HOLISTIC ASSET MANAGEMENT PROCESS ON THE AUSTRIAN MOTORWAY NETWORK

G. EBERL
ASFINAG AUTOBAHNEN- UND SCHNELLSTRASSEN-FINANZIERUNGS-AKTIENGESELLSCHAFT, Vienna
gerhard.eberl@asfinag.at
A. Weninger-Vycudil
PMS-Consult, Engineering Office for Traffic and Infrastructure GmbH, Vienna
office@pms-consult.at

ABSTRACT

Austria, as a part of the European Community, is located in the heart of Europe and thus crossed by one of the most important Trans-European Roads. These motorways, which are in the responsibility of motorway company ASFiNAG, connect the industry areas in Germany and the Benelux countries with the European south and south-east.

Because of Austria's high mountainous topography a key factor in the asset management process is the coordination of measures between pavements and engineering structures (more than 5000 bridges and 200 tunnel-tubes). Due to this fact, the ASFiNAG Asset Management System is used for a net-wide objective maintenance planning process taking into consideration different aspects and demands of the sub-assets to be maintained. It is applied on the whole motorway- and expressway-network with a total length of more than 2,100 km.

The primary aim of the system is on the one hand to guarantee a high availability and road user-orientation and on the other hand to allocate a comprehensive basis for an objective holistic maintenance planning process of both pavements and engineering structures (tunnels, retaining walls, noise barriers, etc.). The main elements of the ASFiNAG Asset Management System are defined as follows:

- Pavement Management System for the systematic maintenance planning of pavements
- Engineering Structure Management System for the systematic planning of bridges, tunnels, walls, etc.
- Management System for the coordination and execution of measures on sub-assets of the road infrastructure

Based on the prognosis of the condition of the single sub-assets and the resultant maintenance activities a comprehensive multi-year construction program can be generated. Beside the estimation of the necessary investments for the different sub-assets the distribution of the maintenance budget to the total infrastructure is a decisive factor of the whole asset management process and can be used as an objective indicator for a customer-oriented asset management of the ASFiNAG-network at the same time.

1. HIGHWAY ADMINISTRATION IN AUSTRIA

In Austria the Motorway network is built, maintained and tolled by a user financed company named ASFINAG. This company does not get any money from the federal budget of the state and it is owned 100 % by the state.

Financing of these tasks comes for the most part by the toll revenues. Fines, and revenue generated from the operation of service stations supplement the income of ASFINAG. For the use of motorways and express roads with trucks 3.5 to maximum permissible gross vehicle weight and buses a mileage dependent toll is payable, cars and motorcycles pay for road usage through a toll sticker, i.e. a time-dependent toll.

The construction schedule is prepared for a period of 6 years in the form of a master plan - based on the technical and economic requirements and in agreement with the Federal Ministry of Transport, Innovation and Technology.

The technical guidelines, which ASFINAG has to fulfill, are developed by the Austrian Association for Research on Road, Rail and Transport, organized as a private association. To the extend, the Federal Ministry of Transport considers these guidelines applicable, it declines them binding for ASFINAG. These guidelines are developed by experts from the fields of science (universities), from federal and province Administrations, from the construction industry and from civil engineering offices.

Within the ASFINAG the operating companies

- one Construction Management Company (BMG)
- two Service Companies (SG and ASG) and
- one Tolling Company (MSG)
- report to a holding company

Within the Group, the two service companies are responsible for the whole operation; they are divided according to regional aspects. All construction work is performed by a construction management company.

Based on operational requirements the service companies launch construction activities on the existing network. These requirements can be derived from

- capacity and traffic quality
- building condition
- traffic safety and
- maintenance requirements

Hence the condition of the building infrastructure is determined exclusively by the service companies and the construction program depends on their needs and requirements.

2. THE AUSTRIAN HIGHWAY NETWORK

The length of the existing Austrian motorways and trunk road network is about 2.200 km and is characterized by the alpine topography of the country. A large proportion of the roads operated by ASFINAG is, therefore, on bridges and in tunnels. The network of ASFINAG has 145 tunnels with about 340 km length of tubes and 340 km of bridges (about 5.020 bridges). Similarly, along the highways and expressways provide some 1.100 km of noise protection walls (3.4 million m²) for the protection of residents from noise pollution. There are also around 1.300 overhead signage portals for signs.

