The Maintainability Approach at ALSTOM Transport

Yves DURAND/ Technical Director

Summary

"Maintainability"¹ is a recent concern for ALSTOM Transport. This novel awareness is a consequence of market changes, and increased focus by Operators on the transportation business itself. This evolution has forced ALSTOM Transport to rebuild its New Build product offering. At the same time, ALSTOM Transport now stands in for the Customer on maintainability issues and hence, is led to develop its own approach to maintainability from the very early design phases.

This approach, supported by an R&D program encompassing the entire product "life cycle"², has the following objective: provide an integrated "logistic support"³ for the railway equipment delivered by ALSTOM Transport. This obviously calls for the implementation of a common language for parts procurement, product breakdown structure, maintenance procedures and cycles, and repair procedures. Also required are an active network to keep the language alive, a real capability to engineer the logistic support, a clear and validated methodological approach, and clearly specified logistic support products.

For the New Build projects, the maintainability approach requires Service engineers embedded into project teams. Logistic support products must also be included in the New Build project work packages. This crossed contribution is based on a responsive, complete and reliable return of experience.

A profound change is taking place. The company culture is evolving. The end result will be better products for our Customers.

¹ Maintainability (EN 50126)
The probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval when the maintenance is performed under stated conditions and using stated procedures and resources. (IEC 60050(191))

² Life cycle (EN 50126)
The activities occurring during a period of time that starts when a system is conceived and end when the system is no longer available for use, is decommissioned and is disposed.

³ Logistic support (EN 50126)
The overall resources, which are arranged and organized in order to operate and maintain the system at the specified availability, level at the required lifecycle cost.
Introduction

Standard EN 50126 defines maintainability as a probability. This concept is rather theoretical, and needs to be complemented by a pragmatic approach in order to be put into practice. In the final analysis, "putting it into practice" means establishing it within a contractual agreement between the manufacturer of the railway equipment and the operator of this equipment, based on results which are easier to measure such as "reliability" and "availability".

The goal which ALSTOM Transport has set itself is to build the means for implementing this agreement, i.e. building "maintainability" in parallel with building the actual equipment. The explanations below describe the approach for which our company has opted. To start with, the reasons why it selected this approach will be presented reasons that practically led to reorganizing the company's products. We will continue by describing the content of the development program that constitutes the prime mover of the "maintainability" approach. To conclude, we will discuss the changes actually taking place within new projects - we will see that this is indeed a Cultural Revolution that will take time to evolve into a new culture.
1. Changes in the railway market

The needs of the railway market, both of the customers and the shareholders of ALSTOM, have recently experienced fundamental changes. To stay competitive in this new context, the company needs to develop products that provide its customers with added value.

1.1. Before

Before these changes, the customers were almost exclusively major public networks who placed orders with the railway equipment manufacturer. These organizations specified themselves the technical and design features in order to suit their largely captive market. The manufacturer's role was to take the specified product, work out its details, adapt it at the industrial level and build it - providing the required quality level as measured according to the precise original specification. The manufacturer had minimal access to practical feedback from its customers. In these circumstances, the customers gave the manufacturer little or no motivation to think in terms of availability and maintainability, especially since the competitiveness of a product was measured basically by its acquisition cost.

1.2. Customer Changes

The ground rules are changing. Customers now judge the manufacturer not only on the acquisition cost but also on the total cost of owning its products. The manufacturer has to play a part in the financing aspect through asset management operations. This means becoming involved in maintenance, to gain better understanding of the in-service behavior of its product, to establish better control over maintenance costs and residual value. The manufacturer is thus required to study the market no longer just in terms of a product technical compliance with performance criteria based on weight, speed, noise, braking etc., but also in terms of service quality and hence maintainability.

In some countries like the UK, the integrated large customer account has fragmented itself into a number of different players ranging through network managers, owners of rolling stock, operating companies granting licenses to franchisees, etc. At the end, this scattering process leaves organizations whose product is "transport" and who are therefore looking for equipment offering the best quality of service for the end customer, i.e. the passenger or the freight owner.

