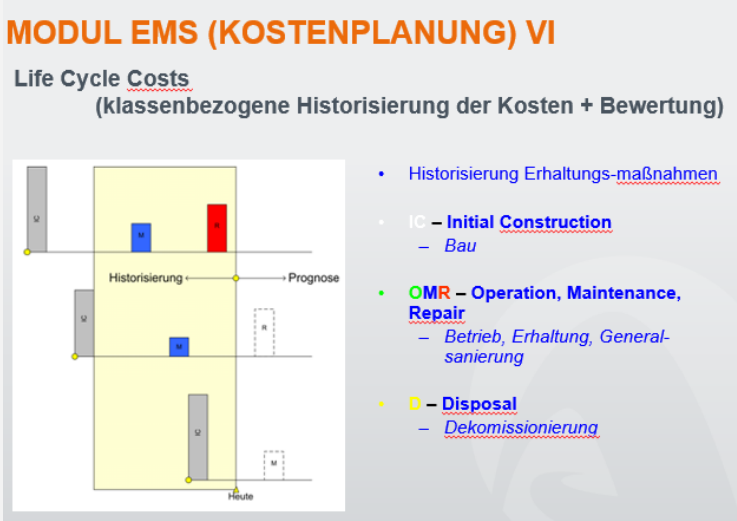
The answers of your posed questions:

Definition and Inclusion of Lifecycle Costs

- Lifecycle costs (LCC) encompass all costs incurred over the entire lifespan of a product or service.

This includes, in the context of road infrastructure, the costs for planning, construction including necessary traffic management for the construction site, traffic disruptions due to reduced capacity, environmental impacts such as increased CO^2 emissions in traffic jams, measures taken to reduce CO^2 emissions by choosing the best bidder (not the cheapest bidder), maintenance, repair, renewal, disposal, and operation

- Bau: Initial Construction
- Instandhaltung: Maintenance
- Instandsetzung: Repair
- Erneuerung: Renewal
- Entsorgung: Disposal
- Betrieb: Operation

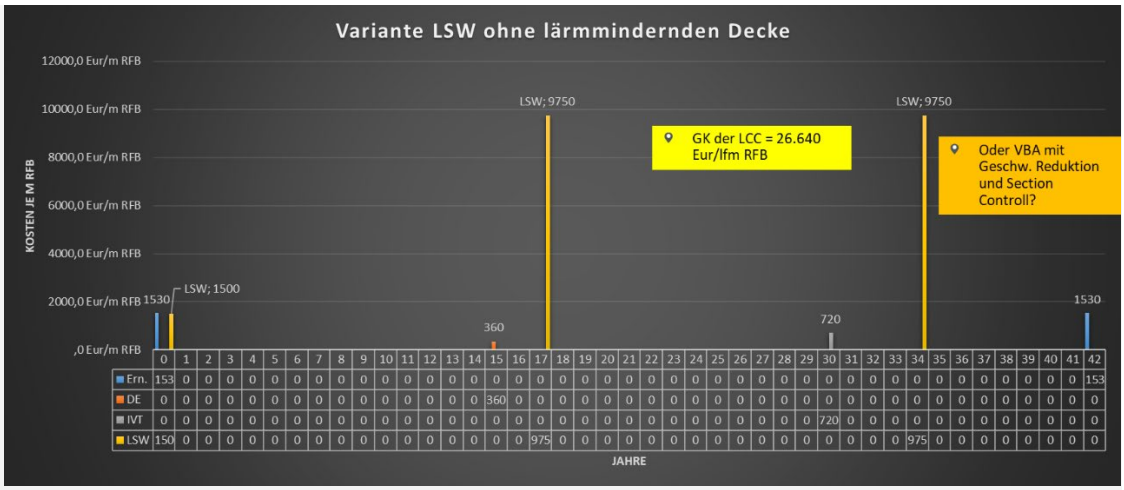


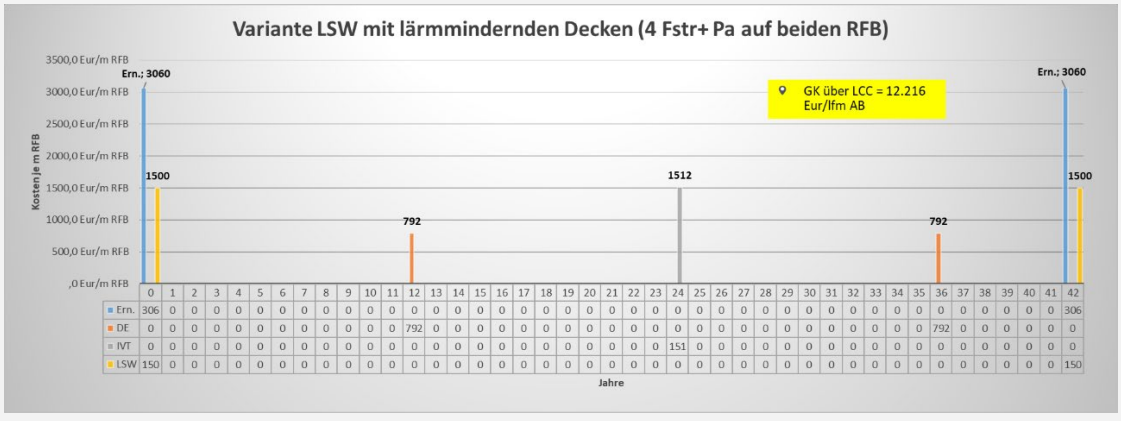
An example of the difference in total costs of 2 strategies that have the same goal of protecting residents with a new, stricter noise protection standard

Comparison:

Strategy 1: Noise protection only by removing the existing noise barrier and building a higher noise barrier. Total Cost/m RW = 26.640 Eur/m

Strategy 2: Noise protection through the existing noise barrier and the use of a noise-reducing pavement. Total Cost/m RW = 12.216 Eur/m





- This method is used to achieve and continuously evaluate the sustainable economic efficiency of investments over their lifecycle, especially for larger projects such as construction projects. By considering all relevant costs over the entire lifecycle, informed decisions can be made and different action strategies can be compared.
- It should be possible to identify the most effective measure over a lifecycle from the implemented actions.