Figure 1: ASFIANG highway network

For ASFINAG operates according to market economy principles and it is owned by the Federal Republic of Austria, all measures on the existing network have to be planned and implemented meeting the highest efficiency and transparency requirements. The objective presentation of the condition of the road network is an important tool for our work. For this reason, ASFINAG decided to develop and implement a computer-based comprehensive system for action planning. This system covers all the components of the road as a system, such as

- road surface
- bridges
- tunnels and galleries
- noise barriers
- retaining walls and
- overhead Signage portals

3. DEVELOPMENT OF AN ASSET MANAGEMENT SYSTEM

One of the key factors for the development of a holistic Asset Management approach are the requirements of the different stakeholders, which are finally responsible for the definition of the asset management process. For the ASFINAG Asset Management System the main requirements of the different stakeholders (users, owners, operators, neighbors, financiers, etc.) can be summarized as follows:

- Provide highest safety and riding comfort on the whole road network.
- Maximize the availability of the whole road network through the whole year.
- Minimize negative effects by traffic to all affected parties.
- Provide an holistic basic of information and data for improvement, structural maintenance and operation of the whole road network.
- Enable an open and objective controlling within the ASFINAG and for the Federal Ministry of Transport, Innovation and Technology (BMVIT).
- Provide high flexibility according to organizational and operational changes within the ASFINAG.

The main objective of the ASFINAG Asset Management System was the establishment of a decision support system for the short- and long-term planning of all improvements and maintenance activities on the ASFINAG network, taking into account the requirements and effects of the different stakeholders. Thus, the focus was not only on pavements but also on engineering structures, like tunnels, bridges, noise barriers, retaining walls, and road equipment or furniture respectively.

In July 1998, the Vienna University of Technology was commissioned by ASFINAG and the Federal Ministry of Transport, Innovation and Technology (BMVIT) with the development and implementation of specific components of the Austrian Pavement Management System (PMS) in cooperation with the road administration authorities. This was the first step in development process of the ASFINAG Asset Management System.

One of the main reasons for the successful approach was a step-wise implementation plan, beginning with the Pavement Management System VIAPMS^{TM} (dTIMS^{TM}), followed by the tailor made Engineering Structure Management System BAUT^{TM} and finally by the establishment of the Management System for the coordination and execution of measures on sub-assets of the road infrastructure as a special module of BAUT^{TM}.

Since 2001 the different components of the ASFINAG Asset Management System are used in practice for the development of the long term and short term construction program and the budget allocation on the motorways and expressways.

In general, the steps of the development of the ASFINAG Asset Management System can be summarized as follows:

- Definition and assessment of the requirements of the different stakeholders
- Definition of main objectives of the ASFINAG Asset Management System
- Establishment of working groups for system development and implementation (ASFINAG EMS core team, working group VIAPMS, etc.)
- Buying and programming of software components
- Data implementation and system-setup
- Development of guidelines and standards
- Continuously system maintenance and improvement (updates, upgrades)
- Continuously data implementation (extension, update)
- Continuously benchmarking and system assessment

At the moment the system offers a high data quality and quantity on pavements, bridges, tunnels and noise barriers, which have the highest priority for maintenance planning issues. The process of data collection aims to extend the inventory data but also to update the existing information periodically or continuously.

4. THE HOLISTIC SYSTEM OF ROAD ASSET MANAGEMENT

4.1. System Approach

The ASFINAG Asset Management System is used for a net-wide objective maintenance planning process in consideration of different aspects and demands on different decision levels (project-level, network-level).

As already mentioned, the primary aim of the system is to allocate a comprehensive basis for an objective maintenance planning process of pavements, engineering structures and road furniture. The main elements of the ASFINAG Asset Management System can be defined as follows:

- Pavement Management System for the systematic maintenance planning of pavements
- Engineering Structure Management System for the systematic planning of bridges, tunnels, walls, etc.
- Management System for the coordination and execution of measures on sub-assets of the road infrastructure

The following Figure 2 gives a schematic overview of the different elements of the ASFINAG Asset Management System.

