

# Building a Concept Solution for Upgrade Planning in the Automation Industry

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**Abstract.** Industrial automation systems are long living systems controlling industrial processes such as power stations or pulp and paper production. These systems have strict requirements on the system's availability since all downtime is costly for factories. In such circumstances, all upgrades require special concern and planning, in a context of collaboration between the automation system's provider and user, to minimize downtimes in the user's critical processes. This paper discusses the problem of upgrade planning for such automation systems. It presents a concept solution based on a case study. The research is a part of broader research aiming at a better understanding of system upgrades in the case study company's service sales. The aim is also to enhance solutions for handling the identification and analysis of upgrades in collaboration between the case study company's internal teams and customers.

**Keywords:** Automation system, Upgrade, Transparency.

## 1 Introduction

Long-living automation systems need to operate for periods in excess of 15 years. They are used to control industrial processes such as water management and pulp and paper production [1]. The systems are firstly installed, then operated and maintained, and finally replaced when they reach their end-of-life.

Automation systems have strict requirements regarding the system's availability and consequently all upgrades need special concern and planning to minimize downtimes in the critical processes they control. However, long-living systems need to be upgraded every once in a while in order to meet environmental changes (standards, technologies, devices) or in response to requests from users (bugs, new features)[2]. Automation system vendors seek to prevent a situation arising in which an automation installation at their customer's place of business reaches the point where a major investment is the only way of ensuring their survival. This could open the door to rival system providers. Therefore, it is advantageous for system providers to provide a more cost-effective path for their customer's automation system, one which evolves through a series of small and manageable steps in order to meet any changing needs. It is also easier for customers to justify and schedule the upgrade of discrete elements of the system than a "big-bang" change that would require long downtimes.

Automation system vendors have upgrade or evolution programs that aim at the systematic and controllable evolution of an installed system. Customer offerings have their own special characteristics but in essence all offerings comprise similar activities, such as understanding the customer's business needs, analysing the current installation and creating and presenting a life cycle plan/analysis for the customer's tailored installation. With these analyses the customer gains an insight into their system from the life-cycle management point of view and also the timing for future upgrades of their system, thus assisting the customer in their budgeting process.

The purpose of this paper is to present a concept solution based on a case study conducted in an automation company. The concept presents stakeholders, information systems and data flows related to the automation systems upgrade process. The first version of the concept, presented in this paper, was constructed in cooperation with the case study company. The concept is generic and does not discuss the tools or technologies used by the case study company in detail. This initial concept solution will be developed further and refined iteratively. At the same time, the case study company will build and pilot tools and guidelines reflecting the solution. In this way, iterative concept definition, practical solution development and pilots gradually accumulate and validate the concept.

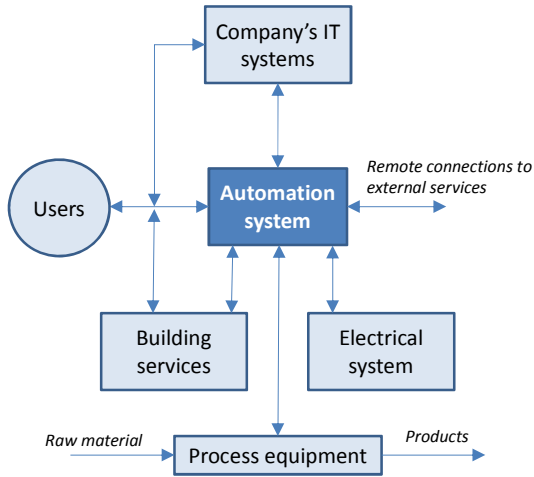
This research and its resultant concept should be of interest to companies that are seeking solutions for the upgrade planning process. The concept also aims to discuss the problem area of upgrade planning, and reports on practical cooperation between the research organisation and the industrial company. Therefore, this research should also be of interest to research organisations.

The paper is organized as follows: Chapter 2 presents the background to industrial automation systems, their upgrading and the role of transparency in this context. The research process is discussed in Chapter 3. Chapter 4 introduces the draft concept for an upgrade planning solution. Chapter 5 draws conclusions.