Political Governance and Budget Allocation

- **Austria's accession to the EU** in January 1995.
- To meet the economic criteria of the EU, Austria's deficit-ridden **high-level road infrastructure was outsourced to ASFINAG** at the end of 1997.

ASFINAG, as the maintainer and operator of Austria's high-level road network, **evolved from** only **a financing company to an operational infrastructure operator** at the end of 1997. This was regulated by the owner (100% the Austrian state) **with a usufruct contract**. This **contract grants** ASFINAG the **toll revenues** from heavy traffic and the revenues from the use of the infrastructure by cars (vignette). As a consideration, ASFINAG must commit, among other things**, to maintaining the road network sustainably and efficiently** so that its functionality (heavy traffic, special transports, car traffic) is always ensured.

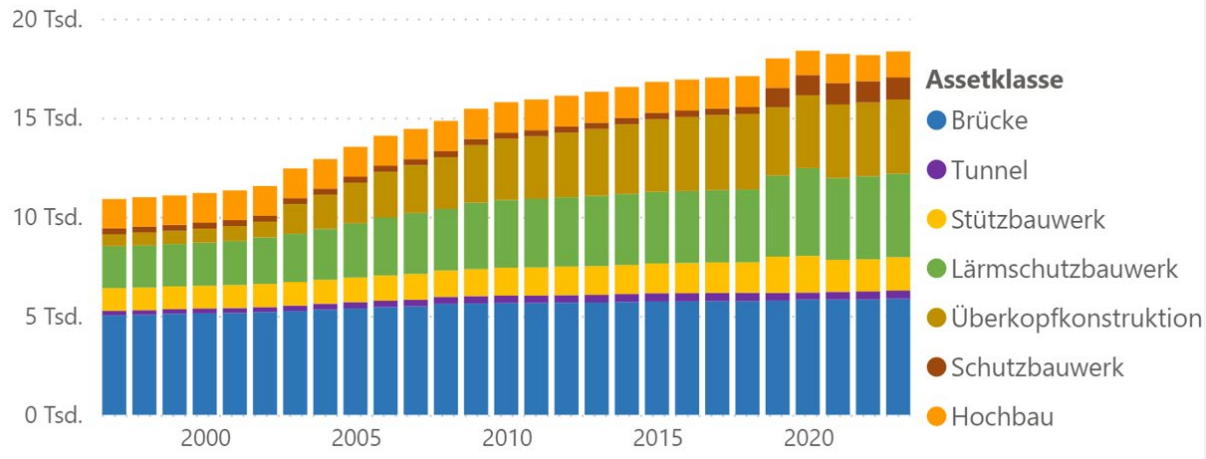
- Advantages of this form of company:

  - **Direct political intervention is no longer possible**.
  - **Politics** is represented **in the supervisory board**.
  - **Revenues (funds) are earmarked**, which are stable over the years and are to be used for the defined tasks according to the usufruct contract; with the stabile bugdet over the years **long-term planning of construction measures is possible**.
  - ASFINAG's organisation structure can adapt to the tasks.
  - **100% public ownership** protects against private interests, which is not the case with private companies.
  - **ASFINAG must account to the owner** (Austrian state).
  - **Unit 2010, it was regularly audited by the Court of Audit** in great detail every 3 to 4 years.

Management and Control of Lifecycle Costs

- With the new operational corporate form at the end of 1997, ASFINAG, among others, has adopted the mandate for management and control as stipulated in the usufruct contract between the Federal Ministry and ASFINAG: THE ASFINAG has to install and use “A pavement management system incorporating bridge and tunnel objects (noise protection, overhead signposts, anchored and unanchored retaining wall objects, etc.) in coordination with the Federal Ministry for Economic Affairs, particularly with regard to the uniform recording and assessment of the construction condition from a technical and economic perspective.”

The required management system was from ASFINAG established by 2007.



This was implemented with the

- pavement prediction model (dTIMS) for the road and the asset management software “BAUT” for assets in the year 2007:
- An asset database system for the assets (facilities/objects):
  - Bridges,
  - Tunnels and galleries,
  - Retaining structures
    - Anchored
    - Unanchored
  - Noise protection structures,
  - Trench structures
  - ……

collected and evaluated with regular inspections (tests and controls), at specified intervals, objects, components, and in some cases, inspection elements are assessed and graded.

The following developed modules should ensure the following tasks:

- **Inspection module** for the regular execution of controls and tests of objects, components, and inspection elements.
- **Construction site reporting module** to minimize simultaneous obstructions due to construction sites and keep travel time extensions within limits.

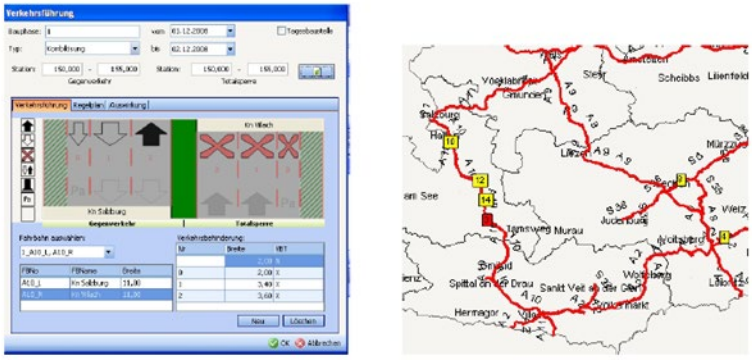


Abb. 8: Verkehrsführung - links - und Baustellen auf (SOTRA)-Korridor - rechts
Fig. 8: Traffic Guidance - left - and Building Sites on (SOTRA)-Corridor - right

- **Dynamic route band module** to select and synchronize measures on different assets; key data could be selected and displayed.