These new customers are from now on willing to accept that their new equipment is similar to other networks and standardized, as long as this guarantees financial savings.

1.3. Changes in ALSTOM Transport services and products

To accommodate these changes, ALSTOM Transport has radically modified its catalogue by offering ranges of standard modular products. Current examples include rolling stock lines like CITADIS, METROPOLIS, CORADIA, JUNIPER, and sub-systems lines like ONIX, AGATE. These developments have created the melting pot for implementation of the "maintainability" approach.

It, moreover, has also radically altered its offer by adding a service dimension. This "Service" activity has increased its share of the turnover from the 4% in 93/94 to 23% in 98/99, at a rate that has yet to show any signs of slackening off.

The service offer is focused on services supplied throughout the service life of the equipment. It is inevitably tied in with controlling the life cycle cost (overall cost of ownership), including the acquisition cost but also the operating cost, the maintenance cost - including renovation and decommissioning costs.
This has naturally given rise to the concept of logistic support throughout equipment service life, without which maintainability is no more than an abstract statistic value devoid of substance.
2. R&D is the mainstay of development

Whenever we talk of changing our services and products, we mean a development program and hence investment in R&D. For the last three years our company has been conducting an ambitious R&D program aimed at improving the maintainability of its equipment with a view to providing its customers with the performance, both availability and quality of service in general, which they rightly expect.

2.1. An R&D program which addresses the entire life cycle

This program addresses the entire life cycle of the product from the very start of its design, while including all of the operating phase and the associated maintenance. The backbone is the LCPC ("Life Cycle Performance and Cost") information system. The practical feedback regarding in-service equipment faults is dealt with via the FRACAS ("Failure Reporting Analysis & Corrective Action System") information system. The design data and the data concerning the associated logistic support are recorded and organized in the CLAMP ("Common Language and Management of Parts") parts classification system and the TrainTracer™ documentation system. The maintenance policy is implemented throughout the study phases using the RCM ("Reliability Centred Maintenance") general methodology which the company is in the course of adapting, by developing the RCM-Light tool, to the constraints dictated by the deadlines of the various study phases. This policy is then adapted to the working practicalities using the same RCM methodology, but this time drawing on the results obtained from the test and monitoring equipment intended to allow conditional maintenance. This equipment is grouped under the generic name "Condition Monitoring". The fault diagnosis is assisted by an "e-Maintenance" remote diagnostic system.

Note:
Renovations are covered by specific developments which are derived from those for new products, and which are not therefore discussed here. It is merely informative to note that the processing of equipment obsolescence and discarding will undoubtedly be the next important areas for research.

2.2. An R&D program structured to provide integrated logistic support

The development is structured around four blocks: a common language, the logistic support engineering, the logistic support products and, as a reminder, the contractual terms.

2.2.1. A common language

Having a common language is paramount, especially in an international, multi-cultural and changing organization such as ALSTOM Transport.

- Parts specification, classification and identification: CLAMP

The first component of the common language is the parts catalogue. The purpose is to identify all the parts to be used for maintenance operations and to define unambiguously their identification code according to the following principle:

"one part = one number, one number = one part".

Access may take place through any attribute or code associated with the part, but the output always delivers a unique code.
This parts catalogue is based on a classification tree in which the leaves are the parts and the branches are the technological families (mechanical, electronic, pneumatic, etc.) and their sub-families. Each level in the tree structure possesses attributes (e.g. type of contact, voltage, rated current, number of contacts, etc.) which are passed down from one level to the next.

Each part is allocated definition data (such as material, protection, drawing references and specification, normalization or standard) and application data (such as projects, customer specifications, customer reference codes, codes used by industrial units, supplier reference codes).

The CLAMP database has become a central tool for ALSTOM Transport. It is now used by 13 industrial units among 36 and deployment is going on. 75 training sessions have been carried out for 400 people (users and administrators). It can be now accessed via the Intranet. It also forms an integral part of the corporate digital mock-up project under development.

