BUSINESS FLOW MANAGEMENT IN COMMUNICATION BASED TRAIN CONTROL SYSTEMS

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Abstract - Today, global competition is growing rapidly in every field of work. There is an increasing trend towards quality all over the world and consumers' expectations about quality are increasing. The prerequisite for being in these conditions is always to keep up with the dynamic structure of the age, to be open to changes and innovations and to adapt new systems, techniques and technologies to their bodies. Otherwise, organizations are doomed to be stayed behind. On the other hand, there have been significant changes in manufacturers' views on quality. It is understood that rather than paying attention to the quality of the finished product, to achieve quality in every stage of a production process is more importantThis system is applied not only in the sectors of production and services but also in Information Technology. Kanban techniques have been developed and implemented recently to control the parameters affecting product and process management, to manage and optimize their deviations. Kanban, Lean Startup, MDD and IDC business flow techniques of Communication Based Train Control Systems (CBTC) in the Railroad Systems using are investigated in this study.

Index Terms - Automation, Communication, Signalization, Train Control, Kanban

I. INTRODUCTION

CBTC systems have become widespread worldwide as a result of the increasing number of new metro systems and the renewal of old metro signaling systems. Today, it is very common to implement a CBTC systems to the metro and light metro systems. It is not preferred to integrate main lines because of many reasons. Increasing the number of CBTC systems bring the necessity of more modular and easy to implement. For this reason, CBTC systems need to be researched and developed more due to increasing safety needs and operational requirements. The precise position of a train through CBTC systems is more accurate than conventional signal systems. This provides a more efficient and safe way to manage rail traffic.

A CBTC system which uses high-resolution train location detection independently of the runway circuits is able to implement Automatic Train Protection (ATP) functions as defined in the IEEE 1474 standard, as well as the optional Auto Train Operation (ATO) and Automatic Train Control (ATS) functions.

There are many types of CBTC systems developed according to customer needs. In addition CTCS (Chinese Train Control System) is developed and very common in China, ETCS (European Train Control System) is very common in Europa. These systems is able to be grouped under grade of automation level (GoA) which defines how much automatic a CBTC system. For instance, in a GoA 2 level system, the train driver is only responsible for opening and closing the doors and activating Emergency Brake (EB) in an emergency situation. In these type systems, the train moves itself, stops at the stations, moves again by applying the tariff according to its own timetable. If the system is on GoA 4, there is no longer a need for a train driver and a driver's cabin. All functions, including functions such as door opening / closing, are operated automatically.

Edge processors are a part of an automatic train control system that can be used for continuous, high-capacity, bidirectional rail-way data communication. Automatic Train Control (ATC): It is the system using to control train movement automatically, to ensure train safety and to guide train operations. The ATC subsystem on the train on-board consists of its own subsystems such as on-board ATP and on-board ATO. On-board ATC communicates continuously with the on-board pathway responsible for safe traffic management. The on-board ATC calculates its position of the train and transmits it to the wayside ATC at small time intervals determined by the train location. As wayside ATC knows all train positions in a CBTC line, it keeps the trains at a safe distance from each other, namely, it keeps the operation going in a safe manner. For this purpose, the wayside ATC generates a Movement Authority (MA) to determine the final destination of the trains. On-board ATC operates the train on a comfortable ride without passing the designated limit, movement authority. In a situation where a new movement authority is not received, the on-board ATC stops the train before the last defined MA point.

Automatic Train Operation (ATO): In the ATO system, speed regulation, programmed stop, door control, performance level regulation or sub-system that performs any or all of the other functions assigned to the train operator. Automatic Train Protection (ATP): A sub-system that protects the ATP system from collisions, high speed and other dangerous

conditions with a combination of fault detection, train detection, train separation and locking.

Automated Train Supervision (ATS): The subsystem monitoring trains in the ATS system sets the performance of individual trains to maintain their programs and provides data to adjust the service to minimize disturbances caused by irregularities. The ATS subsystem also typically includes manual and automatic routing functions.

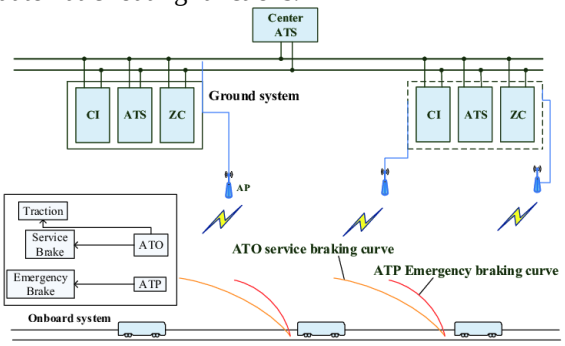


Figure 1 CBTC System [2]

As the name implies itself, the communication is the backbone of the CBTC systems and the whole system depends on the survival of the communication. The signaling companies prefers different type of solutions to make a stable communication. 2.4 GHz wireless communication is a very common communication in which the tunnels and also open air of metro line must be covered by wireless network. All trains should have wireless antennas on front and behind or more. Another one is the leaky cable communication with train antennas which is very stable if it is implemented very well. Also, some signaling companies still offer a thin cable on the middle of the rails (and train has an antenna under its own) which also provide a stable communication but it is open possibility of the failures more because of accessibility.