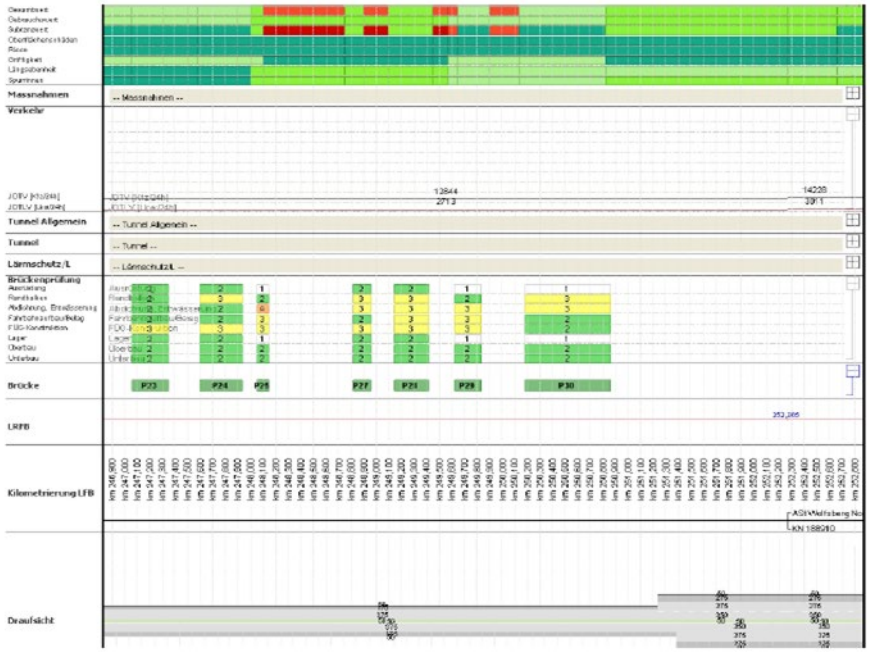


Abb. 9: Streckenband
Fig. 9: Route Band

- **WEBGIS module** to visualize the data on a GIS map.

- **Cost planning module** (EMS cost planning for the stored objects and components).

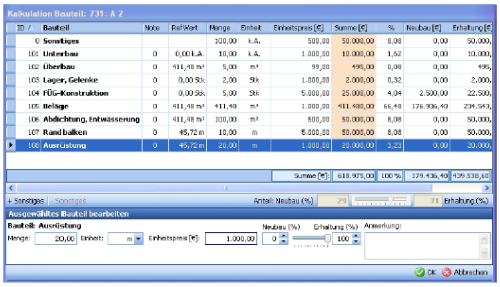


Abb. 5: Kalkulation Objekt

Fig. 5: Calculation Object

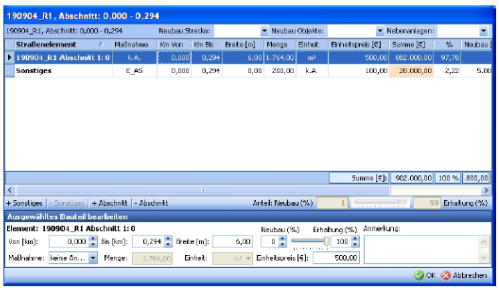


Abb. 6: Kalkulation Abschnitt

Fig. 6: Calculation Section

➢ **Cost linking rule** for the different software products BAUT (in-house development) and the internationally common software SAP (cost mapping).

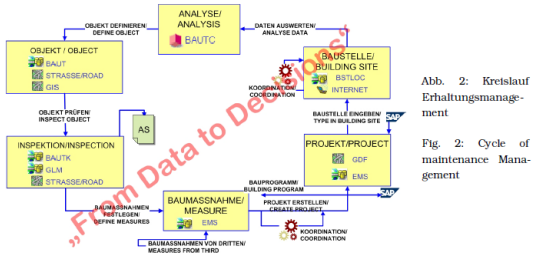


Abb. 2: Kreislauf Erhaltungsmanagement

Fig. 2: Cycle of maintenance Management

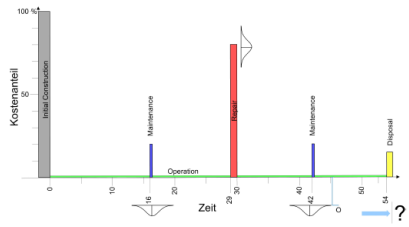
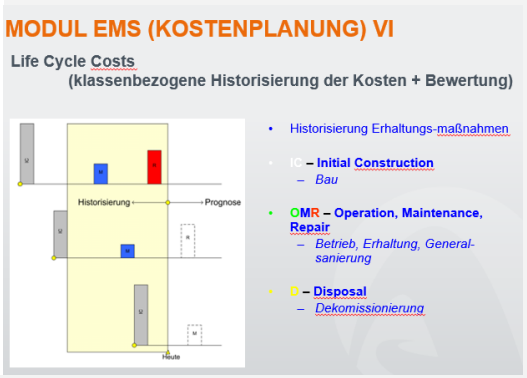


Abb. 3: LCC

Fig. 3: LCC



➢ **Analysis, to check if the goals are in the giving boarders from the Maintanance Strategy**

With the aforementioned foundations and data, and the resulting general renovation concepts for road sections, ASFINAG was able to significantly improve the quality of the Austrian motorway and expressway network in a very short time, use funds efficiently, and accommodate the strong traffic development (November 1989 border opening) through capacity expansions.

