TECHNOLOGICAL INNOVATION AND ORGANIZATION OF MAINTENAINCE OF THE RAILWAY INFRASTRUCTURE

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INTRODUCTION

The innovations introduced in the rail transport in the latest years have had no precedents in the history of the railway. Let us have just a look at the liberalization which has allowed the railway infrastructure to enter the market system with consequent sharing of tasks between the Infrastructure Manager and the Railway Enterprises, in competition with each other, according to the Italian organization which is taken as an example all over Europe.

Moreover, the Italian Railway is especially proud of adopting such safety systems as the SCMT and CSS, near completion both for onboard and on land/trackside types, the GSM-R (where R stands for Railway) system for communications land/train via radio, the High Speed/ High Capacity service which utilizes for the first time in Europe, the interoperational system ERMTS, level 2, without any online light signals and with 'authorization to motion' transmitted automatically to trains by GSM-R radio.

The adoption of traffic remote control systems, increasingly advanced, like the implementation of the Command/Control System (CCS), requires the automation of management processes and the utilization of modern technologies in order to develop a system distributed in the territory, where a single centre is going to perform all the command, control and coordination activities. The result is an operational model which is characterised by simplification of work procedures and a greater cooperation among the different sectors which are nowadays in charge of the rail transport, thanks to the integration of the already existing systems and the openness towards new ones.

The information progress has allowed the creation of distributed databases, defined in terms of maintenance items in order to have a databank which can meet the different maintenance needs inside the industrial maintenance process. In the light of the state of health of the facilities following inspections, by means of the fixed and mobile diagnostics it is possible to plan the necessary ordinary and extraordinary measures, thus giving an overview of the maintenance activities which, together with the needs of the investment resources, allow to plan the requirements of the internal resources.

1. THE ORGANIZATION OF THE MAINTENANCE OF THE RAILWAY INFRASTRUCTURE

The organizational structure, intended as the way of organizing the industrial processes and the staff relations, depends on the strategy and the available instruments which facilitate the achievement of common objectives. Every organization is valid and is not to be considered as a static entity and should therefore keep abreast of the changes, especially the technological ones. The companies which constitute the Italian Railway Group, playing the role of the Railway Infrastructure Manager and being responsible for the maintenance, is the ‘Rete Ferroviaria Italiana S.p.A.’ (Italian Railway Network, Joint-Stock Company). The maintenance of the railway infrastructure is under the authority of the Maintenance Department which divides the Italian territory, made up of nearly 16,000 kilometres of lines, into 15 Infrastructure Departmental Offices. The major “*mission*” at the Maintenance Department is to guarantee a high level of availability of the railway infrastructure ensuring the maximum safety. All this can be obtained by means of an increasingly accurate planning of economic and human resources, a long-term planning of the interventions in the ordinary and extraordinary maintenance, a technical and economic statement of the activities carried out with regard to the state of health of the bodies to be serviced and mainly by means of a control over the infrastructure through the observations following the periodic inspections and the fixed and mobile diagnostics at disposal.

The organization is divided into structures which carry out all the stages of the maintenance process in differently-sized territorial areas (sections/zones, department, Territorial Units), each responsible for the maintenance of its own *assets* within their own territorial jurisdiction, basically divided into two large sectors: the former is the electrical systems (signalling and safety systems, telecommunications systems, energy system, etc.) and the latter is the railway equipment and the related civil works.

1.1 THE INFORMATION SYSTEM ‘IN. RETE’

The process started in 2000 at the Italian Railway Network by activating the Information System In.RETE has stimulated a development of the maintenance which is nowadays supported by:

- a more and more precise and detailed planning;
- a planning allowing the involved people to be assigned to the appropriate role;
- an accurate statement of the technical and economic resources as to the activities to be carried out;
- a control over the infrastructure thanks to the observations made by the mobile diagnostics;
- the possibility of a simple and effective control system.

