use the two tools at the same time. He tried it, and got the same result, mixed up colours. He was too busy to spend time on it so he told her to call the tools support group for HP help (the computer was HP). She did that, to no avail. There was no simple answer. They explained that it was a limitation in the tool, not having enough graphics memory to handle all the colours at once. She still didn't understand. She then asked the SUN support group which gave a much more detailed explanation, and showed her a trick. If you run the NetScape tool first, then the CAD tool, the colours will look correct.

Dissemination/Reporting

This problem was not a Mitel wide problem, in fact, there are only three people in the company who would ever be able to use that particular combination of tools. She (Manwai) did tell the other two, casually because they sit right next to her. The problem did get written down in her notes as usual.

Classification: Process-support; others-telephone, face to face; semi-private-memory, meeting

C.I. #: 79

Date: May 27th

Project: Many

Person: Greg

Functional Assoc.: Approvals testing

Description of incident:

On the cost reduction model of an existing board, the approvals people found that the new version would fail the safety standards in some countries. The reason is that in the redesign there was not enough space between some of the electrical traces on the lower side of the board. The result is that in certain conditions the traces could short out.

Solution:

This is a case where the standards group forced a change on the design group. They asked them to increase the spacing to at least 2mm. This would satisfy all the approval standards and make a safer product. In addition to having them make a change, they insisted that a member of the approvals group sit on early design team meetings to prevent this from occurring in the future.

Dissemination/Reporting

The specifications for the approvals standards are well documented, on paper, but are not available online. This means that there is a reasonable effort required to get the knowledge. Most of the engineers know that there are some standards that they have to meet, but do not know when they change. For this reason the approvals group would like to have a member on every design team at least for the initial stages. That does not take place yet (it does for many, but not all). The design changes were noted in the final technical drawings and posted to the SMS.

Classification: Content-R&D; Self-e-mails, face to face; public-SMS

C.I. #: 80

Date: May 27th

Project: Many

Person: Greg

Functional Assoc.: Approvals testing

Description of incident:

A similar situation occurred with the talktoBX system. This product was started without representation from the approvals group and as a result, they designed a product that failed several tests.

Solution:

They forced a design change and insisted that future versions include a member from the approvals group.

Dissemination/Reporting

This problem was reported as a DPAR because the product was very far along before the approvals deviations were recognized. The DPAR was closed indicating the need to have members from approvals always present at design meetings.

Classification: Content-R&D; self-e-mails, face to face, public-SMS

C.I. #: 81

Date: May 27th

Project: Many

Person:

Greg

Functional Assoc.: Approvals testing

Description of incident:

The FCC of the United States requires (recently) a continuous testing policy. That means that a product must not only pass a test before it goes to market, but it must pass a test every 6 months to insure that changes haven't lowered the standards. The problem is that Mitel has had no policy in doing this, and if the FCC asked for test reports, they could not provide them.

Solution:

Luckily, the current project that is relevant to that law is less than six months in the field, giving Mitel a chance to test and document the product before the deadline. In future, they will have to perform these tests regularly. The approvals group has recently devised a new process that will guarantee that there is always a current test and report on file to satisfy this requirement.

Dissemination/Reporting

The manufacturing group that does the inline testing is now cooperating with the approvals group to perform these routine tests and document them accordingly. There is a new formal document (test report) that is kept on file, both in electronic and paper format that can be audited any time by external agencies, or Mitel groups. The interactions required to get to this stage were done by a small meeting of test engineers, managers and approvals members. E-mails were sent to other relevant people.

Classification: Process-Manufacturing; self-e-mails; semi-public-e-mails, documents

C.I. #: 82

Date: May 26th

Project: USB

Person: Ed

Functional Assoc.: Hardware Technician

Description of incident:

During the final stages of the testing of this project, some sights outside of Mitel were selected for testing the product. These sights would be given a USB phone and computer to try out. The computer part normally would include a power supply that would run the phone, but the supplier of the computers has not completed that task. Mitel has selected an off the shelf power supply which works externally as an interim solution. The problem is that this power supply does not meet the standards for use externally. It normally requires ventilation from within a case, and cable constraints such that the cords would not be pulled on.

Solution:

Even though only 20 units were being shipped for testing purposes, there was still a safety issue. Ed either had to redesign the power supply (modify it) or place it in an external casing. He decided to place cables strain-releases on it, and build a foot to keep it oriented right side up, eliminating the ventilation problem. These solutions are very kludge like, but they do meet the minimum safety requirements (although they are NOT pretty).

Dissemination/Reporting

This critical incident took place in the hallway, on the way to lunch, right before my eyes. It was raised, discussed, argued and solved within five minutes, between the designer and two approvals standards people. The incident is not documented at the moment, but the finished power supply will be listed as part of the BOM (bill of materials) for the sample units shipped to test sights.

Classification: Content-R&D; self-yelling over the wall; semi-private-meetings, BOM

C.I. #: 83

Date: May 24th

Project: Many

Person: Dan

Functional Assoc.: Approvals testing

Description of incident:

Every Mitel part has it's own approvals, and most external vendor parts also do. A recent move in Mitel to save resources was to use external Specification control documents from vendors with external parts, and only have Mitel write SCID's for their own parts (they used to write them even for third party parts). The problem with this is not every company has the same standards or document format, causing much confusion in many cases. It is very difficult to control standards without a standard document format.

Solution:

As a manager in this area, Dan decided to make an action to revert back to the old system where there was at least some form of Mitel specification for every part used, even third party. This route is more costly up front, but in the long run, he believes that it could save money in product redesigns and failures when a part does not meet a certain specification (the intended one). He did make a change to the SCD so that it was cheaper and quicker to implement for a given part.

Dissemination/Reporting

This process of change is not yet complete or fully implemented. When it is, there will be a template of the SCD made available to the component engineers and any other people through the intranet. It will then be made a standard policy to use. For now, the dissemination of the idea is through casual conversation within the group.

Classification: Process-Manufacturing; self-Dakan; public-DaKan

C.I. #: 83 Date: May 24th Project: Many
Person: Dan Functional Assoc.: Approvals testing

Description of incident

The expanded call center product was an ambitious new component of CTI. The project, like many other new ones started without the approvals people on board. When the project was done and ready to ship in April, it failed standards and was stop shipped. The problem is the PC-voice card. It does not meet the criteria for safety standards. It is a product from a third party vendor, and will prevent the Mitel software from shipping.

Solution:

Mitel called the supplier by voice and asked them to get approved. They did get the card certified for safety, but not for use in telecommunication applications. This means that it can be used in a computer, but not for use with telephone equipment. The vendor would not comply further. To date the Mitel product is not shipping because of this component.

Dissemination/Reporting

The problem is well known by many people, including the manager Bernie. At present the problem is stored as a DPAR and a STOP ship addendum to that DPAR in the SMS. It is pending finding a new supplier for the voice card.

Classification: Content-Manufacturing; self-telephone; public-SMS

C.I. #: 85 Date: May 27th Project: Many
Person: Greg Functional Assoc.: Approvals testing

Description of incident:

The North American regulations organizations such as DOC and FCC have recently decided that approvals that are given to PC computers are for the use as a computer, and are not sufficient for the use as a component of a telephony product. The result is that the now widely used plug and play parts of computers must undergo more certification before they may be used by Mitel or other telecom companies.

