Development and integration of TRACTIVITY, a maintenance management system for rolling stock
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Abstract
Most major railways have introduced or are currently introducing computer based Maintenance Management Systems (MMS) for their Rolling Stock. Such systems are often based on either MM software for industrial applications or on commercially available data base packages. Large railway operators can justify the necessary development to adapt the software to their specific needs and their environment. Many of the private railways in Switzerland cannot afford a significant software development.

The paper describes the development of a MMS in a joint venture between private railways and ENOTRAC, an engineering and consultancy company. It highlights the experience gained with the introduction and the practical use of the system.

1. Project History

1.1 Study of Needs and Feasibility, Market Survey
In November 1988, ENOTRAC arranged a workshop for interested engineers of the private railways and proposed a joint development of a MMS. Five private railway operators and two urban transport authorities participated in a study with the following scope:

- identify the common needs of all public transport operators
- identify specific needs of each railway and urban transport authority
- list and compare existing maintenance management systems
- assess the suitability of existing systems to cover the needs
- explore the possibilities to adapt existing systems
- make a commercial and technical proposal for a solution either based on an existing product or for a new development
The seven sponsors of the study cover the variety of railways in Switzerland: Adhesion and rack railways, standard gauge and narrow gauge, 6 different supply voltages (both AC and DC), a rolling stock fleet ranging from 50 to 500 units, diesel and electric rail vehicles, trolley buses, and diesel buses.

The study considered the maintenance practice adopted, the plans and expectations for the future and the experience of other railways with computer assisted maintenance. The following needs emerged as a first priority:

- tracking of components, configuration of vehicles
- history of failures, statistics
- planning of preventive maintenance at a subsystems level
- preparation of work orders for repair and preventive maintenance
- planning and control of resources (human, infrastructure, material)
- management of spare parts
- cost planning and control

A lower priority was given to a computer based technical information system for technical data, drawings and schematics and to operational planning (vehicle rostering).

Most of the commercially available systems found in the survey were originally designed for a specific maintenance application (such as aircraft, ships, cement mills, offshore etc.) and were running on main frame computers. Eight products were analysed, four of them in greater depth. All four covered the core maintenance functions, but they could not equally satisfy the needs of the railways, such as

- structuring of the vehicles over several hierarchical levels (vehicle, subsystems, components, parts etc.)
- use of the common railway terminology and of the existing equipment codes and part numbers
- availability of German and French versions
- flexibility in the layout of screens and forms

None of the systems could meet all essential requirements without adaptation. The possibilities of a cooperation with the suppliers had to be considered. As a minimum, the necessary tools and knowledge should be obtained for autonomous changes of texts and screen layout.

The proposal made in the study was to adapt an existing maintenance management software. For economic reasons, and because of the high risk involved, a totally new development was not recommended. A software developed by INSTA GmbH in Munich, Germany, seemed the most promising basis for a rolling stock application. The standard version, named ACTIVITY, was already in wide-spread use. The fact that specific applications for cable cars and
for aircraft maintenance had successfully been derived from the standard software was encouraging.

1.2 Development of TRACTIVITY

The development started in 1990 as a joint venture between ENOTRAC, four private railways and one urban transport authority. The role of ENOTRAC was to specify and realize the forms and screens, to define and subcontract the necessary enhancements of the standard software and to co-ordinate the whole project. The railways participated actively in design reviews and contributed their practical experience with the maintenance of rolling stock. The main experience gained in this difficult phase of the project can be summarised as follows:

- The changes to the standard program were more significant than expected in the areas of component movements, component tracking and performance related maintenance of sub-assemblies.
- It was difficult for the railways to assess the software functions and their impact at a specifications level.
- It was time consuming and costly to run the whole project in two languages (French and German).
- Invaluable experience was gained in testing pre-releases in a practical application by one of the railways.

The first productive version of TRACTIVITY was released in 1992. Instead of the technical and commercial partnership adopted for the first stage, ENOTRAC decided to develop an enhanced version of TRACTIVITY on its own initiative. This version was released in April 1994. The efficient second stage of development would not have been possible without the sometimes painful partnership of the first stage and without the service experience gained with TRACTIVITY in the meantime.

2. System Description

2.1 Users

TRACTIVITY is used by railway and mass transit operators in their depots and workshops, but also by rolling stock suppliers for their after sales service. Three categories of users can be distinguished:

1. Workshop and depot managers and foremen for planning, issuing of work orders, cost control, and reliability monitoring
2. Workshop and depot personnel for component tracking and history, recording of the work done and for searching of technical information
3. Technical and commercial managers to obtain up to date information on maintenance and repair costs, efficiency, and availability for budgeting and decision making

2.2 Functions

- Vehicle and component tracking and history
- Preventive maintenance based on the requirements of the different subsystems and components (e.g. time intervals, mileage, operating hours, duty cycles, wear)
- Planning of resources, generation of orders and work instructions
- Recording of the work done (preventive maintenance and repair)
- Management of spare parts
- Analysis and statistics (failures, vehicle performance and reliability, scheduled maintenance and repair costs, modifications etc)

These core maintenance functions are complemented by typical service functions such as the forms generator or data import/export interfaces. The design of the software is modular. The allocation of the various functions to the different modules is shown in fig. 2-1.