The Information System ‘In. Rete’ has created a language, a culture of maintenance, a combination of criteria, procedures and approaches which are pivotal in a constant improvement. On the basis of the business maintenance needs, that is the measurement and the recording of every maintenance event which may happen during the life of the infrastructure (measurements and consumption, trend of deterioration, malfunctions, etc.), in order to determine periodically the necessary adjustments in order to ameliorate the efficiency of the maintenance interventions. Figure 1 schematizes the flux of the different processes showing the module and the instrument of the information system which supports that process. The modules of the information system IN.RETE 2000 carried out through the SAP platform are :

- PM (*Plaint Management*) module, designed for the maintenance management;
- PS (*Project System*) module, intended for the economic and financial management of the investments;
- MM (*Material Management*) module, designed for the management process of materials;
- BW (*Business Warehouse*) instrument, a platform for analysing and *reporting* the management control over the areas of the Economic Account and investments, and the platform for ordinary and extraordinary maintenance activities;
- DW (*Data Warehouse*) instruments, a business system for analyzing dynamic reporting data as from the detailed data provided by the business operational systems (In. Rete , Sfinge, Roman).

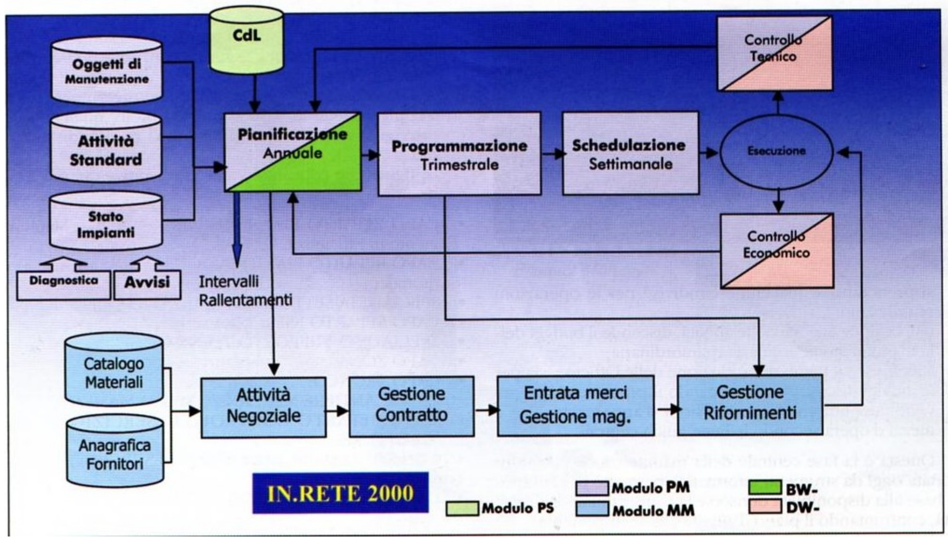

Figure 1 Flux of the maintenance processes

With a view to stimulating the different processes it is necessary to guarantee the definition of the maintenance items in order to have a database which may meet the different maintenance needs inside the maintenance industrial process and to develop other systems as a support of other RFI industrial processes (motion, commercial, investments and assets), with a model which is able to follow the goods in their own peculiarities. It is required to link the items with the different maintenance policy considered as the definition of the relationship between an organizational structure and a range of tasks to perform to a specific maintenance item, so as to ensure a safe and reliable system. Another aspect to consider is to guarantee the observance of the national regulations, which specify how to intervene in the maintenance items. The abovementioned elements help to define the database which is later enriched with reference objects which are used to ensure the **standard tasks,** which should be performed to carry out the maintenance intervention in a given item following the policy arranged in advance. The standard tasks include :

- the “maintenance regulations” which coincide with the description of the tasks and any repetition of frequency if the task is cyclic;
- the “planning elements”, which are the parameters linked to the number of resources (people, means, breakdowns/slowdowns) in terms of length and working hours necessary to define the requirements in the preventive stage.

Another element of the process is the analysis of the **state of the facilities** arising from the inspections at the technical centres, from the fixed and mobile diagnostics which allows to assess the state of ‘health’ of the equipment and therefore to get information in order to direct the predictive or conditional interventions.

