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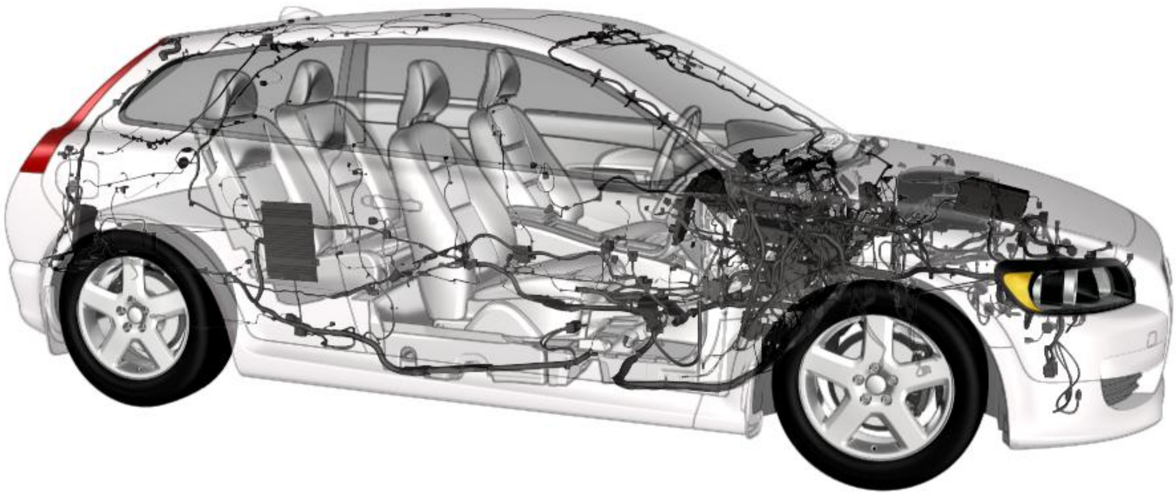

# Software management within Product Development

*Bachelor of Science Thesis in Mechatronics Engineering*

**ERIK JOHANSSON**
**SIV ROMERO SKOGH**
**HENRIK SVENSSON**

Department of Product & Production Development
Examiner: Mats Alemyr
CHALMERS UNIVERSITY OF TECHNOLOGY
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# Foreword

This thesis is part of our Bachelor of Science degree in Mechatronics, conducted at Chalmers University of Technology. The assignment has been carried out at Prototype Vehicles, Volvo Car Corporation, in the fall of 2010.

First and foremost we would like to thank our mentor at Volvo, Magnus Wennström, for the opportunity and the great support. It has been a very interesting experience, continuously providing more knowledge and insight. Mats Alemyr, our mentor at Chalmers, has also been a committed and valuable help.

There are many people who we would like to thank for their tireless cooperation and substantial help. That would unfortunately cover a couple of pages.

However, we would like to send special thanks to:

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Johnny Georgiou, Volvo
Kerstin Skarp, Volvo

Finally, we are proud to present the result of some extensive work, enjoy!

Gothenburg, January 2011

Erik Johansson
Siv Romero Skogh
Henrik Svensson

# Abstract

The software management within Product Development at VCC, *Volvo Car Corporation*, in Torslanda has been studied. Prototype Vehicles has a problem with late deliveries of software for their test objects. In order to find the cause of this, the units involved before Prototype Vehicles have been studied.

The first step of the project was to map up the actual current process. This was done by interviewing people in different parts of the organization. In some ways, the developed map differs from the formal one. It was also compared with the hardware process, which has a better delivery precision.

The next step was to suggest changes to improve the software handling. Key individuals were interviewed, more pointed questions were asked and a flowchart was developed including suggestions for improvement. In order to structure the problems, a report was made with the areas sorted as Units, Roles, Tools and Meetings, listing the problems discovered.

Task Leaders are responsible for the development of software for their corresponding node. The role has been studied more extensively because a large part of the delays naturally occur during this stage in the project. The study has been conducted by interviewing a number of Task Leaders. The information has been compared and analyzed.

The character of the problems found is mainly communicational and structural. A number of areas have been given suggestions for improvement which have already started to be implemented.

# Sammanfattning

Programvaruhanteringen inom produktutveckling på Volvo Personvagnar i Torslanda har granskats. Avdelningen ’Komplett bil’ har ett problem med försenade leveranser av programvara för sina provobjekt. För att hitta orsakerna till detta har enheterna involverade före ’Komplett bil’ studerats.

Det första steget i uppdraget var att kartlägga den nuvarande processen. Detta gjordes genom att intervjua personer i olika delar av organisationen. Bitvis skiljer sig kartläggningen från den formella planen. Den jämfördes också mot hårdvaruprocessen, eftersom hårdvaran har bättre leveransprecision.

Nästa steg var att föreslå förändringar för att förbättra hanteringen av programvaran. Nyckelpersoner intervjuades, mer konkreta frågor ställdes och ett flödesschema med förslag på förbättringar utvecklades. För att strukturera problemen sammanställdes en rapport med de olika områdena sorterade efter Avdelningar, Roller, Verktyg och Möten. I denna listades de problem som uppdagats.

Konstruktionsuppdragsledare är ansvariga för utveckling av programvara för deras respektive nod. Denna roll har studerats ytterligare eftersom en stor del av förseningarna av naturliga skäl uppkommer under detta skede i projektet. Detta har genomförts genom intervjuer med ett antal Konstruktionsuppdragsledare. Informationen har jämförts och analyserats.

De flesta upptäckta problem har den gemensamma nämnaren att de har med kommunikation eller struktur att göra. Förslag på förbättringar har framförts för ett antal områden och har redan börjat implementeras.

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# ABBREVIATIONS

| | **Descriptions and/or explanations** | **På Svenska** |
|---|---|---|
| **AVA** | *Analyze and Verification responsible* | *Analys och Verifieringsansvarig* |
| **AVB** | *Analyze and Verification Requirements* | *Analys & Verifieringsbehov* |
| **BMS** | *Business Management System* | |
| **BOM** | *Bill of Material*<br>– the term used to describe the "parts list" of components needed to complete a sellable end-item | Term som används för att beskriva listan av komponenter som behövs för att färdigställa en säljbar produkt |
| **Boxcar** | – the complete electrical system built on a table | Lådbil |
| **C-note** | *Change note* | **ÄO** -Ändringsorder |
| **CAN** | *Controller Area Network* | |
| **CEM** | *Central Electronic Module* | |
| **CME** | *Central Manufacturing Engineer* | |
| **CPM** | *Chief Program Manager* | |
| **CRB** | *Configuration and Release Board* | |
| **DPL** | *Unit Program Manager* | *Delprojektledare* |
| **ECU** | *Electronic Control Unit*<br>– also called "node" | *Nod* |
| **EESE** | *Electrical and Electronics Systems Engineering*<br>– a department within Product Development | – elavdelningen inom produktutveckling på VCC |
| **ESOW** | *Engineering Statement Of Work* | |
| **FAD** | *Function Area Description* | |
| **FDJ** | *Final Data Judgment*<br>– all engineering designs are completed, "pencil down" | – den tidpunkt då all utvecklingsarbeta skall vara färdigt |
| **FIP** | *Function Implementation Plan* | *Funktionsimplementationsplan* |
| **FSR** | *Final Status Report* | |
| **GPDS** | *Global Product Development System* – a plan describing all program logics (milestones) to be held during the projects | Globalt Produktutvecklings-system |

| | | |
|---|---|---|
| **HIL** | *Hardware In the Loop* | |
| **HPD** | *Handling Of Part Deviation* | – hantering av atrikelavvikelser |
| **KDP** | *Engineering Database* | *KonstruktionData Personvagnar* |
| **KU** | Task Leader | *Konstruktionsuppdragsledare* |
| **LIN** | *Local Interconnect Network* | |
| **M1DJ** | *M1 Data Judgment* | |
| **MOST** | *Media Oriented System Transport* | |
| **MRD** | *Material Required Date* | |
| **NCM** | *Node Check Meeting* | |
| **OBD** | *On Board Diagnostics* | |
| **PA** | *Program Approval* | |
| **PCM** | *Program Configuration Manager* | |
| **PD** | *Product Development*<br>– the development unit within VCC | |
| **PEM** | *Program Engineer Manager* | **TPL** – *Teknisk Projektledare* |
| **POB** | Test object engineer | *Provobjektsberedare, Provobjektsbehov* |
| **PP** | *Pilot Production* | |
| **PS** | *Program Start* | |
| **PSC** | *Program Strategy Confirmed* | |
| **PSS** | *Product System Structure* | |
| **PTC** | *Program Target Compatibility* | |
| **PTCC** | *Program Target Compatibility Checkpoint* | |
| **SCC** | *Software Coordination Center* | |
| **SDB** | *Signal Database* | *Signaldatabas* |
| **SKB** | **SRD,** *System Requirement Description* | *SystemKravsBeskrivning* |
| **SOP** | *Start of Production* | |
| **SRD** | *System Requirement Description* | **SKB**, *SystemKravsBeskrivning* |
| **SU** | | *Systemuppdragsledare* |
| **SW-DRM** | *Software Design Review Meeting* | |
| **SWRS** | *Software Requirement Specification* | |
| **Task Leader** | *Task Leader* | **KU** Konstauktionsuppdragsledare eller Komponentuppdragsledare |
| **TPL** | **PEM -** *Program Engineer Manager* | *Teknisk Projektledare* |

| | | |
|---|---|---|
| | *Technical Project Leader* | |
| **TRM** | *Time Review Meeting* | |
| **TT** | *Tooling Trail* | |
| **TTC** | *Technology Target Compatibility* | |
| **UN** | *Under body* | |
| **UP** | *Upper body* | |
| **VCC** | *Volvo Car Corporation* | |
| **VIDA** | *Vehicle Information & Diagnostics for Aftersales* | |
| **VP** | *Verification Prototype* | |
| **ÄO** | **C-note** – *Change note* | *Ändringsorder* |

# OTHER EXPLANATIONS

| Expression | Explanations | På svenska |
|---|---|---|
| **Target Plant** | Mass production plant | målfabrik |
| **Boxcar** | The entire electric system built up on a table | |
| **Chassi** | A department within PD | |
| **E Series** | Test series only involving electrical components | |
| **Electra** | Software used to set development specifications | |
| **M1 series** | *Mechanical* – vehicles used to verify key specifications in the Under Body area | |
| **Mules** | X1, used for system development in a car | Mula |
| **Pilot Plant** | The plant in which the pre series are built | |
| **PP series** | *Pilot Production* – final construction of pre series to verify the complete construction processes | |
| **Powertrain** | A department within PD | |
| **Prototype Vehicle** | A department within PD | |
| **Purpose of Series Document** | Document describing the purpose of test divided in the diverse series | Syfte Serie Dokument |
| **Running Changes** | Changes made in the middle of a project | |
| **SDA** | Program used to upload software to the car | |
| **TT series** | *Tooling Trail* –first pre series build to verify the process in the **target plant** together with operator training | |
| **VP series** | *Verification Prototype* – to verify the complete car out of production tools | |
| **X0 series** | *Experimental* – system development in a rig for Power train. | |
| **X1 series** | *Experimental* – system development in a mule, mainly for Power train | |

# 1 INTRODUCTION

The current situation within software development and delivery for prototypes doesn’t meet the required levels. A need for a new process has occurred. Software has a lower on-time-delivery precision than the corresponding hardware - about 40 percent compared to 90 percent.

## 1.1 Background

Until recent years Volvo was a player focusing on robustness and safety. Little effort was given to electrical features and high performance. That has all changed. Since the mid 90’s, Volvo has entered the competition in the premium segment, making products increasingly advanced and diverse.

Entering the IT-era has also given a new dimension to car development. The amount of electrical functions which used to be relatively constant from one generation of cars to the next has increased in a way that no one could have predicted a few years ago. IT-services have a short life and are updated constantly. An overwhelming amount of software is now involved in every part of a vehicle.

This does not cope well with the way products traditionally have been developed. Both the infrastructure and routines need an update.

### Infrastructure

All hardware / software parts are released through a database called KDP, *Konstruktionsdata Personvagnar*. It was introduced in the late 70’s and is used all the way from development to aftermarket. Many other systems are used for software handling but no automatic synchronization with KDP is possible. The demands for a new software system have not yet been met. The handling of software becomes difficult because of the amount of systems that are used, and the lack of automatic synchronization.

### Coordination and routines

For a long time the software only represented a tiny part of the product development. Therefore the software processes didn’t need as much coordination as the hardware process. It performed well having a small group of software designers that worked under less regulated conditions. As the development expanded, the structure and thinking partly remained the same, both within the development units and higher in the hierarchy. This lack of structure leaves a huge burden on each group of software designers and makes the process very dependent on the experience within the group.

## 1.2 Aim

The project aims to improve the process of software management to better correspond to the hardware management in terms of delivery precision. It also aims to understand the current software process to then be able to compare against the hardware process. Finally the purpose was to analyze the possibilities to apply the structure of hardware management to the software management.

## 1.3 Delimitations

Developing a new model involves a lot of different steps. The delimitations were set to only involve M1-, VP-series and Boxcars *(see 7.1.8).*

- M1 corresponds to building the UN, *Under body*.
- VP corresponds to building the entire car - both UN and UP, *Upper body*.
- Boxcars include the entire electric system. It is built up on a table and is conducted in five different E-series *(see 6.1)*, as functions continuously become ready for testing.

The scope of units to investigate had to be wide because of their dependency on each other.

## 1.4 Clarification of the issue

There are many reasons causing the software deliveries to be delayed. One of the reasons is that an entire unitary process is missing. Questions to be answered within this thesis are: How does the current process work today? How can the current process be improved? Can the software-process be as organized as the hardware process?

- The first stage of the assignment was to visualize the current software process and software deliveries for the building of prototypes and Boxcars.
- The second part of the assignment was to develop and optimize the current process corresponding to the GPDS plan, *Global Product Development System* (*see 6.1*).
- The third part of the assignment was to suggest conceivable changes to implement within Product Development. Possibilities to implement a BOM, *Bill of Material* which is a specified list of demanded parts/software for each series were also investigated.

## 1.5 Report outline

In the following section, Chapter 2, the theoretical framework is presented. In Chapter 3 Volvo history is introduced to present the company’s growth and position in the world. Chapter 4 describes the electronics growths for the past decades to explain the development situation of today. Then Chapter 5 describes the method used in how the work was accomplished. In Chapter 6 a simplified description of the product development process at Volvo is described. Chapter 7 describes the software process step by step and problems during the process are highlighted and summarized. In Chapter 8 a study of the Task Leaders work situation is presented. In Chapter 9 the theoretical framework is merged with the found situation within software product development at VCC, *Volvo Car Corporation*. Chapter 10 summarizes common problems and suggested solutions are given to most of them. Finally, in Chapter 11 our conclusions for this work are presented.

# 2 THEORETICAL FRAMEWORK

In big organizations there is always the problem of communication. Since the scope of the report covers a huge amount of units and people, working in projects over a long period of time, organizational as well as communications theory are interesting to compare against. This includes issues like feedback, groupthink and aspects of change processes.

Comparison against Lean Product Development System has also been done.

## *2.1 Organization*

For every activity, some form of organization is needed. The concept of organization is usually associated with the formal organization. It is usually described in terms of organizational models in which decision-making, information channels and work processes are described. It also addresses the responsibilities of different managers. The various tasks are set by job descriptions.

There is also an informal aspect of the organization. The informal organization gives life to the organization. The employee tries to shape his work to suit his needs. Similarly, each team will shape their part.

The formal organization is based on the employer's goals for the business. The informal organization is formed by the confrontation between all the demands and expectations on the business from employers, employees, users of the organization and its environment. While the formal organization is set by its management, the informal organization is shaped by the way its members are functioning, and their relation to each other. The formal organization is usually written down. The informal organization is however very rarely documented. It must be learned by working within the organization. The informal organization has decision and information channels of its own. The coffee breaks as forums for information exchange are often just as important as official meetings. In the informal organization a person can have a very different influence than what is meant in the formal.

While the formal organization describes how the work is planned, the informal organization is adjusted to the real world. The informal and the formal organization need to be consistent with each other for a business to function. It’s unusual that the formal and informal organizations are completely separated. However, there are often differences between the two types of organizations. Sometimes there are parts of the formal organization that don´t work. It has therefore been replaced by an informal organization. There can also be major differences between the two. This is usually the case when the organization is unbalanced, such as a poorly planned organizational change or when the objectives of the business are not clearly stated or in conflict. Sometimes it´s through the informal decision-making and information routes the real decisions and important information are carried out - the formal rules are just for show. (Granér 1994)

## 2.2 Communication

The basis of the communication process is that a sender conveys a message to a recipient. The recipient gives some kind of response to the sender's message. But while the transmitter is talking, he receives non-verbal and symbolic messages. As receivers, our minds register what the world gives. However, we do not record all available information. We make a selection based on what we deem important. This is called selective perception and is necessary for us not to be overwhelmed by all the impressions that constantly assault us. Selection is governed by our experiences and expectations. We register what we think is needed, to protect us from various types of hazards. (Granér 1994)

### 2.2.1 Interpreting messages

We imagine that it is the sender's thoughts we are interpreting. Instead it is our internal image of a message we interpret. We therefore don´t necessarily see the real point. This interpretation may be more or less consistent with the sender's intention. We don't know if our interpretation is correct before we have given a response to the sender's message. Thus, the recipient has become the transmitter. There is a distinction between one-and two-way communication. One-way communication means there is no response to the transmitter. A typical example of one-way communication is conveyed by mass media. The result is a situation where the transmitter never knows if the message is understood correctly. (Granér 1994)

### 2.2.2 Feedback

One type of feedback is to give confirmation of what you understand. As transmitters we are often careless in getting confirmation that the recipient has understood. We may assume that all has been understood if no one says otherwise. Alternatively, we ask if all is understood and are pleased to get an affirmative answer. But that can just as well be because they were not listening or they thought they understood, but didn´t.

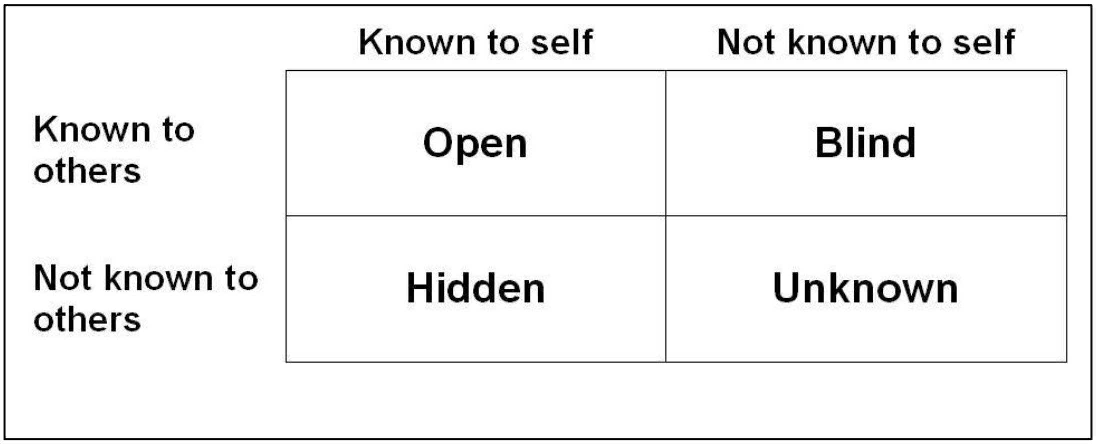
When we do not feel understood, we often react by talking even more about the same thing. Spontaneously, we believe that there is a problem on the content level, but that's not always the case. A better solution is often to communicate about the communication process - why it doesn't work. (Granér 1994)

### 2.2.3 In-group – Out-group

Groups and organizations with fixed boundaries and poor communication often have a way of thinking about themselves and others. This is usually described in terms of "in-group – out-group-thinking". This kind of belief system requires that you don´t know the ones outside the group. You don´t know what they do or how they do it. This way of thinking fills a purpose in the group. “We are good, the threat is outside”. It creates a good atmosphere in the group. Therefore members carefully avoid insight of the others' situation. Employees usually look in a positive light at what their own group members are doing. What "the ones outside" (the other units) are doing is examined with a much more critical eye. "We inside" are active and committed, responsible and purposeful. When a problem occurs, it's because of unfortunate circumstances - usually caused by those outside. "Those outside" have been uninvolved or irresponsible. (Granér 1994)

### 2.2.4 Our consciousness

One way to describe the relationship between conscious and unconscious in the relation to others is the Johari window. The model is based on two conditions. What we are aware of about ourselves, and what others are aware of about us. When put together, we get four possibilities.



| | Known to self | Not known to self |
|---|---|---|
| Known to others | Open | Blind |
| Not known to others | Hidden | Unknown |

*Figure 2.1: The Johari Window*

- The Open area contains things that are openly known and talked about - and may be seen as strengths or weaknesses. This is the self that we choose to share with others.
- The Hidden area contains aspects of our self that we know about and keep hidden from others.
- The Blind area contains things that others observe that we don't know about. It can be positive or negative behaviors, and will affect the way that others act towards us.
- The Unknown area contains things that nobody knows about us - including ourselves. This may be because we've never exposed those areas of our personality, or because they're buried deep in the subconscious.

**The Blind area of the group**

The group's blind area contains things that members do not see, but others do. It is easy to be “blind” and lose perspective on what happens in our surroundings. This may include how we treat certain group members, or unnecessarily complex procedures. It can also be a question of neglecting our own strength, because we are so preoccupied with the problems. Paradoxically, the most ambitious teams are often full of self-criticism, while groups that function poorly conceal this by overestimating themselves. (Granér 1994)

## 2.3 Destructive social phenomenon’s

### Group think

Although adaptation is necessary for cooperation, the conformance efforts will become inhibiting if the limits of differences are too narrow. Too united groups are poor problem solvers. They tend to quickly reach a common conclusion, but they also miss important aspects of the problem because no one doubts that the solution is the best one. A phenomenon that illustrates this is usually called group think.

### Regression

In strenuous, critical or stressful situations we tend to revert to a less mature way of acting. Partially our reactions resemble those we used as children in difficult situations. When the job seems too difficult, we feel a need for strong leaders - a mother or father figure - who take care of everything for us. Another example is to revert to a childish attitude, become defiant, whining or pulling away.

### Projection

Unconsciously the individual tries to liberate himself from internal stress by attributing someone else what he did not want to admit. The own psyche is like a movie projector and others become a display of their own fantasies or feelings. A person feels in a bad mood but does not want to acknowledge it. Instead he is annoyed by how irritated others seem to be. Moreover, it is often projections of feelings of inferiority and incompetence. Those who have good self-esteem tend to lack the need to disparage others.