Solution:

A consortium of telecommunications companies in Canada (mostly in Ottawa) got together and formed a committee to try and change the governmental regulatory decision. This required proof to these agencies that the use of the products in the new application was in now way risky, both from a safety and radio noise standpoint. The agencies compromised and allowed the use of the products with tighter control. If a component of the PC equipment has undergone a test, and all of the devices it will be used with has had the test, and they prove that they will not break the boundaries of the test conditions during normal use, they may be allowed to install devices without further testing.

Dissemination/Reporting

The new agreement defines that products be labeled with very inclusive details about what conditions it may operate under to qualify for the safety standards. In other words, it is not sufficient to say CSA or FCC approved, it must say indoors, for use inside a class B housing of telephony equipment. (example). The new rules were set out in a formal document (by the government) and given to each of the companies. In Mitel the document is kept by the approvals group who disseminate the information by representation on project teams.

Classification: Content-Manufacturing; others (consortium); Semi-public-meetings

C.I. #: 86

Date: May 27th

Project: ISDN

Person: Bill

Functional Assoc.: Software Designer

Description of incident:

Bill was asked to develop a DPNSS-ISDN conversion gateway as part of the ISDN gateway package. He was not given any tools to start with, which would have made the job easier (the tools were simply not available). After the first try, the translation did not work, which was a big hold up to the whole project.

Solution:

Bill decided to take a different approach. He would lead a team of people to write a work around in software, rather than talking to the hardware. He first designed a concept of how the code should work, and what it's specific functions would be. He then assigned two people from the software group to help code it. Together the three people came up with a working solution within a short period of time. From that point on Bill took more of a management role in a new group of people who would end up doing most of the software coding for the ISDN project.

Dissemination/Reporting

Two kinds of documents were made to capture what had been done with this problem. The first was a DS or DOS that included technical detail about each step in the new software, why it was done and what it does. The second type was a FAD which is more of a corporate formality. Both are listed in the SMS. People searching the SMS would have to know the title of keywords intimately to be able to search for it in a routine way. No effort was made to make it findable by future programmers with a similar problem. Bill or the ISDN team would know immediately how to find it.

Classification: Content-R&D; Others-Face to face; public-SMS, DAKAN (FAD)

C.I. #: 87

Date: May 27th

Project: ISDN

Person: Bill

Functional Assoc.: Software Designer

Description of incident:

Robin called Bill with a problem. It seemed that in the SX-2000 series of PBX's there was a certain scenario that allowed the system to drop calls. Robin thought Bill might be a good person to get this fixed. The problem as Bill discovered it turned out to be a confusion in the software of two timers with the same name, and one not getting cleared in time for a call to be made. The result is a timer still going when it should have been removed. The computer loses a message about what to do with the call, and decided that the only thing it knows how to do (logically) is drop it.

Solution:

Bill generated a DPAR in the SMS and called a few other groups to find out more about the code involved. He spent a fair amount of time learning about the specificities of the program that should clear the timer. He then wrote a new program that would insure a "safe" timer cancel, and prevent collisions of names. In addition, he added a line to the system log that said what his changes were doing (for future programmers).

Dissemination/Reporting

The details about this solution are very easy to find since they are located in the log output of the SX-2000 switch (anyone looking in the log would see the results of the code) and the code is commented in the DPAR listed in the SMS. Other programmers would easily be able to make changes, or use the code in similar applications elsewhere.

Classification: Content-R&D; self-telephone, public-SMS

C.I. #: 88

Date: May 27th

Project: ISDN

Person: Bill

Functional Assoc.: Software Designer

Description of incident::

Recently the project manager of the group left for another position within Mitel. This left a hole in scheduling, which slipped badly without documentation, and coordination. In addition, Bill (as a technical leader) had to let go of a key designer within the group.

Solution:

Bill took on the responsibility of group manager. He built a schedule (MS-project) and planned meetings to help share ideas and coordinate efforts. The technical hole was filled by the other members of the team, and Bill spent a good part of his time doing managerial activities (placing more workload on the rest of the group). This solution became more formal as higher level managers acknowledge Bill's new position.

Dissemination/Reporting

Close e-mail contact was made between all the group members for scheduling purposes, but technical discussions were kept to meetings. Mostly meetings are informal, short, and casual. Usually held at one of the members desks. They group sits within 10 meters of each other.

Classification: Coordination-R&D; Self assisted by tool-MS-project; semi-public-e-mail

C.I. #: 89

Date: June 3rd

Project: MC3R

Person: Tom **Functional Assoc.:** PCB designer

Description of incident:

The job of the PCB layout person is to transcribe what the electrical engineers has designed in a CAD tool onto a physical layout plan of a circuit board. This means when there is a change in the electronics, there will necessarily be a change in the layout. Quite often Paul (the MC3R electronic designer) will come over to Tom (about a 40 meter walk) and say "guess what, grease spot" meaning something went wrong, and needs to be changed.

Solution:

Tom has built a repertoire of knowledge about the different electronic designers he has to work with. Depending on who it is will determine how he schedules and executes the layout. For example, with Paul (who usually works with the most complex boards to begin with) he will try to keep all of the likely changed items for last, and perform the guaranteed tasks up front. This usually saves Tom recycles. The process of getting it right is usually long and iterative.

Dissemination/Reporting

Communication between designer and Tom is almost always face to face. Although they do not sit in extremely close proximity. Almost all of the designers and

layout people are on the same floor. It is very difficult to communicate technical details using anything other than the schematic and a finger pointing at the problem. Tom is one of the few people who is OFTEN found at his desk, and therefore this method of knowledge transfer is ideal. Final changes are stored in technical documentation and kept in the SMS. None of the interim changes are kept in a meaningful way (CAD files of older versions are often left on the hard drives of the designers or layout person).

Classification: Content-R&D; self-face to face; semi-private-meetings, memory

C.I. #: 90 **Date:** June 3rd **Project:** MC3R
Person: Tom **Functional Assoc.:** PCB designer

Description of incident:

On most multi-layer printed circuit boards, there is a plane (layer) dedicated to ground and one for power. These are important because very many points on the board will require direct connection to both power and ground. Cadence, the CAD design tool will not allow you to view the isothermic characteristics of these layers, which can be an important indicator of trouble.

Solution:

Tom Elliot (the Cadence tool support person) was at a meeting at Cadence with many users of the product from other companies (a conference). At the meeting this point was raised, and one user said that their tool support person wrote code for use with Cadence that lets you do exactly what you are looking for. He shared the software with everyone. Tom, unaware that Tom Saunderson needed such a tool, brought it home to Mitel, where it was very welcomed.

Dissemination/Reporting

Tom Elliot posted the tool and it's documentation on the Intranet, and gave a demonstration to all the people who use Cadence.

Classification: Content-R&D; Outsider with tools-meeting outside; semi-private-meetings, intranet

C.I. #: 91 **Date:** June 3rd **Project:** MC3R
Person: Tom **Functional Assoc.:** PCB designer

Description of incident:

Tom often encounters scheduling problems. He is responsible for scheduling for the whole group (there are three people who do board layout and two more who support them directly). Project teams book far in advance for time within this group to get a job done. They estimate when they will be ready for board layout. In some cases, they miss

the window, and other groups can take over the space. Sometimes, a priority project will come up, and the group will be book solid..

Solution:

The easiest solution to the problem is to work overtime. This is normal for the group, who spends overtime hours at peak times of the year. Other solutions are to try to reschedule less critical projects. Sometimes this is not a problem since those other projects are behind, or could use some final changes to their design.