## 2 Background

Industrial automation systems are used to control industrial processes such as water management and pulp and paper production [1]. Such systems are "long-living" comprising life-cycle steps from installation, operation and maintenance to their end-of-life (shut-down) [2]. Furthermore, the systems work in conjunction with the other systems and devices in the place of business in which they have been installed, such as the user company's information systems (e.g. ERP, Enterprise Resource Planning), process equipment and electrical system [3] (Fig. 1).

It has been estimated that the value of the worldwide installed base of automation systems reaching the end of their useful lives is approximately 65 billion dollars [4]. This can be seen as a big opportunity for both end users and system providers [4]. End users have an opportunity to consider new system providers and system providers have an opportunity to offer system migration paths in order to gain new customers.



**Fig. 1.** Automation system as part of external systems [3]

Automation system vendors have upgrade or evolution programs that aim at the systematic and controllable evolution of an installed system. They seek to protect their customer base and prevent a situation in which the system installed at their customer's place of business reaches a point where a major investment in their automation plant is the only way to ensure their survival. Instead, automation system vendors provide a cost-effective path for a customer's automation system to evolve through a series of small and manageable steps in order to meet changing needs. Vendor-specific evolution/upgrade programs have their own special characteristics but in essence they all comprise the same logic, containing steps including understanding the customer's business needs, analysing the current installation and creating and presenting a life cycle plan/analysis for the customer's tailored installation. Within these analyses the customer gains an insight into the system from the life-cycle management point of view and understands the timings for future upgrades, thus assisting their budgeting process. However, the cost-efficient maintenance of automation system is complex challenge since they are subject to new requirements, new standards, failures, and technology changes during their operation time [1]. Therefore, automation system vendors are interested to build sustainable long-living systems [1]. They also try to provide evidence for customers about the value of the continuous maintenance of existing equipment [5].

Transparency, both inside and outside of a company, has become an important precondition for successful operations in today's technology industry. With better transparency, companies are targeting at improved control mechanisms and decision making in order to react quickly to market changes and opportunities. Transparency is defined in different ways in the literature [6, 7, 8], but in general, each of these slightly varying definitions highlights the importance of transparency in supporting informed decision-making in companies.

For an automation system vendor offering aftermarket services to B2B customers, transparency becomes critical. With the practices and tools supporting transparency, information important for decision making can be provided in a useful way for decision-makers. From the sales team's (automation system vendor's) point of view a great deal of information is needed in order to make informed decisions in sales negotiations and in preparing profitable offers for potential customers. For the vendor's service organization it is important to get up-to-date information from its R&D department, for instance relating to the content of hardware (HW) and software (SW) releases and their compatibility. Furthermore, complex industrial systems have dependencies to third party components [9] and it is important to understand the dependencies between the system and third party components and their evolution roadmaps. Customer data, offers and contracts are also important information for the sales team. The sales team is also interested in the current system in use by a potential customer. It is also highly beneficial to be aware of the business targets and requirements that the customer has in regard to the system's further evolution. Customer requirements in general are a vital input for the sales team and in fact the customer's whole business needs to be taken into account when considering any innovation and roadmapping processes. Therefore, transparency around the relevant information is very much needed by the sales team for creating successful offers to potential customers.