## 2.4 Change process

When planning changes, it is crucial that the organization's informal side is not neglected. A supervisor at the "floor" knows this. No matter how logically correct a change may seem, it will not be well implemented without staff support. Managers directly related to the business understand the importance of staff satisfaction and engagement.

Among politicians and in organizational and management teams there is often a tendency to see people in the organization as bricks that can be moved around in a game and conduct the same function wherever placed. Thus, it is believed that units can be split and merged, resources rearranged and changes made to the goal without taking into account the staff's reactions. This is obviously an illusion.

A change begins when a problem from any part of the group or organization cannot be managed based on the existing structure. If the change is originating from below, it is welcomed by the employees, and leads to activity and enthusiasm.  (Granér 1994)

## 2.5 Lean Product Development System (LPDS)

The widely adapted Japanese manufacturing concept is known as *Lean Production* and was noticed world widely through a 1990's best seller called *The Machine That Changed the World: The story of Lean Production.* The book describes "the movement of automobile manufacturing from craft production to mass production to lean production" telling the Henry Ford story of the making of cheap cars for the masses; the Toyota story, manufacturing cars without being able to afford the enormous necessary investments of the required machines for mass production.

Lean thinking is about eliminating wastes, adding nothing but value. Mary Poppendieck, a leading pioneer of Lean software development, has translated *The Seven Wastes of Manufacturing* identified by Taiichi Ohono, the mastermind of the Toyota Production System (TPS) to *The Seven Wastes of Software Development.* Mary describes in her article "Principles of Lean Thinking" how Extreme Programming, a set of practices which focuses on rapid software development, works to eliminate the seven wastes of software development:

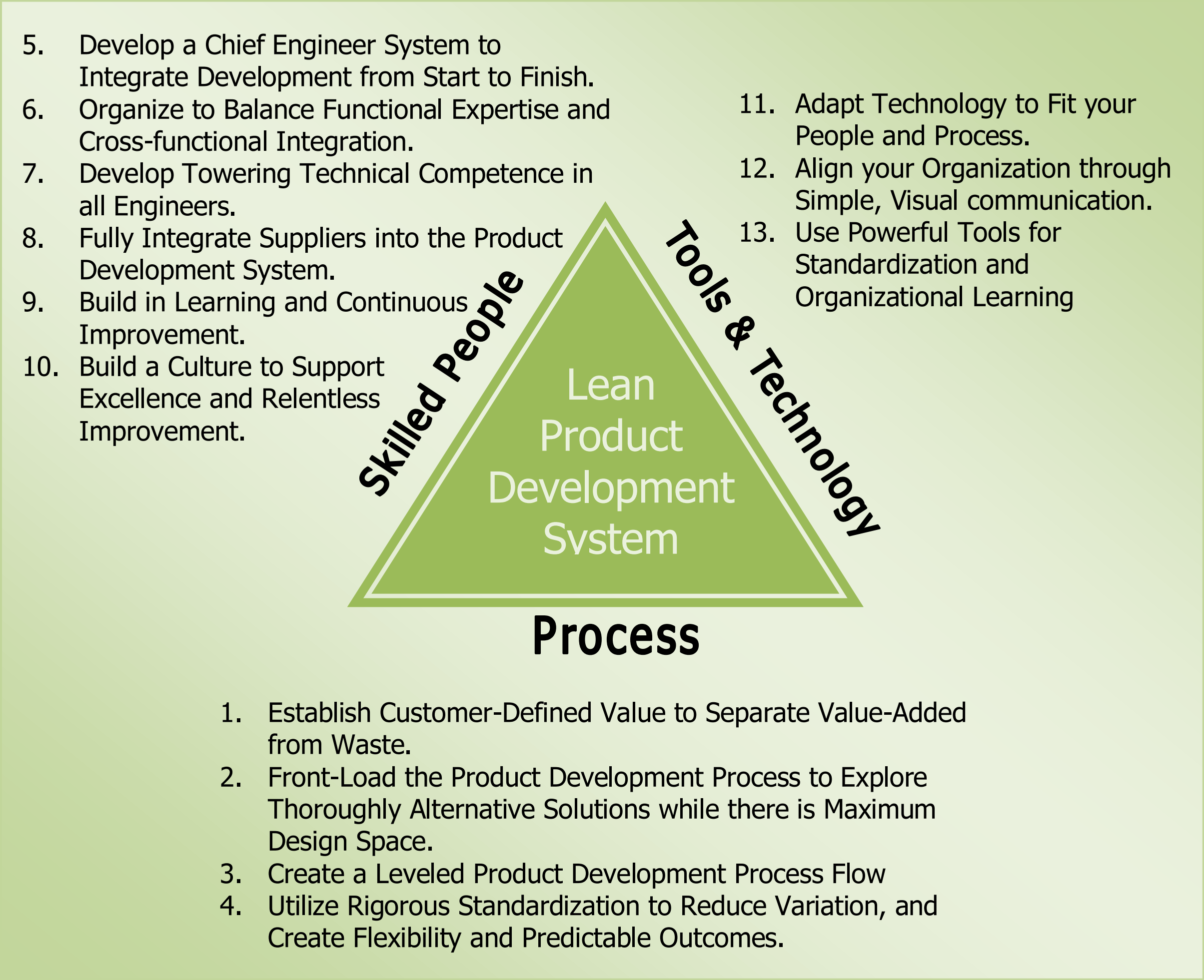
*Table 2.1: How Extreme Programming works to eliminate the seven wastes of software development:*

| ***The Seven Wastes of Manufacturing*** | ***The Seven Wastes of Software Development*** | ***How Extreme Programming Addresses Waste*** |
|---|---|---|
| Overproducing | Extra Features | Develop only for today's stories |
| Inventory | Requirements | Story cards are detailed only for the current iteration |
| Extra Processing Steps | Extra Steps | Code directly from stories; get verbal clarification directly from customers |
| Motion | Finding Information | Have everyone in the same room; customer included |
| Defects | Defects Not Caught by Tests | Test first; both developer tests and customer tests |
| Waiting | Waiting, Including Customers | Deliver in small increments |
| Transportation | Handoffs | Developers work directly with customers |

(Poppendieck 2002)

According to Morgan and Liker the used system model to describe Toyota's PD System has three primary subsystems: 1) *Process*, 2) *Skilled People* and 3) *Tools & Technology,* "these three subsystems are interrelated and interdependent and affect an organization's ability to achieve its external purpose" shown in table above. This is based on the sociotechnical system theory (STS) partly driven by European experiments with workplace democracy and by American academics with engineering and social science backgrounds. STS says that "to be successful, an organization must find the appropriate fit between the social and technical system that fits the organizational purpose and the external environment", meaning that "the technical system includes the policies and standard operating procedures of an organization, including the culture that emerges through the interaction of those people".

Morgan and Liker then define the three subsystems with 13 principles comprising the LPDS model to give the answer of what the underlying principles of product development made Toyota so successful. Those 13 principles are fully described in their book and are as follows:



5. Develop a Chief Engineer System to Integrate Development from Start to Finish.
6. Organize to Balance Functional Expertise and Cross-functional Integration.
7. Develop Towering Technical Competence in all Engineers.
8. Fully Integrate Suppliers into the Product Development System.
9. Build in Learning and Continuous Improvement.
10. Build a Culture to Support Excellence and Relentless Improvement.

11. Adapt Technology to Fit your People and Process.
12. Align your Organization through Simple, Visual communication.
13. Use Powerful Tools for Standardization and Organizational Learning

1. Establish Customer-Defined Value to Separate Value-Added from Waste.
2. Front-Load the Product Development Process to Explore Thoroughly Alternative Solutions while there is Maximum Design Space.
3. Create a Leveled Product Development Process Flow
4. Utilize Rigorous Standardization to Reduce Variation, and Create Flexibility and Predictable Outcomes.

*Figure 2.2: Lean PD Model and 13 principles, Morgan & Liker, 2006 “The Toyota Product Development System”, page 18*

(Morgan & Liker, 2006)

# 3 INTRODUCTION OF VOLVO

Volvo was founded by Assar Gabrielsson and Gustaf Larsson. The automaker was a spin-off from roller ball bearing maker SKF. In 1927 the first series-manufactured Volvo car, the Volvo ÖV4, nicknamed Jacob, rolled off the production line at Lundby. Since then, Volvo has developed from a small local industry to a global player. The ties to Gothenburg have always been strong. A collective pride of the company is shared by many.

*Figure 3.1: The very first Volvo rolls out of the factory*

**Safety**

The first of many Volvo inventions in the field of safety is said to be the introduction of the PV model in 1944. An important safety feature on the model was the laminated glass windscreen. Another popular model was introduced in 1956, the Volvo 120, better known as Amazon. Safety features and accident protection were key issues in the car's design and this was enhanced even further in 1959 when it was equipped with three-point safety belts, an invention that soon was to be implemented in cars worldwide.

**Expanding**

By 1960 the old industrial site at Lundby did not allow further expansion. According to calculations, the volume of production in the plant could be increased to a peak of 55 000 cars a year running day shift and a maximum of 100 000 running with two shifts. The current production plant in Torslanda opened in 1964 and was capable of producing up to 200 000 cars a year. At about the same time another factory opened in Ghent, Belgium. The smaller cars have been manufactured there ever since. Over the years more factories have been opened in Uddevalla and elsewhere. A new factory is currently being built in China. The production number last year was 370 000 vehicles.

### The modern Volvo

A completely new and different Volvo was launched in June 1991. The Volvo 850 was Volvo’s first front wheel drive executive car, with a transverse, five-cylinder engine. Its high level of safety combined with real driving pleasure made the car win many  independent awards. The new direction became the turning point towards the more exclusive model program that has been developed ever since.

In 1999, Volvo Cars was sold to Ford Motor Company. The Volvo trademark was shared between Volvo AB, and Ford. Under Ford ownership many decisions were made in Detroit. Standardizations to fit Ford’s structure were also made. Every new tool or plan has been given names and descriptions in English ever since. The mixture of languages will certainly be noticed in the report.

### Crisis

2008 brought the worst result ever. It caused the biggest layoff in Volvo´s history. The staff was reduced by approximately 6000, including consultants. Ford set out Volvo Cars for sale. Due to the global financial crisis, rationalizations had to be made. This tightened the organization to the brink of collapse, at least in some parts. Roles were removed and the duties distributed over the remaining workforce. People found themselves in the position of being responsible for things they were not trained for.

### Regaining strength

In 2010, a deeply indebted Ford sold Volvo Cars to the Chinese motor manufacturer Geely Automobile. As this is written in early 2011, Volvo´s sales numbers are rising and it has been decided to once again expand the workforce.

### Complexity of big corporations

Within software development the situation is as bad as ever. Volvo was founded as a purely mechanical industry. The basics of the structure are old and have a focus on mechanics. It’s also very accustomed, especially among long-term employees. This causes opposition to changes. Thousands are involved in development. It’s therefore difficult to see the big picture. Very few have knowledge about more than a fraction of the process from early development to final product. A better structure seems to be needed and the seriousness of the situation has now awakened some people’s attention. This report is probably part of the beginning of some serious investigation.

Lean Production is used at the plants, but doesn’t really work in the product development strategy. Lean Production doesn’t allow running changes to be implemented in the way VCC does it. Lean provides changes to be implemented step by step and not too many changes at the same time, which must be the way Volvo has to work. This is much easier to follow by Toyota, when the annual produced cars are over one million, compared to less than four hundred thousand by Volvo.

# 4 THE STRUCTURE OF THE ELECTRIC SYSTEM IN A VOLVO

With the launch of the S80 in 1998 Volvo became a leading user of the CAN network in cars. CAN means *Controller Area Network* and is a system built to use less cables to connect several ECUs, *Electronic Control Units,* also called nodes, that are dependent on each other to carry through a function in a car. For example, when you lock your car pressing a button on the key, the nodes for the driver's door, the other car doors, the flashes and the CEM, *Central Electronic Module* are involved to carry out the locking of the car.

The introduction of building cars with CAN also made it possible to develop a lot of functions that car builders never thought of before, therefore the cable length did not decrease as it was meant to do at first. *Figure 4.1* shows the development of the number of fuses and cable lengths in a Volvo car during the past 80 years. (Olof Hansson, VCC)

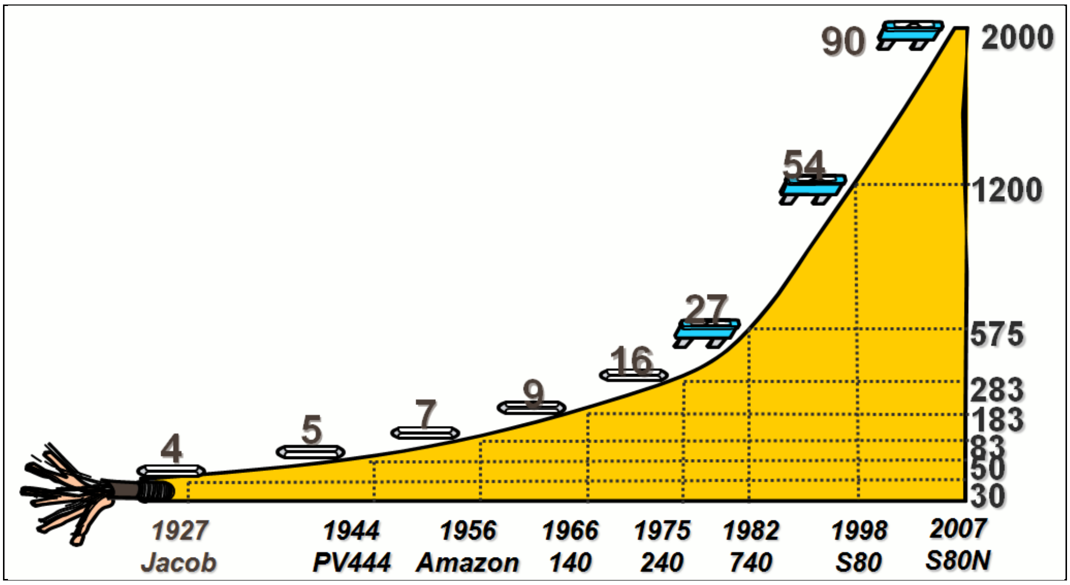


*Figure 4.1: Number of fuses and cable length in meters for the past 80 years*

## 4.1 The different network buses

The electrical system is built on three to four different network buses for data transfer between nodes, depending on the functional content of the car. The network buses are interconnected to each other by the CEM and the OBD, *On Board Diagnostics*. The OBD is the module used to download the software in the car and to analyze the car, for example before doing service. The three different network buses are CAN (HS-CAN, MS-CAN), LIN, *Local Interconnect Network*, and MOST, *Media Oriented System Transport,* and are connected to the ECU: s like in *figure 4.2.*

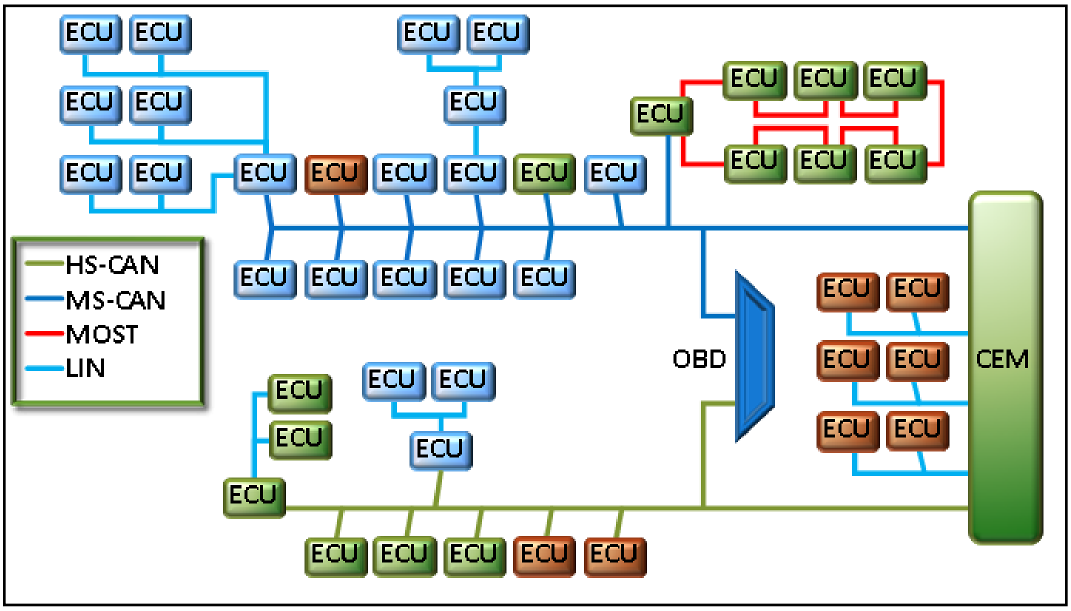


*Figure 4.2: The bus Topology*

### 4.1.1 CAN

CAN is a linear designed bus system with twin-wire copper cables without shielding, used as transmission medium. The transmission rate of information on the bus is middle to high, e.g. 125 – 500 k bit/sec. The application is used primarily in the drive train, in the body and in the safety and comfort systems.

**HS-CAN**

HS-CAN means High Speed CAN and the speed of information on the bus were in 1998 250 k bit/sec. The speed on HS-CAN bus of today is 500 k bit/sec. The ECU: s used for the drive train and the safety functions are connected on this network.

**MS-CAN**

MS-CAN means Medium Speed Can and the speed of information on this bus is 125 k bit/sec. The main functions on this bus network are of a second level nature such as light functions, climate control and driver information.

### 4.1.2 LIN

LIN means *Local Interconnect Network* and the speed of information on the communication protocol is up to 20 k bit/sec. Volvo uses the speed of 9.6 k bit/sec on the LIN buses. LIN is used for less demanding systems where CAN would be a too expensive or too inflexible solution. Functions connected to this bus are of a simpler character such as light modules, rain sensors and seat heating modules.

### 4.1.3 MOST

MOST means *Media Oriented System Transport* and is a communication protocol for systems with high demands on data transfer. The functions carried out with MOST connection are the multimedia components in the car, such as Bluetooth phone module, integrated audio module and the multimedia module.  This network differs from the others being an optical fiber network carrying information much faster than the others, about 25 M bit/sec, but it is also much more expensive than the other networks. The network uses master-slave architecture.

## *4.2 Number of ECUs the past decade*

To understand the difficulty of implementing functions in a car, a review of the development over the past decade is going to be described.

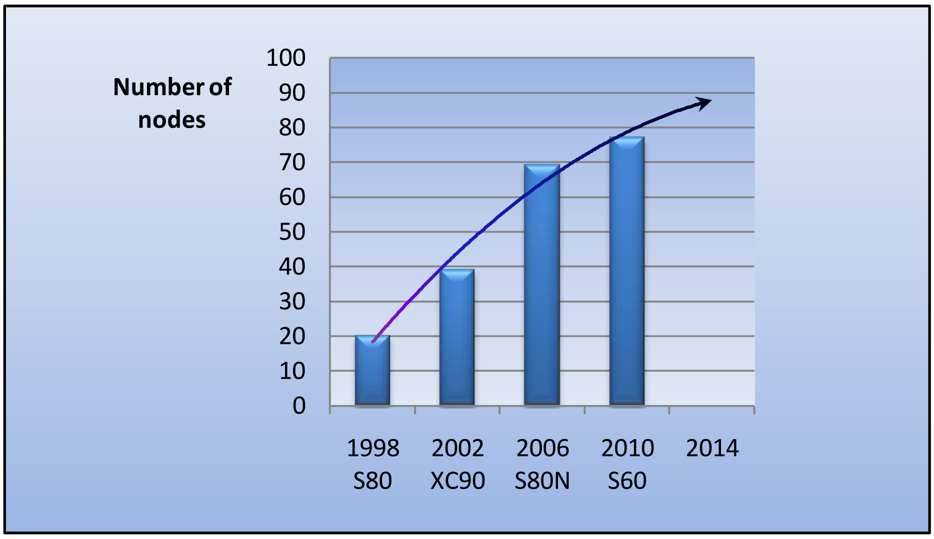


*Figure 4.3: Trend of the development of number of nodes the past decade*

With the launch of the S80 in 1998, the car had 20 nodes connected to the CAN buses. In 2002, the XC90 was introduced to the market built on the same platform as the S80, but now containing almost twice as many nodes, 39 pieces. In 2003 a new platform was introduced, including the S40, and now the amount of nodes was 49 pieces. With the introduction of the new S80 in 2006, the number of nodes included in the car was 69 pieces. The newest launched S60 includes 77 nodes. As described, the number of nodes is always increasing due to the expectations upon the final client of the car. The final client has more and more demands on the functionality of the car. Therefore the development of new functions will demand more and more nodes implemented on the car market.

## 4.3 Difficulties to implement a function

To return to the example of the lock function on the car, which was mentioned earlier, this requires the involvement of three nodes to implement the function "lock the car". The groups of nodes then have to cooperate with each other to carry out the whole function. In this way lots of nodes are involved in lots of functions, and the work implementing all those functions requires well organized work. All teams know to follow GPDS, but running changes demanded during projects makes it almost impossible to follow. Running changes requires starting over, almost from the beginning. This is very often caused by new hardware and is one of the biggest reasons why software is delivered too late.

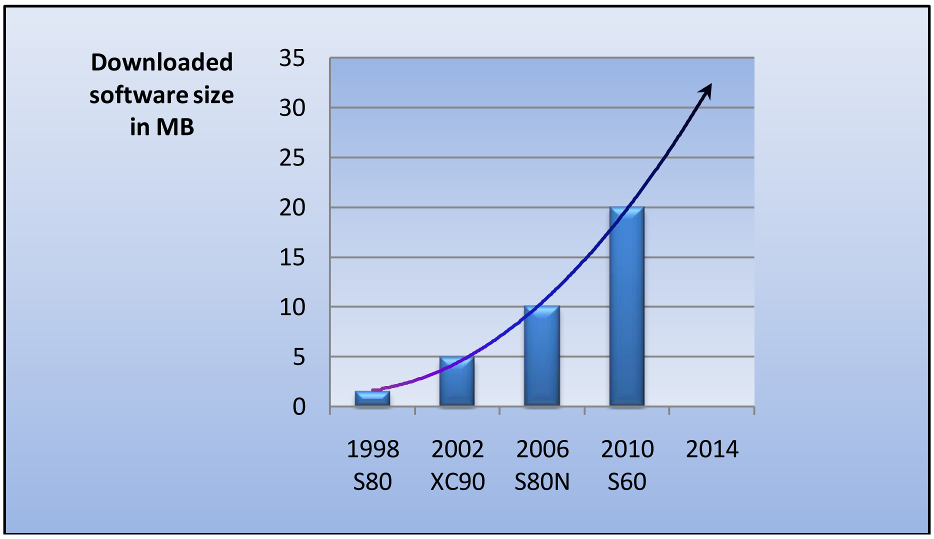


*Figure 4.4: The trend of required amount of software in MB*

Running changes sometimes requires that the existing SDB, *Signal Database*, must be changed. A new node must be connected or an existing node must get a new or another connection. These changes can then affect already completed developed software, which then must be re-developed again to suit the new SDB, *Signal Database*.

