Integrating Existing Tunnels into Modern Facility Management Systems: A New Approach for Operating Tunnels

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ABSTRACT

The service-lifespan of underground structures is usually very long. Some tunnels (esp. railway tunnels) have been in operation for more than 150 years with many more years of service-life to come. Independently of the traffic mode they are used for, they in most cases represent highly needed key elements of the infrastructure network they belong to, leading to strong dependencies on their permanent availability. Therefore it is already a task of high importance and of increasing requirements to generate functional facility management systems for newly constructed underground traffic networks to provide an optimized usability. A task of ever greater challenge is to integrate already existing structures of underground traffic into those modern management and operation systems, which have been developed the last several years, and to reach an even level of sustainability and availability for the infrastructural network as a whole.

In this paper tools and methods for upgrading existing operation systems or creating adapted systems for existing facilities are presented. First the challenge for operating authorities is described and a closer look into the near future of developing operational costs will be provided. Facility management systems, as already used for operating infrastructural networks, are displayed and additional steps for generating a structure-wide operational system, which includes buildings and facilities of all kind and age, will be presented.

1. INTRODUCTION

Traffic tunnels usually are located where no adequate alternatives for traffic are available or at least are connected with considerable disadvantages. Independently of the traffic mode they are used for, they in most cases represent highly needed key elements of the infrastructure network they belong to. That said high service availability is always a main target for the operator. Securing high service availability is thereby strictly connected to an efficient operational strategy, whereas methods of facility management are a useful help in the way they are exercised in the modern real estate economy. Especially taking a holistic approach for evaluating a specific building – thus regarding all phases of a lifetime, as there is planning, construction and operation up to the dismantling of the building – has to be considered as a reasonable method.

Regarding traffic tunnels these reflections do not only have an influence on the German national economy, for example by having a look on public metropolitan and suburban commuter railway systems. Because of Germany being a country, which is highly frequented by transit traffic, especially regarding its location for the European community, these problems are of a serious concern for the EU-wide infrastructural network. Therefore a conclusive and efficient lifecycle strategy has to be carried out to insure high service availabilities for those buildings. In addition, it can be expected that
the fields of operation and maintenance will in future take up a far greater share of the pending tasks for research and development. (Thewes, 2006)

This is already a task of high importance and demand regarding the planning and construction of new infrastructural lifelines, but it’s an even greater challenge for operating already existing tunnels, as – for example – railroad tunnels which have been built during the early years of the last century, but which are still in use and are an integral part of the existing railway infrastructure.

In this paper, after a short and general introduction regarding methods of facility management and after some remarks concerning the operation mode of traffic tunnels, some ways of adapting facility management tools for traffic tunnels are introduced to the reader. Those methods provide a holistic and lifecycle oriented approach to operation of underground infrastructure.

2. FACILITY MANAGEMENT: TOOLS, PROCESSES AND TARGETS

Facility Management (FM) as a method of sustainable and lifecycle oriented operation of real estates and properties, is used increasingly throughout the EU. Presently the aspect of commercial and private building construction remains in its focus, as far as the operation of hospital complexes.

In a general view, FM provides the long-lasting preservation or the enhancement of assets and investments in terms of basic fabric and installations (GEFMA 2004). By using resources in an economically and efficient way, building and service related costs can be limited and reduced throughout the facilities lifecycle. Thereby its lifespan can be expanded, via securing the quality of integral parts of the building and its operation points. This is far more eminent the further new construction of buildings and facilities is reduced for the benefit of renovation and refurbishment (Peil & Hosser, 2005).

Regarding consumption related costs, FM-tools provide a billing which is fair according to the input involved. In addition it will create incentives for the facility’s users to save resources. By a foresighted planning, unexpected and unanticipated costs can be spared for the operator and – as far as renting the facility is intended – high attractiveness of rentable areas will be provided.

In doing so FM has to be regarded as a clearly broader task than a typical building management will come up with. For Germany the DIN 32763 (DIN32763, 2000) contains a decided definition as far as building management is concerned. Including this definition into the considerations it becomes obvious that a classic building management approach is limited only to the use period of the facilities lifecycle, while FM-methods will have an influence throughout all the phase of a facilities lifespan. This aspect applies not only to one specific building. It is a valid diagnosis concerning all process-related entities, company- or authority-wide.

Thereby the single phases of the buildings lifecycle describe all aspects of the facilities lifespan. They are demanding actions which are directly related to the building itself, to its planning, its construction, its operation, up to its dismantling. By doing so, processes can be identified within these phases which need to be integrated into FM-Systems regarding the specific building.

