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The advantages of an integrated company on safety and availability matters

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This article deals with the gains on safety and availability of rail systems for an integrated company. The RATP gathers railway operating, maintenance and engineering activities. To maximize the benefit it can take part of this situation, the RATP adopted an integrated engineering. In a first part, this article describes the organisation of the RATP as an integrated company, then it presents the advantages of this organisation on availability and safety in the project life cycle, and finally it presents the rolling stock example in the middle of the integrated engineering interfaces and the benefits provided by the integrated company.

1 – The RATP, an integrated company

Railway duty holder accountabilities for the overall system or its parts and life-cycle activities are sometimes split between one or more bodies. Usually, it is split between the owner of one or more parts of the system assets, the operator of the system and the maintainer of one or more parts of the system. As an integrated company, the RATP gathers these principal activities related to the railway operating. This position provides the RATP with advantages to maximise its benefits in term of availability and safety. The example of rolling stock shows how useful it is to merge operator, maintainer and engineering staff and skills in order to enhance the availability and safety level.

Experience makes the difference.

The RATP engineering is based on coherent skill background to meet the passenger demand. The engineering organisation is relative to the RATP missions, infrastructure manager and railway operator. The project management calls for a body of departments in charge with the detailed concept, the management of the infrastructure achievement, the train control system and the rolling stock. The RATP engineering is part of the only one in the world which is in charge with a one hundred year old intermodal public transport net. It has to be adapted to the new client demands whilst ensuring daily operation and maintaining the safety level. The engineering deals permanently with operating environments.

A global approach to the life cycle

The engineering provides further services than turnkey solutions; it updates them and improves services provided to operator and passengers. Hence in the full automated subway transport mode, the RATP has not only been pioneer by achieving the full automated line 14. Since its opening in 1998, it is updated and their performances are improved. This global vision of infrastructure life cycle allows obsolescence foreseen. The project economy is thought from beginning including safety, availability, operation and maintenance matters. The post-operation steps are also thought to facilitate coming modifications or renewals.

Line 1 automation, an organisational challenge

The line 1 of the Parisian subway has often been taken as an example for innovation. The automation of the line 1 without service interruption is the only one done in the world. This favourite project of the wider Parisian net updating was organised following different projects and their coordination was decisive to the final success: the installation of the platform doors, the rolling stock commissioning, the new full automated train control system integration, the training, etc. The choice to achieve this project without service interruption allowed only few hours available by night. The 100 works in progress at the same time was another organisational challenge. The understanding of the operation and maintenance constraints were decisive to ensure the safety and availability performances.

The integrated engineering

The engineering offers its client turnkey solution to meet their demand and assists them during the project. The integrated engineering organisation allows providing with more than design activities. It creates cross-fertilisation among operation skills, safety, availability and maintenance matters. Every skill is concerned. The widening of the technical matter range involves enhancement of the collaboration between skills to ensure the functioning of an intermodal transport net. The motivation of the creation of the integrated engineering is to make skills work together in a coherent, balanced and efficient way. The integration could be as well synthesise, technical coordination or system integration. Anyway, it has to be carried out by every stakeholder. It ensures not only the success of the project but also enhances the safety and availability level of the system.

Organising the collaboration

The integration activity needs to take into account the client requirement and to share these requirements with the contributors. But it also needs to raise awareness of integration matters among the project contributors. Each contributor is expected to be attentive to the integration and to have a global understanding of the activity but not only of his contribution. To implement this target, the organisation needed to facilitates links among contributors and between them and the integration.

Structuring missions

Structuring missions are technical coordination, synthesise and system integration:

- The technical coordination gathers the body of activities that ensure the client to have a global solution that take into account every project management activities.
- The synthesise aims to ensure coherence between the activities regarding architectural, functional and technical solutions in the operation and maintenance environment. It is crucial to arbitrate operator, maintainer and engineering constraints including availability and safety matters.
- The system integration gathers the technical activities allowing to take into service a body of components (products/ systems) whose features complies with the expected performances (functions, availability, operation capability, safety, modification capability, etc.). The system integration aims to size the correct amount of cost whilst complying with expected features and safety and availability targets. Even if the system integration is implemented at the latest steps of the project life cycle, it has to be anticipated at the requirement step. And it has to be taken into account by every contributor..