Figure 2: ASFINAG Asset Management Cycle [2]

4.2. Pavement Management System

For the practical execution of the pavement management process the commercial asset management software VIAPMS^{TM} (dTIMS^{TM}) is used. It is based on the LCC-analysis method. This software is used worldwide by a high number of road administration authorities and engineering or consultant offices. The decisive factor of the system, in comparison to other systems, is the possibility of an individual adaptation of the components and models to the framework condition and requirements of the investigated road network. Thus, it was feasible to adapt the system to the demands of ASFINAG-roads and to run the LCC analysis under the given preconditions [3].

In the context of PMS-analysis different maintenance relevant data are included as follows:

- inventory data (net-specific information and reference systems)
- road geometry data
- pavement condition data from visual inspections and measurements
- pavement construction data including maintenance history
- traffic data
- climatic data

The outputs for strategic planning purposes are based on the element (section) related results of LCA/LCCA and the economic assessment within the optimization for each single budget or quality (condition) scenario. The element (section) related identified results will be cumulated for the whole network or for user pre-defined sub-networks (regional, functional, etc.) and include typical outputs as follows:

- Condition distribution of all key performance indicators for the whole analysis period and for all budget/quality scenarios (example see Figure 3).
- Development of average condition of all key performance indicators for the whole user-defined analysis period in a comparable form for all budget/quality scenarios (example see Figure 3).
- Comparison of available and used budgets for the whole user-defined analysis period for all budget/quality scenarios.
- Treatment cost and length distribution of all maintenance treatments for the whole user-defined analysis period for all budget/quality scenarios.

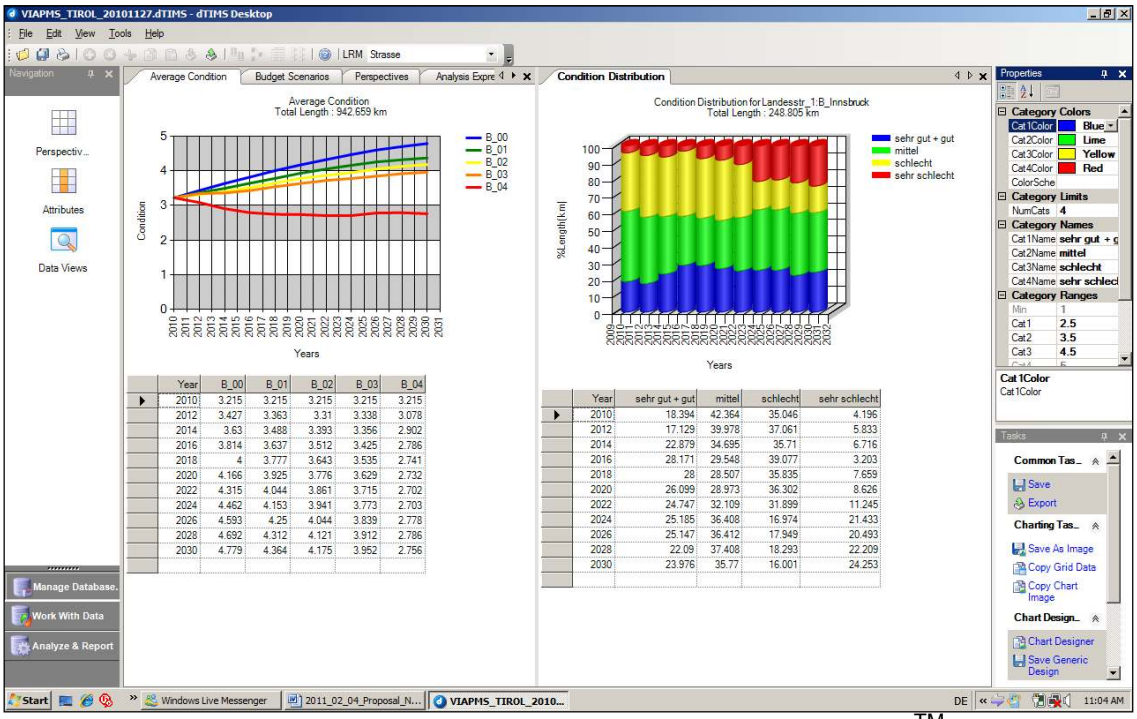

Figure 3: Pavement Management System VIAPMS™

A detailed description of analysis methods, applied models and concepts can be taken from the Austrian Manual Pavement Management 2009 [1].