Dissemination/Reporting

This is a rather critical part of Mitel business. This group cannot hold up important project from shipping. There is communication between Tom and high level directors to approve rescheduling of low priority projects, and overtime work. The communication is almost continuous, and works through e-mail and face to face contact (only when critical issues arise).

Classification: Coordination-R&D; self with tool-MS project; semi-public-meetings

C.I. #: 92

Date: June 3rd

Project: USB

Person: Carl

Functional Assoc.: Software designer

Description of incident:

This designer was asked to build a tool to talk between the computer user interface and the USB port or communications ports on a PC. The purpose of the program is to test and configure the ports and facilitate communications between regular modems, serial devices and the USB phone. This is one component of the PC software package that will ship with the USB phone.

Solution:

This program is being coded in MS Visual Basic 4.0. It is the first exposure this particular designer has had with the environment, but it does have very good online documentation. More technical assistance comes from a coworker, located adjacent to Carl. The coworker happens to be a contracted worker hired by Mitel to bring experience into the company. Part of his mandate is to share knowledge about the programming environment, which is also new to Mitel. Over the wall and face to face communications are used to help debug problems and inform each other on tips and tricks of the software.

Dissemination/Reporting

The experience gained by Carl will eventually be acknowledged by his supervisor in the semi-annual review (people are asked to state and demonstrate what they have learned and achieved during the last review period). His manager at that point will have knowledge (a pointer) to about what Carl can do. The new knowledge, although private could be used by others if they poses a pointer to it.

Classification: Content-R&D; self-over the wall; private-memory, reviews

C.I. #: 93

Date: June 3rd

Project: USB

Person:

Carl

Functional Assoc.: Software designer

Description of incident:

Carl is used to programming in the PBX system, which has a proprietary operating system. The above mentioned software only works in Windows, and as a result, not only does he have to learn the new software, but an entirely new operating system.

Solution:

The learning curve to acquire skills in Windows in quite short, but the knowledge must come from somewhere. In the majority of cases, he simply asked the person next to him (contracted worker) to explain the principals behind what he is doing in Windows. Additional knowledge was gained by doing research in the Mitel library which has a wealth of literature on the subject. This helped Carl communicate the kinds of problems he was having (before he was unable to even express the correct terminology).

Dissemination/Reporting

Dave (contractor) is the manager of a group called System O/S and terminal equipment software. As a manager, he has a good idea about the skills of his workers. In this case he was giving most of the help to Carl so he has a very good idea about the skill set. The pointers are stored in personnel review documents, and in his experience (unfortunately, he is a contracted worker meaning he may not be around long enough to use those pointers).

Classification: Content-R&D; self-over the wall; private-memory, reviews

C.I. #: 94

Date: June 6th

Project: Many

Person:

Steve

Functional Assoc.: Performance engineering/controls

Description of incident:

In order to get critical testing done, this manager needed to get a certain lab connected to live links of ISDN. He knew the links existed elsewhere in the company, so it was just a matter of finding out how to get them installed, and who would do it.

Solution:

After a few phone calls, Steve found out who was the person who put the other links in, and that he was the right person for the job. Unfortunately, it was not a priority for that person to do this job, and was not interested. This is a case where rank was pulled and Steve had him do it anyway. Instead of starting a whole ball of wax by forcing him to do it, Steve convinced him (politically) that the need was urgent, and the benefits would be great to the company. Eventually the other person complied.

Dissemination/Reporting

Originally, Steve found the correct person by going to the manager of the networking group. This manager was able immediately able to identify the correct person for the job. This first contact was done by voice on the phone. The second contact to the engineer was done through e-mail. No records were made of the action or process of getting it done because it was not directly related to the Mitel products.

Classification: Coordination-R&D; self-telephone; semi-private-meetings

C.I. #: 95

Date: June 6th

Project: Many

Person: Steve

Functional Assoc.: Performance engineering/controls

Description of incident:

Steve received and action item to purchase a Flash ROM burner for the software group. since they did not have one, they were responsible for programming many flash ROMs (MC3R for example) and they often are in a rush to complete the task. This equipment is quite expensive, and there are already two existing units in the manufacturing department. This action item had been left to another person about 3 months earlier, and nothing was done about it.

Solution:

Steve did not go out and just buy this equipment because he thought he would try to save money and see if the ones in Mitel could be used. At first, he asked the designers (software) why they needed it now, and what kind of usage they would be getting out of it. Then he went to manufacturing and asked what the usage of their machines were. He found that there was plenty of spare capacity available. And that the turn around time (contrary to an argument from the software designers) was very fast (same day). The software group replied with the fact that the equipment could be tied up during a critical period.

Ultimately the decision was made (Steve) to not purchase more equipment, and have the software people form a new relationship of communication with the manufacturing group. Eventually everyone cooperated.

Dissemination/Reporting

The preliminary research took place mostly by e-mail, but as things heated up, careful notes were made and placed into a action file. Steve was able to prove his point and case by using these notes. They are mostly private now that they reside at his desk.

Classification: Coordination-R&D; self-e-mail, meetings; semi-private-personal notes

C.I. #: 96

Date: June 6th

Project: MC3R

Person: Paul

Functional Assoc.: Hardware designer

Description of incident:

During the last days of development on the large ASIC chip for the MC3R, Paul discovered that the SCSI component was not working as it should. He tried just about everything in the book, but was stumped. He even checked each suppliers specifications against the simulation files to see if there was a deviation.

Solution:

At this point, Paul was not sure if the problem was with the SCSI library or the test tool itself. It was more likely not to be the test tool because he had heard from communication with friends in other companies that the software in this circumstance is solid, and the test library from the SCSI supplier was known good. The limited the problem to the actual code (Paul's work). He took a copy of the code and sent the case to both Synopsis (supplier of the test tool) and NCR (supplier of the SCSI). Synopsis didnt see anything wrong with the way their tools was reporting the trouble and that the problem was in fact valid. The next day (day after) NCR said, of course it does not work, you are out in the timer by 25%! Paul insisted that he was not, and proved it by faxing NCR the page in the specification manual that showed the timer numbers. It turned out to be a misprint. Within three hours of this, Paul had devised a fix for the problem (which made the board a little more messy, but will be cleaned up in a later revision).

Dissemination/Reporting

Because this is so late in the development process, Paul made a DPAR for it when he saw the problem (this way other people could help if he couldn't figure it out). Also he initiated an ECO (equipment change order) that informed manufacturing on the changes to be made to the boards (in this case, the boards were already made, so it meant modifications).

Classification: Content-R&D; Outsider-telephone; semi-private-personal notes, memory, meeting

C.I. #: 97

Date: June 12th

Project: NeVaDa (others)

Person: Peter

Functional Assoc.: Manufacturing

Description of incident:

The platform computer used in most CTI products, supplied by DEC is now obsolete. The computers are no longer available, and Mitel had to make a last time buy. Forecasting predicted how many to buy, and the company would have to come up with a new product to use before that number of units ran out.

Solution:

The number of DEC's purchased will run out in July, and Peter purchased a test machine from Intel, based on the newer Pentium chip. He then tested it with all the CTI products, and found it to be adequate. This was all after researching to see what computer would be most suitable for the Mitel application. The solution was not well liked by one CTI group, who said they would rather have Mitel build a standard box of their own that looked more like the SX-2000 light series of switches. This was accepted by others, but would not be guaranteed to be complete by July. The Intel boxes then became a contingency item for the Mitel box.