The diversity of professional careers

The integrated engineering supports transversality and mobility of every engineer. This mobility allows them to develop complementary skills. This large diversity of experiences in different environments facilitates the finding of the most suitable solution taken into account all the interfaces of the project.

2 – The advantages of an integrated company in the project life cycle

To provide railway applications with safety and availability at affordable cost, they have to be considered right at the beginning of a project and continuously throughout the complete development and operation. At each step of the project, the nearness of operator, maintainer and engineering staff facilitates collaborations between employees, insights and improvement actions. It is essential to define the most efficient concept and to translate it into requirements, to validate safety and availability design, to implement availability and safety monitoring, to optimise availability in operation phase while maintaining safety performances and to allow maintenance optimisations. Being an integrated company makes the job easier to implement Deming wheel at large scale.

Interrelation of RAMS (Reliability, Availability, Maintainability, Safety) activities and nearness between operator, maintainer and engineering

The EN 50126 presents the now widely known interrelation of RAMS-management process and system life-cycle. The nearness between operator, maintainer and engineering provides the RATP with benefits at several steps of the system life cycle. Attainment of in-service availability targets can be achieved by optimising reliability and maintainability whilst considering the influence of maintaining safety. The related requirements should be met and controlled through the ongoing, long-term, maintenance and operational activities and the system environment. The knowledge of these activities and environment facilitates the RAMS study implementation and condition their trust level.

Technical concepts of availability are mainly based on the knowledge of reliability and safety in terms of

- all possible system failure modes in the specified application and environment;
- the frequency of occurrence or the likelihood of each failure mode;
- the consequences of the failure mode on the functionality of the system.

Technical concepts of safety are mainly based on the knowledge of

- all possible accidents and associated hazards that could result from a failure in the system, under all operation, maintenance and environment modes;
- the characteristic of each hazard in terms of the severity of its consequences;
- safety-related failures

As a result, sequence or coincidence of events, failures, operational states, environment conditions in the application that can result in an accident and the frequency of occurrence of the relevant events and failures are decisive factors of the study success.

Obviously, the nearness between operator, maintainer and engineering facilitates the implementation of the RAMS activities. Furthermore, it transforms the traditional focus on accidents and loss to understanding, control and management of threats and hazards. This shift in the availability and safety approach introduces a more profound knowledge on the root causes of faults, errors and failures. It results an approach of treatment of risks in two combined ways, one traditionally focused on identification, evaluation and assessment of risks realized by safety and availability specialists and another one exploring the profound knowledge of operational activities including a wider range of skills and human resources (see figure 3). This principle underpinning the assessment of risks constitutes a comprehensive framework capable of rendering a thorough understanding of the key threats, hazards and the magnitude of potential risks associated with these in a given context.

The organisation principle to ensure exhaustive feedback and lessons retain

Besides the integrated engineering principle developed earlier, the rolling stock department provides with an organisation principle to ensure observation and to help the RATP to improve efficiency by ensuring that lessons learned in the past are retained.

Traditionally, safety and availability are treated as a specialist disciplines and relegated to a particular group of staff solely concerned with these targets. However, whilst safety and availability performances have their specialist niches, its understanding and implementation need data and practices referred to a wider organisation. To take advantages of the integrated company, safety and availability culture and values in accident prevention should be common to all who have a role in the provision of service or systems with a potential to cause harm to the customers or damage to the environment and property. To fit with this claim, apart from specialist activities, the rolling stock department has an inspection entity attached to the director (see figure 2). Observations, suggestions and feedback collection are implemented by the inspection entity. In relation with the operator and the maintainer, this inspection entity ensures of providing with exhaustive feed-backs and trusted trigger events. Furthermore, it ensures a pervasive broadcast of safety and availability culture to both maintainer and operator.