The second most important issue after the communication is to know the position of the trains in high resolution. In CBTC system, all trains have to calculate its own position by using speed detector and vital computer in a safe manner. The train on-board system receive the data fromspeed detectors such as tachometers and calculates the position by integrating speed to obtain location. However, depending on the sensitivity of the sensor, the error in this position calculation will increase by time. So that, there are some reference points along the line and when a train pass this reference point, it resets the error on the position. This means that the reference points should be implemented to the system more frequently especially in stations in order to make possible to stop in an exact stop position.

CBTC systems are divided into several subsystems to enhance modularity and share tasks. The functions of the CBTC system are run in a hierarchical manner. On other words, the functions are segregated to subsystems such as safe-nonsafe, communication related-database related are included within different subsystems. This type of grouping have several advantages like reducing development time and decreasing the complexity of the operation and maintenance.

Main advantages of CBTC systems can be summarized as follows:

- Optimized train speeds to achieve best line capacity, reduce costs and ensure the best passenger comfort.
- Easily practical, start the operation from the first day.
- Automatic operations and easy maintenance.

In modern CBTC systems, trains continuously calculate and transmit their status via radio signals. This includes the exact position, speed, travel direction and braking distance between the other parameters. This information allows the calculation of the space occupied by the train in the road. At the same time, it allows roadside equipment to identify positions of each train on the line that should never be exceed by other trains. These points are transmitted automatically to maintain the speed and comfort requirements. Thus, trains continuously receive information about the distance of the nearest train on the same line and then adjust the safety distances accordingly.

II. BUSINESS FLOW MANAGEMENT IN CBTC

Train Control (CBTC) systems are communication based and digitally encoded management systems such as profile-based track circuit technology. The use of CBTC technology is in many ways of workflow management in railway technologies, as well as the implementation of the Kanban method reduces waste in the process, minimizes inventory, reduces procurement time and capital losses. It is aimed to contribute to Kanban's team work with the thesis.

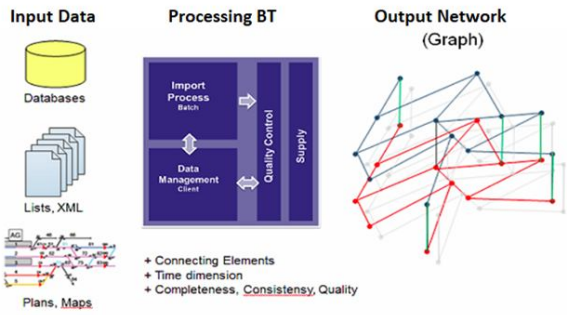


Figure 2 IT Network [5]

Railway technology units contribute to this efficiency by converting large amounts of raw data into an information network for railway program and control. This is the key success criteria for the completeness,

quality and consistency of the information network.

Together with the department manager, release manager, product manager and the leaders of these core teams form the leadership team who share responsibility for the success of the technology unit.

Most interdisciplinary technology departments for railways use Kanban to transform performance into efficiency through gradual improvement.

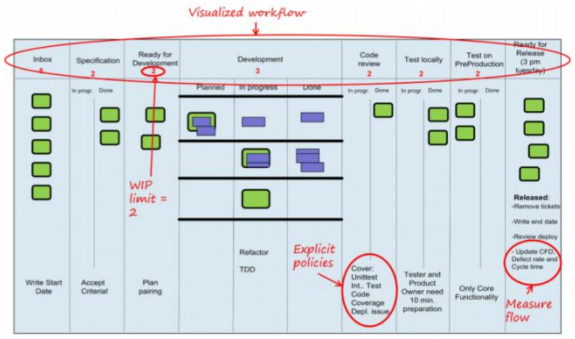


Figure 3 IT Kanban [6]

A. Lean Startup

Unlike traditional product development methods that lead to poor results when uncertainty and risk are found, the Lean startup method successfully adopts uncertainty and risk by verifying assumptions about customers in the product development process.
Lean startup focuses on customer development and the implementation of agile in the provision of successful products or services in a highly uncertain environment.

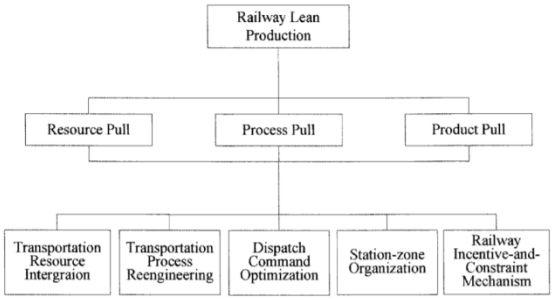


Figure 4 Railway Lean Production Method system [7]

The origins of Lean Startups range from the late 1980s to the work of lean production in Toyota. Toyota has used a timely inventory management to produce small batches of cars in small amounts as distinct from its US competitors. Toyota's focus on quality, eliminating waste and continuous improvement with Kanban has made it a reference point for lean production.