Dissemination/Reporting

The original problem was a DPAR, however there were many product meetings carried out to come to the ultimate conclusion. Further problems were created when one group tried to ship some of the new Intel boxes using the same old part number of the DEC. This is a nightmare for providing field support. The part number is being changed as a BOM by Peter.

Classification: Process-manufacturing; group-meetings; public-BOM, SMS

C.I. #: 98 -101

Date: June 12th

Project: Many

Person: Harry Richardson

Functional Assoc.: Manufacturing

Description of incident:

Please see the DPAR printouts obtained from the SMS for me by this manufacturing representative. They are an excellent example of the good usages of the SMS and how it tracks all those people working on a problem. It first identifies several pertinent pieces of information, then the problems are listed. Finally the problems are resolved by someone and the DPAR is closed. There are also listings of questions to be answered by the post mortum team if applicable.

Each of these problems has to do with manufacturing issues and how they were resolved.

Classification: Content-Manufacturing; others-e-mails; public-SMS

p.1453 amelia medium *closed ETI 1072303AAR1 Manufacturing problems.

from: campbelld assign: amelia type: docn sys: mfg load: -----

orig: richards 95/03/20 plan: 95/06/16 change: 95/06/19 dot: 3 var: al

streams: sx2ksg: closed sx2ks: closed sx2kfd: closed

The following are problems or issues found during the proto build of the ETI CCA 1072303AAR1.

SMT:

- no known problems but D4, D5, T1, and T2 were not placed due to parts

shortage.

- UC1D1 used a socketed DIP EPROM (with EDA Firmware) instead of the preferred PLCC for this build.

Firmware:

- Only the part numbers are released the actual firmware is not yet released.
- a remark on BOM 137849901 requests the label with the ID number be placed on the top of the programmed part. Our process requires the firmware number on the label. Only the last 4 characters of the ID number can put on this 0.25" X 0.25" label with the firmware number. See next for further labeling.

Labeling:

- The ethernet address was printed on label P/N 690450320 and installed on the CCA just below the bar code label. This was done as a trial although the product definition did not specify it. The actual requirements need to be specified on the BOM and assembly drawing.

Mechanical:

- the faceplate assembly can't be installed properly because of interference with leads on S1, and leads and plastic snap-in on J12 and J26.
- the upper locklatch and the faceplate designation have not yet been installed due to parts shortage.

```
***RICHARDS -95/03/20 13:28:38-----STREAM added: SX2KSG-----
***RICHARDS -95/03/20 13:28:38-----STATUS SX2KSG REOPEN ==>
DEFINED-----
***RICHARDS -95/03/20 13:28:38-----STREAM added: SX2KS-----
***RICHARDS -95/03/20 13:28:38-----STATUS SX2KS REOPEN ==> DEFINED-
-----
***RICHARDS -95/03/20 13:28:38-----STREAM added: SX2KFD-----
***RICHARDS -95/03/20 13:28:38-----STATUS SX2KFD REOPEN ==>
DEFINED-----
***RICHARDS -95/03/20 13:28:38-----VARIANT AL ==> AL-----
***LAVRISA -95/03/24 11:21:40-----STATUS SX2KSG DEFINED ==> OPEN----
----
***LAVRISA -95/03/24 11:21:40-----STATUS SX2KS DEFINED ==> OPEN-----
---
***LAVRISA -95/03/24 11:21:40-----STATUS SX2KFD DEFINED ==> OPEN----
----
---LAVRISA -95/03/24 11:21:40-----
Rerouted from LAVRISA to AMELIA
---AMELIA -95/04/20 18:26:52-----
```

SMT:

The reason to use a socketed DIP EPROM (with EDA firmware) is the ETI EPROM firmware was not ready when the prototype is built. Also, other advantage is to test ETI card with backward compatibility of EDA.

To ease for firmware change and reduce development cost, ECO9101 releases the second version of ETI card which changed the DIP EPROM as the preferred part.

Firmware:

ECO9101 releases the source code of firmware, GAL & ID PROM (except EPROM).

Label:

The label of Ethernet ID is included in the BOM & ass'y drawing of ETI Rev.2 and ECO9101 releases it.

Mechanical:

The faceplate and silkscreen are modified by mechanical designer.

---AMELIA -95/04/25 09:46:14-----

Rerouted from AMELIA to CAMPBELLD

---CAMPBELLD-95/05/02 09:44:36-----

At the time this DPAR was written it was not apparent that the vendor who provided the faceplate had missed machining the clearance slots for the leads and plastic pegs on the connectors. Since the faceplates were updated the problem has gone away.

---CAMPBELLD-95/05/15 11:04:14-----

Rerouted from CAMPBELLD to AMELIA

***AMELIA -95/05/23 14:10:04-----STATUS SX2KSG OPEN --> COMPLETE-

***AMELIA -95/05/23 14:10:04-----STATUS SX2KS OPEN --> COMPLETE----

***AMELIA -95/05/23 14:10:04-----STATUS SX2KFD OPEN --> COMPLETE-

---AMELIA -95/05/23 14:10:04-----

***AMELIA -95/06/06 10:22:20-----CHANGEDESC-----

---AMELIA -95/06/06 10:24:54-----

POST MORTEM ANALYSIS - PLEASE ANSWER THE FOLLOWING:

=====

WHERE IN THE METHODOLOGY WAS THE ERROR INTRODUCED?
(Name an activity or a receivable).

The errors were introduced at detailed design stages.

COULD THE ERROR HAVE BEEN DETECTED EARLIER IN THE PROCESS?

The errors could be incorporated in unit DOS, like selecting SMT/Thru-hole preferable parts and defining labels' sizes and their locations.

GIVE A CONCISE ANALYSIS OF WHAT WENT WRONG TO CAUSE THIS PROBLEM

SMT: 1. parts storage is not a design problem.

2. the preferred parts should be chosen for developing, not for production.

Firmware: 1. in this case, EDA's firmware can be released as ETT's preliminary version and updated the firmware later when it is ready.

2. the process of programming ID PROM was a undefined area during unit detailed design. It had been solved in unformal meeting and not been documented.

Labeling: It was a trial item discussed in design review, and did not incorporated in the BOM and assembly drawing.

Mechanical: 1. part errors and shortage are not design issues.

SUGGEST WHAT COULD BE CHANGED TO PREVENT A SIMILAR PROBLEM IN THE FUTURE

Most of the problems in this DPAR are documentation errors. During detailed design stage, we should incorporated all the issues and solutions into documents, even though they are temporary solutions.

PLEASE REFERENCE THE ECO NUMBER WHICH RESOLVES THIS DPAR (if applicable)

ECO 9101.

IF APPLICABLE, PLEASE LIST SUPPORTING DOCUMENTS NOT COVERED

BY THE ECO WHICH HAVE BEEN UPDATED AS A RESULT OF THIS CHANGE

e.g. HFD, TS, TP, etc.

Not applicable.

***HW -95/06/13 09:26:26-----STATUS SX2KSG COMPLETE - CLOSED-

***HW -95/06/13 09:26:26-----STATUS SX2KS COMPLETE - CLOSED---

***HW -95/06/13 09:26:26-----STATUS SX2KFD COMPLETE - CLOSED-

***MONAGHAN -95/06/19 09:55:14-----STATUS SX2KSG CLOSED ---
CLOSED-----

***MONAGHAN -95/06/19 09:55:14-----STATUS SX2KS CLOSED
CLOSED-----

***MONAGHAN -95/06/19 09:55:14-----STATUS SX2KFD CLOSED
CLOSED-----

lib: hw user: richards stream: ----- width: 128 time: 96/06/17 16:26:10

p.1456 gresham medium *closed MC3 1072143AARI Manufacturing problems.

from: jacob assign: gresham type: docn sys: mfg load: -----

orig: richards 95/03/23 plan: 95/04/05 change: 96/05/24 dot: 3 var: al

streams: sx2kfd: closed sx2ks: closed

Design Issues

BOM does not include sockets for Hexadecimal displays XUA22 & XUA25.