Taking a theoretical approach, this structure of processes and phases can be sophisticated up to another level, by generating two different categories of system related duties: primary and secondary processes. Such duties are called primary processes – or core processes – if they belong to the operation or maintenance in a direct way, such as i.e. refurbishment of ventilation. On the other hand, such duties which are doing preliminary works for other processes are called secondary processes, such as costing or accounting.

Next to current procedures of business administration the monitoring of the building, the building management itself and the calculation of its lifecycle costs (LCC) are processes of highest importance. Based on the fact that – regarding typical building constructions – almost 80 % of whole life costs are accounting for operation and maintenance (BMVBW, 2003), its gets quiet obvious that organizing a holistic and stringent building management and reducing costs by using such methods are main impact-objectives for modern and purposeful FM-methods.

For the executing authority transparency and traceability of all processes are main goals, as far as realizing quality of accomplishment and thereby accruing costs. This also has to be provided by using
adequate methods of monitoring and controlling. Therefore so-called “Workflows” can be considered as a useful tool of organized execution. These workflows may help to structure and to homogenize primary and secondary processes. Exemplarily, a workflow for typical building services is displayed in Fig. 2.1. As an additional tool for creating system-immanent transparency, the GEFMA (German Facility Management Association) is currently establishing the so-called “Process-numbering-system” in Germany (GEFMA, 2006). Regulation and Control of process sequences, regarding cost-effectiveness of single FM-service, are possible only if these processes are defined and structured by consistent guidelines. If descriptions of primary and secondary processes are based on defined standards and representative proceedings it is possible to measure and control FM-services and accruing costs in an objective way.

Using the “Process-numbering-system” consequently provides a level of standardization that will keep descriptions of processes and their tools fast and efficient. The numbering-system indeed provides a general structure, but its fineness and its level of diversification can be influenced by the user regarding specific tasks or duties. That said an individual usage of such a numbering-system is possible, facilitating high flexibility and creative freedom.

3. OPERATING TRAFFIC TUNNELS

3.1 Points of operation regarding traffic tunnels

Due to the specific common carriers traffic tunnels feature different points of operation, which are of vital importance regarding to the facility’s function within the transport network. A structured and efficient facility management needs to be focussed on these points.

Fig. 1. Typical workflow for planning and conducting a facility service.
Regarding road tunnels, which are those types of tunnels with the largest need for operational systems, the following points of operations can be pointed out:

- Ventilation
- Lighting
- Communication technology
- Systems for fire safety
- Systems for traffic surveillance, traffic guidance and signalling
- Drainage installations for road surfaces and (in case of permanently drained tunnels) for ground water

In addition, the integrity of the inner lining and i.e. the roadsurface (or railway surface for rail tunnels) needs to be inspected frequently. However, the before labelled points of operation are subject to a higher frequency and intensity of maintenance and repair and naturally do have a shorter span of lifetime. This applies especially if the inner shells or the tracks of a tunnel are built due to high requirements regarding construction and durability.

All these points of operation do have in common that they first require an initial investment during the construction phase and that they generate operational costs during the operational phase of the building of a substantial amount. This also includes costs for energy supply and cleaning. During later phases of the facility’s lifecycle parts and components of these systems need to be exchanged due to ageing, failure or wear. That said it is possible that during the lifespan of traffic tunnels i.e. complete systems for surveillance or traffic guidance are exchanged two or three times (PIARC, 1999). The influence of these matters on the facility’s cost structure needs to be considered for generating a lifecycle cost-model (LCC-model) for tunnels.

Furthermore all points of operation do have in common that their maintenance and repair, even if it’s only on parts of the structure, will generate obstacles and handicaps for the utilization of the building, which results in a decrease of the facility’s service availability. This has to be factored into the considerations as well. At some point the blocking of one track is necessary, at another point a complete tube or the tunnel as a whole has to be taken out of service. Expenses for the general public result accordingly. In addition costs of general upkeep will occur, for instance due to cleaning of the inner shells or the track marks (PIARC, 2005).

That said it seems likely that operational costs and length of the tunnel are correlating. But from unpublished researches by the Federal Highway Research Institute (BASt) the perception has arisen that actually there is no direct link these two parameters. As a result operational costs need to be acquired for every specific object.

### 3.2 Inspection, monitoring, damage detection and data logging

For being able to maintain all points of operation efficiently, a substantial surveillance and detection of deterioration is needed. At this time mostly visual inspections and failure detection which is inherent to the specific system (for instance as function control for ventilation or illumination) is used for German traffic tunnels. The largest part of deterioration detection next to visual inspections is carried out by non-destructive testing methods, for instance as a measurement for the integrity of the inner shell. All collected data needs to be carried over into a management system, as i.e. the building management system designed by the BASt (Haardt, 2004).