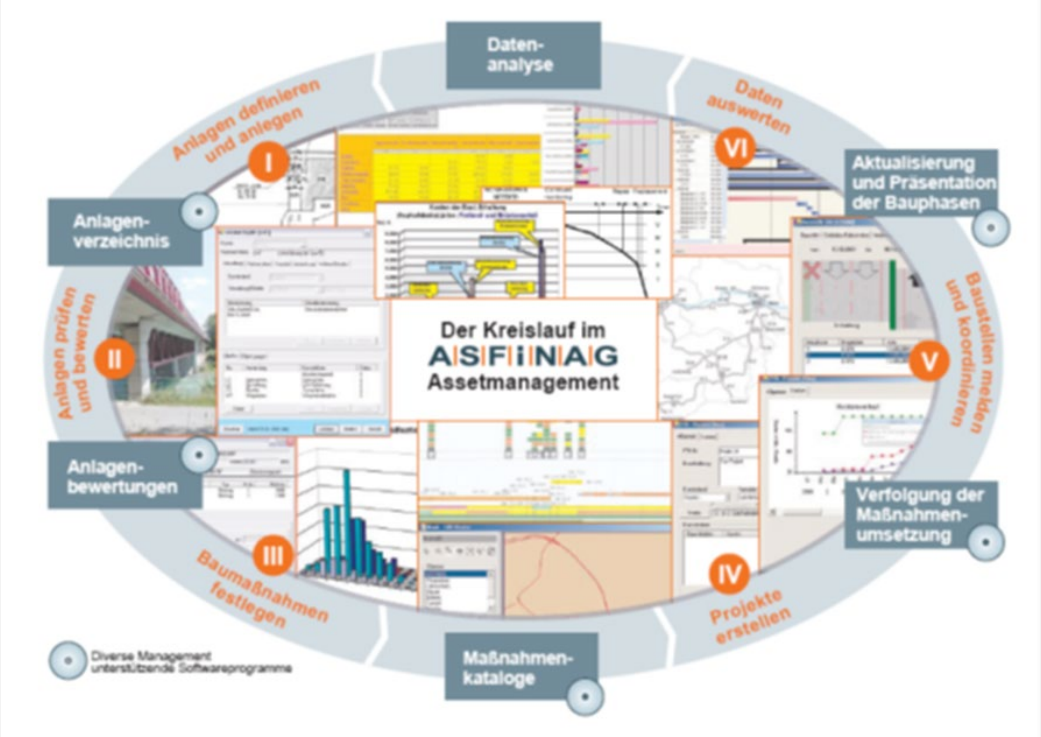
The functionality was fully ensured for passenger and heavy traffic, and special transport on the high-level road network, and traffic safety was continuously improved.

Unfortunately, due to a change in government, significant leadership positions were also replaced during this period, and regular reviews of the fulfillment of the usufruct contract by the Court of Audit after 2010 were discontinued.

Barriers to Implementing the Lifecycle Cost Perspective

- Detailed cost allocation of planned and actual costs requires a consistent structural approach and interaction between multiple departments. The **interaction of different areas of ASFINAG is not always easy**.
- The establishment of long-term stable management systems and their objectives must be anchored in such a way that changes in responsibilities do not hinder their development; The implementation of these management systems and guidelines should be either **per law or contractually anchored**, as in Austria, to ensure that personnel changes in responsibility do not jeopardize the development.
- **Building a well-thought-out sustainable management system** that remains constant over a long period (to recognize and learn from mistakes; 'living a culture of learning from mistakes') and can be further developed.
- **Meaningful and necessary transparency** is not desired by everyone (efficiency can be disclosed and assigned over periods); this leads to regular critical evaluations, which should be standard. **Legally binding transparency for infrastructure operators**, similar to that for publicly listed companies on stock market, **would be desirable**.
- Object/component/inspection element-related planned and actual cost allocation requires a corresponding effort (question of tendering and billing specifications; from my point of view, this is the indispensable prerequisite for a qualitative Building Information System).
- **Lack of pressure and control of the fulfillment of contract points by stakeholders** (in Austria, the Court of Auditors last examined this area of ASFINAG in 2010, i.e., 14 years ago)

Preconditions for Implementing the Lifecycle Cost Perspective



Key components include:

- **Effective database system** with relevant and meaningful data
  - Data components:
    - Structure of assets divided into 3 levels (object/component/inspection elements)
    - Recurring inspections (e.g., 2-year cycle for bridges, inspections every 6 years, controls every 2 years) with condition records
    - Recording construction measures (depth of measures), costs (actual costs after completion and timing of measures)
- **Costs assigned to objects and components,** such as planning, construction supervision, traffic management, operational, ecological, and disposal costs, which can be represented over the lifecycle and can be presented as total costs.
- **Data continuity and stability**, long-term access enabling long-term evaluations
- **Creation of benchmarks with** stable, lasting significance and **long-term comparability.**
- **Creating evaluation possibilities from different perspectives** such as:
  - Comparison of efficient use of funds over the lifecycle
  - Maximizing the respective lifespans of different measures
  - Does the lifespan correspond to the different depths of measures?
  - Does the choice of sequence of measures deviate?
  - Which strategy had the best cost/benefit ratio?
  - Which strategy ist he best solution over the Lifecycle?
  - What costs, traffic disruptions, etc., are caused by the lack of bundling (temporal synchronization of required measures for different assets)?
    - Example: Renovation of a tunnel chain with interspersed bridges
    - …
- **Transparency** towards stakeholders such as the owner (Austrian state, road users, and residents; ensuring sustainable, responsible management towards the owner)
- **Ensuring stability** of further development and assignment at a strategic, professionally competent, independent level (independent decisions without objective critical review by third parties should not be possible)
- **Creating clear statements**

- **Creating awareness** that it must be an instrument that:
  - Quickly identifies misdevelopments,
  - Sees necessary innovations,
  - Shows improved processes and executions,
  - Represents the consequences of changes,
  - Reveals the consequences of bundling,
  - Prevents neglect and misjudgments
  - Minimization of all total costs (operating costs, maintenance, repair, renewal costs) considering the bundling of measures ! **Optimizing of Costs**
- **The goal should be**
  - to evaluate differences in similar problems or questions, recognize inconsistencies, live a culture of error to learn from mistakes, and react quickly.
  - to find the best solution with the best cost benefit
- **essential basis of the Building Information System (BIM)**

Practical Application of Lifecycle Costs

An example of medium- and long-term planning for infrastructure maintenance needs

A **defined maintenance strategy sets goals** that must be adhered to.