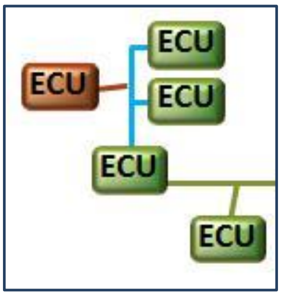


*Figure 4.5: A new node requires changes in the SDB, Signal Database*

# 5 METHOD

The method used in this thesis is a part of Six Sigma called DMAIC. The DMAIC cycle is widely used in production companies all over the world when improving an already existing process. The method has five different steps to work through in order to improve a process. *Define, Measure, Analyze, Improve* and *Control.* (Brassard, 2002).

The focus here is on the software process.

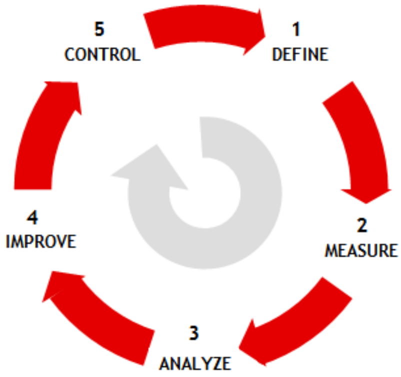


*Figure 5.1: The Six Sigma DMAIC model*

## 5.1 Define the project

Prototype Vehicles has a problem with late deliveries of software for their test objects. In order to find the cause of this, the units involved before Prototype Vehicles were studied. The start point was set to be the beginning of projects, where functions are ordered. It was also set to involve a minimum of hardware development. The delimitation was done in order to have a guidance of what to involve and not, which is a key part to making a good definition of the project. In order to be able to measure the result a study was made of the on-time-delivery precision of the software. This study was carried out by the SCC unit, *Software Coordination Center (see 7.1.5)*, which is the receiver and coordinator of all software releases. When the proposed changes have been implemented a new measurement will be made to see the improvement of the on-time-delivery.

## 5.2 Measure the current situation

The data in this thesis is mainly collected by interviews with employees working in the process and attending ongoing meetings held by units at VCC. Over fifty individuals of different profession have been interviewed covering a good part of the roles and units working with the software. The employees interviewed were selected with the aim of covering the whole software process, from the beginning of the project to the CRB meeting, *Configuration and Release Board (see 7.1.13)*, where the software should be ready. The meetings were initially unstructured and had the objective of understanding the process. Later on more pointed questions were asked to pinpoint the problems causing the late deliveries. The interviews generally lasted for about one hour and were held in different conference rooms. No beforehand preparation was needed for the interviewees.

Since the data was collected from interviews it cannot be seen as fact. The interviewees shared their view of the problems and their own subjective thoughts. To overcome the problem with uncertain information it was compared both against other employees and the database BMS, *Business Management System*. BMS includes information about the assignments for units, role descriptions and different information of how Volvo is supposed to work. Even so, there is still some degree of uncertainty in the information´s credibility. This should be taken into account when reading the report. Most of the information is interpretations and analysis of the employees own thoughts about the process.

The reason for doing so many interviews was to get first hand information from the people working with the process. Reading a piece of paper about how they should work is not the same as collecting information about how they are actually working. The best way to understand the problems in the process is to ask the people that actually work with it.

Based on the information from the interviews with the employees and observations of Volvo meetings the following work was carried out:

- A flowchart showing the current process was developed in order to understand how the process works and what needs to be improved. The flowchart was made in the program Visio which is used at VCC to develop flowcharts. To make sure the flowchart was correct it was shown to several people working in different parts of the process.
- A unit report was created to structure the information and get a wider understanding of the units developing the software. The unit report is designed to answers the questions: *What is the assignment of the unit? What is the problem in the unit? What problems in the unit are caused by other units? What problems affect the following units?*
- To certify the correctness of the unit report and the flowcharts, a verification against Volvo's database BMS was carried out.

## 5.3 Analyze to identify causes

With all the problems reported during the interviews and seen during the participation of the VCC meetings, a sorting of the problems was made. The problems which caused the most negative effect to the on-time-delivery, and were most certain, were put into a problem list *(see chapter 10)*. The list answers the questions: *What is the problem? How can we solve this problem?* The problems were then put into groups with the same root cause: S*tructure*, C*ommunication*, *Tools and system*, *General problems* and *Other problems*.

After going through the problems and understanding the causes of them, an evaluation of the units were made. The unit which had the most negative effect on the on-time-delivery of software was pointed out to be further investigated.

Then a series of interviews with the chiefs of the unit concerned were made to figure out what their problems are and what can be done to solve them. Ten managers from the unit were interviewed, four with a high on-time-delivery rate and six with a low on-time-delivery rate. The sorting of managers with high and low on-time-deliveries was done in order to figure out the difference between the two groups. The interviews were agreed in advanced and organized in the same way for all of the interviewees. The meetings were well structured with seventeen pre decided questions and a self assessment form to fill out. The questions varied from planning, communication, dealing with supplier and organization. The self assessment form involved ten claims which the interviewees rated on a scale from 0-10 depending on if they agreed or not. The claims focused on the same categories as the questions. Both the questions and the self assessment form were created after going through the problems gathered during the fifty first interviews. The questions asked can be seen in *Appendix A1* and the self assessment form in *Appendix A2*.

**Literature studies**

After understanding the biggest problems a literature study was made to understand the problems better and to figure out solutions. Three books were read and are presented in the theoretical framework *(chapter 2)* and in the analysis chapter.

**Analysis**

An analysis of the theoretical framework is done in *chapter 9* where the theory is compared to the problems found.

## *5.4 Improve*

For some of the problems in the problem list suggested solutions were added, others were just highlighted without any solution, with the intention of enlightening VCC of their existence.

A new improved flowchart was made taking the problems and solution suggestions into consideration.

Solutions were developed in two ways:

- Interviews with employees who work in the process and have knowledge about different problems in their unit
- Brainstorming

## *5.5 Control*

After implementation a new study will be made to see if the on-time delivery precision has improved.

# 6 FUNCTION IMPLEMENTATION

This chapter will describe the software part of the Product Development process used by Volvo. First the GPDS plan will be described as well as the C-note, *Change-note*, a tool used within PD. Then a simplified process map will be presented and explained with focus on function implementation.

## *6.1 GPDS, Global Product Development System*

The product development system used at VCC is developed by Ford and Volvo with benchmarking at Mazda. The plan is named GPDS and is a compressed plan implemented in 2006 including the best parts from the three companies to minimize the time of development. The plan points out all the milestones for the projects to follow during the process.

The longest time required to develop a complete new product is about 50 months. The electronics product development is done in three departments: Chassis, Powertrain and EESE, *Electrical and Electronics Systems Engineering.* EESEs' part of the plan in major projects is about 46 months and is named EESE GPDS plan. This includes five E-series, E0 to E4, for software deliveries to be final. The software articles are released at the CRB meetings before being downloaded to the prototypes.

The delivered software to the E-series is used to test the functionality on Boxcars, which means that the entire electric system is built on a table *(see 7.1.8)*. The GPDS plan also includes six additional prototype series, XO, X1, M1, VP, TT and PP. Those series are built up as mules i.e. in already existing car models that have been modified for system development. Most often those series are represented by Boxcars as well.

According to the delimitations of this project the focus is to involve only the M1 and VP series. This chapter will primarily describe the process for software deliveries to those series. The GPDS plan includes milestones and *figure 6.1* shows only the important milestones for the software deadlines to those series.

## *6.2 C-note, Change note*

When a project is to be started, C-notes are used to describe how a change from an existing car is going to be. There is one C-note created for each node involved in the project and it includes descriptions of all the software and hardware articles.

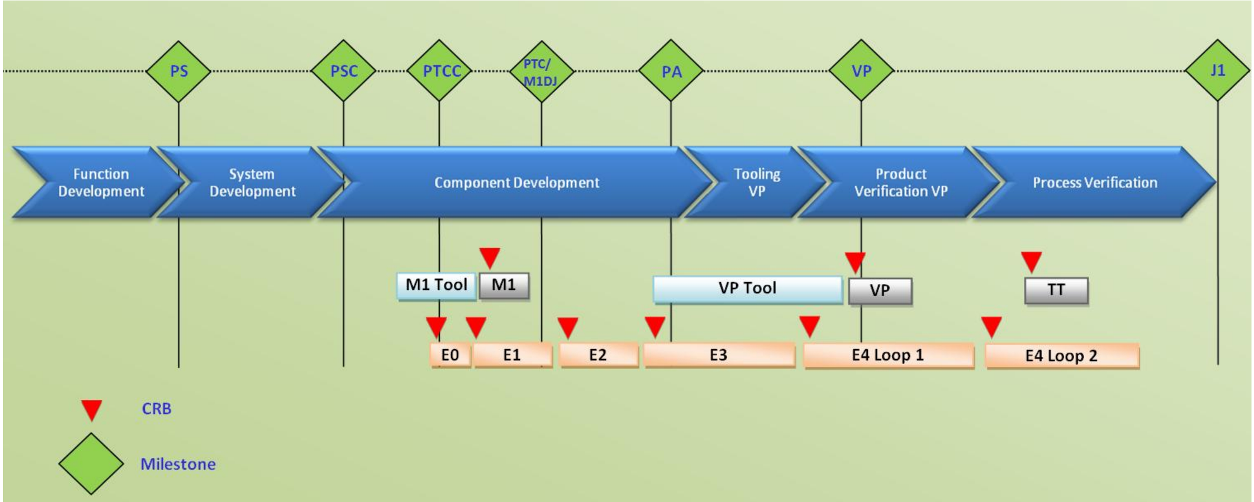


*Figure 6.1: Simplified GPDS with important milestones to the M1 and VP series and the Job #1 milestone*

*Table 6.1: Milestone description*

| **Milestone** | **Milestone full name** | **Milestone description** |
|---|---|---|
| **PS** | Program Start | Agreement to proceed obtained |
| **PSC** | Program Strategy Confirmed | Work plan and resource availability to achieve successful delivery to PTC is confirmed |
| **PTCC** | Program Target Compatibility Checkpoint | Complete System selection to align targets |
| **PTC / M1DJ** | Program Target Compatibility / M1 Data Judgment | A single design theme is confirmed |
| **PA** | Program Approval | Program objectives are approved and mass production prelim activities initiated |
| **VP** | Verification Prototype | First complete vehicle builds |
| **J1 / SOP** | Job #1 / Start of Production | First production ready for cross-functional activities confirmed |

## 6.3 *Simplified process flow*

The following map *(figure 6.3)* focuses on function implementation. The intention is to show how projects are initiated and distributed over a branch of units. They are all involved in carrying out a function – in this case developed by the electrics unit.  The map ends with a successful test of the function.

In the initiation phase the project is planned and a framework for construction is set. All functions are specified and later described in detail. For instance, the system designer specifies the interface of communication etc. in the SRD, *System Requirement Description*.

When this is completed the project passes a gate called PS, *Program Start*. Based on the SRD the project starts up in full scale. The document is passed on to all involved units.

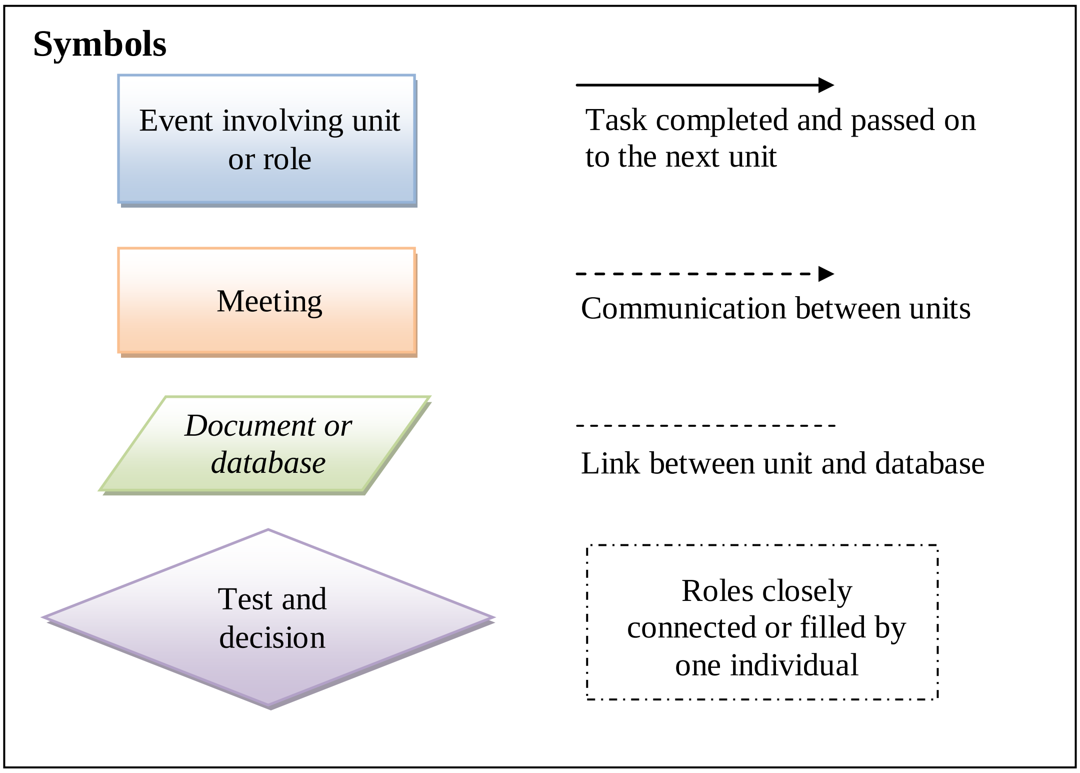

Symbols
Event involving unit or role
Task completed and passed on to the next unit
Meeting
Communication between units
Document or database
Link between unit and database
Test and decision
Roles closely connected or filled by one individual

*Figure 6.2: Descriptions of Symbols to the Simplified flowchart*

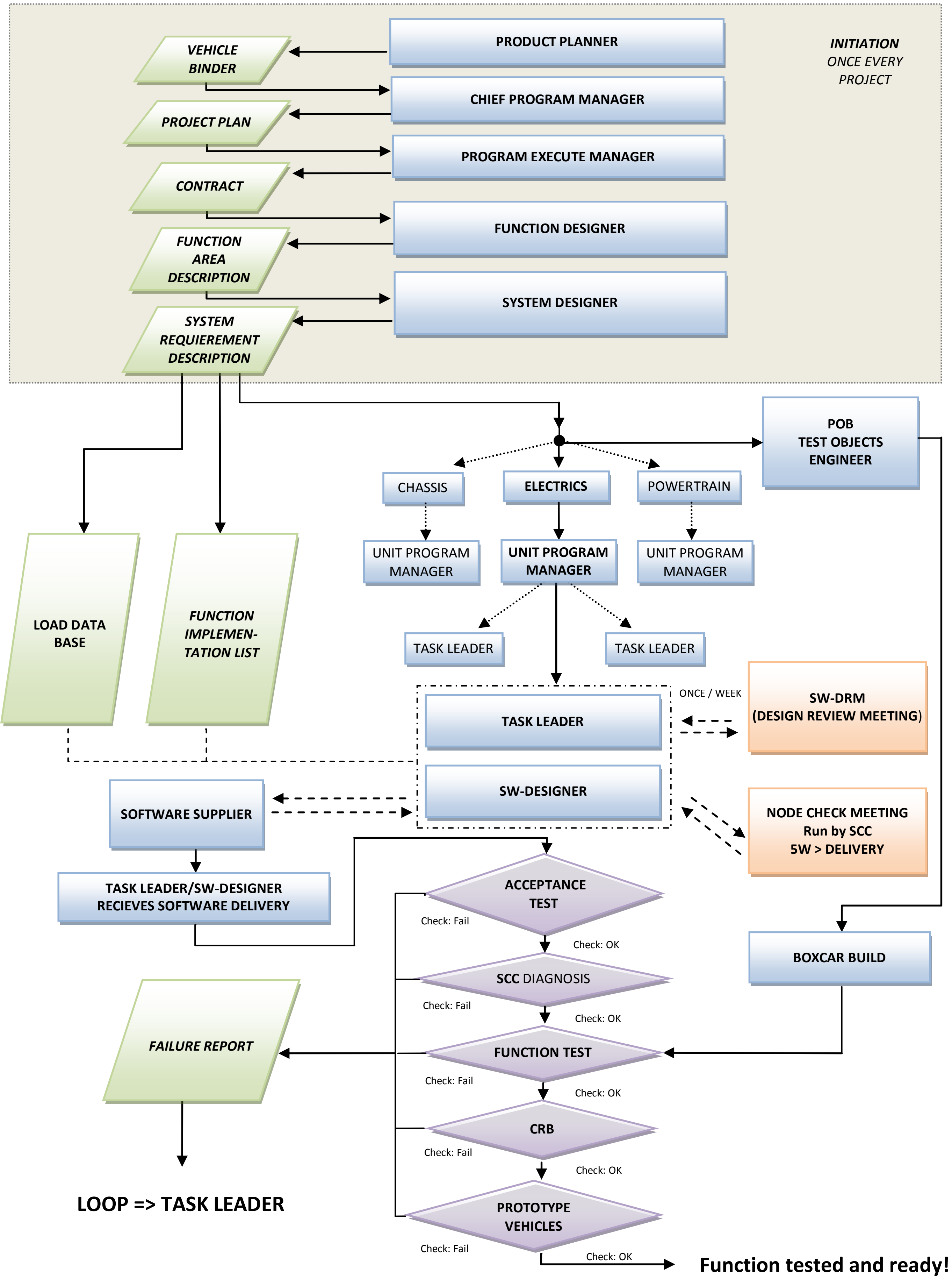


*Figure 6.3: Simplified flowchart*

## 6.4 Map explanation

**PRODUCT PLANNER:**
Decision is made to develop a new model.

**VEHICLE BINDER:**
Basic required specifications such as colors or surround sound.

**CHIEF PROGRAM MANAGER:**
Delivers programs to agreed objectives.

**PROJECT PLAN: GPDS (Global Product Development System).:**
Generic plan including every aspect of the development. Includes deadlines etc.

**PROGRAM EXECUTE MANAGER:**
Manages the industrial development and deliveries a vehicle program according to GPDS

**CONTRACT:**
The project signs a contract with the line organization which handles economic means.

**FUNCTION DESIGNER:**
Creates a list FAD, *Function area description* of all functions in the car.

**FUNCTION AREA DESCRIPTION:**
FAD can be seen as an initial form of a Drivers Owner's Manual to explain how car functions/features are supposed to be working and used but not how they are technically implemented.

**SYSTEM DESIGNER:**
The System Designer develops and maintains electrical systems solutions based on the FAD. All functions are specified and later described in detail. The System Designer specifies the interface of communication etc.

**SYSTEM REQUIEREMENT DESCRIPTION:**
Specified list of demands on parts and functions.

**UNIT PROGRAM MANAGER:**
Determines activities to complete the unit's total commitments.

**TASK LEADER:**
Responsible for realization of the functionality in their corresponding node.

**SW-DESIGNER:**
Handles software development for a node. Communicates with suppliers, adjusts the software to fit the car and orders testing.

**SOFTWARE SUPPLIER:**
For instance Bosch who has a big cart of sub-systems for cars.

**SW-DRM (DESIGN REVIEW MEETING):**
Once a week SCC organizes a meeting where software designers are invited due to issues affecting their corresponding node.

**NODE CHECK MEETING:**
Five weeks before delivery deadline SCC calls all Software Designers scheduled to deliver. The question is "What will you be able to deliver?"

**ACCEPTANCE TEST:**
A test to verify basic functionality. Does the node communicate at all?

**SCC DIAGNOSIS:**
Before being added to the database KDP, files and documentation are manually checked for flaws and mistakes.

**FUNCTIONALITY TEST**
Further testing conducted in boxcars, equipped with the hardware that the software is intended to control.

**CRB**
Final meeting where decision is made whether to release the software or not. Are the tests satisfactory, documentation complete etc?

**PROTOTYPE VEHICLES:**
Prototype vehicles conducts testing of cars in different situations and environments.

**FAILURE REPORT:**
If a system fails, this is documented and an extra loop starts.

**TEST OBJECTS ENGINEER:**
Orders hardware necessary for each test object ID.

**LOAD DATA BASE:**
Contains information about wiring etc.

**FUNCTION IMPLEMENTATION LIST:**
FIP is updated by contact with the software designers. It indicates which function is supposed to be ready at a given time – e.g. ready to which series.

# 7 THE CURRENT SOFTWARE PROCESS

This chapter will describe the current software process all the way through the different units and functions. It also presents the way the software development goes to become a final product to be downloaded into the car or the test object. Problems affecting the units, problems within the units as well as problems affecting the next unit will be described. Then the chapter is visualized to get an idea of the connections.

## 7.1 Treated areas within the process

The departments within VCC which manage the software have been divided into:
1) ***units / role,*** 2) ***role*** and 3) ***tool / meeting.***

The division ***units / role*** describe primarily the assignment by a role within a unit/department and secondary the problems within and around it. When the software management is a part of a role, the description is divided just into ***role***; this means that the overall task within the role isn't just software management but only the software management is described. The third division presented is ***tool / meeting*** and describes just the tools and meetings required by the role or unit to manage the software development.

The different units / roles / meetings in which the software is handled are visualized in the process map below with blue numbers, making following the described areas easier within the process. A fully scaled flowchart is shown in *Appendix B1*. Not all presented units / roles / meetings are represented in the process map or the appendix. The reason is because they are difficult to visualize in the same flowchart. *Figure 7.1* shows a simplified flowchart and *figure 7.2* shows the same, but is bigger to easier follow the software process.