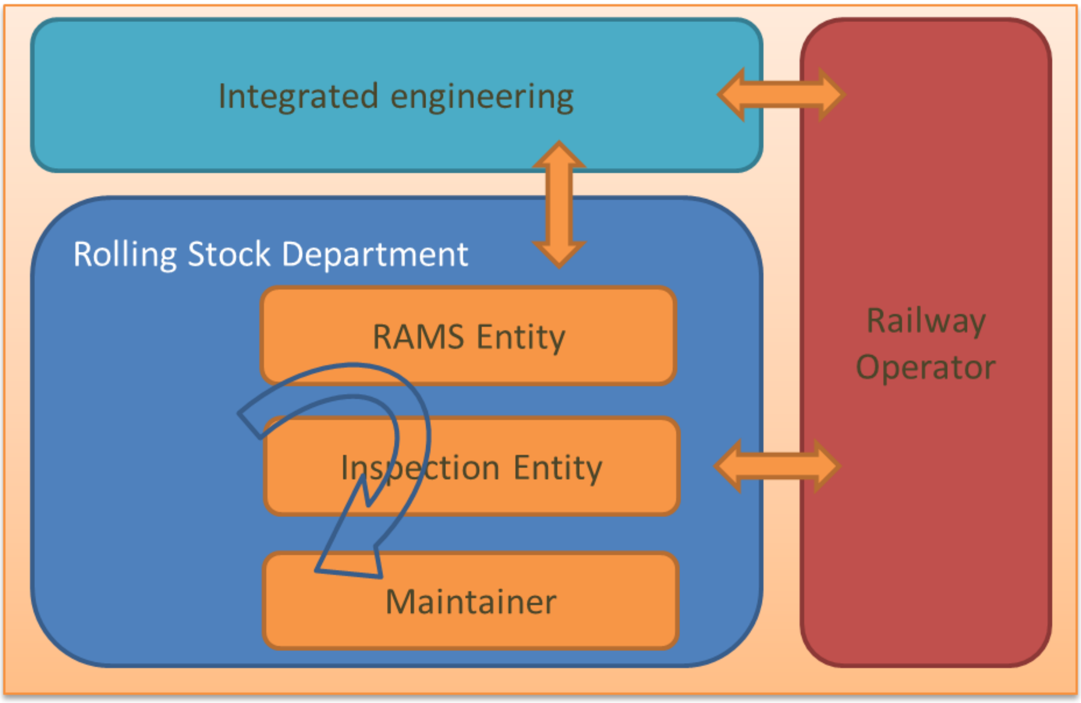

Figure 2: Interrelation between operator, maintainer and engineering

The other facet of the organisation principle is the ability to learn and capitalise on the railway operation and on the new and innovating systems (see figure 3). A key instrument supporting the learning process is the recording of relevant knowledge and resultant learning. Once more the nearness between operator, maintainer and engineering makes the job easier to collect up-to-date directory of operational threats/hazards that needs to be initiated at system level whilst being updated for local conditions. One of the tools established by the rolling stock department to implement this task is the daily inspection report accessible to the whole department to inform them about all pertinent issues which may relate to their roles and tasks. It includes records of reported failures, threats, incidents and accidents and any analysis establishing causation and the degree of harm or damage caused. It is crucial that these are captured, shared openly and employed actively to enhance systems and processes with a view to prevent future occurrences (prevention principle). This is an essential aspect of learning.

The focus on organisation and learning ensures that competent people are trained and lessons are learnt from faults, failures, incidents and accidents with a view to eliminate or minimise future occurrences.

