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CORE BRIEF

Strategy, policy and operational maintenance of electrical systems and equipment of metro networks

The equipment and installations making up the electrical systems of metro networks are undergoing rapid technological development, which in turn is having a direct impact on maintenance strategies and organisation. Transport operators all over the world are therefore increasingly looking into:

- *new forms of maintenance strategy, policy and organisation;*
- *the feasibility of new outsourcing policies;*
- *improving economic efficiency and Life Cycle Cost (LCC) in particular*

The development of maintenance strategies is directly related to equipment renewal policies.

The renewal of technical equipment or systems can be decided on the basis of the following criteria:

- **Regulatory obsolescence**: This type of obsolescence is brought about by modifications to general regulatory provisions that set an obligation to comply within a given period (e.g. legislation banning asbestos);

- **Commercial obsolescence**: This relates to cases where there is a clear discrepancy between the means actually used to carry out a functional requirement and the means available or in use on the market (e.g. rolling stock with an outdated appearance, or a ticketing system unable to accept payment by bank card or cheque issued in euros).

- **Functional obsolescence**: Obsolescence arising when existing equipment cannot be brought into line with new operating requirements, regardless of the type of upgrade measure (e.g. new functions required by an operator to significantly increase or reduce intervals in a speed control system).

- **Technical obsolescence**: Obsolescence arising when spare parts or technical skills for a particular technique or machinery are no longer available.

- **Deliquescence**: State by which an equipment or system is increasingly unable to perform its assigned function due to a significant reduction in mean time between failures (MTBF) or increase in mean time to repair (MTTR). In this case the failure level of the equipment is considered unacceptable.

- **Reduction in Life Cycle Cost (LCC)**: The overall cost of the equipment/system is deemed too high in relation to market supply.

Type of obsolescence observed in a study of 19 networks (percentage)

Type of Obsolescence	%
Technical	43
Functional	28
Deliquescence	21
Reduction of LCC	5
Commercial	2
Regulatory	1

Paris

The organisation of maintenance services evolves in line with equipment renewal and the new strategies that are implemented in a different manner.

New trends have nonetheless been observed:

• *Maintenance has become a totally customer-oriented service*

Traditionally, maintenance indicators used to measure the availability and technical reliability of installations. However, new indicators now also increasingly measure the degree of quality perceived by passengers. Indeed, non-availability during peak hours will not have the same impact as during off-peak periods. Contractual requirements, included for example in contracts between organising authorities and operators, put more emphasis on measuring the number of passengers delayed than the overall technical availability of installations.

• *"Design to maintenance[1]" specifications tend to be standardised by Integrated Logistics Support (ILS)*

Operational maintenance is defined as early as possible by *Maintenance engineering* and is subject to specifications known as *Integrated Logistics Support* (ILS). The manufacturer awarded the contract is required to supply all the data necessary for operational maintenance and the estimation of life cycle costs.
The aim is to define the support system by integrating all the operating and maintenance requirements and restrictions into the project and programme management.

• *Operational maintenance (OM) is performed in parallel with the main engineering project*

The scheduling of maintenance must allow for the OM of new equipment and installations. OM ensures the safety, availability and durability of installations throughout their life cycle.

The global project of system installation or renewal increasingly involves two elements that run in parallel:
- the design, manufacture, validation and start-up of the main system;
- the organisation or adjustment of operation and maintenance.

There is an organisational distinction between *on-site maintenance* (1st level) and *equipment needing to be dismantled* (2nd and 3rd levels) and repaired in specialised workshops.

• *Monitoring techniques are becoming widespread with the creation of the central maintenance centre*

Most transport networks have a *central maintenance* centre for *monitoring* all equipment. It is usually located in the same place as the control centre.
As is the case for automated metro lines, on-board equipment transmits maintenance data to this centre continuously or at set intervals, making it possible to monitor the availability of ATO-ATP-ATC systems[2] in real time.