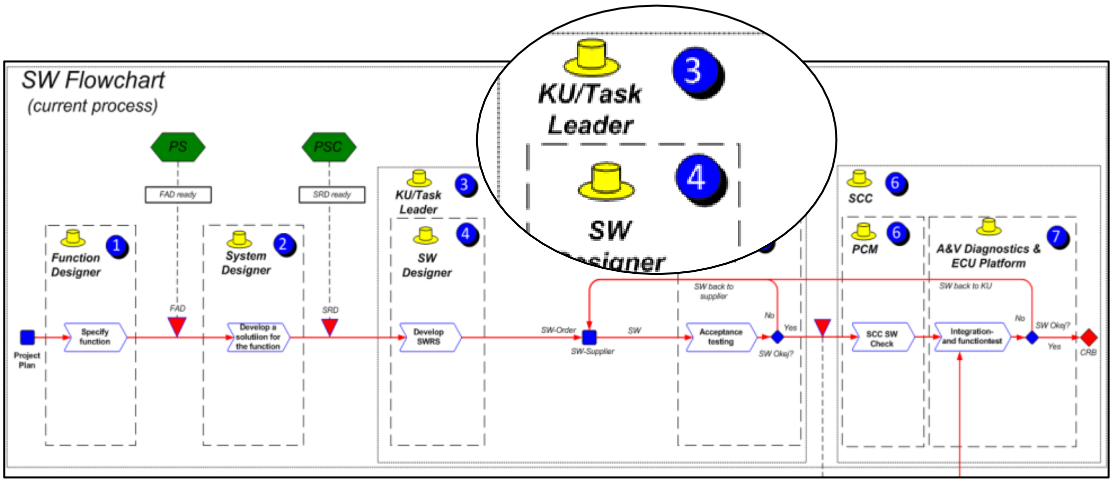


*Figure 7.1: Simplified flowchart of the current process*

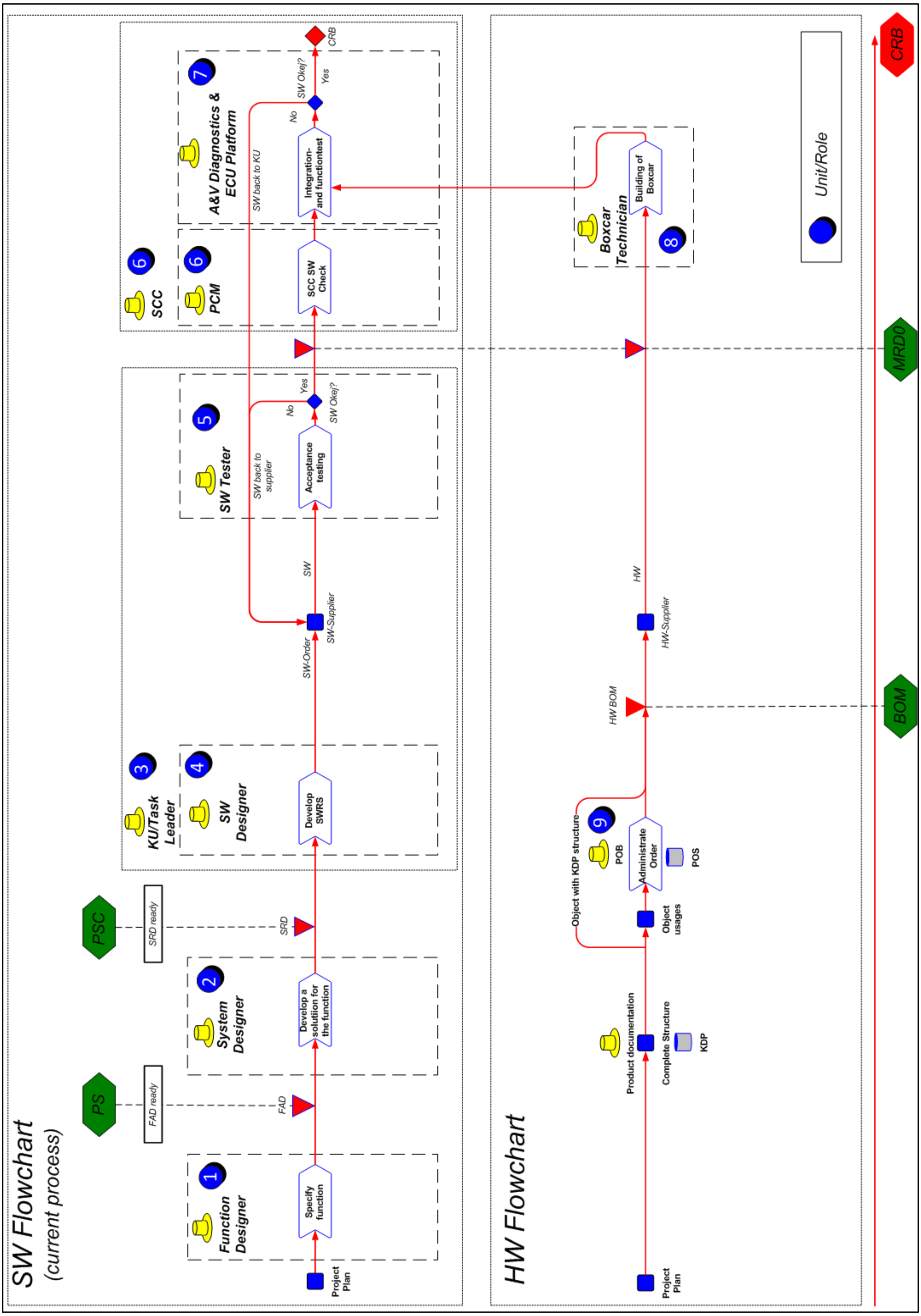


*Figure 7.2: Simplified software flowchart of the current process*

Each mentioned area will describe the unit's:

- Assignment
- Problems caused by other units (prior units)
- Accumulated problems in prior units
- Problems within the unit
- Problems affecting other units

The chapter describes the incoming problems to the current area as accumulated problems from prior areas. This means incoming problems plus problems originating within the current unit are summarized as outgoing problems.

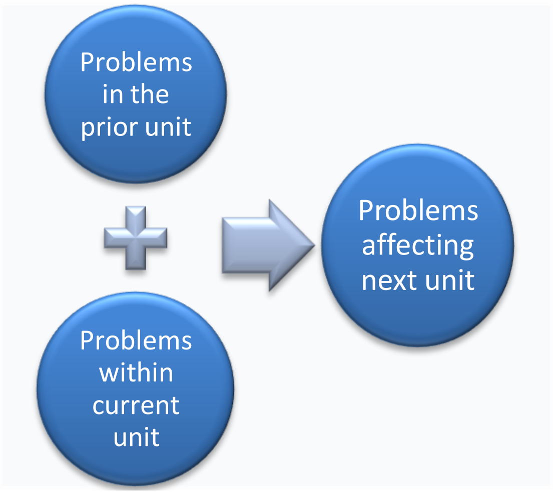

Problems in the prior unit
Problems within current unit
Problems affecting next unit

*Figure 7.3: Summarized outgoing problems*

### 7.1.1 Unit / Role: Function Designer

1

**Assignment:**

To create a list of all the electric functions in the car. For each assigned feature a FAD, *Function Area Description* is created. The FAD document is used to describe and specify the behavior and functional requirements of the functions/features within a function area. The FAD can in many cases be seen as an initial form of a Driver's Owner Manual explaining how the car's functions/features are supposed to be working and used but not how they are technically implemented. The described features are often structured according to the principle of action (e.g. push button) – a function is activated (e.g. the car´s central locking is activated).

The Function Designer is responsible for constructing a detailed design- and simulation model used to validate the functional areas with the help of the Purpose of Series Document *(see 7.1.15)*. This model is used by the Task Leader to find out what must be finished to each series, in order to be tested. The information will then be posted to the FIP, *Function Implementation Plan (see 7.1.14)*. Other tasks are to manage deviations from the function constructer and to participate in reviewing the SRD.

**Problems caused by other units:**

- The **client (the project)** gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

- It can be difficult to meet the deadlines due to running changes.
- The function designer doesn't check if the Task Leaders have the capacity to make the deliveries for the different series in time.
- Purpose of Series Document is not used as much as it should be, because of the vague descriptions in it.
- Doesn't have knowledge of which hardware is available for each series.

**Problems affecting other units:**

- It often takes more time than intended to produce a FAD. The following parts in the project are then forced to do their job in shorter time to keep their deadlines.
- The FAD can be interpreted in several ways and can be unclear for subsequent units and has no feedback during the project. The system designer is primarily affected.
- The Function Designer puts too high demands on the implementation of the functions for the different E-series which affect the Task Leader.

### 7.1.2 Unit / Role: System Designer

2

**Assignment:**

Based on the FAD, create a comprehensive system solution, a SRD. The SRD should contain:

- Which hardware components are required
- Which software is required and which ECU:s are involved

The System Designer's responsibility is also to ensure that the system solution will be verified.

**Problems caused by other units:**

- **Function designer:** The FAD is often delayed and sometimes vague and open to interpretation when the SRD is developed.

**Accumulated problems in prior units:**

- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

The SRD has not been signed off with the FAD, which can create problems later on when the SRD must be changed when discovering that the FADs demands are not met in the SRD.

**Problems affecting other units:**

The SRD can be interpreted in several ways; it's sometimes unclear for subsequent units. The System Designer is not getting/giving any feedback during the project.

### 7.1.3 Unit / Role: Software Designer

**Assignment:**

- Develop a SWRS, *Software Requirement Specification,* from the SRD. The SWRS's functional requirement is based on allocated system requirements from the model of Elektra (normal procedure).
- Distribute feedback to the FIP Status Report.
- Responsible for ensuring that the software is verified by writing a test order to an acceptance tester (SW-tests) and an integration tester.
- Participate at NCM, *Node Check meeting,* and SW-DRM, *Software Design Review Meeting (see 7.1.12)* when called.

**Problems caused by other units:**

- **SW suppliers** are not finished in time for deadlines and software is not good enough.
- **System designer:** SRD is often vague and finished too late. When creating a SWRS, a personal interpretation of the SRD is often used.

**Accumulated problems in prior units:**

- **Function designer:** The FAD is often delayed and sometimes vague and open to interpretation when the SRD is developed.
- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

- Demands to software supplier are not clear enough. Some Software Designers do not send part deadlines (for E-series) to the supplier. Suppliers just send what is finished so far when it is time to deliver to the different series.
- When the supplier misses a deadline or mismanages there is very little VCC can do to put pressure on them. Volvo is seen as a small customer and isn't as important as e.g. Ford.
- Poor communication between Software Designers, which creates problems due to strong dependence between one another.
- Software Designers have to break down the FIP to node level on their own. This causes problems because it becomes a matter of interpretation.
- Software Designers just see the different software deliveries and not to the function. They don't see the whole picture (the function). This is shown in *table 7.1*. This is due to poor communication between Software Designers or Task Leaders and the FIP.
- Poor communication and control between Software Designers and Function Designers when checking if the ordered function is correctly implemented.

*Table 7.1: Three nodes are needed to carry out each function. At CRB, four software articles are delivered but none of the functions are completed.*

| Function | ECU 1 | ECU 2 | ECU 3 | Function working |
|---|---|---|---|---|
| 1 | Done | Done | N/A | **NO** |
| 2 | N/A | Done | Done | **NO** |

**Problems affecting other units:**

- SWRS is interpreted differently by different suppliers and can be vague.
- Part deadlines which should be present at each series are missing or not followed.
- Poor communication regarding late software deliveries to software tester which causes problems for tester in order to plan the tests.
- Software files are not always complete, header might be empty/with errors when sent to SCC.

### 7.1.4 Unit / Role: Software Tester / Acceptance test

5

**Assignment:**

The acceptance tester performs testing of the basic features and of the software, approximately 10 % of the total tests is done here. The tests are performed on a rig and the tester controls that basic functions are safe and not likely to disrupt the network when connected to the other nodes i.e. common system communication problems is to be found.

**Problems caused by other units:**

- **Task Leader:** Delayed software delivery and/or poor quality of the software. Part deadlines are missing or not followed.
- **POB,** *Provobjektsberedare (7.1.7)***:** Delayed hardware deliveries and/or poor hardware quality

**Accumulated problems in prior units:**

- **SW suppliers** are not finished in time for deadlines and software is not good enough.
- **System designer:** SRD is often vague and finished too late. When creating a SWRS a personal interpretation of the SRD is often used.
- **Function designer:** The FAD is often delayed and sometimes vague and open to interpretation when the SRD is developed.
- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

Due to time constraint, acceptance tests at Volvo are sometimes skipped. Tests done by the supplier are then accepted as sufficient.

The hardware needed for the tests is sometimes missing. In those cases old hardware must be used and may not be reliable.

There is lack of structure of what should be tested. It depends on the experience of the tester and the tests vary a lot from different testers.

**Problems affecting other units:**

The acceptance tests are delayed and do not provide sufficient information about whether the software is good enough.

Since only 10% of the software is tested, the risk of software defects in the integration and function tests are high.

### 7.1.5 Unit / Role: SCC, Software Coordination Center / PCM, *Program Control Manager*

6

**Assignment PCM:**

- Check if the software deliveries from Task Leaders have the correct format and documentation.
- Initiate integration tests through the tool **eTracker**.
- Organize and manage the CRB meetings which are preceded by the NCM and SW-DRM.
- Release software to SW Archive *(see 7.1.5.1)* and make software files available in SW Configuration *(see 7.1.5.1)*.
- The SCC department is responsible for the NCM, which is held about five weeks before CRB, and SW-DRM which is a weekly meeting.

**Problems caused by other units, according to the SCC team:**

- Software Designer or Task Leader cannot deliver software in time, i.e. to the MRD milestone, *Material Required Date*.
- The C-notes are incomplete and not ready in time.
- The test order consists of wrong information, e.g. hardware id-code.
- Redeliveries of software generate twice as much work.
- Hardware is missing in the boxcar, or does not match the intended test due to changes made after the POB unit ordered the hardware.
- Capacity problems due to that the systems are not coordinated in terms of time management and also due to lack of coordination between different projects.
- Received files have incorrect format and/or insufficient documentation.
- Delayed software deliveries and poor prior information about it.

**Other problems:**

- **Task Leader:** Delayed software delivery and/or poor quality of the software. Part deadlines are missing or not followed.

**Accumulated problems in prior units:**

- **Acceptance test:** Is sometimes not done or not sufficient.
- **POB:** Delayed hardware deliveries and/or poor hardware quality.
- **SW suppliers:** are not finished in time for deadlines and software is not good enough.
- **System designer:** SRD is often vague and finished too late. When creating a SWRS a personal interpretation of the SRD is often used.
- **Function designer:** The FAD is often delayed and sometimes vague and open to interpretation when the SRD is developed.
- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

Lack of IT-systems requires manual handling which gives a potential for failure (human factor). Lotus Notes *(see 7.1.5.1)* is outdated and there is no synchronization with SW Archive. Documentation must be done manually in Excel documents. This can be difficult to survey. The automatic orders are first used at the VP series, which leads to a lot of manual work on the prior series and the risk of failure is high. KDP is first used in the VP series i.e. only in the cars built on the following Target Plants: VCT in Torslanda, VCG in Gent and PFS in Uddevalla.

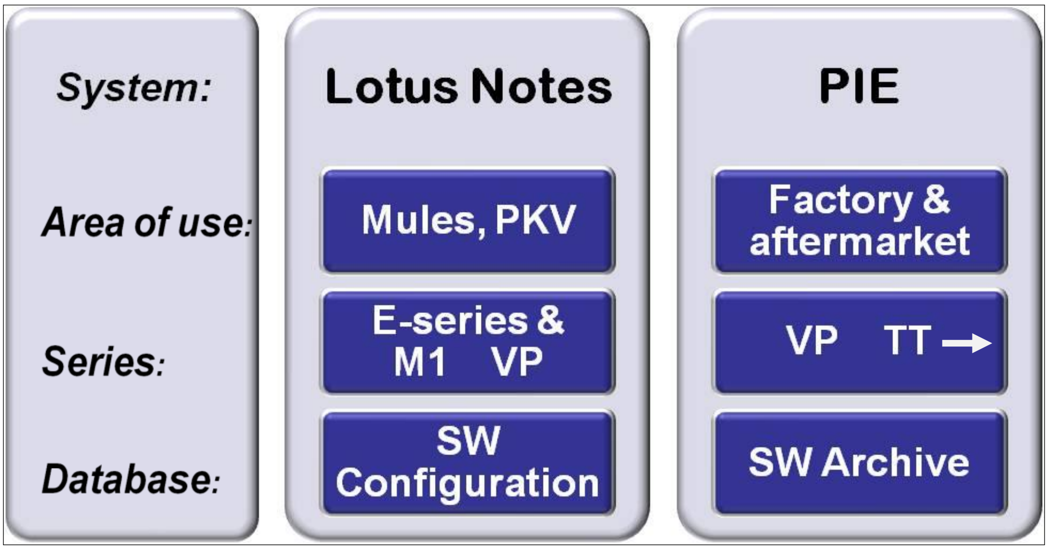
When a Task Leader misses a deadline there is not much the SCC team can do, they lack power.

**Problems affecting other units:**

Mistakes in manual handling can result in incorrect documentation and file placement which creates problems mainly to the **Function** and **Integration** team (verification team).

Delayed software and poor information about it can cause big problems.

### *7.1.5.1 SCCs management of software against product at VCC:*



| System: | Lotus Notes | PIE |
|---|---|---|
| Area of use: | Mules, PKV | Factory & aftermarket |
| Series: | E-series & M1 VP | VP TT → |
| Database: | SW Configuration | SW Archive |

*Figure 7.4: Illustration of the software articles management*

**SW Configuration** is a database where software for each constructed series is specified. All software used for assembly is uploaded here, as well as software updates between the series. Updated parts get the same article number but a new “version number” (letters) is included.

**SW Archive** is a database where software for assembly in Target Plant is stored. SW Archive cannot handle articles with version numbers; it means that every updated article must obtain a totally new article number.

**VIDA**, the aftermarket system, can read the software context in cars built in series from TT and forward, but not from the VP series which are built in the target plant. This causes problems when mules in the M1 series are built using VP donor vehicle built in the Target Plant or an old M1 built on Pilot Plant.

### 7.1.6 Unit / Role: A&V Diagnostics & ECU Platform (Verification team) Integrations and Functions tests

### BMS: System Integration Test & System Test

**Assignment:**

- Perform integration and function test:
- Integration tests are done in a Boxcar, in order to verify that the nodes are communicating correctly.
- Functional tests are done in a Boxcar, in a mule or in a complete vehicle, depending on the series. This is done to make sure that all the functions are working as intended. The test environment should be consistent with the ultimate target or production environment as much as possible to minimize the risks that environment-specific defects are not detected during the tests.

**Problems caused by other units:**

- **SCC:** Mistakes in manual handling can result in problems like incorrect documentation and file placement. This can lead to nodes being loaded with the wrong software. Late deliveries and lack of information causes problems planning the tests, both software and hardware.
- **Task Leader:** Delayed software delivery and/or poor quality of the software. Part deadlines are missing or not followed.
- **POB:** Delayed harsware deliveries and/or poor hardware quality

**Accumulated problems in prior units:**

- **Acceptance test:** Is sometimes not done or not sufficient.
- **POB:** Delayed hardware deliveries and/or poor hardware quality.
- **SW suppliers:** are not finished in time for deadlines and software is not good enough.
- **System designer:** SRD is often vague and finished too late. When creating a SWRS a personal interpretation of the SRD is often used.
- **Function designer:** The FAD is often delayed and sometimes vague and open to interpretation when the SRD is developed.
- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

Problems with manual handling cause internal problems such as:

Dragging files directly from Lotus Notes (SW Archive) to the program, SDA, used to upload software to the car, is not possible. The files must first be downloaded to the hard drive and then added to the SDA. The name of the file does not indicate what the files contain, thus making it harder to organize the files.

**Problems affecting other units:**

The integration and functional tests are delayed and do not give satisfactory results. In some cases errors in the software are discovered too late to be fixed for the next series. This leads to series passing without a chance to test the corrected software.

### 7.1.7 Unit / Role: POB, Test Objects Engineer (Provobjektsberedare)

9

**Assignment:**

Based on the x-list (a general list of articles the different prototypes should include is based on the AVB, *Analysis and Verification Requirements*) and the data from KDP develop and compile HW-BOM-lists for Boxcars and M1/VP in consultation with DPL / Task Leader *(see 7.1.9)* responsible for each area.

**Problems caused by other units:**

Late deliveries and insufficient information cause planning problems.

When ordering hardware, C-notes are not completely finished. This causes problems such as ordering incorrect hardware.

**Accumulated problems in prior units:**

- The **client** (the project) gives vague and/or late information about which functions should be implemented. There are often new requirements during the project.

**Problems within the unit:**

Ordering incorrect hardware.

**Problems affecting other units:**

Incorrect hardware is ordered which cause problems.

### 7.1.8 Unit / Role: Boxcar Technicians

8

**Assignment:**

- Build Boxcars in rig in accordance with project needs and time schedule.
- Ensure that the Boxcar has the correct status and configuration, regarding hardware / software and according to series specifications.

**Problems caused by other departments:**

Delayed hardware deliveries and poor prior information about delays causes difficulties in planning.

**Problems within the unit:**

Jobs are piled up because of goods being delayed. The tests schedule must then be changed to another time, where other project tests are planned, so those have to be changed as well. This means that at certain times the workload can be very high.

**Problems affecting other units:**

Delayed goods deliveries and poor prior information about it causes difficulties for the integration and function tests to be planned.

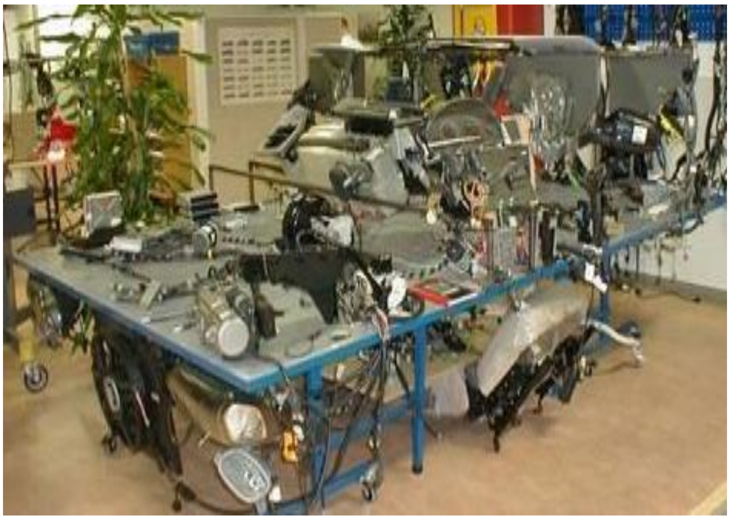


*Figure 7.5: Boxcar – the complete electrical system is built up on a table*

### 7.1.9 Role: UPM, Unit Program Manager at EESE (DPL, *Delprojektledare*)

**Role:**

Assigned by the PEM, *Program Engineer Manager,* to operate and manage a product development project towards set targets.

- Follow decided structure, GPDS and applicable procedures of BMS.
- Lead the cross-functional software work on behalf of the PEM within each project.
- Manage SW-DRM which is a comprehensive Technical Project meeting.
- Manage the construction of boxcar / HIL rig, *Hardware In the Loop.*
- Manage and update the FIP.
- Make decisions (approval / rejection) about releases of software articles in consultation with the PCM to CRB.
- Approve delivery plan for software and software deviations.
- Decide on various software related issues, for example, planning Boxcar / HIL rig, SDB changes, etc.
- Monitor and report the software status (eTracker).