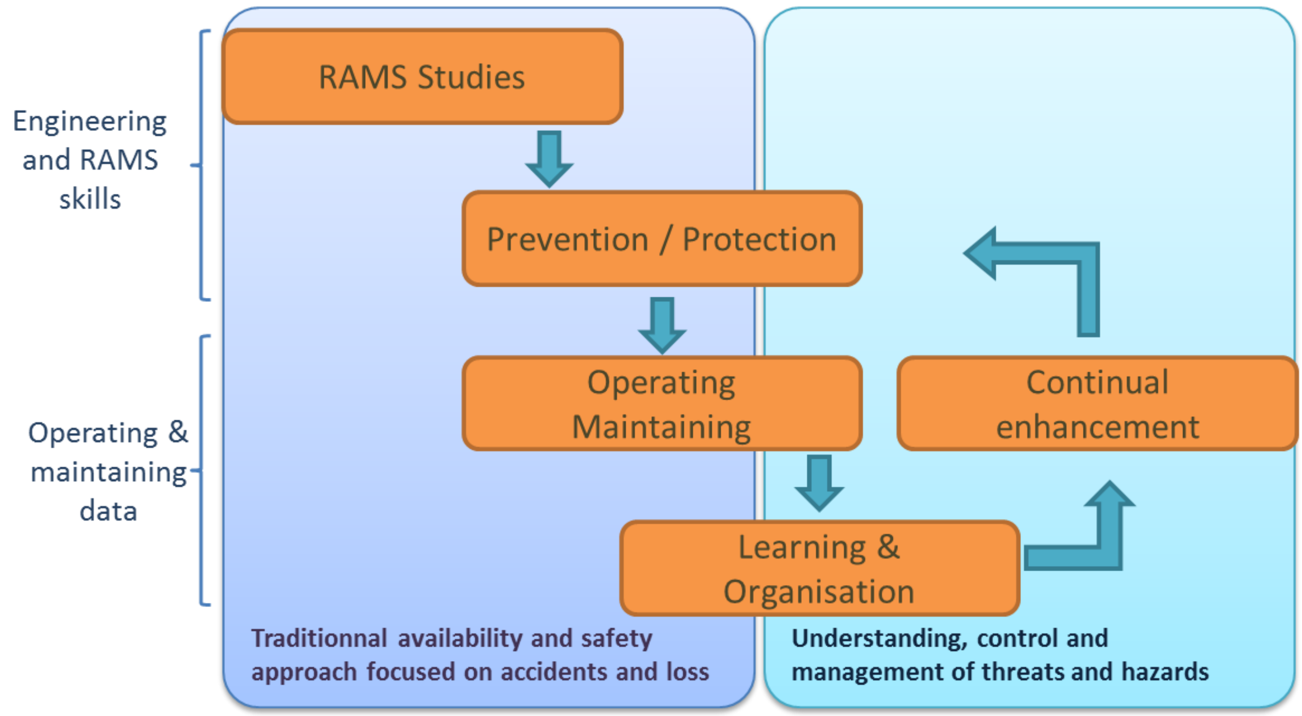

Figure 3: The organisation to ensure exhaustive feedback, lessons retain and continual enhancement

The figure 3 shows the advantages provided by the nearness between operator, maintainer and engineering. This organisation provides further advantages than prevention and protection to threats. It ensures exhaustive feedback, lessons retain and continual enhancement. Prevention is all measures, processes, activities and actions including maintenance aimed at eliminating or reducing the likelihood/frequency of threats/hazardous states with a potential to cause harm and loss. Protection is all measures, processes, activities and actions aimed at reducing the likelihood/frequency or severity of potential accidents arising from the hazardous states or security breaches.

Continual enhancement principle

Whether identification of key performance indicator are key instruments to maintain a high level of quality, proactive control of risks by sharing operator, maintainer and engineering skills is a key instrument in enhancement of availability level while maintaining safety level.

The continual enhancement of performance principle is essentially constituted by a comprehensive approach to identification and monitoring of precursors to accidents and relevant criteria of availability and safety. The nearness of the operator, the maintainer and the engineering is crucial to ensure exhaustive feed-backs and trusted trigger events. Examples are developed farther between the operator and the proximity maintenance workshop.

Besides, it has been noticed that enhancement of availability or safety performance could arise from the introduction of novel feature or functionalities or identification and strengthening of the barriers to hazards through adoption of new materials and technologies. The focus on availability or safety consequences due to the introduction of a novel feature or functionality arise the share of operator, maintainer and engineering skills to sustain safety performances. Improvement results have been noticed from this joint effort.

Furthermore, the event observation and performance information can help for detecting trends, or precursors to accidents. This information is communicated to all stakeholders and employed to systematically eliminate the unacceptable levels of faults, failures and errors arising from human or automation sources, thus preventing accidents.

3 - The rolling stock, a sub-system in the middle of the interfaces of the integrated engineering

To begin with, safety and availability are often seen as contradictories and, when necessary, their adjustment is deft to achieve. Door function typically illustrates the balance to be achieved between the two. It is not only a design issue; it is also related to maintenance and operation. Collecting operation data and maintenance feed-back on door events is essential for engineering to work out the most efficient and realistic quantitative requirements combining safety and availability. Being an integrated company ensure exhaustive feed-backs and trusted trigger events. Furthermore, it allows maintenance optimisations on time consuming tasks. Collector shoe problems, unusual wheels wear, flange lubrication are also good examples of interface devices that needs different field skills (infrastructure, operating and rolling stock at least) to find sustainable solutions.