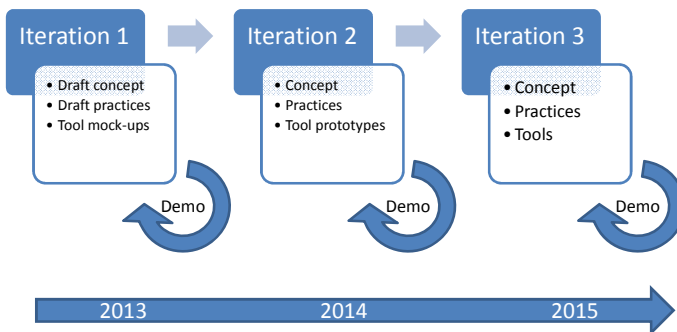
### 3 Research Process

This work was carried out within the international research project *Varies (Variability In Safety-Critical Embedded Systems)* [10]. The research was undertaken in cooperation with a company that operates in the automation systems industry. The company offers automation and information management application networks and systems, intelligent field control solutions, and support and maintenance services. This research focuses on the automation system product sector. Automation systems are multi-technological systems comprising HW and SW. The role of SW is increasing in automation systems – as it is across all engineering domains. Typically, the customer-specific, tailored installation of the system is based on a generic product platform and a new version of this product platform is released annually. The (generic) main sub-systems in an automation system include: Control Room, Engineering Tools, Information Management and Process Controllers.

Engineering tools are used to configure the automation system to fit the customer's context. This includes, for instance, the development of process applications and related views. The customer-specific configurations of automation systems are long-living and need to be maintained and updated, if necessary. Case company highlighted that the importance of upgrade services has increased. An increasing proportion of revenue comes from the service business. Each update will be analysed individually to find the optimal solution for the customer based on the customer's business needs. Because of the demands of customer-specific tailoring there are many customer-specific configurations in the field containing sub-systems from different platform releases (versions). Therefore, the service organisation (the system provider)

needs to track each customer configuration of an automation system and detect what upgrades are possible for each customer. Upgrade requirements may mean that an upgrade escalates across several sub-systems for compatibility reasons. This needs to be detected and analysed in order to produce accurate information for upgrade sales negotiations. Since the prominence of service business (offered by the system provider) has increased, it is important to fine-tune the upgrade service sales process to enable focused and accurate upgrade service offerings.

This research is part of broader research aiming at a better understanding of system upgrades in the case study company's service sales team and at enhancing the solutions for handling upgrade identification and analysis in the case study company. The aim of the paper is to present the first version ("Iteration 1", Fig. 2) of the concept. This illustrates the stakeholders, information systems and data flows related to the automation system's upgrade planning process. This concept will be refined iteratively in future (Fig. 2). At the same time, the case study company is enhancing its existing tools, developing new tools and piloting them in relation to upgrade planning. Therefore, iterative concept definition, practical solution development and prototypes/pilots gradually accumulate and validate the concept.



**Fig. 2.** Iterative plan for the development of concept, practices and tools in collaboration with a case study company

The concept presented here is based on the case study data that was collected using interviews and workshops. Firstly, five people from the case study company's service team were selected for interview. All interviewees had in-depth experience of working within the company's service function. Secondly, participants were selected for workshops, drawn from both the service and R&D teams. These workshops were held *in situ* at the case study company, during which additional case study data was uncovered, then fed back and discussed. The case study data revealed what solutions for upgrade planning are currently in use by the case study company and what existing or desired features the service team finds most useful. Furthermore, two to three people from the case study company participated in a number of workshops where the focus of the work was refined and the practices and concept were drafted, presented and reviewed. Concept-building was supported by a collaborative environment tool

providing concurrent access for the case study company representatives and researchers whilst describing the concept solution (Fig. 3). (The research team was located in Oulu, northern Finland, and the case study company is located in Tampere, southern Finland.) The intention was to collect all concept-related discussions and material in a shared space where both the researchers and company representatives could easily share the material and ideas related to concept-building. The collaborative environment implemented was a SharePoint extranet site.