**Problems:**

Do not have sufficient understanding of the details in the process. A couple of years ago there was a post called SU, *Systemuppdragsledare,* who had a closer role and more understanding of the details in the process.

DPL should be tougher when someone misses a deadline.

DPL does not work according to the GPDS plan and BMS in its' fullness. This is accepted but creates problems when employees think it is okay to not follow the plan.

DPL must accept running changes (orders) which cannot be carried out on time.

DPL should ensure that FIP is used more and is reported to on time.

There is no respect for SW-DRM which the DPL is responsible for and sometimes is the DPL not even there.

### 7.1.10 Role: Task Leader (KU, *Konstruktionsuppdragsledare*)

3

**Role:**

Manage a product development assignment for a specified component / subsystem toward its' target. The role can be established during PSC, *Program Strategy Confirmed*. The Task Leader is responsible for the assignment from PTCC, *Program Target Compatibility Checkpoint*, until FSR, *Final Status Report.*

The Task Leader has the responsibility for a PSS range, *Product System Structure*, or a component or several components, depending on their severity. They have a Software Designer who manages the software development.

**Main Tasks:**

- Receive agreed order in forms of a TTC contract, *Technology Target Compatibility,* and then industrialize the assignment in CDJ, *Concept Data Judgment.*
- Manage the assignment through a cross functional team and ensure that all results and deliveries are in accordance to the TTC contract.
- Manage the project according to plan with a set task structure.
- Develop, monitor and update relevant time plans for the current task.
- Initiate and assure decisions, both in the project and in the line organization *(see figure 8.11)*, when deviations occur.
- Communicate the project targets, commitments, status and forecasts in both internal and external assignments.

**Problems**:

- The Task Leader does not work according to the GPDS plan and BMS in its' fullness. This is accepted but creates problems when employees think it is okay not to follow the plan.
- The C-note is created and established too late, which causes problems for SCC and the building of Boxcar.
- The Task Leader makes insufficient demands on the software suppliers. This provides unclear orders that do not meet all deadlines. When the supplier misses a deadline or doesn't agree with the Task leader the Task Leader lack measures to address.
- Poor communication between Task Leaders which creates problems due to strong dependence among each other.
- The C-note is created too late and is not used for either the M1- or the E-series.
- The Task Leader has to break down the FIP to node level by himself. This causes problems because it becomes a question of interpretation.
- Poor communication and control between Task Leaders and Function Designers when checking if the ordered function is carried out correctly.
- Late signing of contracts with the supplier cause late deliveries.
- Demands on supplier are given first after the signing of contract, which cause delayed software when the start of development is delayed.

Realizing the functions is not number one priority. Software Designers just see to the different software deliveries and not to the function. They don't see the whole picture (the function). This is due to poor communication between Software Designers or Task Leaders and possibly the FIP. See *table 7.2* below.

*Table 7.2: Three nodes are needed to carry out each function. At CRB there are four software articles delivered, but none of the functions can be tested because two software deliveries are missing.*

| **Function** | **ECU 1** | **ECU 2** | **ECU 3** | **Function working** |
|---|---|---|---|---|
| 1 | Done | Done | N/A | **NO** |
| 2 | N/A | Done | Done | **NO** |

### 7.1.11 Tool / Meeting: TRM, *Time Review Meeting*

**Assignment:**

The TRM, *Time Review Meeting* is used as a reconciliation meeting between different departments in a project. The meeting discusses and makes decisions regarding deviations for series construction. TRM-forum starts at the beginning of the project and is conducted through the whole project.

TRM provide the project management with information about late deliveries in order to assess if the status level of the materials is sufficient to build the current series.

The units report at TRM deviations from the Purpose of Series Document and from the specification for the current project.

**Before the meeting:**

The Task Leader reports deviation in the system Pre HPD, *Handling of Parts Deviations*, before the TRM-meeting. The Task Leader anchors the deviation with the Analysis & Verification Manager at each unit, and with responsible CME, *Central Manufacturing Engineer*. Information is sent to the manager of Project Corporation. The meeting is held at least every two weeks.

**Meeting:**

- After response from the AVA, *Analyze and Verification Responsible,* and CME the Test Leader can present the deviation for discussion in TRM.
- The Project Planner sends a notice to the affected units.
- TRM makes a decision about deviation.
- The decision/order is noted in the system Pre HPD

**Problems:**

The meeting is insufficient to synchronize the entire project. Affected participants do not always show up, which can lead to decisions being made without all affected people getting the information. Software should be treated with the same importance as hardware.

### 7.1.12 Tool / Meeting: SW-DRM & NCM

**Assignment:**

SW-DRM is a comprehensive Technical Project meeting for all the units. A forum to discuss issues about the management, schedules, changes in software and SDB. After NCM the status of project is discussed.

Node Check Meeting is a meeting to establish what software to test at the different series i.e. what software should be delivered at the CRB meeting.

**Contents of SW-DRM:**

- FIP, and deviations from FIP
- Deviation reports
- Changes in the SRD, which affect more than one node
- Node changes affecting more than one node
- NCM software deliveries
- Planning and status of Boxcar
- SDB issues
- Diagnostic issues
- Planning issues (software plan, check-up lists and software deliveries)
- Testing Complete vehicle
- Ongoing and aftermarket changes

SW-DRM has the responsibility and authority to take decisions regarding:

- Approval of the software delivery plan.
- Approval of deviations from SW-plan (from FIP and / or specific software-related requirements)

The information presented and the decisions taken on the SW-DRM shall be communicated to all staff in the technical project who is working with nodes software. SW-DRM documents are available in Lotus Notes database TM94000.

**Problems:**

DPL isn’t tough enough when someone misses a deadline.

There is no respect for SW-DRM which the DPL is responsible for and sometimes is the DPL not even there.

The FIP isn’t used enough by the Task Leaders and is just a forecast.

The meeting is insufficient to synchronize the entire project. Affected participants do not always show up, which can lead to decisions being made without all affected people getting the information.

The meetings have a potential that is not fully utilized by the Software Designers or Task Leaders, who have little control over their own deliveries to respective series, according to the SCC team.

### 7.1.13 Tool / Meeting: CRB, *Configuration & Release Board*

**Assignment:**

The forum is used to approve and release software parts for the different series at least two weeks before they are used.

**Checked at CRB:**

- Testorder/CRB checklist
- Acceptance test
- Integration test
- VIDA test
- Information about compatibilities and next planned release

**Problems:**

The software isn't delivered in time or is not good enough.

DPL isn’t tough enough when someone misses a deadline.

There is no respect for the deadlines at CRB which the DPL is responsible for and sometimes is the DPL not even there.

### 7.1.14 Tool / Meeting: FIP, *Function Implementation Plan*

**Assignment:**

An operation plan to work after, follow up and state deviations during the project in order to get a problem free test object.

**FIP describes:**

- What is planned to be implemented in each series.
- When is it planned to be implemented.
- Deviations from the plan.
- The level of functionality to be included in each series (E-Series and X1, M1).

**Problems:**

FIP is a forecast but is often seen as fact. It could be used more if it were more reliable.

Do not get sufficient feedback from System Designers to update the FIP, the System Designers in turn should receive updates from the Task Leaders (communication is not working good enough across the stage).

Some Function Designers do not modulate in Elektra with the result that FIP cannot be broken down to Node level. (This is the old way of doing it)

Powertrain and EESE do not interpret the FIP in the same way e.g. different understanding of DI, *Design Intent*. EESE thinks that calibration should be included in DI and Powertrain does not. This could be because Powertrain has a lot of calibration in their functions.

FIP is not broken down to node level which would make it easier for Task Leaders to know what they have to deliver to each series.

### 7.1.15 Tool / Meeting: Purpose of Series Document

**Assignment:**

A document that explains:

- Why each series should be built
- What should be finished in each series
- What to test in each series

In order to test the functionality of the electrical components during development, a concept for synchronizing deliveries was released. It is called E-series. Five series run parallel to the other series, E0 - E4. For each series specific requirements should be adapted and make the process more synchronized, this is included in the Purpose of Series Document.

**Problems:**

The document has never been fully developed and is open for interpretation. While some Function Designers implements parts of the plan based on experience, others neglect its' existence. The result is less organized tests and testers who never know what to expect. Therefore they cannot plan the testing as would be preferred.

Functions planned to be tested lack parts of the software needed to make the function work. This is due to misunderstanding of what should be tested which should be in the Purpose of Series Document.

The FIP isn't based on the Purpose of Series Document as it should.

## 7.2 Visualizing problems of the software process

In order to summon the problems affecting the different units they have been visualized in the picture below. Problems are passed on trough the units continuously creating more delays and new problems.

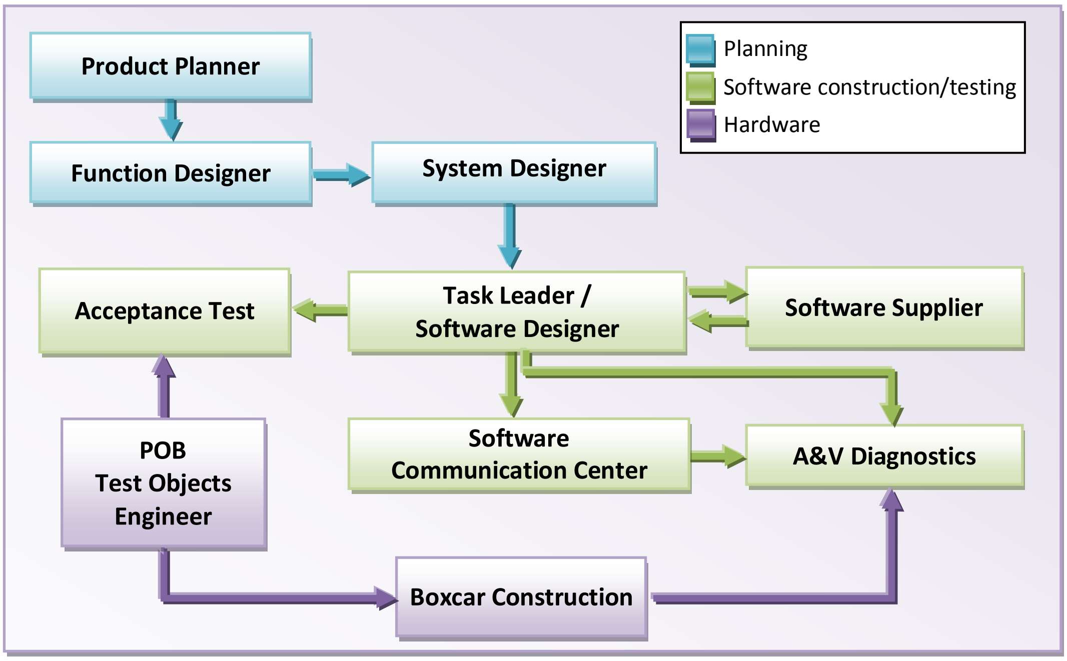


*Figure 7.6: The way in which problems affect following departments / units*

# 8 TASK LEADERS

A great part of the delays occur during the Task Leaders work. Therefore an expanded study has been conducted for this role in order to see the reason why, and what can be done to improve the situation. The interviews have been agreed on in advance and conducted in conference rooms. The meetings have lasted for approximately one hour. There has been no need of preparations for the interviewees. The interviews have been conducted in the same way for everyone. Seventeen questions have been asked, mainly focusing on planning and communication *(see Appendix A1)*. The interviewees have also filled out a self assessment form, rating different aspects of their work situation on a scale from 0-10 *(see Appendix A2)*. The information has then been compared and analyzed.

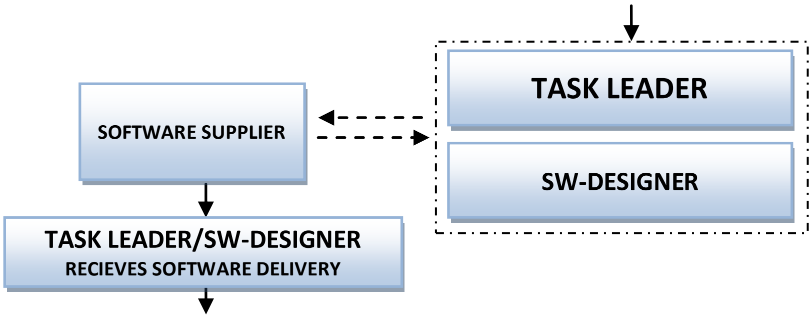


*Figure 8.1: The Task Leader is a key figure as chief of his development unit.*

The Task Leader is a key figure as chief of his development unit. There are about fifty task leaders in software development. The lack of structure has subjected them to a difficult situation. A Task Leader is in the midst of a large variety of different units. That makes social competence an important skill.

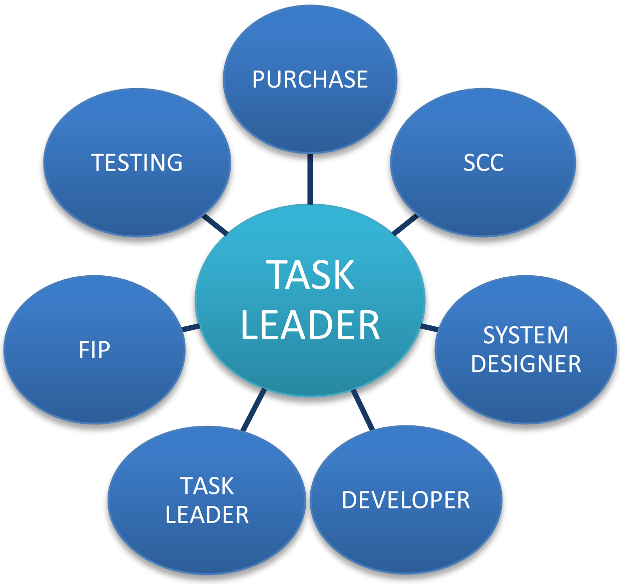


*Figure 8.2: A Task Leader is like a spider in the net*

The different Task Leaders and their units have differences in performance. The aim has been to map up patterns. Delivery statistics have also been used to get a view of what factors are the most important. There are many variables that are not reflected by statistics. With help of people inside the organization, the goal has been to take these matters into account when interpreting the information.

## *8.1 Indicators of performance*

Software Coordination Center is the receiver of software before the releases. The unit has statistics of the software deliveries. This data is of course non-disputable in the sense that it reflects if an expected delivery is on time or not. The expectations are however, based on a prognosis given by Software Designers at Node Check Meeting, five weeks before deadline.

### 8.1.1 MRD – Material Required Date

The graph illustrates the delivery precision for expected software. It shows the mean outcome distributed over 100 days. The mean value is five days overdue. Software delivered late does not have better functionality which otherwise could be a reason for the delay. Instead it actually has less impressive performance according to statistics.

The top three reasons for the delays are said to be:

- SRD is delayed and specifications unclear
- Contracts with supplier are scheduled late
- Running changes are made during projects

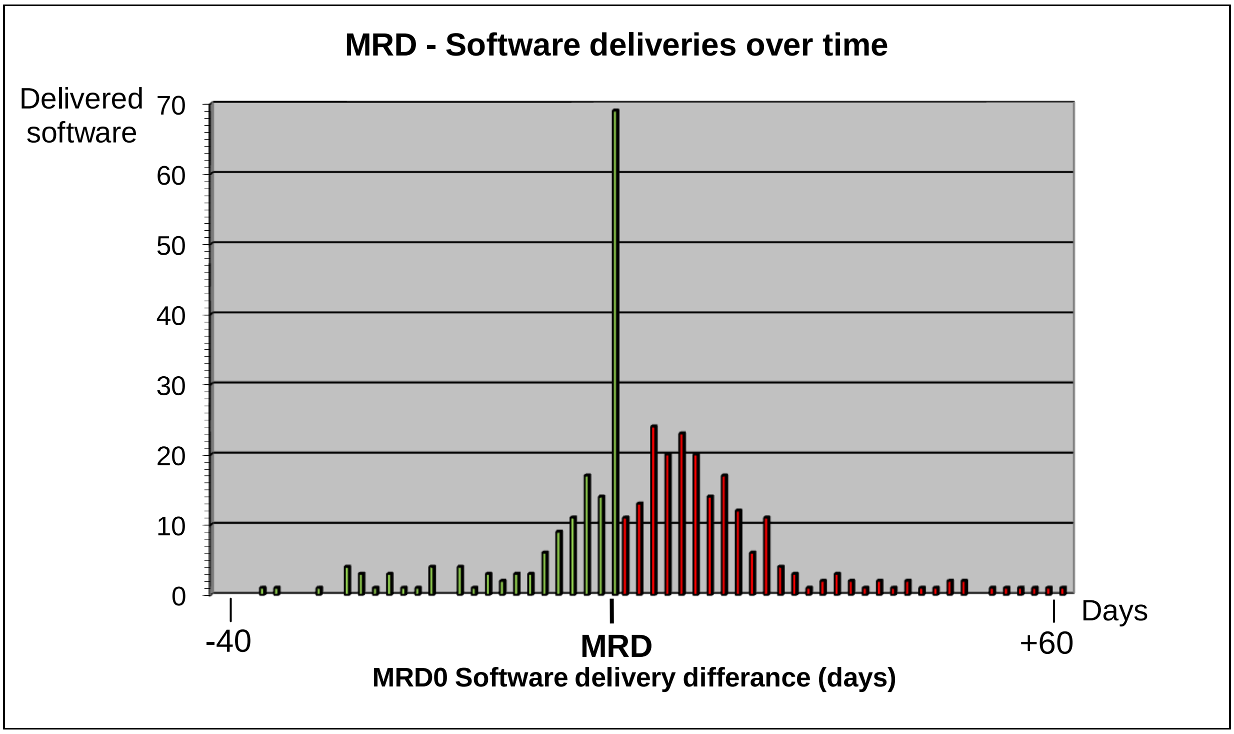


*Figure 8.3: The delivery precision for expected software*

### 8.1.2 Completeness of delivered software & documentation

An acceptance test is supposed to be done before adding files to KDP. It's part of the required documentation and should be available before release. However, this is rarely done due to time constraints. Instead, it's accepted at CRB and conducted parallel to the more advanced tests, which start when the files have been delivered and added to KDP. This means that some of the files lack functionality.

### 8.1.3 Delivery flaws discovered at Software Coordination Center

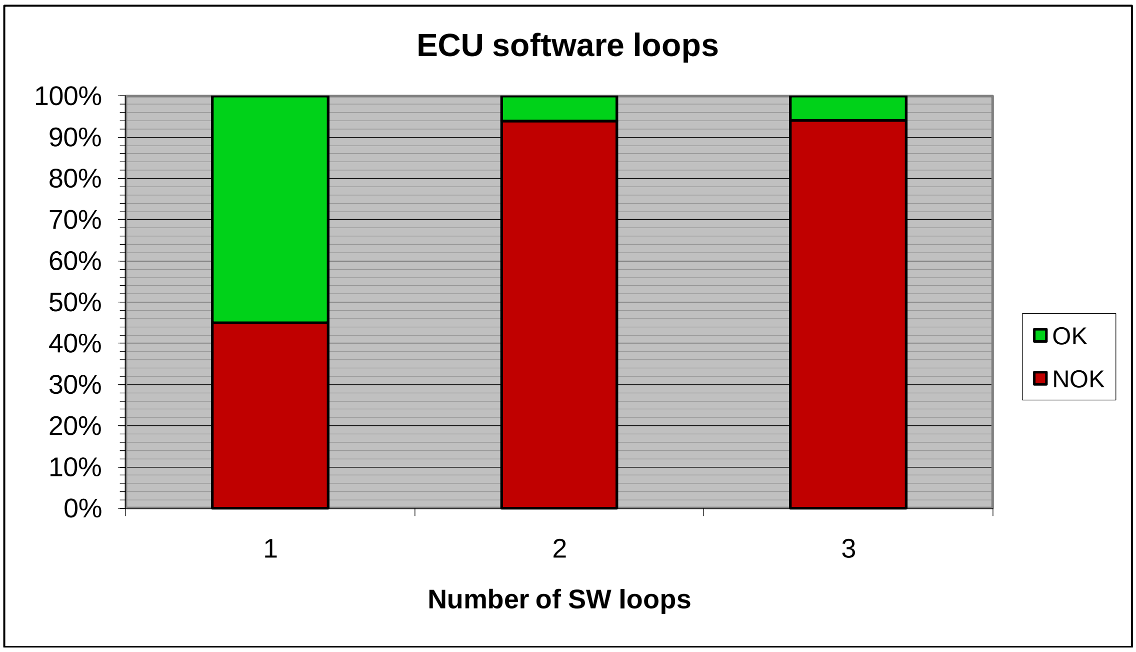


*Figure 8.4: Software delivery flaws*

About 45 percent of the software deliveries are not accepted at the first release. This is caused by flaws and mistakes in documentation.

The system of manual documentation clearly presents a problem. The information is supposed to be fed into KDP. Because of incompatibly with other systems used for loading the software into the cars, the handling becomes clumsy and dependent on manual updating of excel sheets. The software testers then have to extract information from the excel documents in order to know which file in the system to download.

## 8.2 Self assessments

When the self assessments are put together the following picture unveils. When combined with verbal information gained at the interviews some aspects have been interesting to follow up.

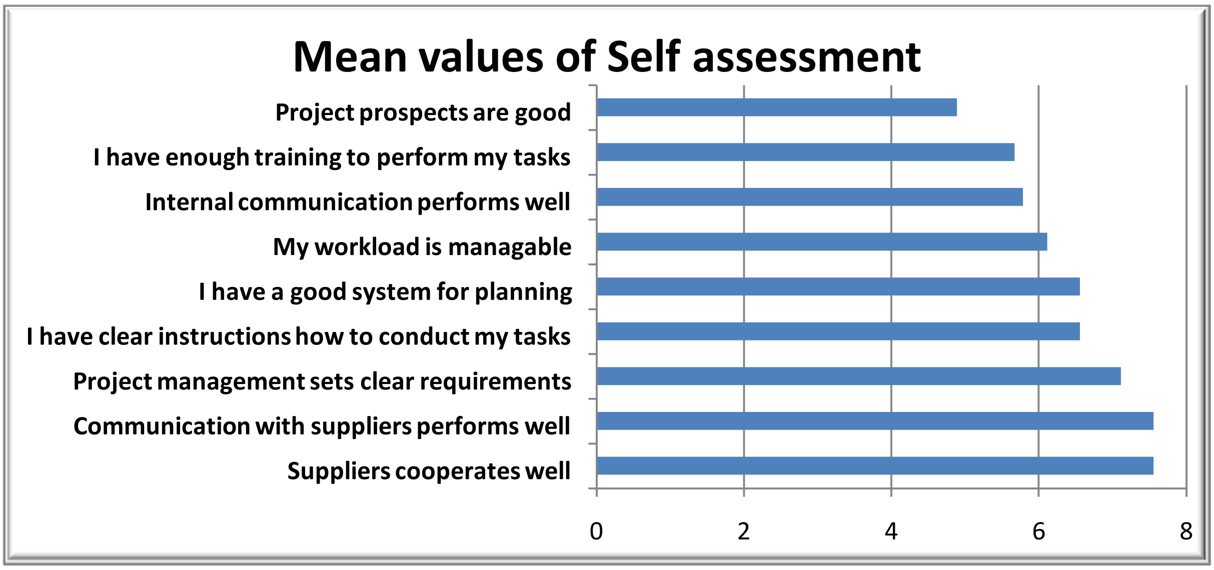


*Figure 8.5: Result of Self Assessments*

These graphs illustrate the ratings sorted by delivery precision. For instance, interview object A has a delivery precision of 33%, meaning that 33% of the software deliveries are delivered before MRD. The trend line below indicates an expected connection between delivery precision and self assessed workload.