Defining availability target requirements on particular functions

The provision of exhaustive feed-backs and trusted trigger events makes the job easier to define accurate and ambitious requirements fitting with realistic operating. Trying to find a way of improvement of the rolling stock availability in operation, the requirement of new rolling stocks as MI09 (double deck train to operate on RERA) and MP14 (rubber wheel type rolling stock to operate on full automated lines 14, 4 and Grand Paris lines) has been optimised for availability targets. Previous availability targets have been required only on global availability performances. For these new rolling stocks, a feedback study on operating trains has been carried out. The results of this feedback study involve defining a new way of requirement to work out the most ambitious availability level. As a result, availability targets have been defined not only at system level but also at function level. Availability targets have been defined for door function and traction system based on the combination of operation and maintenance feedback.

Technical problem solving without railway operating damage

Introduction of a new rolling stock in operation or automation of an existing line are situations that can affect availability or safety. The rolling stock has interfaces with many systems and is a good example to show the benefits drawn by the integrated company.

Solving collector shoe problems:

The line 1 automation while continuing railway operation was a real challenge in many ways. Most of the operation problems have been anticipated and the nearness between operator, maintainer and engineering played a first role in this success. For example, negative and earth collector shoes presented damages. Different factors have changed with the automation of the line. The collector shoe was from two different types and reacted differently to damages, full automated railway operation changed the operation speed so that the constraints get harder and the railway track was aging. This problem has been solved without operation impact by the collaboration of the infrastructure manager, the rolling stock engineering and the rolling stock maintainer. The share of thorough knowledge in each subject was necessary to solve the problem.

Another example of interface problem is the positive collector shoe. A fold up problem of positive collector shoes arose after the automation of the line. As for the negative and earth collector shoe problem, the collaboration between the operator, the rolling stock maintainer and the rolling stock engineering has been necessary to solved this problem without operating impact. The organisation of the proximity maintenance was a key of this success.

The proximity maintenance manager is hierarchically related to the operator manager of the line. It makes the communication easier but also it raises awareness of operation issues among the maintainers and maintenance issues among the operators. Thus, when problem occurs the staff is used to working together and has the up to date information to solve it.

Solving iron wheel unusual wear:

The last example drawn from the line 1 automation is the iron wheel unusual wear. At the interface between the rolling stock and the railway track this iron wheel problem brings out other interface causes. Actually, this problem is neither due to the wheel neither due to the railway track. The cause of this problem is in the interface between the rolling stock traction and brake software and the full automated train control system. The finding of the root cause needed the collaboration between the transport system engineering and the rolling stock engineering. Thorough knowledge in each matters and collaboration between operation, maintenance and engineering was essential to solve this problem and to save time.

Solving flange lubrication problems:

Flange lubrication is also a good example of interface device that needs the collaboration of different skills to find sustainable solution. This interface of lubrication between the wheel and the rail is deft to adjust and needs a continuous observation. The organisation put in place for this function calls for different department expert backup. This wide range of skills is essential to solve this kind of problem. The task is hardened by the rolling stock diversity. For example, the introduction of the new rolling stock MF01 in line 2 made appear lengthening of brake distance at particular points. The root cause was the diversity of contact surfaces between the wheel and the rail that created lubricating grease accumulation. This problem has been solved without operating impact thanks to the collaboration of the operator, the rolling stock maintainer and the railway track maintainer.

Optimisation of maintenance efficiency:

These previous examples show the benefits the RATP can draw from its integrated engineering organisation. It shows that the collaboration of a wide range of skills is a key to solve specific problems without rail operation impact. But this organisation provides also with performance enhancement. Its thorough knowledge in each matters and its interface understanding allows the RATP cost optimisations on activities related to availability and safety without performance impact. For example, optimisation on rolling stock maintenance tasks are studied and back up to reduce the maintenance cost while maintaining the availability and safety performances.

Conclusion

The RATP gathers railway operating, maintenance and engineering activities. To maximize the benefit it can take part of this situation, the RATP adopted integrated engineering organisation and principles. The nearness of operator, maintainer and engineering staff facilitates collaborations between employees, insights and improvement actions. Furthermore, it transforms the traditional focus on accidents and loss approach implemented by RAMS experts to understanding, control and management of threats and hazards implement in a more pervasive way. The focus on organisation and learning ensures that competent people are trained and lessons are learnt from faults, failures, incidents and accidents with a view to eliminate or minimise future occurrences. Examples of technical problem solving are developed to illustrate the advantages of the integrated company principles in availability and safety performances. And the collaboration between the operator, the maintainer and the engineering is crucial to ensure exhaustive feedbacks and trusted trigger events and then to allow continual enhancement principle.