In a long term view it has to be expected that a surveillance of tunnels with monitoring-systems and - procedures will be exercised more widely. Therefore integral parts of those systems will be integrated i.e. into newly designed inner shells or road surfaces. To homogenize these systems and buildings with our existing infrastructural network will be one of the bigger tasks of the underground construction process of the future. Already existing buildings which were not specified for such a use of maintenance systems during the planning and construction phase, need to be reequipped and to be carried over into modern management systems. Therefore new data-logging- and management concepts permitting a network-wide controlling and monitoring, based on defined standards and following decided rules, have to be developed.
4. MAIN FEATURES OF FUTURE FM-SYSTEMS FOR TRAFFIC TUNNELS

4.1 Essential differences between the operation of traffic tunnels and other facilities

If methods of modern facility management should be applied to buildings of the underground infrastructure, first of all the differences between the diverse kinds of buildings and their occupancy need to be compiled.

Comparing classical building constructions with traffic tunnels in this context, the most essential difference between both cases can be identified in the provider/user-relationship. Regarding the building constructions from an operational point of view users are often considered as clients within the system. This is normally not the case for users of underground traffic infrastructure. Only on few occasions, for example contemplating underground intersections where different types of common carriers are interconnected or if the traffic building is carried out under the contractual rules of public-private-partnerships (PPP), this might occur as a basis for financial considerations.

Another difference can be identified in cases of breakdown or failure of the specific building/facility. Albeit the loss of infrastructure has a huge influence on the national economy, users of underground infrastructure normally do have the ability to chose another common carrier, for example by changing routes or directions to their destination. In comparison the loss of a building construction or the specific facility terminates the possibility of economical application for the user. That said user concerns – and thereby targets and aims of facility management methods – do have a subordinate ranking regarding underground infrastructure.

Another notable difference can be found in different cost structures regarding building constructions and underground infrastructure. As mentioned before, building constructions require about 80% of their whole life costs for operation, maintenance and refurbishment. Regarding facilities of the underground infrastructure this amount is expected to be significantly smaller. This not only true compared the mentioned scopes, but also if the different common carriers are compared with each other. I.e. because of the different systems of traffic engineering which have to be used for railway tunnels compared to road tunnels, operational costs vary carrier-wise.

These boundary conditions have to be considered for an efficient transformation of facility management tools for usage as operational support of underground infrastructure.

4.2 Selection and adaption of applicable methods and tools of facility management

Regarding the mentioned premises, some applicable methods and processes which provide efficient FM-systems can be identified, selected and integrated as cornerstones of future operational systems.

- **Lifecycle cost analyses (LCC):**
  Up to now such calculations are in most cases used approximately during comparisons and selections of different construction methods and versions. Henceforth this calculation process should be carried out regarding all components of the structure, especially operating systems of tunnel structures, and it should accompany the whole lifecycle of the structure.

- **Workflows:**
  For every common carrier specific workflows regarding specific operational points need to be developed. This provides a structured and efficient accomplishment of operational tasks of all kind.

- **Data models:**
  Congruous to these workflows new data models need to be developed providing a homogenized transfer of all operational data throughout the whole lifecycle of a underground structure.

- **Process numbering system:**
  By implementing specific process numbering systems verified to the demands of every specific common carrier, operational costs gain transparency and become transferable into further LCC-analyses. In addition one will reach comparability between different carriers and different buildings.

- **Computer Aided Facility Management (CAFM):**
In an ideal case all aspects mentioned above are integrated into a computer model, together with particular solution-strategies regarding the specific building respectively the specific facility. This model provides collection of all process-related data, its analysis and delivery to the operating authority. Future CAFM-System can be based on the BMS mentioned in chapter 3. Therefore the BMS should be adjusted and extended according to the defiances of modern facility management.

First realizations of these conceptual ideas have already been carried out at the Institute for tunnelling, Pipeline Technology and Construction Management (Maidl et al., 2004), i.e. in terms of developing an adjusted LCC-model created for specific operational points (drainage systems (Thewes et al., 2007)), specific workflows or by generating first data models for several sections. The next step will the design of holistic operation systems for buildings and facilities of underground traffic infrastructure containing so far attained cognitions and the optimization of these systems for specific buildings.

5. SUMMARY

Buildings of underground traffic infrastructure are increasingly demanding operational systems and structures which are currently used primarily as tools and processes of the building construction sector. These demands are connected to a need for higher availability and durability of all facilities. Therefore methods, tools and processes of modern facility management systems are perfectly suited, if they are adjusted to the specific problems of underground traffic infrastructure, especially their users and their technical boundary conditions.

In this connection a much more purposeful approach is needed, especially regarding homogenized guidelines, codes and directives within the EU.

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