- The support data: LBS, TrainTracer™, LCPC
  The LBS (Logistic Breakdown Structure) is the backbone of all the logistic support data. The breakdown is organized from the maintainer’s viewpoint so as to identify the LRUs (Line Replaceable Units).
  The goal is to obtain a unique standard breakdown which is valid for the maintainer, is constant over time and across projects, and is compatible with the many other views of the product (WBS, PBS, FBS, GBS etc.).
  The strictly predetermined part is limited to two levels since, with a greater number of levels, the engineering and technology changes or contractual requirements would reduce continuity to being merely ineffective.
  The practical feedback on the behavior of the in-service equipment will henceforth take place using this breakdown for all new projects.

TrainTracer™ and LCPC are twin systems; both built on the LBS structure whose nodes they use.
TrainTracer™ is the maintenance documentation system. The ultimate aim is to elaborate the maintenance documentation during the design phase, and to update it with ease throughout the life of the product. This modular and structured documentation uses the XML standard. The advantage of this is a high re-use factor of the information fragments from one project to the next. The structuring makes it possible to trace all uses and successive versions and their application during engineering developments.
The original data provided by the design departments is communicated through a standard neutral format.
TrainTracer™ can accommodate most data formats: text, 2D images (to be upgraded for 3D) from CAD, video, digital images.

TrainTracer™ is presently applied to Korean TGV, all French CITADIS tramways – Orleans, Montpellier, Lyon -, West Coast Main Line in the UK, Singapore metro, Washington metro in the US among others.

LCPC comprises the database describing the life of the product in terms of maintenance (preventive and corrective actions for each component, and associated economic data) and computational tools which allow simulations of operation runtime, LCC calculation and subsequently availability.
The maintenance tasks are organized in modules that are attached to the LBS tree structure. Each task uses the list of required material, required skills and required tools. LCPC makes it very easy to construct new models from previously processed models, using "cut & paste". For calculations, LCPC makes it possible to download the useful data into a spreadsheet programmed with standard computation algorithms for offline handling. Dedicated software makes it possible to compile all types of reports. LCPC is now currently used by several Service units for their LCC and performance simulations and calculations: CEA in France, LHB in Germany, Australia for the Hillside project, and also by several New Build units (Le Creusot, Tarbes, Belfort).

2.2.2. **Logistic support engineering**

In such a large organization as ALSTOM Transport, logistic support engineering is relevant to every project and requires the creation of skill networks and the use of shared methodology in order to maintain its consistency.

- **The LCC Centre of Expertise**
  The company has decided to form an LCC center of expertise funded by the R&D program. It is led by a "Maintainability" expert, and has a Steering Committee and a network of experts, located in the various profit centers, who reflect our geographical organization and our products. The center of expertise fulfils a support role for the industrial Units, which it helps in setting realistic objectives and monitoring their achievement.

- **The RCM approach**
  RCM is by no means a recent discovery. It is a maintenance methodology that has already been extensively used in many industries worldwide. The principle of RCM is to weigh up the causes and consequences of failures so as to maximize the performance (in particular the availability) of the equipment, while minimizing the life cycle cost (overall cost of ownership). RCM provides a solid methodology basis for creating the maintenance plan and improve it on-site. The method focuses on defining conditional maintenance actions, systematic tasks for restoring the estimated service life of the equipment, and equipment replacement tasks. It provides objective medium of dialogue with the technical departments during the design phase. It helps to define re-engineering actions during service life. RCM is applied to many key products, e.g. WCML, CITADIS, METROPOLIS.

2.2.3. **On-site support products**

- **Diagnostics, breakdown service and practical feedback.**
  On the basis of "case base reasoning" and "data mining" algorithms, a ground-level diagnosis tool has been developed. After a pilot period on the rolling stock of London's Northern Line, the product is currently being used in an evaluation phase on Scotrail. The continuation of the program, which will take place in 2001, will on the one hand, load faults via the train - track communication in order to create a tool for remote diagnosis and breakdown logistic preparation, and on the other hand, will integrate the algorithms in the onboard monitoring/ control systems.
Since the 1980s, the company has been setting up practical feedback tools, but successive mergers have brought other tools of different origin. A combined system is being developed under the name FRACAS.
FRACAS allows henceforth a centralized database to collect the practical feedback information from a number of projects, both new and in maintenance/renovation.
Following complete deployment, FRACAS should be integrated into the diagnosis system.