In the light of these databases and the state of health of the facilities, it is possible to go on **planning** the requirements of the essential interventions, both ordinary and extraordinary, in order to have an overview of all the maintenance tasks which, supplemented with the needs for the investment resources, allow to arrange the requirements of the resources. In this way, the business “calendar “ is put into operation in order to start up the supply processes of all the resources required to carry out the interventions which, in order to be timed to the different stages of definition of the necessary resources in the year ‘n’, considered as the year of implementation of the interventions, are going to occur in the year ‘n-2’:

- the supply process of the materials provided by the central warehouses is activated;
- the technical scenario, which accounts for the need for intervals/breakdowns and slowdowns on the lines required for the execution of works, is constructed;
- the schedule for the human resources is arranged to do the necessary work;
- the machinery shared for the most significant operations is booked;
- the optimization of the activities determines the *budget* of the ordinary and extraordinary maintenance;
- the production plan for the shops is defined for the building activities according to the supply process as well as for the servicing of the equipment and means according to the central guidelines.

This is the main stage of the maintenance which is nowadays supported by information instruments and allows to verify whether the activities can be carried out by comparing the scheduled activities to the availability of resources.

After defining the activity plan which is, as the implementation time draws near, adapted to the answers provided by the different supply processes, the following step will be the **operational planning,** on a 3-month basis, optimized on the basis of the calculation of capacity of the used up resources and the reply to the supply of necessary resources.

The planning is developed by drawing up work papers which are sent to every work centre (Zones / Sections), suitably identified in the system IN. RETE.

The **implementation** phase is preceded by a **scheduling** activity, at least every week, in order to assign the various work papers (tasks or networks, for ordinary or extraordinary maintenance and investments maintenance respectively), to work teams and to every single operator.

The malfunctions of infrastructure give rise to damage which should be reported in the information system into the section **notice of damage**, in order to go on with the technical inspection of the infrastructure. The technical inspection arises from the calculation of technical indexes and *performances* as well as from analytical methodologies of faults, effects and critical points. Once the most critical areas have been pinpointed by the indexes, the use of the operational methodology *magec* (carried out in work groups) makes it possible to obtain the critical components of the technical centre previously and efficiently spotted, in order to outline proposals to overcome the critical points and to rationalise the maintenance interventions.

Besides being listed, the faults should be supported by specific tasks. All the interventions, whether planned or not, need to be subject to final revision to guarantee the chronological recording of the maintenance interventions in the information system. Moreover, the final revision allows to exercise an economic control so as to technically intervene in the maintenance policy and consistency and to record the costs in the book-keeping system. The optimization of the different processes requires an organization which, in a clear and unambiguous way, identifies the person who **plans, programs and performs** the different tasks. Each approach by process has also to identify the person who controls the physical execution of the task.

The leading figures in the current organization of the infrastructure maintenance are the following :

- **Head at the Planning Division** : is in the different managerial organizational structures and guarantees the formulation of the plan as well as the three-month planning which ends with the publication of work papers of the activities scheduled in the quarter. These activities need to be carried out in collaboration with the Head at the Execution Division. Moreover, the Head at the Planning Division has to monitor how the planning is going on through the analysis of the final balances.
- **Head at the Execution Division** : besides taking part in the planning, he/she has to facilitate the execution of tasks optimizing the relationships with the structures of the external technical parties for a productive allocation of the essential resources. The main task of the Head at the Executive Division is to physically monitor the tasks and facilities in the form of inspections of systems of jurisdiction and construction sites carried out by internal staff and external businesses, considering the state of maintenance and preservation of the technical centre.
- **Head of Section / Head of Zone** : is in charge of the railway safety and has to ensure the quality of the tasks performed and reported in the tasks of ordinary maintenance or in the network in case of activities in investment

account, jointly scheduled by the Heads at the Planning Division and at the Execution Division every three months. Should the results of the controls over equipment be calling for urgent interventions, the Head has to intervene promptly indicating the problem and taking any relevant measure in order to eliminate any potential risk.

The execution of a proper maintenance ensuring such availability of the infrastructure to make the railway traffic safe and regular, depends on the certainty that every person in his/her role, takes on his/her own tasks with responsibility and quality sharing the objective to give customers safe and punctual railway traffic.