Examples of goals, which must be achieved.:

- **Goals:**

ERHALTUNG

Alt

ERHALTUNG GEMÄSS STRATEGISCHER ZIELVORGABEN

Umsetzungsziel 2024ff	Ampel	Begründung
Bauwerks- und Anlagensicherheit Ingenieurbauten und Hochbau		Für alle Ingenieurbauten und Hochbauten mit Note 4 und schlechter sind Maßnahmen im BP eingemeldet bzw. in der Maßnahmendefinition, oder die Sicherheit wird über kürzere Prüfintervalle/Sonderprüfungen oder zusätzliches Monitoring gewährleistet.
Zustand EM-Einrichtungen in Tunnel		Die eingemeldeten Maßnahmen in Tunnel der Black-out Kategorien 1-3 sind mit den Fertigstellungsterminen lt. Anforderung im BP eingetaktet.
Substanzerhalt Ingenieurbauten		Erhaltungsgetriebene Maßnahmen im BP für Ingenieurbauten mit Note 3 oder besser dienen dem pro-aktivem Substanzerhalt und verhindern eine progressive Zustandsverschlechterung.
Baustellenfreiheit		Auf Grundlage der Planungsversion P41 wird die Baustellenfreiheit im Gesamtnetz für die Jahre 2024 und 2025 eingehalten. Auf den Einzelkorridoren kann der Zielwert nicht eingehalten werden.
Begrenzung Erhaltungsrückstand Fahrbahn		Der Richtwert wird im BP-Zeitraum lediglich mit 0,6%-punkten überschritten reduziert sich am Ende der 6-Jahresperiode auf 9,9%. Es sind keine negativen Auswirkungen auf die Verkehrssicherheit zu erwarten. Ein halten dieses Zustandes ist langfristig anzustreben.

2

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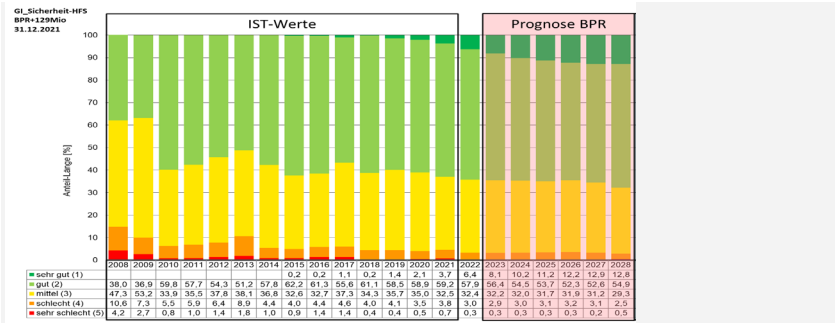
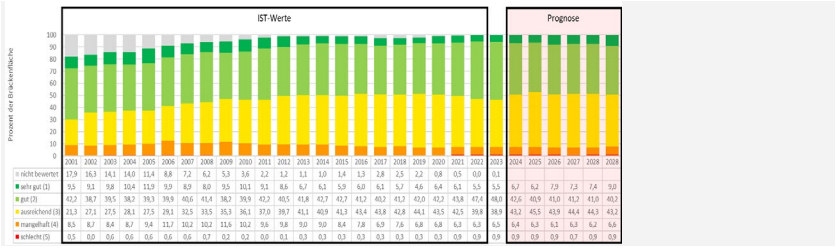
- **Network safety**
  - ✓ Road construction
    - ○ Usability Safety Condition 5 < 3%



  - ✓ object safety
    - ○ Bridges, e.g., max. 10% of bridge surfaces in conditions 4 and 5



    - ○ Tunnels
      - Structural
      - Electromechanical equipment

- Noice protect walls
- …

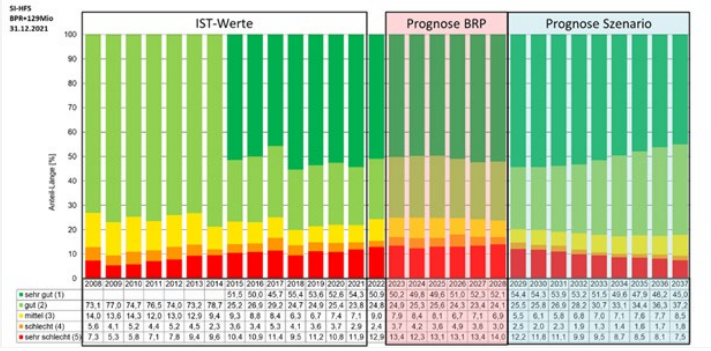
- **Network availability (construction site freedom)**

  - ✓ Construction site freedom for the entire network > 95%

- **Substance preservation**

  - ✓ Limitation of maintenance backlog for roadways (implementation of necessary renewals, etc.)

Substance preservation max. 10.6% in condition 5



- **CO2 reduction**
- …
- **Long-term estimation of maintenance needs in quantities** (not in Eur.)