4.3. Engineering Structure Management System

The Engineering Structure Database Austria - BAUT - started in 1997 as a simple bridge database and developed into a comprehensive facility database with the claim to form an asset management tool. At the moment it consists of several modules of the maintenance management:

- BAUT: Information to constructions like bridge, noise barrier, tunnel, etc. are administrated as well as inspections, shortcomings and investments on objects.
- BAUTK: Information of defects are administrated in this module, it is strongly linked to the module BAUT.
- EMS: The maintenance management system serves the calculation and administration of construction measurements and projects. There is an interface to the SAP of the ASFINAG.
- Construction site: This module enables the administration of construction sites, among others traffic guidance and its impact on the road user can be defined.
- Road: In this module pavement construction and condition are administrated. Offered graphical displays are GIS and strip map.

The Engineering Structure Management System is a Data-Warehouse-Solution that is built up hierarchically. The basic possibilities in BAUT are the administration of data - construction, construction sites, etc. - as well as graphical display - GIS, strip maps, OLAP-Analyses, etc. (see Figure 4).

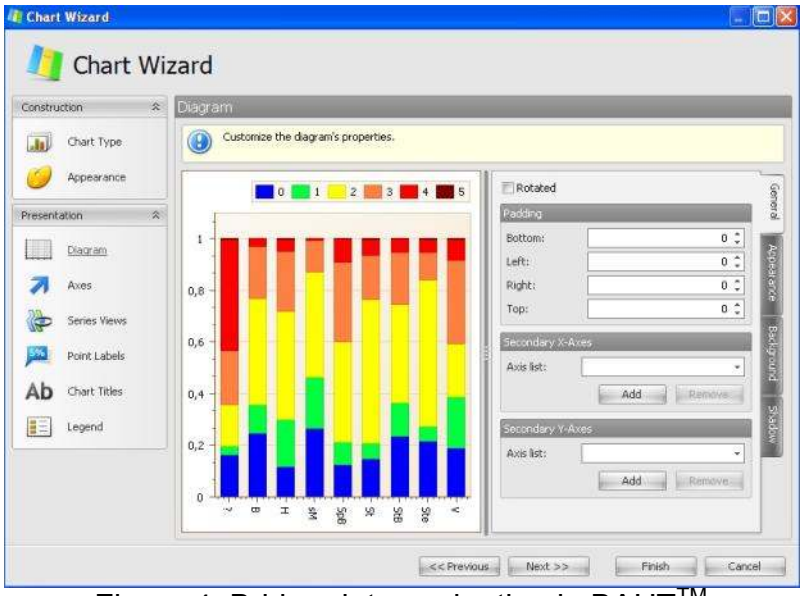

Figure 4: Bridge data evaluation in BAUT™

Since the end of 2007 an online version of the BAUT exists. The Online-Version is running in the so called „Portalverbund“ and offers simple access to the database for other road administrations like federal, state and community administrations.

4.4. Optimized Coordination of Maintenance Activities

The optimized coordination of maintenance activities on a high-level road network in a mountainous region is a complex process. Of course, the availability of the road network is the decisive factor for all maintenance and operation activities, which will be defined in form of so called “Maintenance Projects” and summarized in the short- and long-term maintenance program.

The process to be applied can be described as semi-automated routine, where the input information will be generated in the different sub-systems (VIAPMS^{TM}, BAUT^{TM}), brought together automatically and provided in a readable form for the system users. Nevertheless, the final definition of a Maintenance Project, which can consist of maintenance activities from different sub-assets, will be carried out by an engineering assessment and judgment in mutual agreement between the local engineers and the strategic division of ASFINAG.

The main input for this process is:

- Strategic, network-level results of the PMS-analysis (based on LCA and different budgetary preconditions).
- Section-based maintenance treatment recommendation from the PMS-analysis (pre-defined maintenance budget).
- The strategic, network-level results of the analysis of the engineering structures.
- The project level results from detailed investigations of the engineering structures and its elements.