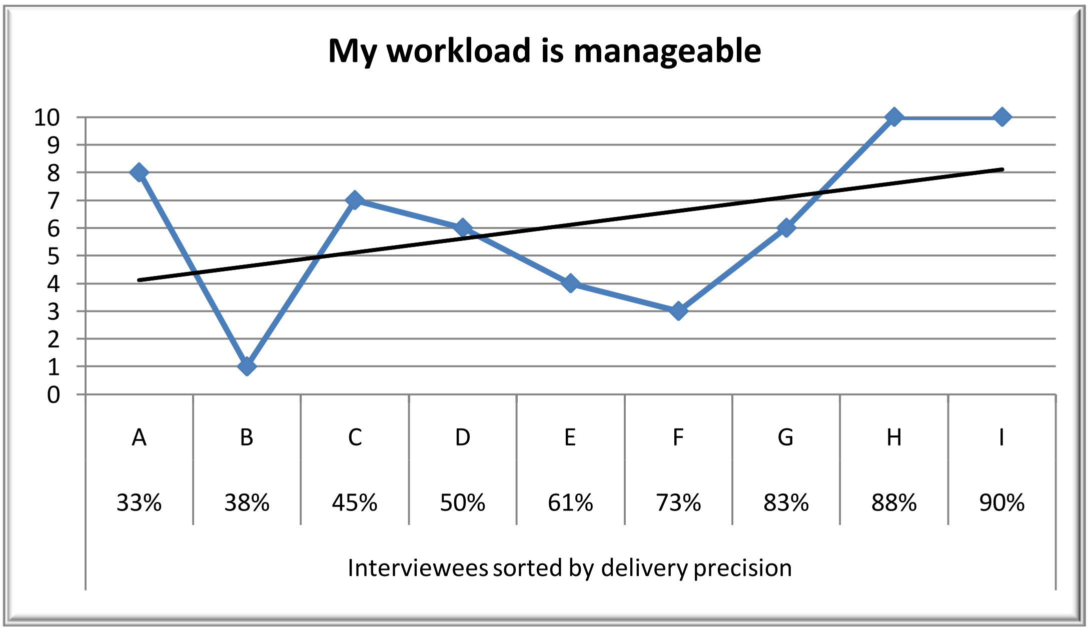


*Figure 8.6 Trend line indicating connection between delivery precision and self assessed workload*

Having a good system for documentation and planning are also key issues as seen in the graph below. As the System Task Leader role (SU) was removed in the electrics unit during the crisis, some find the workload to be overwhelming and responsibilities unclear.

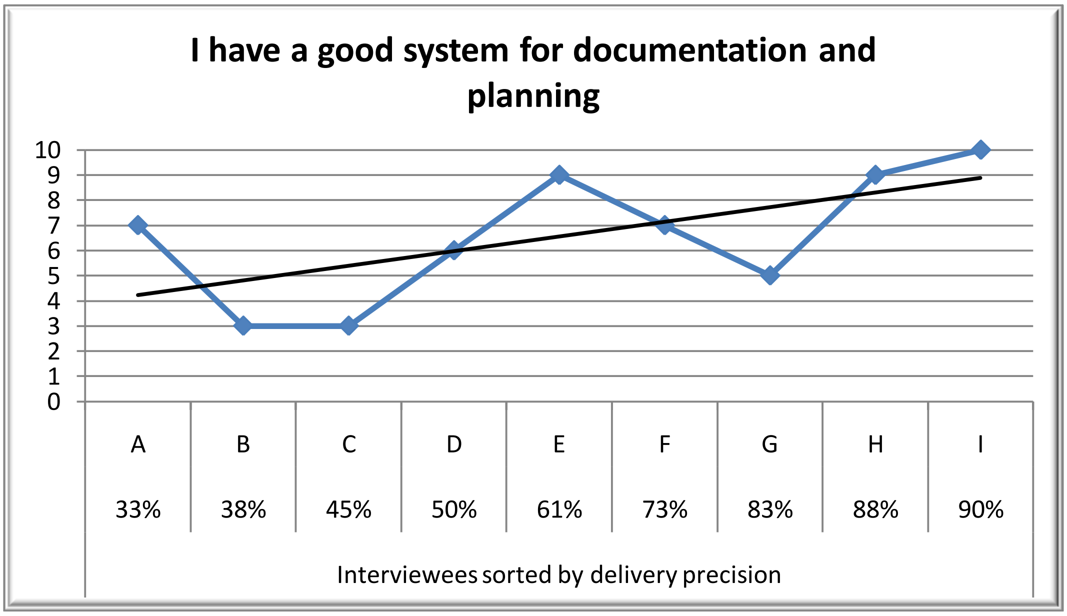


*Figure 8.7: Trend line indicating connection between delivery precision and having a good system for documentation and planning*

## 8.3 Problems discovered

### Project prospects

It’s agreed by all that GPDS is realistic to follow in theory – but there´s a large difference between theory and reality. The plan is not designed to allow running changes in the middle of projects. Start-up is almost always delayed, often due to late purchasing. While projects do start up, the involved personnel are preoccupied by putting out fires in other projects that are due for delivery. Continuously during projects, specifications are changed, added or removed.

### Communication with Software Supplier

Software suppliers are generally considered to be one of the least problematic issues. The trend line doesn´t indicate any differences between high and low achievers. The criticism that is mentioned is that the suppliers don’t always see the importance of deadlines. It’s rare though, that the suppliers are ultimately responsible for missed deadlines. Japanese suppliers are very structured, provide important information and are easy to cooperate with, while Germans tend to have a more difficult attitude. There is a difference in mentality.

When problems do occur, there’s a lack of possibilities to put pressure on the supplier. Since VCC is a relatively small player, suppliers tend to prioritize bigger customer’s needs.

It takes some social skills to put pressure on suppliers. Some seem to manage that skill very well. Others could use help. There’s a big difference between being a great programmer and a diplomatic star. It doesn’t always combine. Therefore a clear structure for raising the issue to a higher level above might do good.

## 8.4 Dependency on initiatives

Each Software Designer interprets the Software Specification Description (SRD) and creates a plan for his unit. This is done differently depending on the Task Leader. No clear instructions are available or known. Running Changes also create difficult situations.

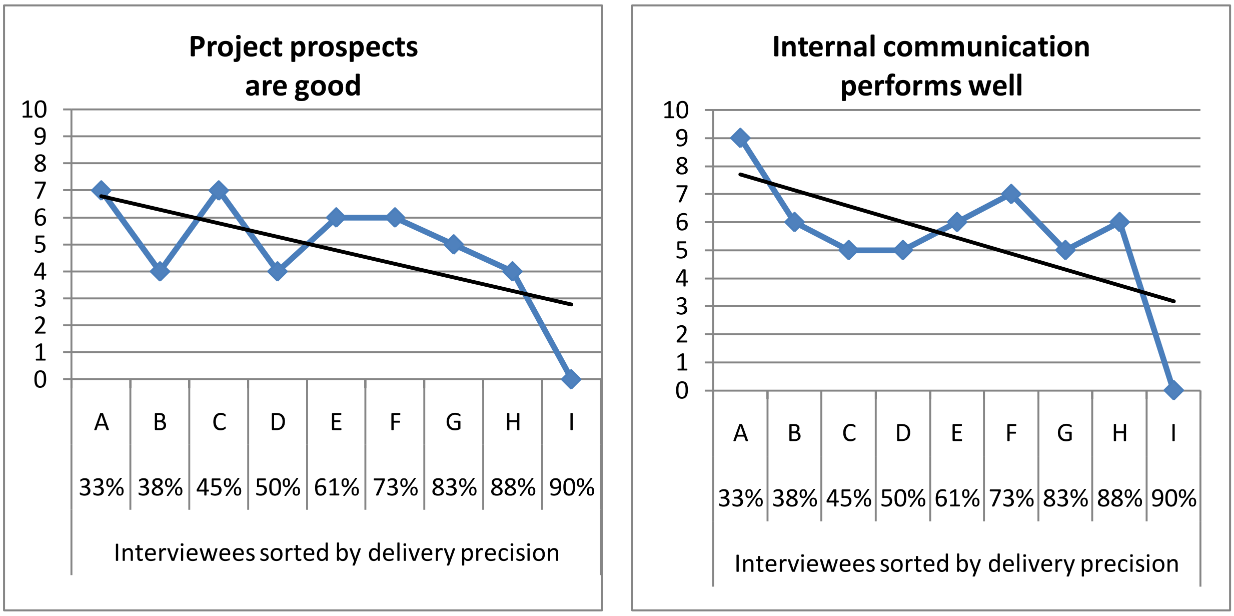


*Figure 8.8: Trend lines*

Project prospects and internal communication both receive worse ratings by high achievers. A couple of interesting connections can be drawn.

In order to be successful, there is a total dependency on own initiatives and information gathered in informal ways. When doing so, the seriousness of the situation is noticed. When looking outside the group and seeing the bigger picture, project prospects don't look very good. Furthermore, one will be subjected to the difficulties of information gathering in the organization, which seems to be a tough task.

**Major differences in approach to developer**

- High achievers do not think the plan is specified enough. They feel dependent on informal communication and own initiatives. "Go get the information instead of receiving it". Others claim to have enough information based on the GPDS and 'Purpose of series'.
- High achievers have a more outgoing personal style.
- High achievers deal themselves with suppliers. Others miss better support from Purchase, who lacks technical skills.
- High achievers give more detailed information to the supplier. They use the FIP-list more in their communication with suppliers.

All interviewees have a way of their own to organize their work. Software plan, communication praxis, interpretation of SRD and FIP. To develop a standard to do things and better coordination between the groups are key issues. Some ways are better than others but experiences don't seem to be communicated. All interviewees have given a unique answer to every question.

**Common problems**

- Lack of feedback – Nothing to compare against
  Demands are not stated clearly. Task leaders are unaware of their performance compared to others. Since it isn't known there is no search for better ways to work.

- Demands are not stated clearly in "Purpose of Series"
  'Purpose of Series' should help scheduling deliveries from software suppliers, but is not specific enough to make a difference.

- Poor information about project changes.

There is no guideline to hold on to. Nor does the Task Leader know the performance of his own unit or how high performance is expected. No reward is given for a job well done and it doesn't have consequences to perform badly. The DPL is nearest responsible for software performance. It's of course easier to do nothing. It could be a fear of conflicts. It's up to the DPL to keep high standards, but it doesn't seem to be subjected to any risk of losing the position if it isn't done.

### 8.4.1 Solution - Clear and known processes

**Needed changes:**

- A clear structure for raising the issue of negotiation with supplier to a higher level.

- IT-system to coordinate diverse aspects and provide current information, making information search less demanding.

- Specifications should be broken down to node level in the Specification Requirements Description (SRD), to assure generic handling in all units.

- The Function Designer should have the overall responsibility throughout the project, making misunderstandings less likely to occur.

- Better feedback and a forum for discussing plans and methods.

- Improve the Purpose of Series Document. Add details about all needed software for each series.

### 8.4.2 Incentive system

This is usually associated with economic means. Money is of course a driving force but there are others too.

The Hawthorne effect is a well known example from the Human relations movement that shows another aspect of what motivates us. Recognition, to be seen and be shown interest, is a factor whose importance is often understated. In this case it appears to have a big unexploited potential.

### 8.4.3 Support from Product Development Manager necessary

The organization is structured as a matrix. Each project has a hierarchy of its own.  In order to have changes like this implemented in all units, the instruction must ordinate from PD-level. That's where all three units first meet in the hierarchy.

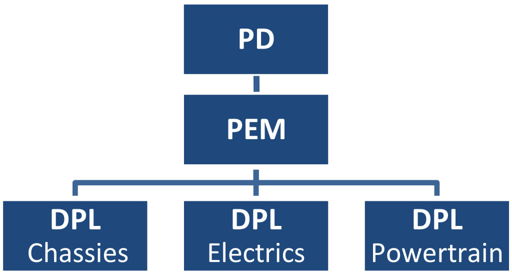


*Figure 8.9: Hierarchy organization*

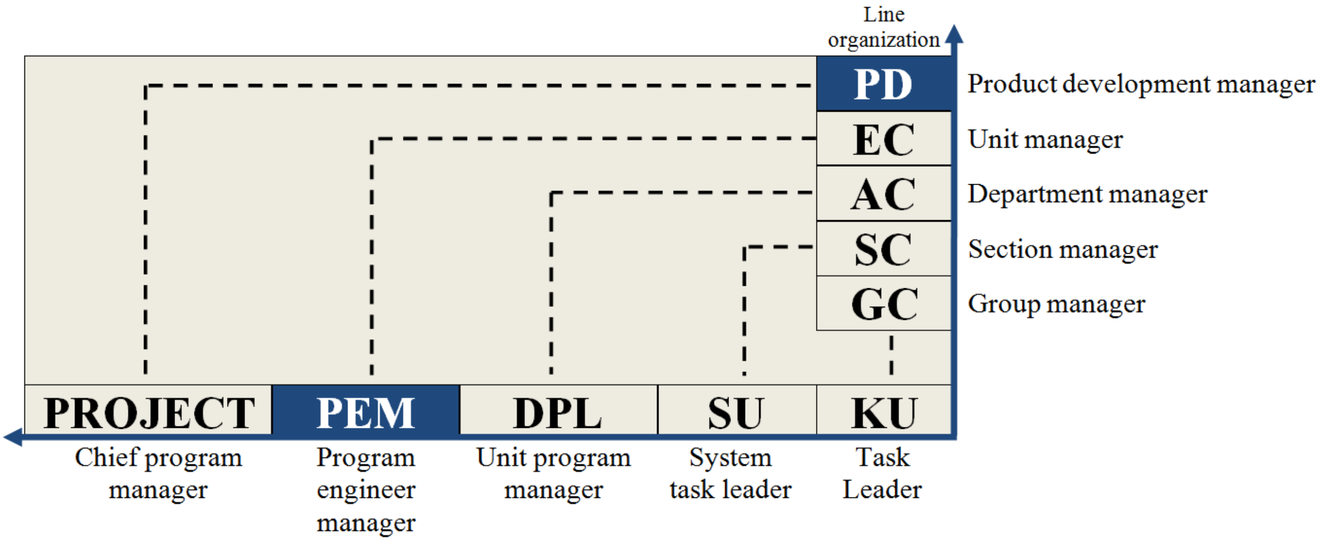


*Figure 8.11: Matrix organization*

# 9 APPLYING THEORY

This chapter compares the situation at VCC against the theory of organizations and group dynamics.  Over fifty individuals of different professions have been interviewed, covering a great part of the functions in the development process. The lack of structure in the software process will be discussed together with subjective conclusions. These conclusions are based on interviews and meetings attended as observers as well as statistics from self assessments and Software Coordination Center. To a large extent the information gained by interviews are subjective interpretations.

## 9.1 Hardware vs. Software handling

The following figures show a major difference in software and hardware handling in the initial phase of projects. The highlighting in *Figure 9.1* shows the area of concern. BOM, *Bill of Material*, is a list where all specifications have been broken down to pieces. It has been used for decades in hardware development, but not within software development. It's up to each Task Leader and Software Designer to do that. How to do it is not specified, therefore creating an insecure process. The handling of specifications is done differently in each unit. The formal rules are not sufficient and an informal way of doing things has taken its place.

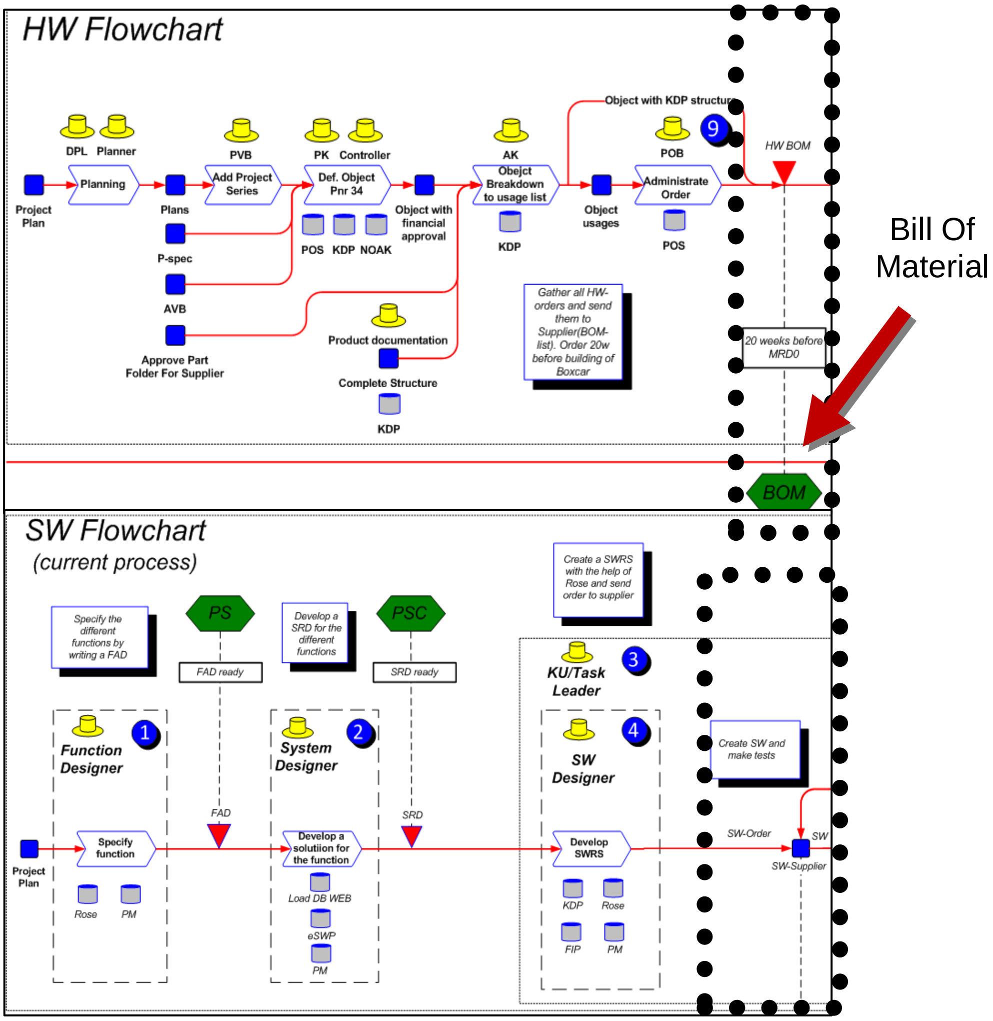


*Figure 9.1: Major differences in software and hardware handling*

## 9.2 Isolated groups

The lack of structure makes the process very dependent on communication skills among the units. An informal way of working can do well up to a certain point when the organization simply becomes too big.

Depending on the Task Leader, things are done differently. Some ways are more successful than others, but experiences don't seem to be communicated. Each group has their own structure, their own thinking – and very little knowledge about things outside the group.

## 9.3 Feedback and handshaking

The group's blind field contains things that members do not see, but others do (Johari Window). We carry on the same way and often fail to recognize things like unnecessarily complex procedures. The different groups all have their unique way.

Paradoxically, the most ambitious teams are often full of self-criticism, while groups that function poorly conceal this by overestimating themselves. Eight software designers assessed their competence on a scale from 0-10. The answers here are combined with statistics from Software Coordination Center.

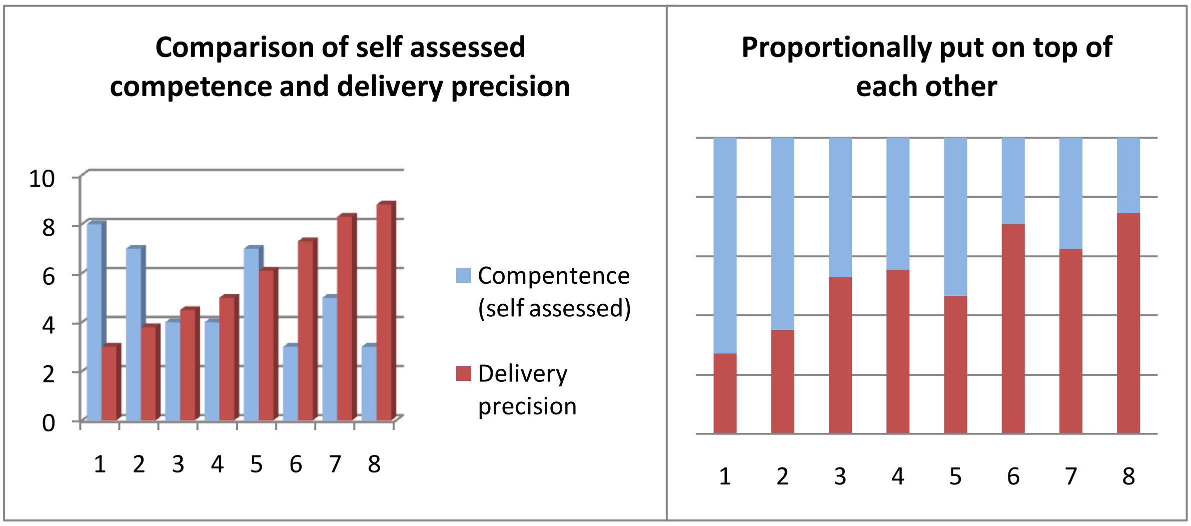


*Figure 9.2: Self assessed competence compared to delivery precision*

If we ignore all other variables in the graphs above, such as different software suppliers and complexity of different nodes, we get a clear view. One can interpret the diagrams in two ways. Either the interviewees on the left side are compensating for a known lack of competence, or they don´t know what is expected of them.