Assumed same as MC2E P/N 562021000.

14 pin socket 562000000 for the rev strap XUE32 was not on the BOM.

SMT REV STRAP should be used when the artwork is changed.

P/N wrong on resistors R55-R66,R219-R220. Wrong P/N is S200009300. Correct P/N is S200093000. This was wrong in the design file and Dainq BOM.

1 board feducial does not have the keep clear zone. Copper mesh tight to the feducial. If a 4th feducial would have been put in the other corner this would not be an issue.

***RICHARDS -95/03/23 15:53:40-----STREAM added: SX2KSG-----
 ***RICHARDS -95/03/23 15:53:40-----STATUS SX2KSG REOPEN ==>
 DEFINED-----
 ***RICHARDS -95/03/23 15:53:40-----STREAM added: SX2KS-----
 ***RICHARDS -95/03/23 15:53:40-----STATUS SX2KS REOPEN ==> DEFINED-

 ***RICHARDS -95/03/23 15:53:40-----STREAM added: SX2KFD-----
 ***RICHARDS -95/03/23 15:53:40-----STATUS SX2KFD REOPEN ==>
 DEFINED-----
 ***RICHARDS -95/03/23 15:53:40-----VARIANT AL ==> AL-----
 ***JACOB -95/03/24 11:24:50-----STATUS SX2KSG DEFINED ==> REOPEN--

 ***JACOB -95/03/24 11:24:50-----STREAM removed: SX2KSG-----
 ***JACOB -95/03/24 11:24:50-----STATUS SX2KFD DEFINED ==> OPEN-----
 --
 ***JACOB -95/03/24 11:24:50-----STATUS SX2KS DEFINED ==> OPEN-----
 -
 ---JACOB -95/03/24 11:24:50-----
 Rerouted from JACOB to GRESHAM
 ***GRESHAM -95/03/27 14:31:30-----STATUS SX2KFD OPEN ==>
 COMPLETE-----
 ***GRESHAM -95/03/27 14:31:30-----STATUS SX2KS OPEN ==> COMPLETE-

 ---GRESHAM -95/03/27 14:31:30-----
 ---GRESHAM -95/03/27 14:31:30-----
 All BOM omissions are corrected by ECO 9048.
 The feducial problem is corrected by ECO 9064.
 ---GRESHAM -95/03/27 14:31:30-----
 All BOM omissions are corrected by ECO 9048.
 The feducial problem is corrected by ECO 9064.
 ---GRESHAM -95/03/27 14:55:36-----

POST MORTEM ANALYSIS - PLEASE ANSWER THE FOLLOWING:

=====

WHERE IN THE METHODOLOGY WAS THE ERROR INTRODUCED?
 (Name an
 activity or a receivable).

Error was introduced at Engineering Release

COULD THE ERROR HAVE BEEN DETECTED EARLIER IN THE
 PROCESS?

(Name an activity or activities).

No

GIVE A CONCISE ANALYSIS OF WHAT WENT WRONG TO CAUSE THIS PROBLEM

BOM omissions were caused by failure of hardware designer to add mechanical piece parts to the NCA BOM.

Feducial problem was caused by a malfunction of the shape VOID function in allegro, which accidentally wrote over the clear area around the feducial.

SUGGEST WHAT COULD BE CHANGED TO PREVENT A SIMILAR PROBLEM IN THE FUTURE

1. Design entry system should automatically add mechanical call-outs when selected components imply their existence. (ie. connectors automatically call up corresponding screws.)
2. BOM generation program that is run on the allegro board file should also include mechanical parts added to the assembly in allegro, especially sockets.
3. Bugs in copper balancing programs can be corrected.

PLEASE REFERENCE THE ECO NUMBER WHICH RESOLVES THIS DPAR (if applicable)

ECO 2048 & ECO 2064

IF APPLICABLE, PLEASE LIST SUPPORTING DOCUMENTS NOT COVERED

BY THE ECO WHICH HAVE BEEN UPDATED AS A RESULT OF THIS CHANGE

e.g. HFD, TS, TP, etc.

(not applicable)

***GRESHAM -95/03/28 10:13:26-----STATUS SX2KFD COMPLETE --
SUBMITTED--
***GRESHAM -95/03/28 10:13:26-----STATUS SX2KS COMPLETE --
SUBMITTED---
***GRESHAM -96/05/23 13:20:58-----STATUS SX2KFD SUBMITTED --
COMPLETE--

***GRESHAM -96/05/23 13:20:58-----STATUS SX2KS SUBMITTED ==>
COMPLETE---

***JACOB -96/05/24 14:30:12-----STATUS SX2KFD COMPLETE ==>
CLOSED-----

***JACOB -96/05/24 14:30:12-----STATUS SX2KS COMPLETE ==> CLOSED-

lib: hw user: richards stream: ----- width: 128 time: 96/06/17 16:26:26
p.1531 amelia low *closed MFTG problems on ETI 1072303AAR2
from: lavrisa assign: amelia type: docn sys: mfg load: -----
orig: richards 95/05/25 plan: 95/07/14 change: 95/07/31 dot: 3 var: al
streams: sx2ksg: closed sx2ks: closed sx2kfd: closed

Socket XUCD1++2 P/N 562004750 was not on the BOM.

MAC Address label was shown on CCA instead of Faceplate. Location and orientation should be shown. There should be a note on the drawing stating that the label has to match the address programmed into UD17++1.

Blank label P/N 690450320 was called up on BOM with no definition of print requirements. Printed label should be given an assembly part number and its BOM should call up the blank label with remarks for printing instructions. See MITEL1 BOM 690450320-MAC.

Jumper P/N 560042016 was not shown on the assy drwg and the BOM has no designation. We used (W2-W7). A detail is required to show the location.

Jumper P/N 560041000 Qty 1 was not on the BOM. We used designation (W1). A detail is required on the assy drwg to show its location.

see - MCO AA19442 -

- MCO AA19453 was written because the firmware was not released or available.

- MCO AA19488 was written because only 1 screw P/N 633027438 was called up on the BOM. Should be qty 3.