The combination of both output of PMS-analysis and assessment of engineering structures is done by using advanced visualization technology. This effective maintenance planning tool allows the asset managers to combine and compare the needs of maintenance activities of different sub-assets and to present all information in a descriptive and clear manner to the decision makers. The visualization is carried out in form of

- strip maps and
- thematic maps

The strip maps are the basis for the definition of the annual maintenance program including information of further investigations on project level. In the following Figure 5 the information from pavement construction, pavement condition, bridge condition and noise barrier assessment are displayed as an example.

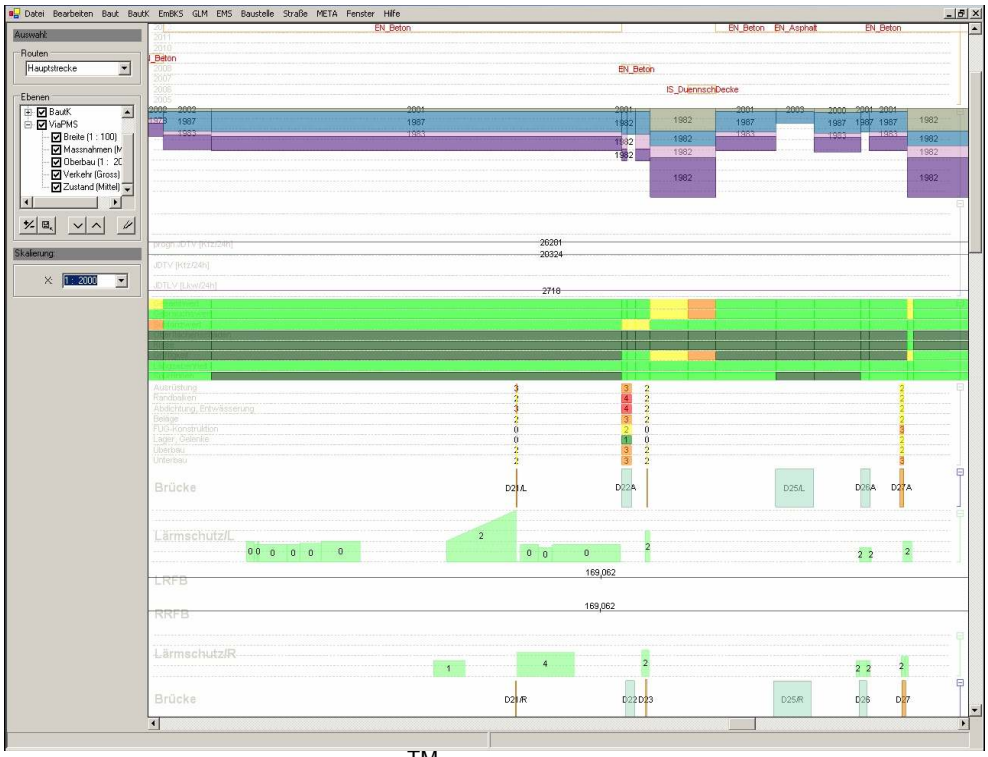

Figure 5: BAUT^{TM} holistic data visualization

The thematic maps visualize different aspects and characteristics of the pavement and structures and will be used primarily in the decision process at strategic level and for public relationship purposes.

A future oriented approach for the combination of maintenance activities on different sub-assets will be the implementation of cross-asset procedures into the systems. Because of the growing number of information to be considered the manual engineering judgments gets more and more complex and the system users are not able to handle the number of information effectively anymore. Thus, it is planned to implement a cross-asset optimization support tool into the system. For this system extension the following steps will be carried out:

- Analysis and assessment of cross-asset management processes
- Definition of mathematical procedures for cross-asset optimization
- Implementation of the new algorithm to be into the Asset Management System
- Testing and adaptation of algorithm in close cooperation with the system users
- Practical application and training of system users

5. HIGHLIGHTING OF NEEDS FOR MAINTENANCE BUDGET AT STRATEGIC LEVEL

One of the key tasks throughout the decision making process is the highlighting of needs for maintenance budget for the different sub-assets. This output of the system allows the ASFINAG to show clearly the strategic decision makers the long term development of the condition distribution of the pavement and the engineering structures for different budget preconditions and to convince them to spend the needed money into road maintenance. Furthermore it is also an instrument to confront the policy level with the consequences of a negligent approach to road maintenance.