To date, 12 training sessions have been organized for more than 50 people, mainly in the UK. Deployment is starting up in France, Spain, Belgium, Poland and Venezuela.

- Equipment service life monitoring.
A variety of instruments are under development at various validation or implementation stages. They will make it possible to carry out non-destructive examination of the equipment. They are:
- The Vision system: This is an automated inspection instrument making it possible to measure wear levels without dismantling and during running (up to 25 km/h). A set of laser cameras images the parts to be measured, and a computer correlates the various views in order to obtain dimensional measurements on various coordinates. The system is currently in operational use for monitoring wheels (profile, diameter, flange height, flange width), blocks, friction pads, brake-shoe inserts and power collection shoes on the London Underground Northern Line and is part of our depot equipment proposal for several projects.
- The EMFaCIS system: This instrument, based on eddy currents and using a bank of sensors, permits 3D geometrical reconstruction of surface cracks with 3 mm length and 0.1 mm width in ferrous alloys and 0.25 mm in non-ferrous alloys, without having to carry out special preparation (sandblasting) of the part. A fairly broad distance tolerance relative to the part (16 mm for ferrous alloys) greatly facilitates use of the device. This instrument is currently being used by the Eastleigh renovation workshops in England. We are today in position to make service proposals for the use of this facility.
- The Vibration system: This system is based on analysis of the vibration spectra. It is under validation in Spain.

- Other technologies are also being studied.
- Although this is a slight departure, it is worth noting that these developments rely on the implementation of an integrated maintenance management system which has been made possible by our experience in Spain, Great Britain, Mexico, Canada, etc.
3. The relationship between "New Projects" and "Service"

Improvement of maintainability requires collaborative work by the hardware designer and the maintainer. This joint work is difficult to organize because interests may seem incompatible. The designer may even sometimes regard the concern for maintainability as an extra constraint—a hindrance for him in meeting design deadlines that are always too short.

3.1. The design for quality process

Notwithstanding, the positive advances made by ALSTOM Transport have been outstanding. For example, in the design of the CITADIS products, important joint work was carried out between the designers and Service engineers to offer a logistic support which is successful with customers. It is generalized, in particular, by the inclusion in the internal "Design for Quality" process (which is currently an internal standard) of work packages which relate directly to the maintainability elements explained above.

3.2. Contributions by "Service engineers" to the stock projects

This process involves the participation of Service engineers from the very first steps of the project. A number of cases are currently ongoing, e.g. WCML, Hillside XTRAPOLIS. This work, which is still in its incipience, shall become the standard in the near future. It requires that the Service engineers have the technical and organizational ability to require to re-engineer or re-design portions of the project if the work packages of concern to them have not been completed. On the other hand, enjoying this right entails the obligation to load the project promptly with full, accurate and reliable feedback data, starting from the preparation of the tender.

3.3. The integration of "Service" tools with "New Projects"

This work will come to fruition when the Service tools are integrated with the design tools. It is an open work which is being carried out through the DMA-GS digital model project. It is also a major work that will still require fully two years for completion.
4. Conclusion

The mission of ALSTOM Transport Service is:

To provide the most innovative, cost effective and comprehensive quality service to the rail transportation industry around the world

In order to be achieved, this mission requires the "maintainability" approach to become common working practice throughout the company. This represents a very fundamental cultural change, but one which is extremely positive and beneficial for our company and our customers.

ALSTOM Transport Service was born in July 1997 with an annual turnover of about 150 M. Its turnover is now close to 1 Billion, progressing swiftly. It maintains and renovates thousands of railway vehicles of various types and various OEM's, new and already in service.

Based on this concrete experience, maintainability is now a key approach the company is focussed on. It has already made great strides, and will rise to the challenge confidently.