***RICHARDS -95/05/25 13:18:52-----STREAM added: SX2KSG-----
***RICHARDS -95/05/25 13:18:52-----STATUS SX2KSG REOPEN ==>
DEFINED-----

***RICHARDS -95/05/25 13:18:52-----STREAM added: SX2KS-----

***RICHARDS -95/05/25 13:18:52-----STATUS SX2KS REOPEN ==> DEFINED-

***RICHARDS -95/05/25 13:18:52-----STREAM added: SX2KFD-----
 ***RICHARDS -95/05/25 13:18:52-----STATUS SX2KFD REOPEN ==>
 DEFINED-----
 ***RICHARDS -95/05/25 13:18:52-----VARIANT AL ==> AL-----
 ***LAVRISA -95/05/30 09:52:42-----STATUS SX2KSG DEFINED --> OPEN----

 ***LAVRISA -95/05/30 09:52:42-----STATUS SX2KS DEFINED --> OPEN-----

 ***LAVRISA -95/05/30 09:52:42-----STATUS SX2KFD DEFINED --> OPEN----

 ---LAVRISA -95/05/30 09:52:42-----
 Rerouted from LAVRISA to AMELIA
 ***AMELIA -95/06/13 13:34:50-----STATUS SX2KSG OPEN ==>
 SUBMITTED-----
 ***AMELIA -95/06/13 13:34:50-----STATUS SX2KS OPEN ==> SUBMITTED--

 ---AMELIA -95/06/13 13:34:50-----

ECO 9196 is incorporated the following information:

- Under P/N: 1072303AAR2 CCA ETI Card
 change P/N:560042016 JMP CONN 2X8 QTY:5
 remarks: W2, W4-W7
 add P/N:560042000 JMP CONN 2X1 QTY:5
 remarks: W1, W8-W11
 add P/N:562004750 SKT DIP 28P QTY:1
 remarks: XUCD1++2
 change P/N:633027438 SCRW TF PAN-XPT QTY:3
 add a remarks on P/N:690450320 LABEL BLANK
 remarks: PRINT ON LINE 1: "MAC ADDRESS"
 PRINT ON LINE 2 THE ADDRESS IN FORMAT
 08-00-0F-XX-XX-XX
 WHERE XX MEANS THE COUNT UP OF NUMBER
 FROM 00 TO FF.

- On the ass'y drawing of ETI card P/N: 1072303AA, says

apply Note 1.9: LABEL MUST MATCH THE ADDRESS PROGRAMMED IN UD17.

show the locations of jumper blocks (W1-W11) and the label of MAC address.

- The source code of ETI's EPROM is released.

***AMELIA -95/06/13 13:42:58-----STATUS SX2KFD OPEN ==>
 SUBMITTED-----
 ***AMELIA -95/07/19 10:34:38-----STATUS SX2KSG SUBMITTED ==>
 COMPLETE--
 ***AMELIA -95/07/19 10:34:38-----STATUS SX2KS SUBMITTED ==>
 COMPLETE---
 ***AMELIA -95/07/19 10:34:38-----STATUS SX2KFD SUBMITTED ==>
 COMPLETE--
 ---AMELIA -95/07/19 10:34:38-----

POST MORTEM ANALYSIS - PLEASE ANSWER THE FOLLOWING:

=====

WHERE IN THE METHODOLOGY WAS THE ERROR INTRODUCED?
 (Name an
 activity or a receivable).

At 3.24 ENG ECO documentation release in Phase 3.

COULD THE ERROR HAVE BEEN DETECTED EARLIER IN THE PROCESS?

Yes, it could been detected earlier before the ECO and drawings are released.

GIVE A CONCISE ANALYSIS OF WHAT WENT WRONG TO CAUSE THIS PROBLEM

The error is the documentation was wrong at the beginning.

SUGGEST WHAT COULD BE CHANGED TO PREVENT A SIMILAR
 PROBLEM
 IN THE FUTURE

1. Consulting with manufacturing's expertise and including the changes in the previous ECO can prevent those errors happened.
2. Put mechanical parts in design files can prevent from creating errors.

PLEASE REFERENCE THE ECO NUMBER WHICH RESOLVES THIS
 DPAR
 (if applicable)

ECO 9196.

IF APPLICABLE, PLEASE LIST SUPPORTING DOCUMENTS NOT
 COVERED
 BY THE ECO WHICH HAVE BEEN UPDATED AS A RESULT OF THIS
 CHANGE
 e.g. HFD, TS, TP, etc.

Not applicable.

```

***AMELIA -95/07/26 11:39:04-----CHANGEDESC-----
***AMELIA -95/07/26 13:24:26-----CHANGEDESC-----
***HW      -95/07/31 08:14:00-----STATUS SX2KSG COMPLETE --> CLOSED-
----
***HW      -95/07/31 08:14:00-----STATUS SX2KS COMPLETE --> CLOSED---
---
***HW      -95/07/31 08:14:00-----STATUS SX2KFD COMPLETE --> CLOSED-
----
lib: hw    user: richards stream: ----- width: 128 time: 96/06/17 16:26:42
p.1528 amelia medium *closed Assembly problem on ETI Paddle 139424301R1
  from: lavrisa assign: amelia type: fnc_a sys: mfg load: -----
  orig: richards 95/05/23 plan: 95/07/14 change: 95/08/04 dot: 3 var: al
streams: sx2ksg: closed sx2ks: closed sx2kvs: closed
  
```

Socket header P1 P/N 569087130 did not fit in the holes in the PCB.

Deviation AA19467 was used to substitute qty 3 of P/N 566074010 for
 the above connector for a qty of 48 CCA's.

It would be preferred to have a single piece connector for P1 as
 the 3 piece connector has to be fixtured to keep it aligned for
 soldering.

```

***RICHARDS -95/05/23 11:24:00-----STREAM added: SX2KSG-----
  
```


***RICHARDS -95/05/23 11:24:00-----STATUS SX2KSG REOPEN ==>
 DEFINED-----
 ***RICHARDS -95/05/23 11:24:00-----STREAM added: SX2KS-----
 ***RICHARDS -95/05/23 11:24:00-----STATUS SX2KS REOPEN ==> DEFINED-

 ***RICHARDS -95/05/23 11:24:00-----STREAM added: SX2KVS-----
 ***RICHARDS -95/05/23 11:24:00-----STATUS SX2KVS REOPEN ==>
 DEFINED-----
 ***RICHARDS -95/05/23 11:24:00-----VARIANT AL ==> AL-----
 ***LAVRISA -95/05/24 15:03:02-----STATUS SX2KSG DEFINED ==> OPEN----

 ***LAVRISA -95/05/24 15:03:02-----STATUS SX2KS DEFINED ==> OPEN-----

 ***LAVRISA -95/05/24 15:03:02-----STATUS SX2KVS DEFINED ==> OPEN----

 ---LAVRISA -95/05/24 15:03:02-----
 Rerouted from LAVRISA to AMELIA
 ***AMELIA -95/06/13 11:46:44-----STATUS SX2KSG OPEN ==>
 SUBMITTED-----
 ***AMELIA -95/06/13 11:46:44-----STATUS SX2KS OPEN ==> SUBMITTED--

 ***AMELIA -95/06/13 11:46:44-----STATUS SX2KVS OPEN ==>
 SUBMITTED-----
 ---AMELIA -95/06/13 11:46:44-----

This problem is caused by an incorrect component model for allegro, and
 the model is fixed in the library. The second version of ETI paddle card
 has been updated. ECO 9198 released the new artworks.

***AMELIA -95/07/26 17:21:12-----STATUS SX2KSG SUBMITTED ==>
 COMPLETE--
 ***AMELIA -95/07/26 17:21:12-----STATUS SX2KS SUBMITTED ==>
 COMPLETE---
 ***AMELIA -95/07/26 17:21:12-----STATUS SX2KVS SUBMITTED ==>
 COMPLETE--
 ---AMELIA -95/07/26 17:21:12-----

POST MORTEM ANALYSIS - PLEASE ANSWER THE FOLLOWING:

=====

WHERE IN THE METHODOLOGY WAS THE ERROR INTRODUCED?
 (Name an
 activity or a receivable).

In Unit Detailed Design.

COULD THE ERROR HAVE BEEN DETECTED EARLIER IN THE PROCESS?

Yes, it could be detected when the model was being created.