Beside the calculation and presentation of the future maintenance needs the ASFINAG Asset Management System is used also as a benchmarking instrument showing the development of condition within the last 10 years. In the following figures the condition distribution of pavement constructions (Figure 5) and of bridges (Figure 6) are shown as examples.

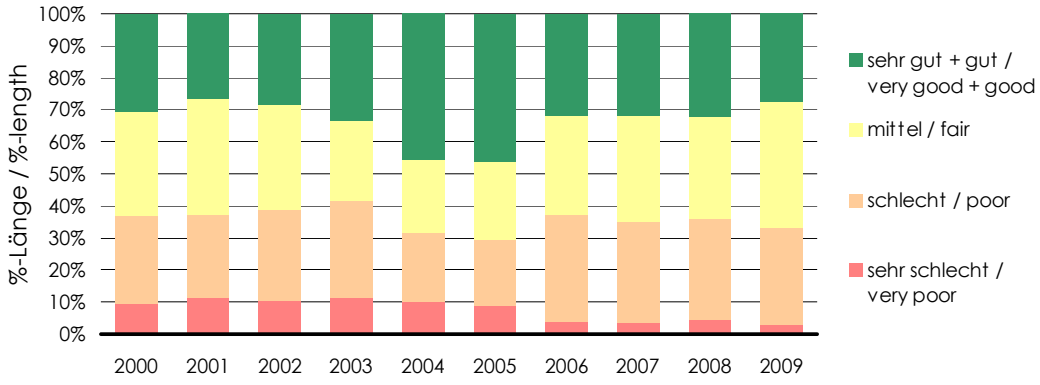

Figure 6: Condition distribution total condition index pavement [2]

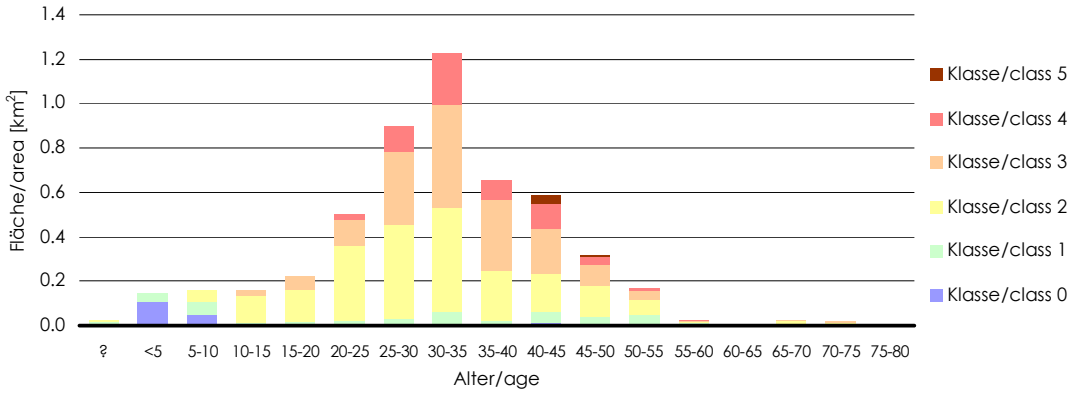

Figure 7: Condition distribution bridges subject to age classes [2]

The development of the condition of the different sub-assets of the ASFINAG road infrastructure, expressed by different key-performance indicators and calculated for different budget scenarios are the basis for the decisions on strategic levels. Thus, the performance prediction will be updated every year and summarized in an internal ASFINAG Asset Management Report, which includes the following strategic results:

- condition distribution for single and combined indicators for the whole analysis period subject to different preconditions
- cost (investment) distribution for the whole analysis period subject to different preconditions
- length of maintenance sites and cost summary for the whole analysis period subject to different preconditions
- backlog development for the whole analysis period subject to different preconditions

The following figures show the condition distributions for pavements (Figure 8) and for bridges (Figure 9) based on a pre-selected budget-scenario as a part of the reporting within the ASFINAG Asset Management System.