A view shared by many is that Software Design Review Meeting (SW-DRM) lacks pressure on the Software Designers. Failing to deliver is not even embarrassing. If we are never told otherwise, we will think that everything is in order. Therefore no effort will be taken to find ways to improve.

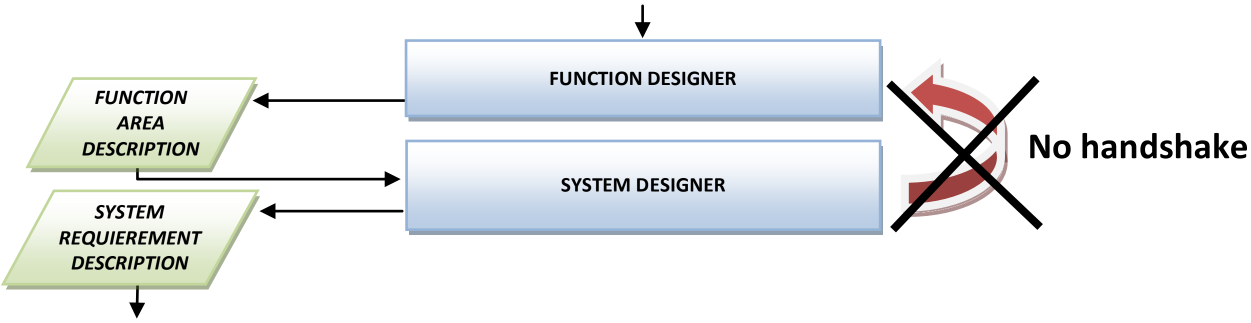


*Figure 9.3: There is a lack of handshaking between different areas*

Mistakes and misunderstanding are common between the units. The lack of handshaking adds misunderstandings, one to the other, and builds information that is very far from the original intention. E.g. the FAD, *Function Area Description,* is followed by the SRD, *System Requirement Description*, and so on, as shown in the figure above. Sometimes mistakes are not found until the delivered software fails to function.

## 9.4 Organizations inside the organization

The development process involves a huge number of units with similar or diverse purposes. Planning is conducted at different levels and development is divided into groups based on their corresponding hardware. Moreover there is testing, coordination, implementation - the list can be made long.

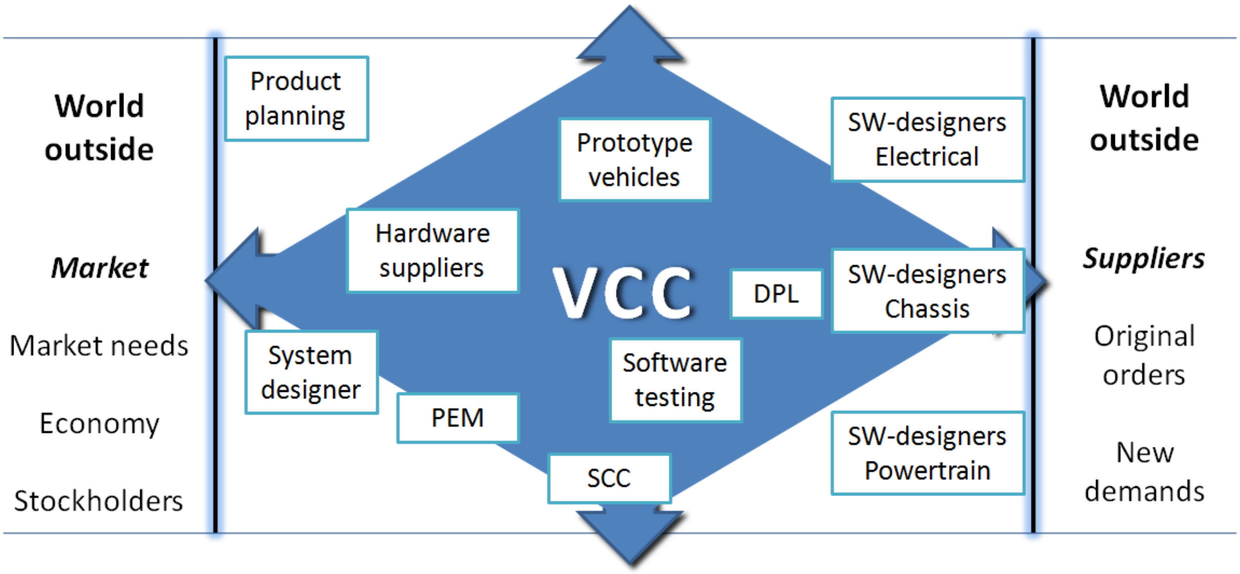


*Figure 9.4: Different point of views depending on placement*

The members of a unit obviously see the problems they are dealing with themselves clearer than problems in other units. Groups and organizations with fixed boundaries often have a way of thinking about themselves and others. What is significant is that you don´t know the ones outside the group. You don´t know what they do and how they do it. “We are good, the threat is on the outside”. If problems occur, it’s because of unfortunate circumstances – usually caused by those on the outside. "Those outside" have been uninvolved or irresponsible. In one aspect the thinking pattern fills a purpose within the group. It creates a good atmosphere and closer bonds between members. Therefore, it’s not always prioritized to stay current with the other groups.

This is probably no news. For some it might be, when placing it into the context of software development at VCC. Awareness of its existence is important. We often carry on in the same way, not reflecting on issues like this. When listening to interviewees, the blame for problems is often put on a unit as far away as possible.

To illustrate another example, people involved in product planning sometimes see other brands releasing a new function. They want the same function implemented in a car under development. They can´t see how there can be a problem “writing a few extra lines of code” in the middle of a project. In fact, it causes major problems. People on the other side might – maybe rightfully – disagree with many changes. Projects are scheduled by GPDS, but when running changes make it impossible to follow, what´s the use?

## 9.5 Finding common ground

Discussions and meetings are carried out continuously alongside daily work. As mentioned, people have very little knowledge about things outside the own group. The plans shared by the units are interpreted differently. GPDS is a plan incorporating another plan called 'Purpose of Series'. This plan is supposed to make deliveries for boxcars at different stages in the development process synchronized for testing. If it worked, a planned test would always have the needed hardware and software components. However, it's been interpreted differently in the units.

An explanation for this could be quite human. We make a selection based on what we deem important. Each unit recognizes what is important for the own unit to function. The web of units that are dependent on different functionalities developed by the unit to fit their corresponding part of the system is not known.

An initiative to summon representatives from the units concerned has been carried out by Prototype Vehicles during this investigation. The intention was to straighten out the issue of 'Purpose of Series' by discussing the matter once a week during a couple of weeks. This was not successful since the participants' corresponding frames of reference are so different. The discussions halted at once because of misunderstandings.

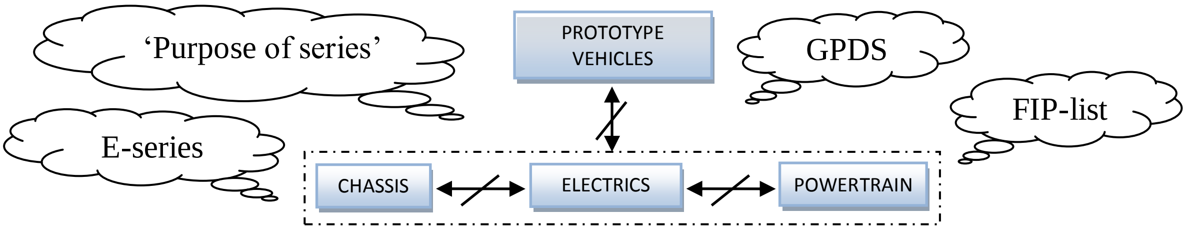


*Figure 9.5: The participants corresponding frame of reference differs*

A bigger initiative is needed to obtain answers to the questions. The plans must be known and furthermore accepted by all involved.

## 9.6 Resistance against change

There is a strong agreement across the software organization that changes need to be made. The structure is already outdated, and demands for more functions are coming in at a fast rate. That should be a good condition for a change process to begin. However, Volvo is a big ship to turn around. The basics of the structure are old and have focus on mechanics. It's also very accustomed, especially among long-term employees.

### “That won’t work”

The words seem to come as a reflex when changes are proposed. Changes always cause problems in the initial phase. That might be why people fear them. It could also be a fear of losing a formal or informal position by applying it. However, it is the normal way to act. At a meeting intended to discuss changes a man had an outburst and asked “Don’t we already build cars or what!?” This kind of behavior is called regression and is a typical irrational way of acting in situations that make us disturbed.

On the other hand we are dependent on progress. It’s the changes that have led us to where we are today. If the change has a good foundation, the resistance often wears out quickly. When it has been implemented and employees get used to it, the benefits begin to unveil. You don’t build a city overnight, and without changes, Volvo would have only one car model. Its’ name would be Jacob.

## *9.7 Lean Product Development System*

The basic idea of Lean Product Development System is eliminating waste, adding nothing but value. The product development in VCC requires running changes into the project process, making it possible for VCC to deliver the style and features required by the customers. Running changes are necessary to obtain market share. But this also means that engineers in the beginning of the project’s process know that the effort must be made over and over again, and that is really is a big waste. It is time for VCC to overlook the software process and find new ways to handle the processes, in order to put the work effort “just in time” and having engineers do their work only once.

Comparing to how the workload is distributed, engineers must put all their effort to “put out fires” instead of working according to the GPDS plan. A new project requires about 50 months of development; this is what the hardware development requires to be developed. Software can be developed much faster than this but must also follow the hardware process, because they go hand in hand. The most difficult task to perform is to predict how the world is going to look like and what features the customers will be expecting from a car three to four years ahead. For example, to develop features into the car that will be compatible with the iPhone6 or 7 within three years is almost inpossible. Not even Apple knows what those gadgets will contain.

# 10 COMMON PROBLEMS AND SUGGESTED SOLUTIONS

This chapter presents problems which cause late deliveries of the software to the building of prototypes. Some of the problems will be added with a solution suggestion. Other problems will just be highlighted for VCC, to show that this is a problem and should be dealt with. The problems will be sorted into five categories: *Structure, Communication, Tool and System, General problems* and *Other Problems.*

The red numbers refers to the suggested solutions shown in the *Appendix B2*.

## *10.1 Structure*

Problems caused due to lack of structure.

### 10.1.1 Building of Boxcar

2

**Problem:**

The tests in boxcars are planned to be done in the same week as the building of the boxcars. This causes problems because the tests can't be started before the boxcar is built.

**Solution:**

The building of boxcar is moved one week earlier in order to be ready for the start of tests. The boxcar should then be finished at MRD1.

### 10.1.2 MRD0/MRD1 and acceptance test

3

**Problem:**

The software should be delivered to VCC at MRD0 according to the plan. At the same time SCC should get the software. This causes problems due to that an acceptance test should be done before the software delivery to SCC.

**Solution:**

The software is delivered to VCC at MRD0 which then is acceptance tested and delivered one week after to SCC at MRD1. This is already in the plan and will be changed soon.

### 10.1.3 SCC, Software Coordination Center

5

**Problem:**

SCC has a central role in the software management process handling all the software releases. When dealing with other units, the SCC-team lacks pressure. The SCC unit is by tradition a part of the EESE department *(see figure 10.1 below)* which can be a reason for the lack of respect, they are at the same level as the other departments. Once, it was easy to see why, because all software was connected to hardware developed in the same unit. Today the situation has changed. Software has now become such a large part of the car that there is no reason for SCC to remain under the EESE department.

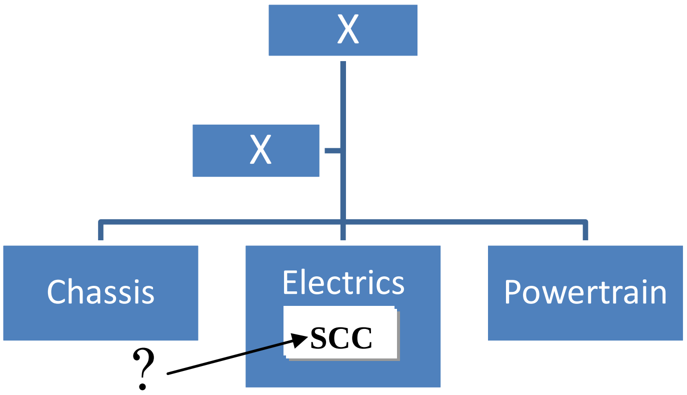


*Figure 10.1: Should SCC remain in the Electrics Unit?*

**Solution:**

The SCC unit should be moved from EESE to a new position which must be stronger. This will probably give SCC more pressure when the software is late delivered. The SCC unit then will become a stronger role in the software management process.

## *10.2 Communication:*

Problems caused due to lack of communication.

### 10.2.1 Feedback

**Problem:**

In such a large company as VCC it’s hard for employees to see the whole picture and follow if specified things have been understood in the correct way. This can lead to a lot of problems when descriptions can be interpreted in other ways than intended. Descriptions of functions have to be completely clear to make sure that the next unit understands them. There can’t be any misunderstandings between the units. The FAD, SRD and SWRS have to be spotless and crystal-clear when written, but are often vague and hard to understand. This causes problems for the following units who have to try to work with the vague description.

**Solution:**

Sign-offs should be better to make sure the receiving unit understood the description as intended. They should work according to the V-model *(see 10.6)*.

### 10.2.2 Feedback to Task Leaders

**Problem:**

The Task Leaders don't know their on-time-delivery precision e.g. the performance is not known. This is important feedback. In order to improve you need to know that you have a problem and what it is.

**Solution:**

Check at SCC how well the different Task Leaders are doing and send it to the DPL who can give them feedback and work with the ones who need to improve.

### 10.2.3 Communication between departments

**Problem:**

When developing a car all departments have to work synchronized in order to get the prototype finished in time. They are all working for the same goal and need to communicate in a good way. This is a problem at VCC. The communication between EESE and Power train is not sufficient. They are both needed when testing in mules (M1) and VP and should work together as a team with the same main goal.

### 10.2.4 Communication between Task Leaders

**Problem:**

In order for a function to work it usually needs several nodes working together. This demands a good level of communication between the different nodes. Sometimes at VCC the communication is deficient and the Task Leaders just focus on the thing they have to deliver and not on the function which should be implemented. The FIP should help the Task Leaders to focus on the functions but is sometimes not sufficient enough.

### 10.2.5 Communication between Task Leader and SW-supplier

**Problem:**

How to handle the supplier varies a lot between different Task leaders/Software Designers. Some of them are very good in communicating with the supplier when others have bigger problems. When the supplier misses a deadline or disagrees with the Task Leaders/Software Designers there is not much the Task Leaders/Software Designers can do. Volvo is a small customer for the supplier and there aren’t many suppliers VCC can choose from. This leads to a lack of respect from the supplier and more difficulties for VCC to get their demands accepted. Another thing that adds to the problem is that VCC has about 40 different suppliers which all have different ways of working.

**Solution:**

Set a standard how to handle the supplier.

## *10.3 Tools and systems:*

Problems caused by the lack of system or tools, or problems in a tool or system.

### 10.3.1 BOM-list

1

**Problem:**

The SCC unit doesn’t have a part list to check what software parts should be delivered to MRD0 (on suggested flowchart MRD1,*Appendix B2*) and CRB. Late deliveries which are not brought up in SW-DRM are noticed first at MRD0 (on suggested flowchart MRD1), which causes problems for the verification teams (A&V) who have to replan their tests. The NCM is not sufficient enough to get the software delivered in time. Both SCC and the Task Leaders should know from the top what should be delivered and not from the person delivering (the Task Leader).

**Solution:**

A “SW-BOM” (function list) is created which shall correspond to the HW-BOM that already exists. The SW-BOM-list includes information about what articles should be delivered to MRD0 (on suggested flowchart MRD1) for each E-series and M1/VP. This list makes it possible for SCC to be able to check if the software articles will be delivered on time. This will also help the verification teams (A&V) who will get quicker information when something is delayed and can then plan their tests better. Also the Task Leaders obtain better knowledge and structure of what they are supposed to deliver.

### 10.3.2 GPDS plan is not followed

**Problem:**

Ther are many reasons to why the  the normal way of doing things is to not follow the plan. When running changes are forced into the GPDS plan, the plan cannot be followed any more. According to GPDS the functions-list should be frozen at a certain time, and no more functions should be added or changed. But even then a running change can be forced and the function list changed, the freezing of the list is overruled. This leads to problems for all the units when the plans have to be changed and extra resources have to be used to fix the late change. When a running change is forced it is okay not to follow the GPDS-plan. This sends signals that it’s okay not to follow the plan and problems can be fixed outside the plan.

### 10.3.3 Purpose of Series

**Problem:**

Some of the Task Leaders and the SCC unit don’t know what should be tested and delivered at/to each series. Another problem is that people think that E2 should have the same software as M1, which is not the case. All this should be included in the Purpose of Series Document. The Function Designer should also be able to look into the Purpose of Series Document to see when the designed function should be tested/implemented. The Purpose of Series Document is very vague and lacks information. This planning document would help a lot in the process when correctly written but at the moment no one takes responsibility for it.

**Solution:**

Improve the Purpose of Series Document by making it more specified and make sure every department use it. VCC has to figure out who must be responsible.

### 10.3.4 The FIP

**Problem:**

The FIP is not completely accurate, it contains empty slots and is more of a forecast than fact. The problem is that the FIP sometimes is seen as fact. The FIP isn't working as intended and doesn’t give the help needed for the Task Leaders.

**Solution:**

The FIP should be changed from a forecast to an order. Instead of telling people what might be implemented at the different series it should work as a plan to follow. The task leaders should follow the FIP and work with the functions and not just software articles. The FIP could be of so much help if it were working correctly. The FIP should also be broken down to node level before being given to the Task Leaders.

### 10.3.5 The KDP-system

**Problem:**

KDP is first used at the VP series and is a help. But when it comes to E-series and M1 the KDP system isn’t used. The system makes it easier to organize and structure the work. Problems caused by human errors could be minimized with the help of a system.

## *10.4 General problems:*

Problems which are general for all the departments and units.

### 10.4.1 Running changes

**Problem:**

VCC is a small car company in a global perspective and competes in the premium car league. The other car companies competing in this league are BMW, Mercedes and Audi. Those companies are much bigger and have a stronger economic platform compared to VCC. VCC is forced to do running changes to compete in this league. But there are lots of problems with running changes.

**Solution:**

VCC needs to look into this.

### 10.4.2 Putting out fires

**Problem:**

Instead of being well prepared and following the plan a ”putting out fires” mentality has occurred at VCC. When one problem is fixed, the next problem has to be dealt with. The problems have started long before they are dealt with. VCC is handling the problems in a wrong way, e.g. in the beginning when problems occur the solution is to order the people responsible to fix it telling them that it’s their problem. Ignoring problems like this cause even more problems when the workload is moved to the end of the project.

**Solution:**

People should help each other as a group. In the end of a project when a problem occurs everybody helps to fix it and it should be so in the beginning of the project as well. Problems should be dealt with before they get too big.

### 10.4.3 Missing a deadline

**Problem:**

Missing a deadline has become a normal way of working at VCC. The biggest reason for missing a deadline is running changes which are the systems’ fault. This makes delayed deliveries and missing of deadlines more accepted because it's the running changes of the systems’ force. The system loses respect when it’s okay to miss a deadline over and over again. It is also easier to miss a deadline in the beginning when its two years until the car should be ready. People can’t see how much it affects the units in the end when they are a little late.

**Solution:**

Missing a deadline in the beginning of a project shouldn't be more accepted than in the late part of the project. People should help each other at the beginning in the same way as they do at the end. DPL and SCC should make it clear that missing a deadline is not acceptable.

### 10.4.4 Software importance

**Problem:**

The Software is not delivered in time and it’s time to realize that software is becoming a bigger and bigger part of the car. It’s not just a couple of lines written in a program, it’s a vital part of the car. The software is not treated with the same respect as the hardware. The software will probably continue to increase in cars in the future, so it’s time to change and be best at it.

The hardware process has a clear structure which is not the case for the software process. Hardware is easier to get a grip on. It’s known that it takes time to adjust tools for manufacturing and that those can’t be changed overnight. What is neglected or not known is that the same goes for software. Changes can´t be implemented overnight. Software Designers rate suppliers high according to their self assessment, see *Appendix A2*. The problem is in VCC.

**Solution:**

Software should be treated with the same importance as hardware and have a clear structure. TRM should treat software with the same importance as hardware. This also goes for the DPL.

## *10.5 Other problems:*

Problems that do not fit into any other category:

### 10.5.1 Implementing of the Function

4

**Problem:**

There are hundreds of functions in a car and it’s the functions/features the customer values. So it is very important that the functions are working. When a function doesn’t work there is no one to hold responsible. The Functions Designers who ordered and wrote the description for the function are already working on a new project.

**Solution:**

The Function Designers should be responsible that their function is working as intended at the end. They should also get feedback during the process and check what is happening. They should make sure that the nodes who are working with the function are communicating. The function designer should write the test order at the end and see if the function is working as intended. The V-model *(see 10.6)* shows how it should be done.

### 10.5.2 E2 and M1

**Problem:**

Employees don’t know that software for E2 and M1 shouldn't be the same. At the moment there is a lot of confusion and beliefs that E2 and M1 should get the same software because they are being built at the same time. The hardware can vary a lot between the two, therefore different software must be delivered.

**Solution:**

This should be added in the Purpose of Series Document, the SW-BOM and the FIP.

### 10.5.3 Contracts (Task Leader - Supplier)

**Problem:**

The Task Leader should have a supplier ready in time to deliver software to the different series, but in some cases this is not finished until the middle of the E-series. Another problem is that all the demands are not set when signing a contract with a supplier. So even after signing a contract with the supplier they have to agree on the demands. Both of these problems can delay the deliveries of the software.

**Solution:**

Better feedback and help to Task Leaders who are delayed with the software deliveries.

### 10.5.4 DPL

**Problem:**

There is not enough structure for the DPL to follow the employees, e.g. when the C-notes should be set. The DPL doesn’t have enough detailed understanding of what’s happening and cannot help the employees until the problem already is upon them.

**Solution:**

Bring back the SU role and/or get a better system or structure for them to see how it is going.

### 10.5.5 Acceptance test

**Problem:**

There is lack of structure of what should be tested and it often depends on the experience of the tester.

### 10.5.6 SW-DRM

**Problem:**

There is lack of respect for this meeting, sometimes the DPL doesn’t even show up. The meeting has a potential that is not fully utilized by the Software Designers or the Task Leaders, which have little control over their own deliveries to the respective series, according to the SCC team.

## 10.6 The V-model

The V-model describes a software development process. Feedback and sign offs should be done with the previous designer to certify that the description has been correctly understood. When the software is developed verification should be done by the designer to make sure it's working as intended. This can be seen in the figure below.