B. Model Driven Development

To develop a safe and reliable CBTC system, the CBTC software must be properly developed. Model driven development (MDB) is one of the approaches that follow the accuracy of the software. With the help of software engineering technologies, MDD is being carried out these days. The primary feature of MDB is the software development which is the main part of the system and in this development process products are not computer programs, but models. In contrast to the traditional approach, the study can let to make prototypes earlier and control the model by quickly simulating the validity of the model so that the advantages of the MDD approach can be determined.
In an attempt to implement the Model-Driven Development approach, the CBTC software can be developed to model the CBTC system consistently and test the system with the help of a CASE tool.

When developing software for CBTC systems, various software engineering techniques must be used to comply with standards such as IEC 62279 for the safety and reliability of railway software.

Here presented an attempt to implement MDD approach in the development of the CBTC system. For this, a development process called Harmony and a CASE tool named Rhapsody are adopted.

C. Harmony Process

Harmony is a model-based hybrid iterative process that supports increased software engineering as well as top-down system engineering.

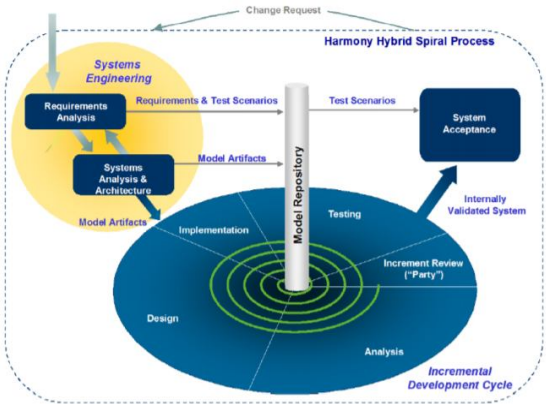


Figure 5 General Harmony Hybrid- spiral [8]

D. The Incremental Development Cycle

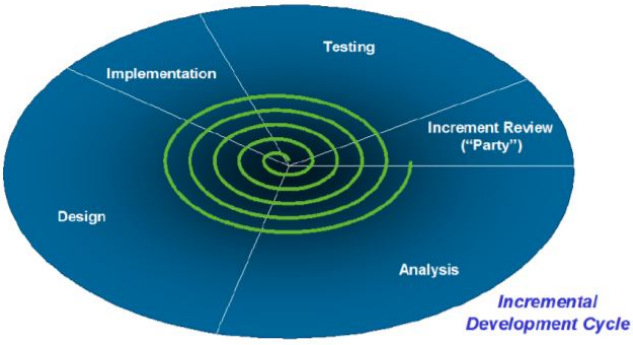


Figure 6 Incremental Development Cycle (IDC) [8]

The Incremental Development Cycle (IDC) is an incremental process in which the requirement items are selected from a set of predetermined requirements (on the one hand a UML / SysML model and on the

other represented as a set of test vectors) and vertical segments.IDC consists of five stages:

• Analysis,
• Design,
• Application,
• Testing,
• Increment Review.

An analysis model focuses on defining the features required for any acceptable solution. In the analysis phase, objects and classes with object identification strategies are determined for each use case

CONCLUSIONS

CBTC communication is more radio based. The fact that the CBTC systems operate independently from the track circuits reduces the number of hardware required. These systems which were formerly mechanically and electromechanically made are now made electronically and computer based depending on the development of technology. The use of CBTC technology in many ways for workflow management in railway technologies, as well as the implementation of the Kanban method reduces waste in the process, minimizes inventory management, reduces procurement time and capital losses.

REFERENCES

[1] C.S. Yang, J.S. Lim, J.K. Um, J.M. Han, Y. Bang, H.H. Kim, Y.H. Yun, C.J. Kim, Y.G. Cho LS Industrial Systems, Anyang, Developing CBTC Software Using Model-Driven Development Approach Korea, (2008)
[2] Richard Yu, Deep Reinforcement Learning-based Performance Optimization for Communication-Based Train Control Systems.
[3] B. P. Douglass. "Real-Time UML Workshop for Embedded Systems", Newnes, (2007).
[4] H.P. Hoffmann. "UML2.0/SysML-Based Systems Engineering Using a Model-Driven Development Approach", I-Logix, (2005)
[5] www.infoq.com/articles/kanban-on-track
[6] Boeg, Jesper. Priming Kanban: a 10 step guide to optimizing flow in your software delivery system. Trifork, 2011.
[7] Applicability and Methods of Lean Production in Railway Transportation Organization: A Case Study of Urumqi Railway Bureau in China, IJR International Journal of Railway Vol. 1, No. 2 / June 2008, pp. 45-58
[8] C. Atkinson, T. Kuhne. "Model-Driven Development: A Metamodeling Foundation", IEEE Software, Volume 20, Issue 5, pp. 36-41, (2003).
[9] www.infoq.com/presentations/kanban-change-railway
[10] IEE 1474.1. (2004).Standard for Communication Based Train Control (CBTC) Performance and Functional Requirements, IEEE Vehicular Technology Society
[11] IEEE 1474.3. (2008). Recommended Practice for Communications-Based Train Control (CBTC) System Design and Functional Allocations, IEEE Vehicular Technology Society.

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