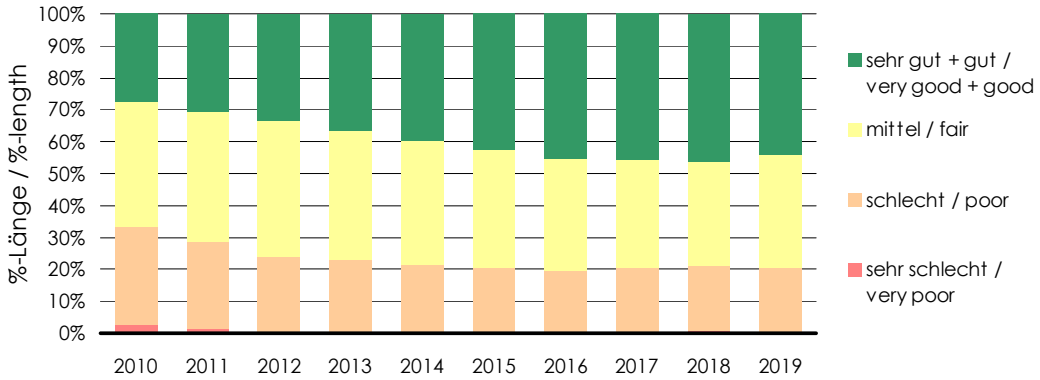

Figure 8: Predicted condition distribution total condition index pavement [2]

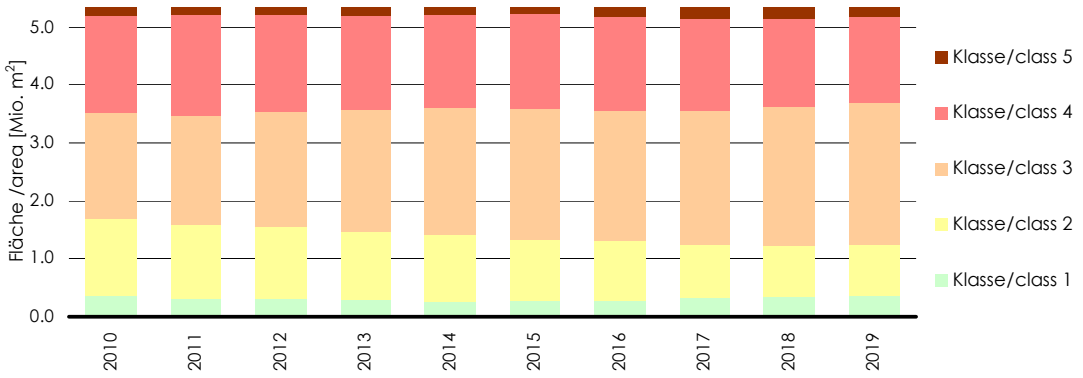

Figure 9: Performance prediction bridges per 1st January of the year [2]

Beside the estimation of the necessary investments for the different sub-assets the distribution of the maintenance budget to the total infrastructure is a decisive factor of the whole asset management process. The following Figure 10 shows the distribution of the maintenance budget with a total amount of approx. 304 Mio. € to the different sub-assets for the year 2009.

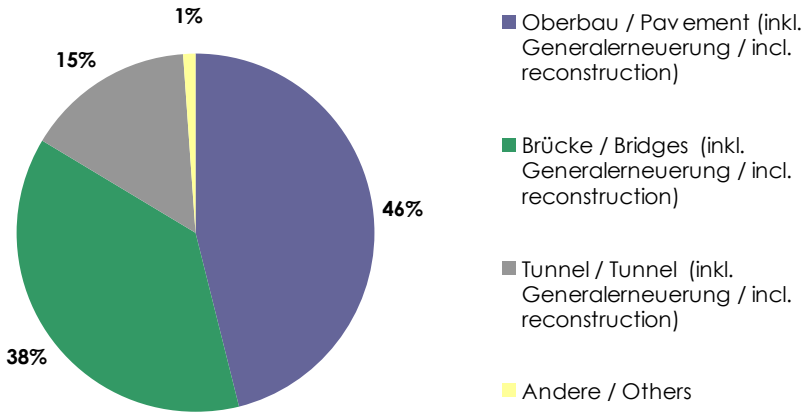

Figure 10: Distribution of the total maintenance budget to the sub-assets (2009) [2]

Based on the prognosis of the condition of the single sub-assets and the resultant maintenance activities a comprehensive multi-year construction program can be generated and prepared for strategic decision. This construction program is the basis for the execution of all maintenance measures and can be used as an indicator for a customer-oriented asset management of the ASFINAG-network at the same time. The following Figure 11 shows the planned investments for the different sub-assets as an output of the construction master plan 2009.