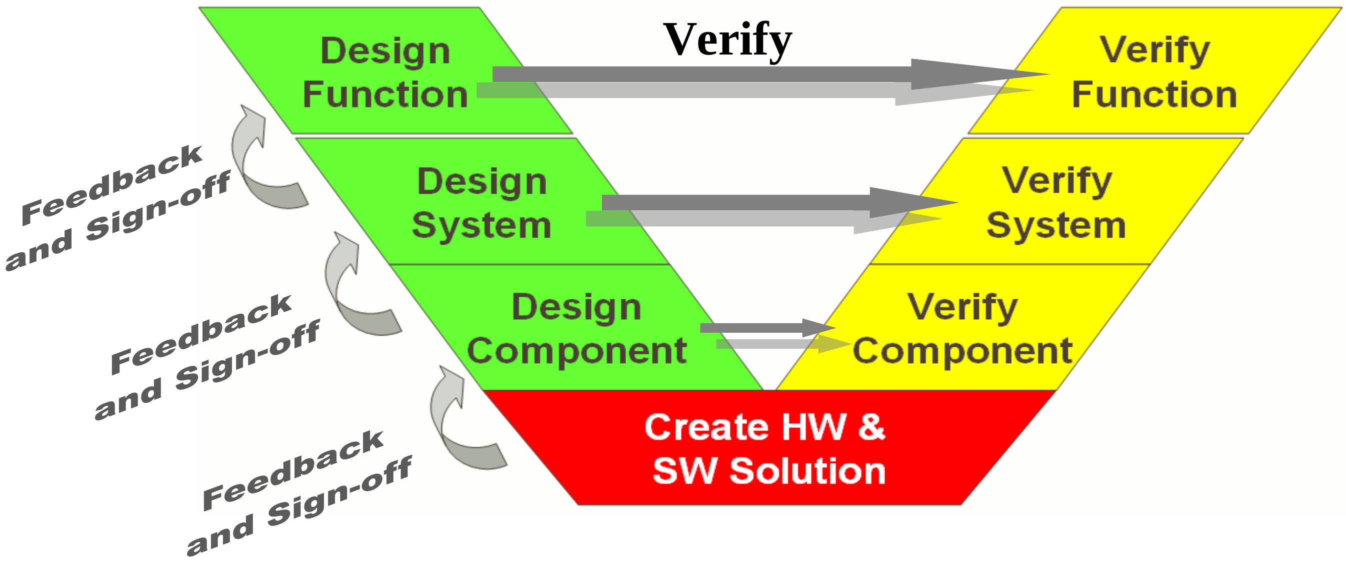


*Figure 10.2: The V-model*

## 10.7 Recommendation

As seen in this chapter many improvements are possible at VCC. Solving the problems all at once would be very difficult. In this part a recommendation to VCC will be made as to where to start the improvement work. The four things VCC are recommended to start with are:

### *Task leaders and the SCC need better structure with the help of a SW-BOM*

The problem today is that there is no structured way of knowing what the Task Leaders should deliver to SCC. With the help of the SW-BOM both the SCC-team and the Task Leaders could more easily see what is supposed to be delivered. The SW-BOM will be created from the KDP-system as the HW-BOM. This will help because the problem with human errors will decrease when a system is involved. This should also be fairly easy to implement when a BOM-list already is created for the hardware.

### *The SCC-team needs stronger status*

SCC is the team collecting and releasing all the software parts from the different departments. When a Task Leader is delayed with the delivery there is not much that the SCC team can do. They have to trust in the DPL from that department to fix the problem. The DPL is the one who agrees and acts on late deliveries in their own department. This is a bit weird because the DPL will then check if his own work is good enough. One reason for the lack of respect for SCC could be that they are a part of the ESSE department, other departments at the same level may think it's not a major thing to be late with deliveries to another department at the same level. So the SCC team should have a stronger position instead of working under the EESE department. SCC should be moved in order to make them more powerful.

### *The Function Designers need to be responsible for the implementation of their function*

The functions are highly important in the car. VCC needs someone in charge of each function who can see the whole picture. The function Designer is the best one to do this work. This will probably help to get a higher working percent on the first functions test.

### *Departments and units need to interpret common plans and tools in the same way*

This is a big problem in VCC. What's the point of having a plan when departments read it in different ways? There must be a clear and common way of understanding plans and tools. Communication between the different departments need to work perfectly when they are so dependent of each other. VCC must look into this directly and continue to work with this. Software is now a part of the car and needs to be dealt with in the same way as the hardware, they are equally important. This is a major problem needed to be fixed in order to make VCC a better working company.

# 11 CONCLUSION

This chapter will summarize and conclude the report. The objectives, experiences and an analysis of the work that has been done will be discussed. Three initial issues were mentioned in the introduction.

**How does the current process work today?**

The process was mapped up on a high level to make room for all major units on a single page. It provides a compressed view of the complete process, only involving the relevant units and roles. This has not been available before. The map is included in *Appendix B1.*

**How can the current process be improved?**

Suggestions for improvement have been given in a number of areas. The most important ones are listed below. It is also visualized in an improved software map, included in *Appendix B2.*

**Can the software process be as organized as the hardware process?**

In some aspects it can, in others not. Software BOM seems feasible to implement, giving a better structure for software releases. A key ingredient is also to realize the limitations of software development in the same manner as the restrictions of hardware development are known. Pushing for impossible demands will result in quality problems and poor delivery precision.

## *11.1 Experiences*

The initial delimitations were soon discarded as too narrow. To understand the problems the investigation had to be made further back in the process. That made the scope so wide that the time schedule was too limited. Understanding the process in ten weeks is hard enough. This has unfortunately forced us to leave interesting issues out. Creating solutions for all problems proved to be inconceivable. The focus was moved to just pinpoint the problems. A number of problems have been verified, giving some insight in the complex structure.

It has been surprisingly easy to book meetings. People have been very cooperative and have managed to add meetings to their already busy schedule. A lot of people were interested in using the thesis as a means of communication to make themselves heard and share their views. That might indicate a weakness in the communication structure. People see problems and have ideas but need the attention of the management to carry out improvements. This seems difficult.

## 11.2 Credibility analysis

These conclusions are based on interviews and meetings attended as observers as well as statistics from self assessments and Software Coordination Center. To a large extent the information gained by interviews are subjective interpretations and analysis.

There is no doubt that the problems mentioned exist. What can be discussed is the seriousness of some of them and whether they are problems in themselves or symptoms of bigger ones.

## 11.3 Recommendations

With that in mind, the most important ways of improvement have been found to be the following:

- The Function Designers need to be responsible for the implementation of their function during the whole project.
- Task leaders need better structure, feedback and less isolated groups.
  To set goals and measure performance. To provide knowledge about what is expected.
- Software Coordination Center needs higher status and a better IT-solution for coordination.
- Task leaders, Software Coordination Center and Software Testers need better structure by implementing a SW-BOM.
- Units need to interpret common plans and tools in the same way. Resources are needed to start a project involving all concerned in order to create understanding of others needs and a common interpretation.
- The Purpose of Series Document needs to be improved by adding more specific demands.

## 11.4 Final words

It’s obvious that Volvo´s roots are in mechanics. Software doesn’t seem to be considered an issue by the management. It’s not as easy to get a grip on as hardware is. The problems run deep, and we have probably just touched the tip of an iceberg. On the other hand we have met many committed and experienced employees. They have all showed a deep interest in finding ways for improvement. Volvo has a lot of work to do in order to make the process run smoothly but also a very committed staff.

**Stefan Jacoby, President and CEO of Volvo Cars, focused on Volvo's brand refinement and future in the U.S. when he kicked off the Los Angeles Auto Show by delivering the Motor Press Guild (MPG) keynote address on November 17th 2010.**

"From now on, you can expect us to do things faster, better and smarter," says Stefan Jacoby. "We will bring new ideas to the market quicker than before. We are focusing on a driver centric approach and we will stand out from the crowd by delivering a distinct, individualist car experience. Not by copying our main competitors. Instead, we will do it by carving out our own, unique Scandinavian profile."

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Morgan & Liker 2006: *The Toyota Product Development System, Integrating People, Process, and Technology,* Productivity Press, New York

**Reference article:**

Poppendieck, Mary: *Principles of Lean Thinking*, LCC 7666 Cernelian Lane, Eden Prairie, MN 55346 USA, 952-934-7998

**Other references:**

Brassard, Michael 2002: *The Six Sigma Memory Jogger II, A Pocket Guide of Tools for Six Sigma Improvement Teams,* GOAL/QPC, Salem, NH, USA

**Reference persons:**

Olof Hansson, VCC, Göteborg, tel. 031-325 07 97

# APPENDIX A1

## Frågor till KU/SW-ansvariga: Namn:
## NOD:

### *Planering:*

- Känner du att du har rätt förutsättningar att dra igång dina planerade aktiviteter vid projektstart?
- Har du full koll på vilka förserier som skall byggas i ett specifikt projekt och på ditt innehåll i respektive serie/projekt?
- Hur håller du i ordning på komplexiteten av SW-carry over/carry back mellan olika bilprojekt?
- Vet du vad som skall ingå i en SW-leverans (SW, provning utförd, dokument osv)?

### *ÄO:*

- Vem har ansvaret för att sköta produktdokumentationen (ÄO:t) inom er nod?
- Vad ser du är fallgroparna för att hålla ordning på att produktstrukturen (grind PTCC) är korrekt beskriven i ditt ÄO? (var gör man mest fel)
- Har du rätt kompetens/utbildning för att skriva ÄO:n?
- När tidsmässigt sker din etablering/uppdatering av ÄO:t?

### *Leverantörskontakt:*

- Hur förmedlar du informationen till leverantören om att den skall leverera rätt(innehåll / korrekt ) SW i rätt tid?
- Har leverantörerna tillgång till SW-plan och våra MRD-tider?
- Vilken information är med i ESOW (Syfte serie, FIP)?
- Hur hanteras artikelnumren gentemot leverantör?
- Hur fungerar samarbetet med inköp rörande SW-frågor?
- Erfarenhet kring nya/gamla leverantörer?

### *Huvudfrågor:*

- Hur säkerställer ni inom ert team att rätt SW levereras i rätt tid till rätt byggnation?
- Finns det något du skulle vilja ändra på kring detta?
- Din erfarenhet i rollen (antal år, bättre/sämre med åren)?

# APPENDIX A2

## *Vad anser du om följande?*

Gradera från 0 – 10

*Håller inte med* *Håller helt med*

**Projektledningen ger tydliga krav på vad som förväntas av projektet**

0 1 2 3 4 5 6 7 8 9 10

**Min arbetsbelastning är hanterbar**

0 1 2 3 4 5 6 7 8 9 10

**Projektförutsättningarna är goda**

0 1 2 3 4 5 6 7 8 9 10

**Kommunikation internt på VCC fungerar väl**

0 1 2 3 4 5 6 7 8 9 10

**Leverantörerna ger klara besked och går bra att samarbeta med**

0 1 2 3 4 5 6 7 8 9 10

**Ytterligare utbildning skulle öka min möjlighet att utföra mina arbetsuppgifter**

0 1 2 3 4 5 6 7 8 9 10

**Det finns tydliga instruktioner för hur arbetet ska bedrivas**

0 1 2 3 4 5 6 7 8 9 10

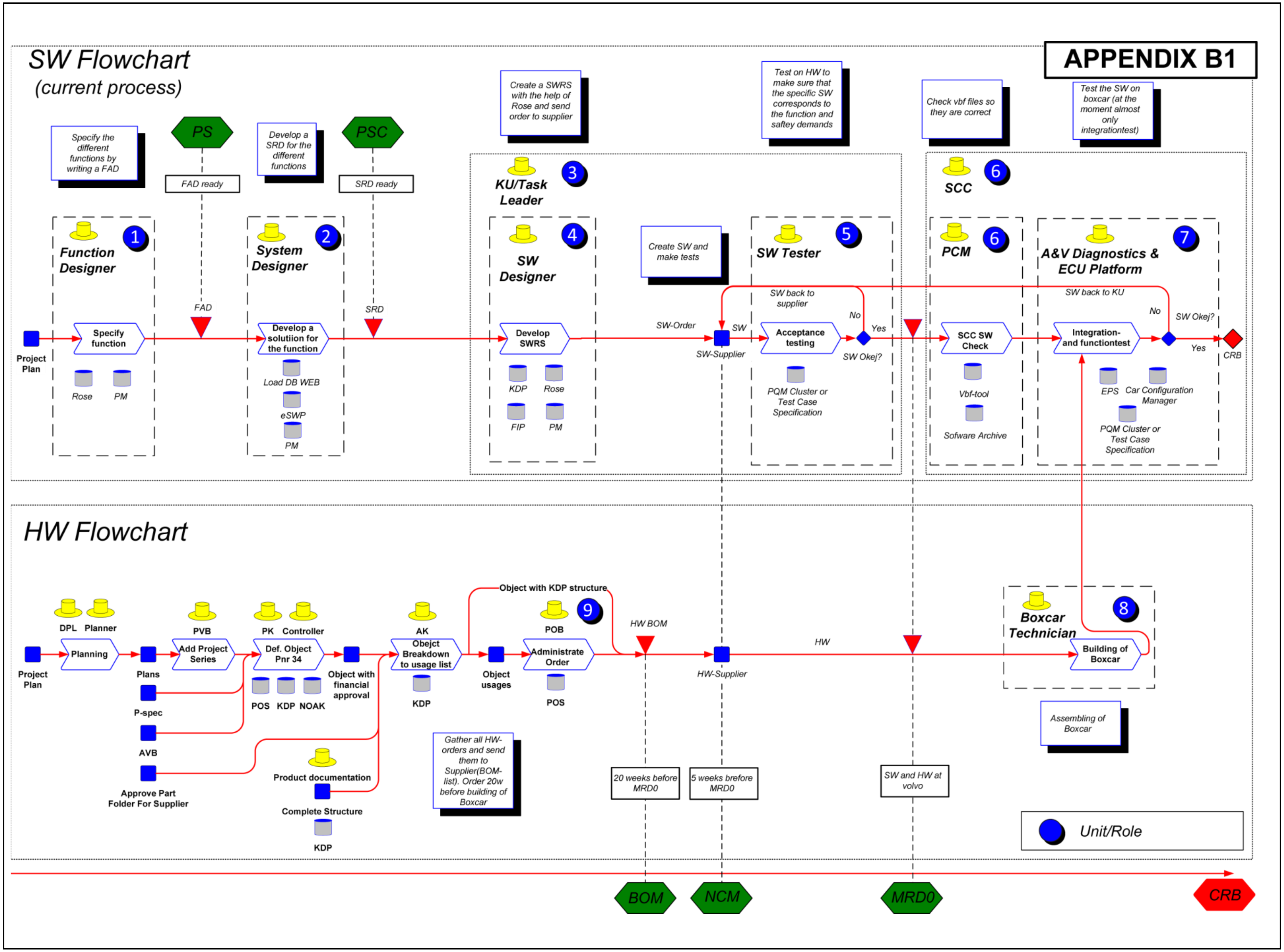
**Det är ordning och reda på dokumentation och planering**

0 1 2 3 4 5 6 7 8 9 10

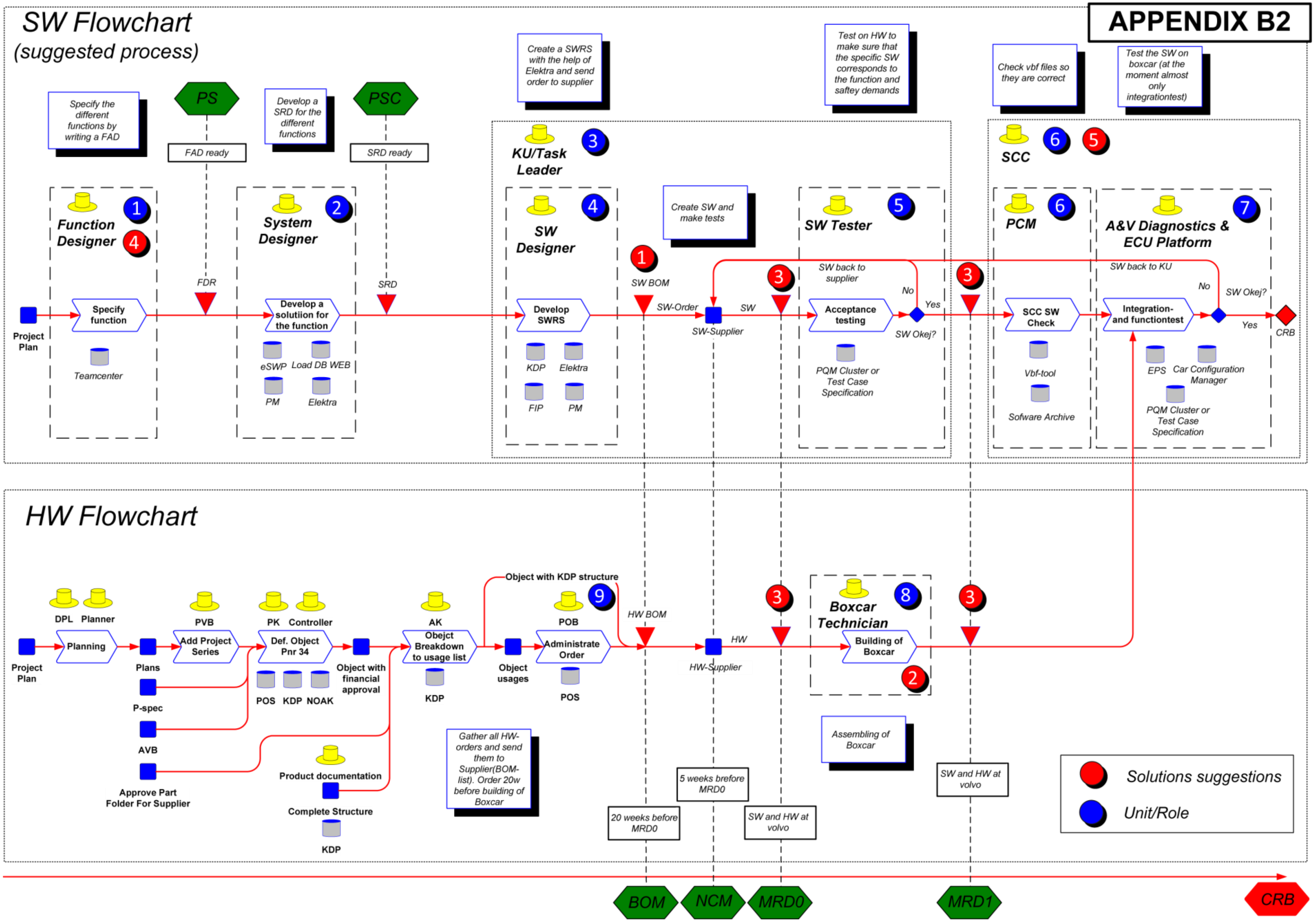
**Kommunikation mellan VCC och leverantörer fungerar väl**

0 1 2 3 4 5 6 7 8 9 10

# APPENDIX B1


SW Flowchart
(current process)
Specify the different functions by writing a FAD
PS
FAD ready
Develop a SRD for the different functions
PSC
SRD ready
Create a SWRS with the help of Rose and send order to supplier
Test on HW to make sure that the specific SW corresponds to the function and saftey demands
Check vbf files so they are correct
Test the SW on boxcar (at the moment almost only integrationtest)
Function Designer
1
System Designer
2
KU/Task Leader
3
SW Designer
4
Create SW and make tests
SW Tester
5
SCC
6
PCM
6
A&V Diagnostics & ECU Platform
7
Project Plan
Specify function
Rose
PM
FAD
Develop a solutiion for the function
Load DB WEB
eSWP
PM
SRD
Develop SWRS
KDP
Rose
FIP
PM
SW-Order
SW
SW-Supplier
SW back to supplier
Acceptance testing
No
Yes
SW Okej?
PQM Cluster or Test Case Specification
SCC SW Check
Vbf-tool
Sofware Archive
SW back to KU
Integration- and functiontest
No
SW Okej?
Yes
CRB
EPS
Car Configuration Manager
PQM Cluster or Test Case Specification
HW Flowchart
DPL
Planner
Project Plan
Planning
Plans
P-spec
AVB
Approve Part Folder For Supplier
PVB
Add Project Series
PK
Controller
Def. Object Pnr 34
POS
KDP
NOAK
Object with financial approval
AK
Obejct Breakdown to usage list
KDP
Product documentation
Complete Structure
KDP
Object with KDP structure
Object usages
POB
9
Administrate Order
POS
Gather all HW-orders and send them to Supplier(BOM-list). Order 20w before building of Boxcar
HW BOM
20 weeks before MRD0
HW-Supplier
5 weeks brefore MRD0
HW
SW and HW at volvo
Boxcar Technician
8
Building of Boxcar
Assembling of Boxcar
Unit/Role
BOM
NCM
MRD0
CRB

# APPENDIX B2


SW Flowchart
(suggested process)
Specify the different functions by writing a FAD
PS
FAD ready
Develop a SRD for the different functions
PSC
SRD ready
Create a SWRS with the help of Elektra and send order to supplier
Test on HW to make sure that the specific SW corresponds to the function and saftey demands
Check vbf files so they are correct
Test the SW on boxcar (at the moment almost only integrationtest)
KU/Task Leader
3
SCC
6
5
Function Designer
1
4
System Designer
2
SW Designer
4
Create SW and make tests
SW Tester
5
PCM
6
A&V Diagnostics & ECU Platform
7
Project Plan
Specify function
Teamcenter
FDR
Develop a solutiion for the function
eSWP
Load DB WEB
PM
Elektra
SRD
Develop SWRS
KDP
Elektra
FIP
PM
1
SW BOM
SW-Order
SW-Supplier
SW
3
SW back to supplier
Acceptance testing
No
Yes
SW Okej?
PQM Cluster or Test Case Specification
3
SCC SW Check
Vbf-tool
Sofware Archive
SW back to KU
Integration- and functiontest
No
SW Okej?
Yes
CRB
EPS
Car Configuration Manager
PQM Cluster or Test Case Specification
HW Flowchart
DPL
Planner
PVB
PK
Controller
AK
Object with KDP structure
POB
9
HW BOM
Project Plan
Planning
Plans
Add Project Series
Def. Object Pnr 34
POS
KDP
NOAK
Object with financial approval
Obejct Breakdown to usage list
KDP
Object usages
Administrate Order
POS
HW-Supplier
HW
3
3
Boxcar Technician
8
Building of Boxcar
2
P-spec
AVB
Approve Part Folder For Supplier
Product documentation
Complete Structure
KDP
Gather all HW-orders and send them to Supplier(BOM-list). Order 20w before building of Boxcar
5 weeks brefore MRD0
20 weeks before MRD0
SW and HW at volvo
Assembling of Boxcar
SW and HW at volvo
Solutions suggestions
Unit/Role
BOM
NCM
MRD0
MRD1
CRB