1.2 THE COMMAND AND CONTROL SYSTEM (CCS)

The Command and Control System (CCS), a primary instrument for real modernization of the infrastructure of the Italian Railway Network, allows to manage the railway traffic from a single host and ensures at the same time the maintenance supervision of lines, hundreds of kilometres long. Developed for the Italian Railway Network since the 1990s, the National Railway Group, in charge of the infrastructure, has jurisdiction over hundreds of kilometres of railway lines, mainly characterized by a heavy volume of traffic of both goods and passengers and by high speed gear trains. The system, which has been devised to handle components and apparatuses of electromechanical and computerized technology, is flexible and able to go with the development of the railway network, subject to constant progress (double tracks, new town plans with regard to railway stations, introduction of state-of-the-art technologies). Moreover, compared to the equipment of previous generations, CCS operates following a '*global*' view : besides managing the traffic and minimizing any prospective anomaly, it integrates a subsystem of diagnostics and maintenance of the apparatuses, checks the closed-circuit monitoring system of the stations and regulates the information to passengers, increasing the quality of the service.

Moreover, it improves the regularity of the traffic, increases the punctuality of the trains, reduces the inefficiency in terms of extent and length, copes with emergencies and disseminates real-time information to passengers. Links and equipment possess different levels of redundancy, physically distinct routes, differentiated communications facilities.

The CCS host of the Sicilian Railway Network is going to be located in Palermo and to link the north to the south of the island, from Palermo to Messina and Syracuse covering over 500 Kilometres of railway line.

It utilizes transmission systems equipped with SDH 155 / 622 Mbps technology on optical fibres. By CCS the operators run, in a simultaneous and integrated manner, the following four subsystems : traffic, information to passengers, closed-circuit monitoring and safety, diagnostics and maintenance.

The first is used for the control and management of railway traffic; the second allows to disseminate, automatically and in real time, all the information on train gears, the third ensures closed-circuit monitoring systems in the remote-controlled and unattended stations, the fourth facilitates the maintenance giving diagnostics information and monitoring the facilities installed in the host (server, workstation, synoptic tables, etc) as well as those placed in the stations and along the lines (peripheral server and CCS apparatuses, level crossings, control boards and units of power and telephone supply, etc.).

1.2.1 THE CCS FUNCTIONAL MODEL

The CCS aims fall within the context of development and revival of the rail transport in the national territory:

- command and control of traffic arteries and main junctions;
- development of organizational models;
- improvement of efficiency of the rail transport;
- reduction in operating costs;
- enhancement of quality of the service provided:
  - regularity;
  - services to consumers,
- diffusion of technological innovations,
- maintainability of the system;
- improvement of maintainability of the infrastructure,
- improvement of management of emergencies.

In order to achieve these aims, CCS requires the complete automation of management processes and the utilization of cutting-edge technologies in order to have a system distributed in the territory, where a single centre is responsible for all the command, control and coordination tasks. The result is an operational model which is characterised by simplification of work procedures and a greater cooperation among the various sectors which are today running the rail transport, by means of the integration of already existing systems and the openness towards new ones.

From a logical and functional point of view, the system is divided into six macrofunctions:

- traffic,
- diagnostics and maintenance;
- information to passengers;
- safety, closed-circuit monitoring system;
- general functions (including the management of timetables, execution programmes and works related to infrastructures, alarm system);

- system functions (including functions of configuration, documentary media, chronological recording of events, e-mail);

The functions are carried out at two levels (Host and Peripheral Units) with the exception of the Diagnostics and Maintenance functions which are performed at three levels (Host, Peripheral Units and Maintenance Facilities).