➢ **Example: Procedure for maintenance planning by ASFINAG**

For road construction, using dTIMS:

- **5 different budget scenarios** (Do-Nothing Scenario, 200 million EUR/year, 250 million EUR/year, 300 EUR/year, up to Unlimited Scenario) based on:

  - Existing conditions for the entire network
  - Current cost estimates

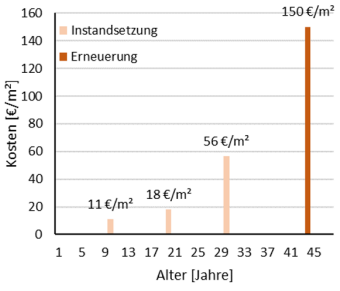


Abbildung 47 – Regellebenszyklus Straßenoberbau Betonbauweise (Preisbasis 2022)

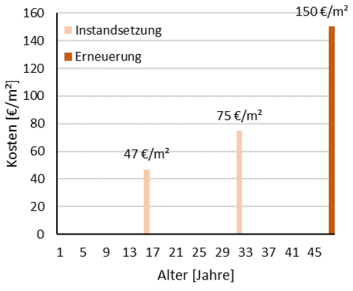
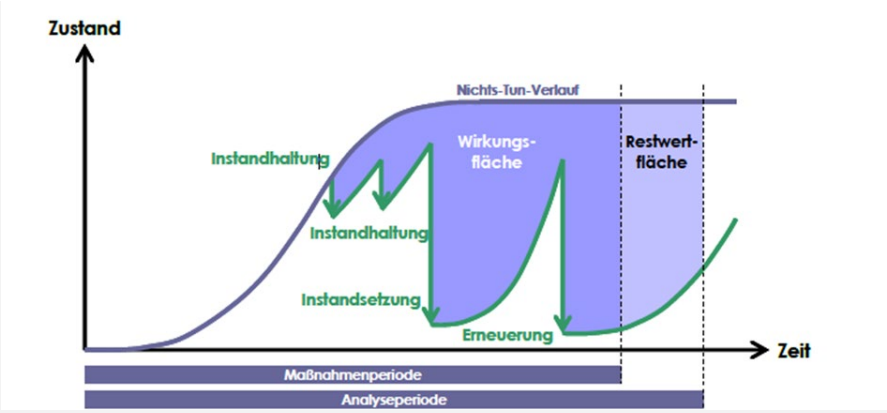


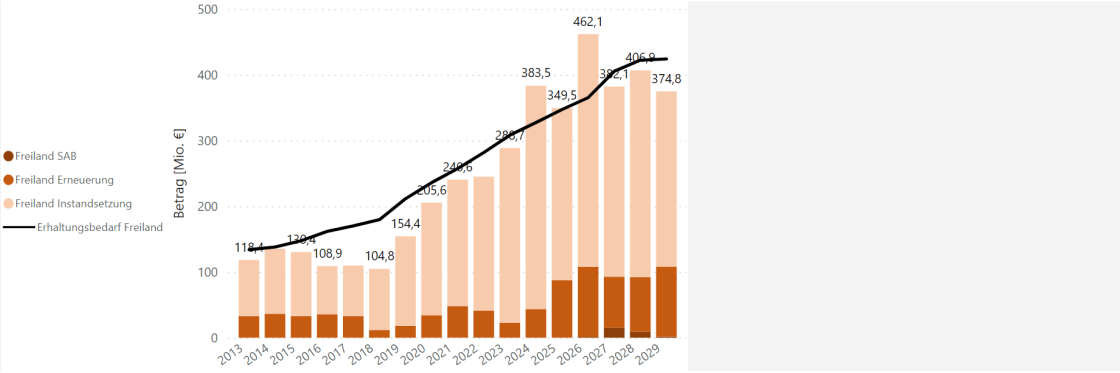
Abbildung 48 – Regellebenszyklus Straßenoberbau Asphaltbauweise (Preisbasis 2022)

  - Stored aging curves

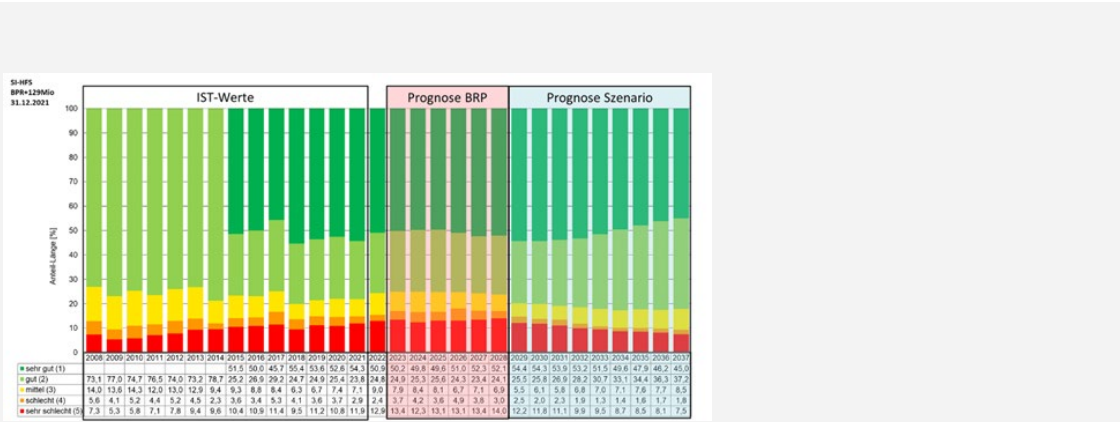


The figure schematically shows how the benefit of a maintenance strategy can be expressed in the form of a dimensionless ratio through the calculable “impact area” (also referred to as the “area between the curves”). If the technical, condition-related effect of individual maintenance measures is large, the benefit is also high.

Cost/benefit-based measures are determined over a medium- and long-term period for the entire network.