• *New technologies allow activities to be grouped by maintenance level*

In the past, metro companies arranged maintenance of installations by technology or servicing skills. Dedicated crews were specifically in charge of signalling, speed control, control centre, message display, communications, and so on.
In the new systems, applications are integrated into a single technology, and maintenance teams therefore tend to be organised by maintenance level rather than by application.

• *Systematic preventive maintenance at set intervals continues to apply to most equipment.*

However, this type of maintenance is becoming less common due to the spread of electronic and computerised systems superseding electro-mechanical applications.

[1] *i.e. manufacturing process taking maintenance needs and constraints into account as early as the design stage.*

[2] *ATO: Automatic Train Operation; ATP: Automatic Train Protection; ATC: Automatic Train Control (ATO+ATP)*

• As the demand for availability increases

Maintenance crews need to be increasingly on-duty, meaning extending the *hours of service*.
Some sub-systems, such as train dispatching, ATC or passenger information displays used to be simply considered as "operating aid" systems. Today these systems are increasingly indispensable for the nominal operation of metros; this means maintenance crews are required to cover longer hours of service (including staying on standby-duty at home over weekends).

• Optimisation of Reliability Centred Maintenance (RCM).

Reliability Centred Maintenance (RCM) procedures are now being introduced. Like *predictive maintenance*, RCM is more relevant for electromechanical equipment (subject to wear) than for electronic equipment.

Stringent safety management and the growing use of quality management principles are drivers of progress.

Transport companies draw a clear distinction between the following:
- safety equipment (control-command and signalling)
- non-safety equipment (telecommunications, displays, supervision)

Special attention must however be paid, as certain equipment, though not specifically designed for safety purposes, may be involved during operation or maintenance procedures that contribute to *overall safety* (e.g. radio communications are not necessarily designed specifically for safety purposes, but their availability may contribute to overall safety).

In the case of safety equipment, *maintenance procedures* entail hazard and risk analyses. Certain *authorisations* are often required for staff, and specific training and expertise required.

Equipment is individually monitored on site by *change control management*, while maintenance interventions are subject to *double checking* and related traceability procedures.

Quality management is increasingly implemented throughout entire maintenance organisations, taking into account the specific nature of safety equipment. It is increasingly common for procedures to be organised by "process", and include reporting of non-conformities, thus contributing to a dynamic of continuous progress.

Certification by external bodies is becoming increasingly popular.

Hamburg


Madrid

New tools for economic and technical optimisation

There are indicators to measure the *work efficiency* of maintenance technicians:
- for maintenance crews, in 75% of metro companies;
- for individual technicians in only 30% of metro companies.

In general, *technical indicators* are as follows:
- number of faults and failures, with identification of those with an impact on train operation;
- time necessary for maintenance team to arrive on site and repair time;
- down time and impact on train delays;
- availability, reliability, MTBF, recurring issues;
- volume of preventive maintenance;
- costs.

All these data are stored and processed by Computerized Maintenance Management System (CMMS).

Documentation is usually computerised to make it accessible from work stations.
Test systems are increasingly integrated to equipment via Built-In Test Equipment (BITE).

Operating experience and *statistical analysis* are increasingly widespread methods.

Conclusions

1. Modifications to the **maintenance** schedule are required following equipment renewal. **Technical obsolescence** is the main cause of renewal.
2. Maintenance must be specified and scheduled into system design from the outset, by following a parallel engineering strategy. New **maintenance specification and optimisation methods** are now being implemented by metro operators (ILS, RCM, remote maintenance, and so on).
3. **Relations with the manufacturing industry** must be set out clearly for both parties.
4. Intervention **procedures** for safety equipment must include hazard and risk assessments. **Quality Management** procedures are becoming widespread.
5. **Computer software programs** are subject to specific procedures that must be taken into account.
6. The **maintenance technician** requires specific skills that must be constantly refreshed.
7. **The purpose of maintenance** is: passenger safety, availability of facilities and economic optimisation. Many tools and methods are available to meet these ends.

Prepared by the Electrical Installations and Safety Systems Subcommittee of the Metro Division.

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