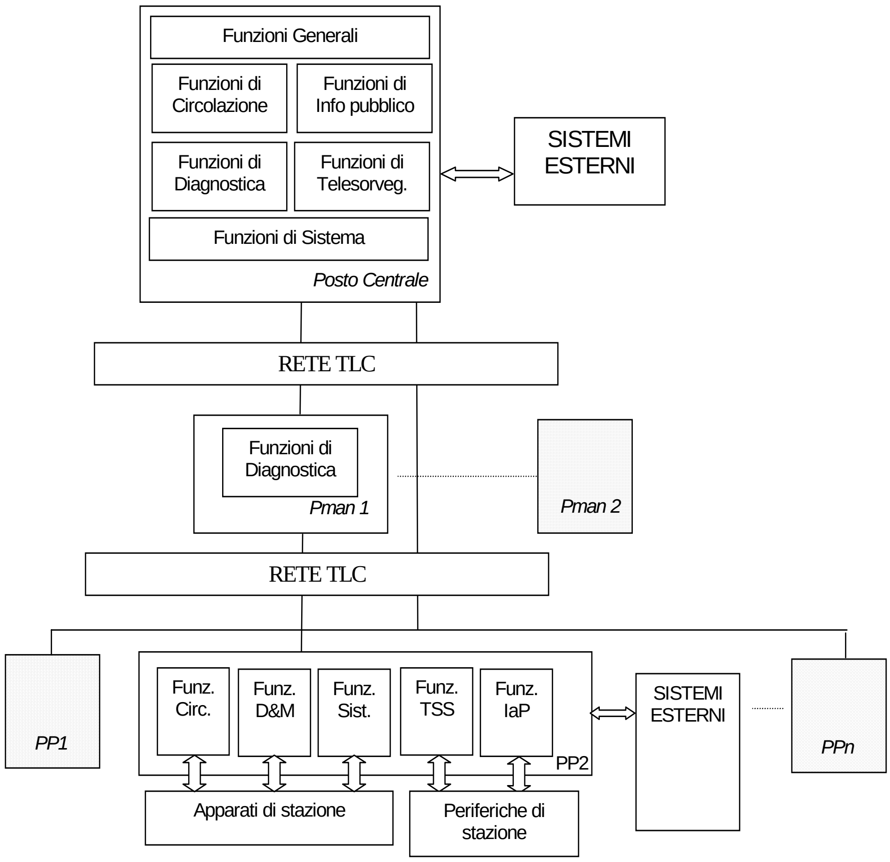

Figure 2 Functional Architecture of the CCS System

Traffic Functions

Traffic functions are the following:

- Management of remote controls and commands

- Real-time monitoring of the traffic performance
- Traffic regulation
- Interfacing with other systems connected to train traffic

At the Host the traffic functions enable the operators to manage and supervise the traffic, at the Peripheral Units they mainly see to data exchange with station equipment (acquisition of controls and sending of commands) apart from specific functions of operator interface as a subsystem of those provided for at the Host.

Diagnostics and Maintenance Functions

The Diagnostics and Maintenance functions enable to:

- monitor the bodies and equipment which fall within the system-controlled area, in order to spot the anomalies even in a predictive manner wherever possible;
- telecontrol the auxiliary apparatuses;
- monitor hardware and software components of the system itself.

Among the Diagnostics and Maintenance functions there are the information instruments supporting the planning and in situ execution activities of the interventions (as well as the interface with the maintenance management system IN. RETE.2000).

The functions are carried out at three levels :

- Host: intended for supervision, monitoring and coordination to the logistic support to interventions
- Maintenance Facility: having functions similar to those at the Host, to which it is hierarchically coordinated (but with competences in a limited area)
- Peripheral Unit: representing the system interface with the field and having instruments supporting the operators during maintenance interventions.

As to specific functions of the Diagnostics management of the Railway System (calculation of algorithms, representation of information, management of diagnostic alarms, etc.) the Enterprise will employ the SCADA-FS, a product supplied by RFI in order to generate, characterize and integrate the applications SCADA-FS-AP into the system, at every functional level (PC, PP and Pman).

Functions of Information to Passengers

The functions of Information to Passengers allow the automatic management of announcements to the public, on the basis of data processed by the traffic functions, improving the service existing in the attended stations and providing the service in the unattended stations and stops in the controlled area.

Control and supervision functions are carried out by the Host, the management of the local display and sound diffusion equipment is transferred to the Peripheral Units.

Safety and Closed-circuit Monitoring Functions

Safety and Closed-circuit Monitoring Functions allow to remotely control technological premises and areas given over to passengers service at stations and stops, as well as technological areas and premises at the Host.

The images deriving from closed-circuit television as well as intrusion and fire alarms, properly distributed in the closed-circuit-monitored Peripheral Units, are collected both by the Host and the PMan.

Moreover, a specially equipped area, the so-called "Crisis Room", providing functions and further instruments to manage emergency circumstances, has been arranged at the Host.

1.3 THE TRAIN GEAR CONTROL SYSTEM

In the latest years the Italian Railway Network has been widely subject to technological investments in order to raise its safety standards and to take them to the highest world levels.

Such projects as SCMT (Sistema di Controllo Marcia Treno – TGCS, Train Gear Control System), ERMTS (*European Rail Traffic Management System*) and finally SSC (Sistema di Supporto alla Condotta - CSS, Conduct Support System) are the result of the efforts which will lead to the thorough covering of the network.