- **Assessment of the predicted development of the substance** value as a result of all measures



- **Determination of the relevant scenario** to not exceed the limit value for the given substance value (Condition 5 <10.6%)

- Basis for the budget approximation of assets through **long-term forecasting**

ERHALTUNG

ENTWICKLUNG DER LANGFRISTPROGNOSE

Neu

Position	Einheit	LFP 2019 (Preisbasis 2022)	LFP 2020 (Preisbasis 2022)	LFP 2021 (Preisbasis 2022)	LFP 2022 (Preisbasis 2022)	LFP 2023 (Preisbasis 2022)
Straße						
Annuität über den Lebenszyklus (Beton)	€/m² und Jahr	**4,21**	**4,67**	**4,63**	**4,81**	**5,35**
1. Instandsetzung (Beton)	€/m²	0,00	6,29	6,39	9,33	11,00
2. Instandsetzung (Beton)	€/m²	24,79	14,68	16,17	16,42	18,00
3. Instandsetzung (Beton)	€/m²	0,00	52,42	39,65	43,18	56,40
Erneuerung (Beton)	€/m²	122,86	122,66	132,46	133,39	150,20
Annuität über den Lebenszyklus (Asphalt)	€/m² und Jahr	**4,31**	**4,87**	**4,95**	**5,01**	**5,66**
1. Instandsetzung (Asphalt)	€/m²	35,56	30,40	19,57	20,17	46,80
2. Instandsetzung (Asphalt)	€/m²	35,56	52,42	56,13	56,76	74,60
Erneuerung (Asphalt)	€/m²	122,86	122,66	132,46	133,39	150,20
Brücke (70 Jahre)						
Annuität über den Lebenszyklus (70 Jahre)	€/m² und Jahr	**41,09**	**40,00**	**43,08**	**48,63**	**62,91**
1. Instandsetzung	€/m²	193	188	246	242	301
2. Instandsetzung	€/m²	593	577	704	693	769
3. Instandsetzung	€/m²	237	233	294	290	360
Neubau	€/m²	1854	1803	1772	2179	3225

- Straßenoberbau (Asphalt)
  - 1. Instandsetzung nach 16 Jahren – Erneuerung Deck- und Binderschicht
  - 2. Instandsetzung nach 32 Jahren – Erneuerung Deck- Binder- und 1.Tragschicht
  - Erneuerung gesamter Gebundener Oberbau nach 48 Jahren
- Straßenoberbau (Beton)
  - 1. und 2. Instandsetzung nach 10 bzw. 20 Jahren – Fugensanierung und Kantenschäden instandsetzen
  - 3. Instandsetzung nach 30 Jahren – Black-Topping
  - Erneuerung nach 44 Jahren
- Brücke
  - 1. Instandsetzung nach 20 Jahren– Erneuerung Deckschicht und FÜK
  - 2. Instandsetzung nach 39 Jahren– Abräumen bis auf das Rohtragwerk
  - 3. Instandsetzung nach 55 Jahren– Erneuerung Decksichtung und FÜK
  - Erneuerung nach 74 Jahren

ERHALTUNG

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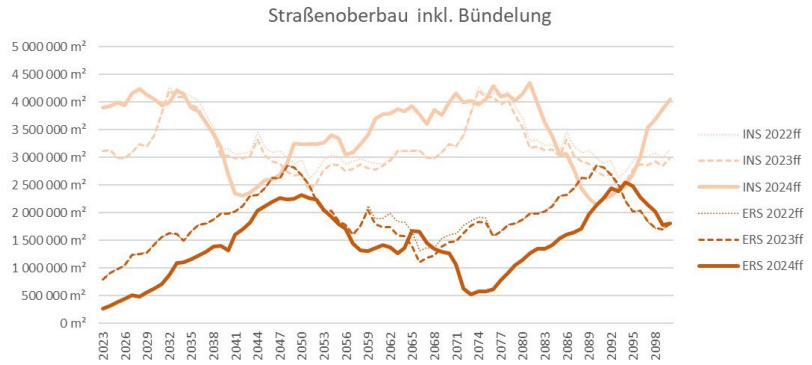
ERHALTUNGSBEDARF

Abschätzung des langfristigen Bedarfs – Mengen Straßenoberbau



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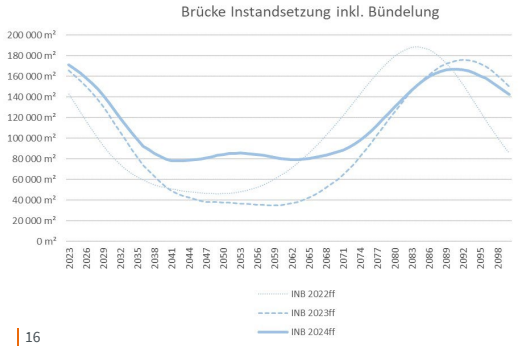
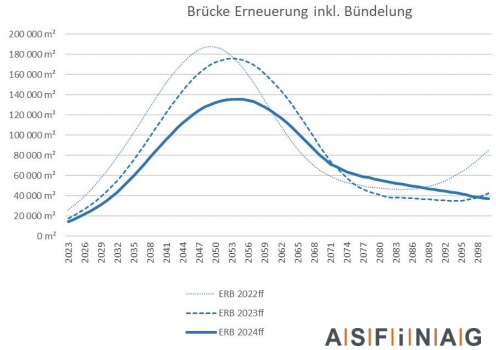
Abschätzung des langfristigen Bedarfs – Mengen Brücke