GIVE A CONCISE ANALYSIS OF WHAT WENT WRONG TO CAUSE THIS PROBLEM

Pick a wrong dimension from specification drawing.

SUGGEST WHAT COULD BE CHANGED TO PREVENT A SIMILAR PROBLEM IN THE FUTURE

A checking process can prevent the similar problem in the future.

PLEASE REFERENCE THE ECO NUMBER WHICH RESOLVES THIS DPAR (if applicable)

ECO 9198.

BY THE ECO WHICH HAVE BEEN UPDATED AS A RESULT OF THIS CHANGE

e.g. HFD, TS, TP, etc.

Not applicable.

***MONAGHAN -95/08/04 15:33:40-----STATUS SX2KSG COMPLETE -->
CLOSED-----

***MONAGHAN -95/08/04 15:33:40-----STATUS SX2KS COMPLETE -->
CLOSED-----

***MONAGHAN -95/08/04 15:33:40-----STATUS SX2KVS COMPLETE -->
CLOSED-----

Appendix III

C.I. #: 1	Date: March 13th	Project: ISDN-Gateway
Classification: Process-Management; decision made in team-face to face; semi private-meetings		
C.I. #: 2	Date: March 13th	Project: ISDN-Gateway
Classification: Coordination-R&D; team decision- meetings; Public-SMS, DaKAN		
C.I. #: 3	Date: March 15th	Project: ISDN-Gateway
Classification: Content-R&D; team decision in person; Public-SMS, meeting		
C.I. #: 4	Date: March 15	Project: ISDN-Gateway
Classification: Content-Testing; team effort; public-SMS		
C.I. #: 5	Date: March 15th	Project: MC3R
Classification: Process-management; self-face to face; public- SMS and document vault		
C.I. #: 6	Date: Mar 1, 18	Project: Functional
Classification: coordination-management; self assisted by tool-networks, postings; semi-private-meet		
C.I. #: 7	Date: March 18	Project: MC3R
Classification: coordination-R&D; self assisted by tool-Msproject; Public-MSPProject		
C.I. #: 8	Date: March 18	Project: MC3R
Classification: Content-R&D; Self-Face to Face; private-memory		
C.I. #: 9	Date: March 18	Project: MC3R
Classification: Content-R&D; Self assisted by tool (CAD/CAE)-Face to Face; SMS (DPAR) Public		
C.I. #: 10	Date: March 18	Project: MC3R
Classification: Content-R&D; Self-Face to Face; SMS-public		
C.I. #: 11	Date: March 26	Project: MC3R
Classification: Content-R&D; Self (experience)-Face to face; semi-private-meetings		
C.I. #: 12	Date: March 26	Project: MC3R
Classification: Content-R&D; Self-face to face; private-memory		
C.I. #: 13	Date: March 26	Project: MC3R
Classification: Content-R&D; Paul and other people outside-telephone; semi private-meetings		
C.I. #: 14	Date: March 26	Project: MC3R
Classification: Content-R&D; self assisted by tools-e-mail; private-memory		
C.I. #: 15	Date: March 26	Project: MC3R
Classification: Content-R&D; Self (experiment)-private; semi-private-meetings		
C.I. #: 16	Date: April 4	Project: MC3R
Classification: Content-R&D; self-face to face; semi-private-meeting		
C.I. #: 17	Date: April 4	Project: MC3R
Classification: Process-R&D; Self(experimental); semi private-personal files, libraries		
C.I. #: 18	Date: April 15	Project: MC3R
Classification: Content-R&D; outside person-phone; semi-private-meetings		
C.I. #: 19	Date: April 15	Project: MC3R
Classification: Content-R&D; self (experimentation); semi public - SMS		
C.I. #: 20	Date: April 15	Project: Many
Classification: Coordination-R&D; self-phone; semi-private-meetings		
C.I. #: 21	Date: April 15	Project: Many
Classification: Process-management; group meeting-face to face, e-mails; semi-public- action orders		
C.I. #: 22	Date: April 15	Project: Many
Classification: Process-Management; tool assisted-intranet; public-intranet		
C.I. #: 23	Date: April 18	Project: ISDN-Gateway
Classification: Content-R&D; Self-e-mails; public-SMS		
C.I. #: 24	Date: April 18	Project: MC3R
Classification: Content-R&D; self (experimentation)-face to face; Public-SMS		
C.I. #: 25	Date: April 18	Project: MC3R
Classification: Content-R&D; Self-face to face; semi-private-meetings		
C.I. #: 26	Date: April 18th	Project: MC3R
Classification: Content-R&D; Outside people- face to face; public-SMS, meetings		
C.I. #: 27	Date: April 18th	Project: MC3R
Classification: Process-R&D; Outside person-telephone; semi-public-intranet, meetings		
C.I. #: 28	Date: April 18th	Project: MC3R
Classification: Process-R&D; Self-face to face; private-memory, personal notes		
C.I. #: 29	Date: April 18th	Project: MC3R
Classification: Process-R&D; self-meetings; semi-public-meetings, physical documents		
C.I. #: 30	Date: April 18th	Project: MC3R
Classification: Content-R&D; tool assisted- face to face; semi-private-meetings		
C.I. #: 31	Date: April 18 th	Project: MC3R
Classification: Content-R&D; outside person-telephone; private-personal notes		
C.I. #: 32	Date: April 23 rd	Project: MC3R
Classification: Content-R&D; Self-face to face; semi-public-SMS, tools manager, intranet		
C.I. #: 33	Date: April 24 th	Project: MC3R
Classification: Content-R&D; self-face to face, e-mails; semi-private-mentioned in SMS, tools support		
C.I. #: 34	Date: April 23 rd	Project: MC3R
Classification: Coordination-R&D; others (meeting) face to face; semi-private-personelle files		
C.I. #: 35	Date: April 23 rd	Project: ISDN-gateway
Classification: Content-R&D; Self (group)-face to face; semi-private-meetings, personal notes		
C.I. #: 36	Date: April 23 rd	Project: ISDN-gateway
Classification: Content-R&D; Other person - face to face; semi-private-meetings, notes		