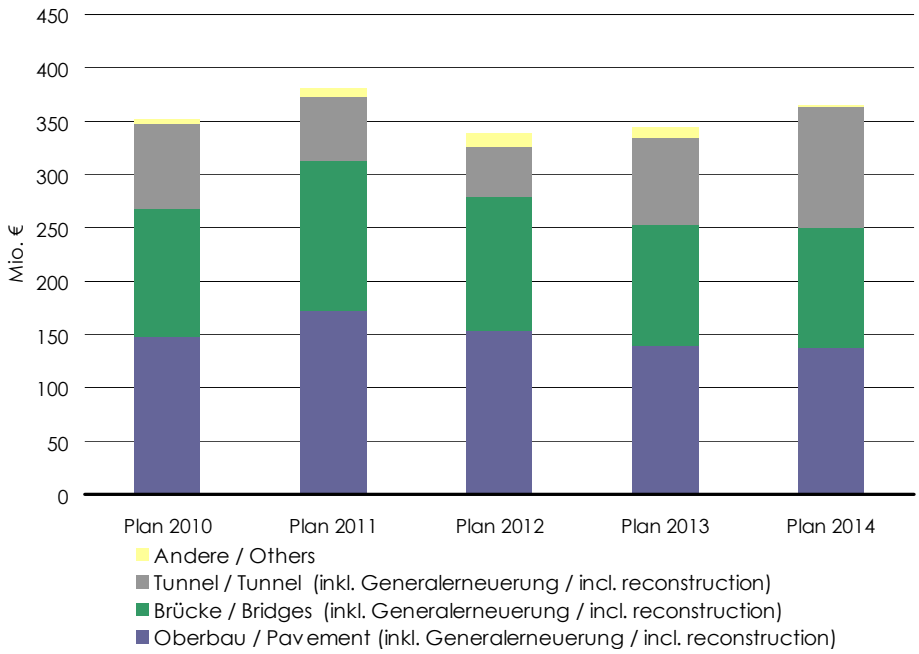

Figure 11: Distribution of the total maintenance budget to the sub-assets (2010 to 2014, price basis 2010) [2]

6. CONCLUSION AND OUTLOOK

The quality of the ASFINAG Asset Management System is critically dependent on the quality and extension of available underlying data and information. Therefore, the main focus of any follow-up work is on a significant improvement and extension of the data used in the process. This includes not only the collection of new data but also the maintenance and updating of existing data as part of a nation-wide data management system.

Because of the high number of information to be assessed and included in the management process the tasks for the local engineers as well as for the strategic managers are getting more and more complex and the efficiency of the system becomes critically. Thus, it is essential to provide only this information which is necessary for the respective decision process. This means that any extension of data and information must be critically assessed according to their degree of detail and their use. Especially the implementation of cross-asset management procedures should help the system users to select the necessary information (input data as well as results from the analysis).

The implementation of the ASFINAG Asset Management System depends, however, not only on the availability of the different components or elements but also, to a large extent, on the system users' willingness to give this system preference over the currently used and time-proven methods. As in many fields of technology, the engineers of the ASFINAG have to learn first to work with the system to understand the results and recognize the potential benefits.

REFERENCES

1. Weninger-Vycudil A., Simanek P., Rohringer T. und Haberl J. (2009). Handbuch Pavement Management in Österreich (Manual Pavement Management in Austria 2009). Schriftenreihe Strassenforschung. Heft 584, BMVIT and ASFINAG, Vienna (in German)
2. Weninger-Vycudil A., Litzka J., PetschacherM. (2010). ASFINAG Asset Management Report 2010. ASFINAG, Vienna, (unpublished)

3. Litzka J., Weninger-Vycudil A., Petschacher M., Maurer P. (2007). Austria – National Report, Asset Management: Technical Inputs to Decision Making. PIARC, XXIIIrd World Road Congress, Paris.