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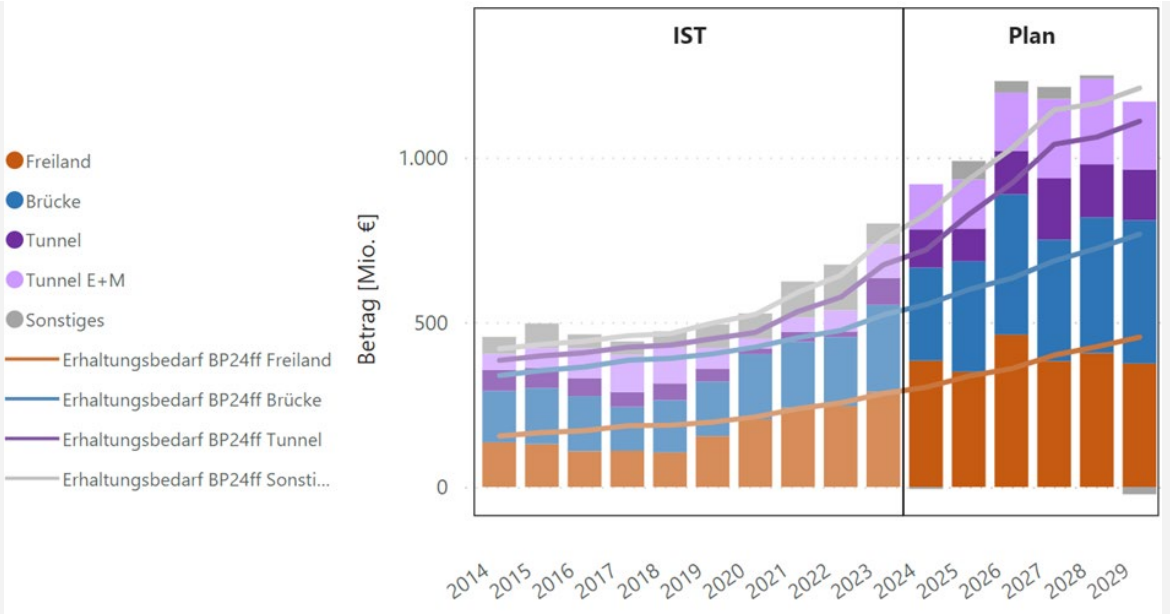
AISFiNAG

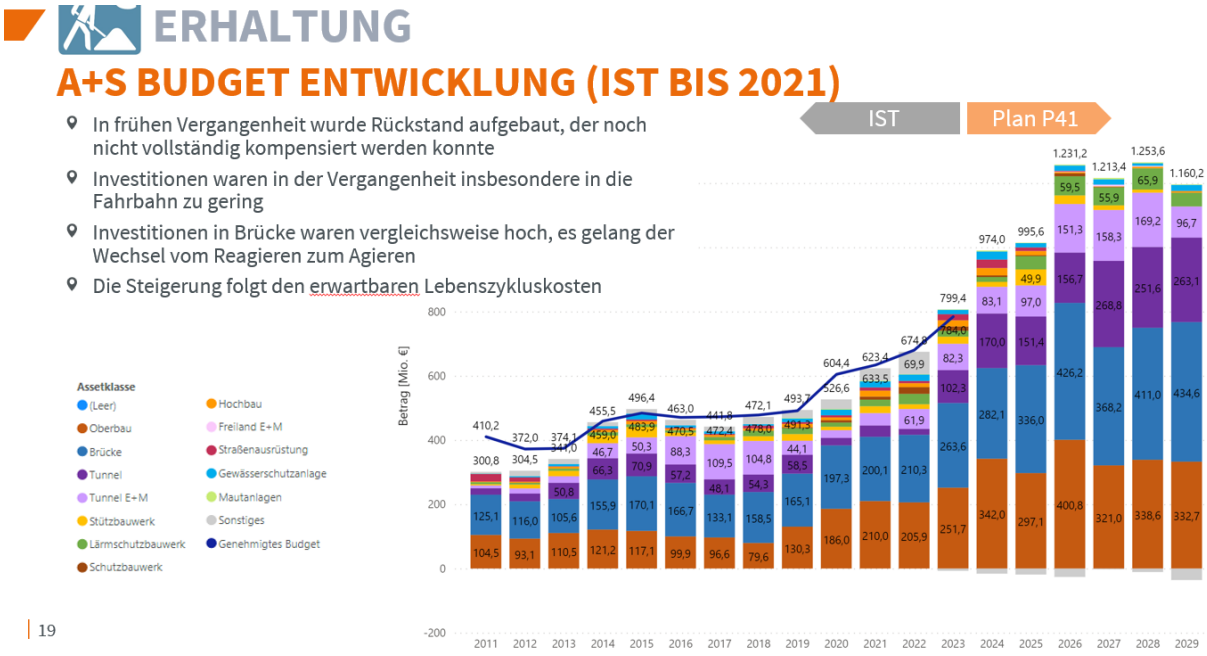
- For example all Bridges must have measures in the next following 6 years
- **Local ASSET managers refine the proposals from dTIMS** for measures in the short- and medium-term period (the next 6 years) based on core drilling investigations and construction cost indicators
- The projects defined by the local ASSET managers are mapped in **the medium-term construction program for the entire A+S network** for the following 6 years and presented to stakeholders

➢ Integration of measures on objects of other assets after defined criterias



➢ After the implementation of the measures, the corresponding measures, the time of implementation, and their costs (**LCC only for road construction in dTIMS**) are recorded, and the conditions are adjusted.

➢ The determination of the **construction program is submitted to the Federal Ministry and approved by them.**



Response to the submitted questions:

• How are the life cycle costs of facilities tracked?

Currently, they are not (anymore)! In my view, as in the past, it should be possible to call up the sequence of all incurred costs, their timing, and the depth of measures in the life cycle when accessing the object/components. Only in this way can the efficiency and sustainability of the measures be ensured through comparisons.

• At what organizational level are LCC costs tracked: at the project level, middle or upper management, in the government, or outside the organization?

In middle or upper management or the ministry, to ensure the efficiency of fund utilization.

• In which phases is LCC monitored and what data is used?

Currently, only in the planning phase of road construction, to recommend cost/benefit optimized measures for the forecasted medium-term construction program.

• How are the societal costs of operational disruptions and disturbances considered?

Currently, only the cost of site management is considered. In the past, the ecological and economic components that were taken into account led to a preference for heavily burdened sections with the calculation algorithm used at that time.