C.I. #: 37	Date: April 23 rd	Project: ISDN-gateway
Classification: coordination-R&D; self assisted by tool-	face to face; semi-private MS Project	
C.I. #: 38	Date: April 23 rd	Project: ISDN-gateway
Classification: Process-R&D; person assisted by tool-DAKAN;	public-DAKAN (fad)	
C.I. #: 39	Date: April 23 rd	Project: ISDN-gateway
Classification: Content-R&D; self-face to face; private-memory		
C.I. #: 40	Date: April 23 rd	Project: ISDN-gateway
Classification: Content-R&D; self (experimentation) - over the wall; private-memory		
C.I. #: 41	Date: April 23 rd	Project: MC3R
Classification: Process-R&D; self-meetings; semi-private-meetings		
C.I. #: 42	Date: April 24 th	Project: USB
Classification: Content-R&D; Others-telephone, face to face, meetings; semi-public-ECO (SMS)		
C.I. #: 43	Date: April 24 th	Project: USB
Classification: Content-Marketing; self-e-mails, face to face; Public-DAKAN		
C.I. #: 44	Date: April 24 th	Project: MC3R
Classification: Process-Management; self assisted by tools-NOTES; semi-public action order, Lotus No		
C.I. #: 45	Date: May 6 th	Project: USB
Classification: Process-Manufacturing; self-e-mails; semi-public meetings; CAD/CAE files		
C.I. #: 46	Date: May 6 th	Project: USB
Classification: Process-Manufacturing; self-face to face; Public-CAD/CAE, SMS		
C.I. #: 47	Date: May 6 th	Project: Many
Classification: Process-R&D; Self-Meetings; Public-Meetings, physical documentation		
C.I. #: 48	Date: May 10 th	Project: USB/others
Classification: Content-R&D; Others (group)-meetings; semi-private-meetings		
C.I. #: 49	Date: May 10 th	Project: USB/others
Classification: Content-Manufacturing; Self assisted by tools-Internet; Private memory		
C.I. #: 50	Date: May 10 th	Project: USB/ Classification: Cont
Manufacturing; Self assisted by tool-CAD/CAE; Semi-private-Meetings, personal notes		
C.I. #: 51	Date: May 10 th	Project: USB
Classification: Content-R&D; Self assisted by tools-CAD/CAE; Public-SMS		
C.I. #: 52	Date: May 10 th	Project: USB
Classification: Content-R&D; Self-meetings; semi-public-SMS, personal notes		
C.I. #: 53	Date: May 10 th	Project: USB
Classification: Content-R&D; Other person-assisted by tool (SMS); Public-SMS		
C.I. #: 54	Date: May 10 th	Project: USB
Classification: Process-Manufacturing; Self-face to face; semi-private-meetings, personal notes		
C.I. #: 55	Date: May 10 th	Project: USB
Classification: Process-R&D; Self-e-mail; public-SMS		
C.I. #: 56	Date: May 10 th	Project: SS-7000
Classification: Content-R&D; Others-telephone; Public-SMS, DaKan, personal notes		
C.I. #: 57	Date: May 10 th	Project: Many
Classification: Content-R&D; Others- telephone, face to face; Private-personal notes, memory		
C.I. #: 58	Date: May 14 th	Project: Many
Classification: Content-Support; Self-e-mails; Public-SMS		
C.I. #: 59	Date: May 14 th	Project: Many
Classification: Content-Support; Others assisted by tool-SMS; Public SMS		
C.I. #: 60	Date: May 15 th	Project: USB
Classification: Content-Management; self-meetings; public-DaKan (pod)		
C.I. #: 61	Date: May 15 th	Project: USB
Classification: Coordination-Management; Self-telephone; Semi-private-meetings		
C.I. #: 62	Date: May 15 th	Project: USB
Classification: Content-R&D; Other person-Face to face; Semi-private meeting, personal notes		
C.I. #: 63	Date: May 15 th	Project: 400 series
Classification: Content-R&D; others-meetings, e-mails; public-SMS, personal notes		
C.I. #: 64	Date: May 23 rd	Project: Many
Classification: Coordination-Manufacturing; tool assisted-intranet, postings; Public DAKan		
C.I. #: 65	Date: May 23 rd	Project: Many
Classification: Content-Manufacturing; self-apprenticeship; semi-private-meetings, apprenticeship		
C.I. #: 66	Date: May 23 rd	Project: Many
Classification: Content-Manufacturing; Others (group) face to face; semi-public meetings		
C.I. #: 67	Date: May 23 rd	Project: ISDN-Gateway
Classification: Process-R&D; Self-e-mails; Public-SMS		
C.I. #: 68	Date: May 23 rd	Project: ISDN-Gateway
Classification: Process-R&D; Self-meetings; public-SMS		
C.I. #: 69	Date: May 23 rd	Project: ISDN-GateWay
Classification: Process-support; others-telephone; private-memory		
C.I. #: 70	Date: May 24 th	Project: USB
Classification: Content-R&D; Self assisted by tools (CAD/CAE); semi-private-personal notes		
C.I. #: 71	Date: May 24 th	Project: USB
Classification: Process-support; self-library; private-memory		
C.I. #: 72	Date: May 24 th	Project: 401+, USB
Classification: Content-R&D; self (experimentation); Semi-public-SMS, memory		
C.I. #: 73	Date: May 24 th	Project: 401+, USB
Classification: Content-R&D; self (experimentation); Semi-public-SMS, memory		
C.I. #: 74	Date: May 24 th	Project: 401+, USB

Classification: Content-R&D; self-experience; semi-private-personal notes, memory, meetings
 C.I. #: 75 Date: May 24th Project: MC3R
 Classification: Content-R&D; self-over the wall; semi-private-meetings
 C.I. #: 76 Date: May 24th Project: MC3R
 Classification: Content-R&D; self-her notes; private-personal notes
 C.I. #: 77 Date: May 24th Project: MC3R
 Classification: Content-R&D; self-her notes; private-personal notes
 C.I. #: 78 Date: May 24th Project: MC3P
 Classification: Process-support; others-telephone, face to face; semi-private-memory, meeting
 C.I. #: 79 Date: May 27th Project: Many
 Classification: Content-R&D; Self-e-mails, face to face; public-SMS
 C.I. #: 80 Date: May 27th Project: Many
 Classification: Content-R&D; self-e-mails, face to face, public-SMS
 C.I. #: 81 Date: May 27th Project: Many
 Classification: Process-Manufacturing; self-e-mails; semi-public-e-mails, documents
 C.I. #: 82 Date: May 26th Project: USB
 Classification: Content-R&D; self-yelling over the wall; semi-private-meetings, BOM
 C.I. #: 83 Date: May 24th Project: Many
 Classification: Process-Manufacturing; self-Dakan; public-DaKan
 C.I. #: 84 Date: May 24th Project: Many
 Classification: Content-Manufacturing; self-telephone; public-SMS
 C.I. #: 85 Date: May 27th Project: Many
 Classification: Content-Manufacturing; others (consortium); Semi-public-meetings
 C.I. #: 86 Date: May 27th Project: ISDN
 Classification: Content-R&D; Others-Face to face; public-SMS, DAKAN (FAD)
 C.I. #: 87 Date: May 27th Project: ISDN
 Classification: Content-R&D; self-telephone, public-SMS
 C.I. #: 88 Date: May 27th Project: ISDN
 Classification: Coordination-R&D; Self assisted by tool-MS-project; semi-public-e-mail
 C.I. #: 89 Date: June 3rd Project: MC3R
 Classification: Content-R&D; self-face to face; semi-private-meetings, memory
 C.I. #: 90 Date: June 3rd Project: MC3R
 Classification: Content-R&D; Outsider with tools-meeting outside; semi-private-meetings, intranet
 C.I. #: 91 Date: June 3rd Project: MC3R
 Classification: Coordination-R&D; self with tool-MS project; semi-public-meetings
 C.I. #: 92 Date: June 3rd Project: USB
 Classification: Content-R&D; self-over the wall; private-memory, reviews
 C.I. #: 93 Date: June 3rd Project: USB
 Classification: Content-R&D; self-over the wall; private-memory, reviews
 C.I. #: 94 Date: June 6th Project: Many
 Classification: Coordination-R&D; self-telephone; semi-private-meetings
 C.I. #: 95 Date: June 6th Project: Many
 Classification: Coordination-R&D; self-e-mail, meetings; semi-private-personal notes
 C.I. #: 96 Date: June 6th Project: MC3R
 Classification: Content-R&D; Outsider-telephone; semi-private-personal notes, memory, meeting
 C.I. #: 97 Date: June 12th Project: NeVaDa (others)
 Classification: Process-manufacturing; group-meetings; public-BOM, SMS
 C.I. #: 98 -101 Date: June 12th Project: Many
 Classification: Content-Manufacturing; others-e-mails; public-SMS

END

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FIN