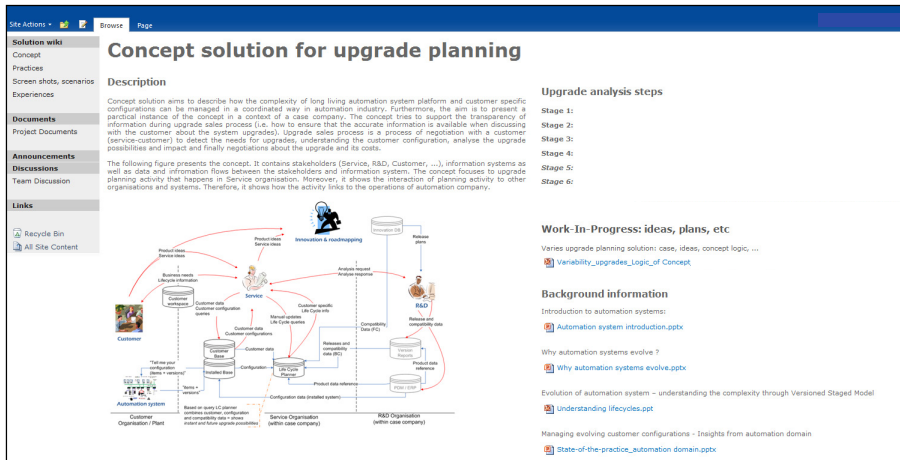
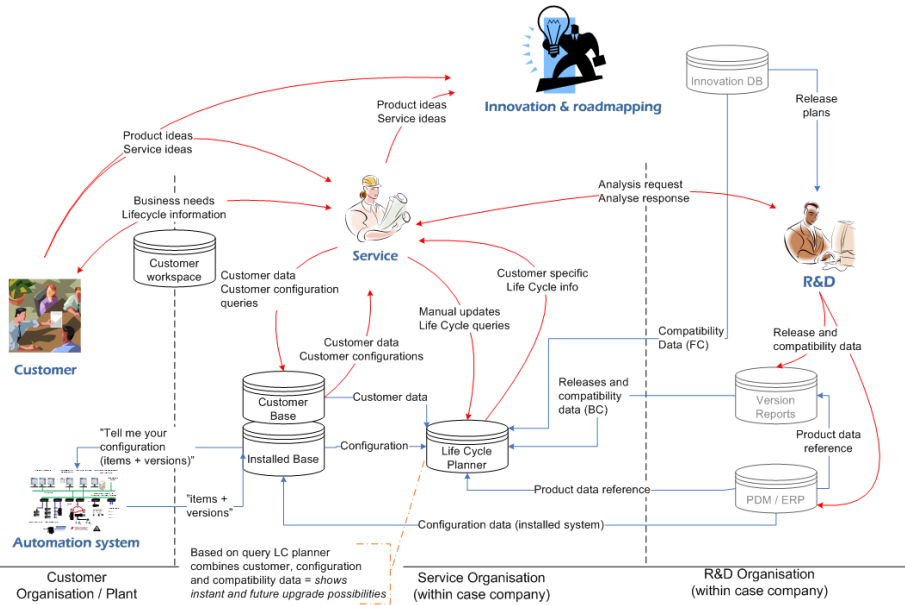


Fig. 3. Collaborative environment for concept development

## 4 Concept Solution

The concept solution aims to describe how the complexity of long-living automation system platforms and customer specific configurations can be managed in a coordinated way from an automation system provider perspective. The concept highlights the transparency of information during the upgrade sales process, such as how to ensure that accurate information is available when discussing system upgrades with the customer. The upgrade sales process lies within the remit of the service team and is about: negotiating with the customer to detect the requirements for upgrades; understanding the customer’s tailored configuration; analysing the upgrade opportunities and impacts; and finally negotiating over the upgrade and its costs. In this context, collaboration and transparency across the organizational boundaries internally at the provider company and with the customer company is vital.

Fig. 4 illustrates the first version of the concept defined during the first iteration. It contains stakeholders/organizational functions (Service, R&D, Customer, Innovation/Roadmapping) and information systems as well as the data and information flows across organizational boundaries and their information systems. The concept solution focuses on upgrade planning activity that lies within the remit of the service team.