Obviously, in order to always guarantee the top level of performance, the components of such technologies are required to work perfectly. It is therefore pivotal to develop proper diagnostics systems which may reduce the time of any potential inefficiency in case of malfunction or anomaly, and enable the maintenance operators to intervene in a prompt and accurate manner.

SCMT has been the first system to come under a new philosophy concerning **diagnostics and maintenance**, the so-called " *Remote Diagnostics*" .

1.3.1 THE REMOTE DIAGNOSTICS SCMT

The SCMT System consists of the two subsystems SST on land/trackside and SSB aboard. Thanks to an accurate and systematic link between the information transmitted by SST by means of Information Points, made up of buoys and encoders, and the logics implemented by SSB, it is possible to construct speed profiles and therefore guarantee an automatic protection of the train gear.

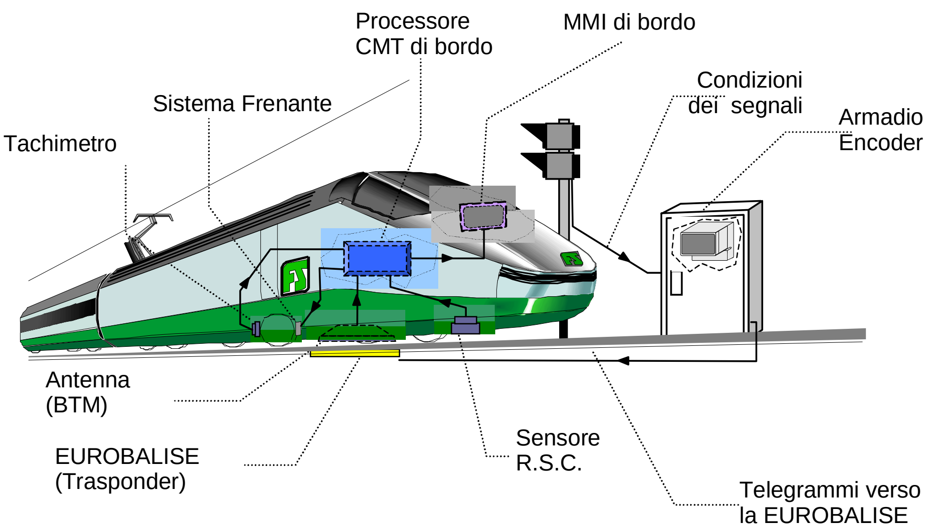

Figure 3 Functional Architecture of the SCMT System

The diagnostics of the correct functioning of the two subsystems is obtained from the graphical interface MMI which is at the Conduct Personnel's disposal on each carriage equipped with SCMT. Besides allowing the data input concerning the train and giving further information on the train gear, by indicating for instance variations in line equipment, reduced-release speed or codes displayed on track circuits, such interface shows the Conduct Personnel the diagnostic data concerning SSB and SST.

In order to handle, clearly and promptly, with the diagnostic information which is daily transmitted by the network and facilitate the task of the Conduct Personnel as well as the Coordination Centres in charge of the infrastructure maintenance, a monitoring system called 'Remote Diagnostics System SCMT' is being developed to enable :

- real-time transmission of the diagnostic information displayed on MMI by means of an SMS message via GSM-R from the train;
- real-time sorting of the diagnostic information to the coordination centres in charge of the infrastructure and traction maintenance.

The remote diagnostics subsystem is characterized by an aboard subsystem SSB-DR and a land/trackside subsystem SST-DR. The aboard subsystem consists of a modem whose task is to send an SMS properly encoded with the diagnostic information. The land/trackside subsystem consists of a server suitable to:

- receive the SMS;
- identify the type of error, either SSB or SST;
- in case of malfunction of SST, localize the information point responsible for signalling, by means of an appropriate data base;

- in case of malfunction of SSB, identify the Traction Coordinator and the relevant system;
- send the error signals via e-mail or, alternatively, via fax to the parties concerned by means of personal data (name, surname, role, telephone number and e-mail).

ENDNOTES

The research and potentialities of diagnostics and maintenance systems increasingly advanced will provide advantages and constant monitoring of every system applied to the railway infrastructure. This is certainly the trend which will provide a significant improvement in results and maintenance efficiency, in order to have an infrastructure which best suits the current requirements for reliability.

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