![Fig. 2-1 Allocation of functions to the TRACTIVITY modules](image)

2.3 Rolling Stock Specific Requirements

The characteristics of rolling stock maintenance are, in comparison with industrial plants or buildings, the large number of identical systems (vehicles), the frequent movements of interchangeable components, the complexity of the preventive maintenance, and the splitting of maintenance tasks between depots and workshops. As a consequence,
the software had to be particularly powerful and flexible in the three areas described below. The use of library data was already satisfactory in the standard version. The major enhancements for the rolling stock version were necessary in the other two areas.

2.3.1 Use of Library Data
All common data for a series of vehicles or for one type of component are stored once in a library. Only the serial numbers and any deviations from the standard need to be entered individually for each vehicle. This reduces drastically the time spent for data entry and the space occupied. This concept is extended to the scheduled maintenance tasks: standard work instructions are stored once and then called wherever applicable.

2.3.2 Structuring of Vehicles and Component Movements
Parent-child relationships between sub-assemblies are possible over up to 5 hierarchical levels. If an object (say a bogie) is removed from the vehicle for repair or overhaul, all subordinate objects (motors, wheelsets, brakes) will be moved with it, together with their current performance state (mileage, working hours, duty cycles), their history and their maintenance schedules. This ensures correct planning of the preventive maintenance for each object and full traceability of all components. The structure of a vehicle can be expanded or reduced during its lifetime.

2.3.3 Performance Driven Maintenance
The preventive maintenance tasks can be defined specifically for each object (vehicle, sub-assembly, component...). The due date will be forecast by the system in accordance with the user defined performance criteria.

![Diagram showing links between performance counters and subsystems.](image-url)
Each object can have its own performance counters or it can be linked to the counters of a parent object. In the example shown in figure 2-2, the bogies and the traction motors are linked to the mileage of the vehicle, whereas the compressor motor accumulates the working hours of the compressor group.

2.4 Software Concept

The software concept is shown in figure 2-3. All maintenance specific functions are performed by a Kernel (written in C++) which is identical for all applications. The adaptations of screens and dialogs for the various fields of application, i.e. industry, buildings, aviation, rolling stock, are realised in the next layer. All enhancements which are unique to the rolling stock version make use of elementary functions offered by the library of the Kernel. With this concept, the users of specific applications (such as TRACTIVITY for rolling stock maintenance) can benefit from the ongoing development of the standard software.

The choice of MS-Windows as the interface to the external world has an even greater advantage: a large number of drivers for peripherals (printers, barcode readers, scanners, screens, mouse) are available. Standard applications can be used for text editing and for drawing. The users are more and more familiar with the typical Windows features like the clipboard, multi windowing, pull down menus, buttons etc.

Figure 2-3 Software Concept

2.5 Platform Requirements

TRACTIVITY is running on PC's and on PC networks. The software can be installed locally or on the file server. In networks, the data are normally stored on the file server. The platform requirements are:
• 386 or 486 processor with a minimum of 4 MB memory
• Harddisk with at least 40 MB free space prior to the installation
• VGA compatible monitor, mouse
• DOS version 3.3 or higher, MS-Windows 3.1 or higher

3. Integration in an Existing Environment

To avoid a duplication of data entry, a data exchange is necessary between the maintenance management system and existing applications, typically the administration system for personnel data and cost, the stores system for spare parts data, or the fuel station for consumption and mileage of road vehicles.

The long term target is clearly the use of a common, standardised database. In the real world, interfaces between different applications often use data files for a periodic exchange of data. The inconvenience is a duplication of data with the risk of inconsistency. A maximum of flexibility is required from the 'late comer', normally the maintenance software. TRACTIVITY offers two types of data interfaces:

• Import/export functions using standard format files
• DDE (Dynamic Data Exchange), a standard communication between Windows applications

With the use of DDE, it is possible to establish on-line connections with other programs and to eliminate the risk of data inconsistency. Both types of interfaces ease the integration into an existing computer environment considerably, but it is still necessary to configure the data links specifically for each application or even to design interface programs.

4. Implementation and Use

Once all the hurdles of a software development project have been taken, human barriers can hamper the introduction and use of the maintenance management system in a railway organisation. An instrument which claims increased efficiency and reduced costs is not necessarily welcomed by the work force in times of unemployment. There may be other, less political difficulties:

• local spreadsheet applications seem threatened by a centralised maintenance management system
• workers are faced for the first time with a computer application

Data interfaces between existing local applications and a new maintenance management system can be a way of peaceful coexistence. Training and support must be focussed on the practical application. Users should learn how they can benefit from the system for their daily work. Assistance is also essential for the preparation of the system: Examples can be offered for vehicle structures, preventive
maintenance procedures, forms, and tables. With the staged introduction of the system, e.g. for part of the fleet, results can be obtained after a short time.

5. Practical Experience, Conclusions

User friendliness has proved to be a debatable term: not all users can equally enjoy the flexibility and power of a Windows application. TRACTIVITY allows to define the access individually for each user. Only accessible functions appear on the screen and in the menus. For difficult operations like movements of subassemblies, guidance and checks have been built in to help infrequent users and to exclude the loss of data. To give even inexperienced users on the shop floor access for their specific needs and to allow data entry right at the front, interface programs have been developed with a robust DOS style user interface.

The introduction and productive use of TRACTIVITY by the various railway operators and rolling stock manufacturers covers a wide band width: one railway has suspended the project, others have introduced the system very speedily and are using it successfully.

The practical experience with TRACTIVITY has shown that a maintenance management system for rolling stock can be economic even for medium or small size public transport operators and for rolling stock manufacturers. The quality of the software is a precondition, but training, management commitment and the effort of those directly involved are equally crucial for the success of the project.

6. References