**Fig. 4.** First version of the upgrade planning concept solution

The concept identifies the information systems that are needed internally for managing customer-specific configurations, dependencies and customer information. Furthermore, it incorporates an information system for communication and collaboration externally with customers. The primary information systems that relate to the upgrade planning process are: Customer Workspace, Customer Base, Installed Base and Life Cycle Planner. These are described as follows:

- *Customer Workspace*: a collaborative tool where the service organization and customer can discuss, share material and comments regarding the installed automation system.
- *Customer Base*: a database containing information about customers and customer sites.
- *Installed Base*: a database containing information about customers' installed systems, including: SW versions, applications, HW, third-party SW and HW versions, licence information, etc. Some of this information is collected automatically via a network connection with the customer's automation system.
- *Life Cycle Planner (LCP)*: a tool that combines the platform's forward (FC) and backward (BC) compatibility information together with the installed base information. Based on this information, the LCP describes the dependencies existing in a single customer configuration taking into account the needs of that customer (remembering that small changes may escalate into other sub-systems). Furthermore, it describes the future upgrade requirements for the sub-systems in a timeline (for instance, the upgrade requirements for each sub-system during the next five years).

The process of upgrade sales begins with the identification of the customer's requirements for upgrades. Here the understanding of the customer's business logic is extremely important in identifying any bottlenecks in the customer's industrial processes, and proposing remedies for them. Service engineers work closely with customers, typically at the customer's place of business, which puts them in a good position to understand the customer's issues and requirements. Close cooperation with the customer allows the identification and collection of product and service ideas for the innovation and roadmapping function that contributes to future product and service offerings. The impetus for an upgrade may originate from the customer side (e.g. a requirement for a new functionality) or from the automation system provider side (e.g. a component or third party SW end-of-life notification from a component supplier).

Identifying the customer's configuration reveals the exact configuration for that customer's automation system. The information is stored in an Installed Base database. The system comprises information such as SW and HW versions, applications, third-party SW/HW, etc. Accurate information is needed to minimize errors in the update planning process since the existing configuration is needed as a baseline for upgrade analysis.

In the analysis phase, the service team - in cooperation with the R&D team - analyses what needs to be updated in the customer's configuration in order to meet the requirements of the customer whilst maintaining the customer's automation system in good condition. Here, the information about system dependencies is crucial. Dependency information shows how far updating one sub-system may escalate to other sub-systems in a customer's configuration. This information is important for the service team in order for them to compose an accurate upgrade offer for a customer. In this concept, the Life Cycle Planner tool combines dependency information with the information on the customer configuration and upgrade requirements. Based on this information it produces life cycle plans. The life cycle plan presents the life cycle of each part of the system, illustrating for a single customer what needs to be upgraded and when, and at what point in time a bigger migration might be needed. The plan supports the customer in preparing themselves for the updates, e.g. by predicting costs, schedules for downtimes, rationale for management, etc. For the service team, this tool gives an understanding of upgrade needs from which they can propose and justify updates for a customer in a timely manner that maintains the customer's automation system in good condition.

## **5 Conclusions and Future Work**

This paper presents a concept solution based on a case study conducted in an automation systems company. The concept presents stakeholders, information systems and data flows related to the automation systems upgrade planning process. The concept highlights the importance of transparency of information between the provider company's own internal organizational units and their customer during the upgrade sales

process. The main question is how to ensure that accurate information is readily available when discussing system upgrades with the customer.

The first version of the concept was constructed in cooperation with the case study company. The concept is generic and does not discuss in detail the names of the tools or technologies that are used in the company. This concept will be refined iteratively. At the same time the company will enhance, build and pilot tools and guidelines reflecting the solution. Therefore, iterative concept definition, practical solution development and pilots gradually accumulate and validate the concept. The limitations of the study relate to the nature of the case study method. The concept will be iteratively constructed and demonstrated in cooperation with a case company operating in automation industry. Therefore, first the concept will be limited to that context. However, there is an intention to harvest more experiences about the use of concept also in other domains (e.g. telecommunication domain).

This paper also reports on practical cooperation between a research institute and an automation company. The paper explains how researchers and company representatives have cooperated to contribute to both research and practice.

This research and its resultant concept should be of interest to companies that are seeking solutions for the upgrade planning process. The concept also addresses the problem area of upgrade planning in general and reports on research cooperation between a research organisation and an industrial company. Therefore, this research should also be of interest to research organisations.

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