Functional Concept

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1 Disclaimer

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Links and references inside of this document may refer to other documents inside of the program SmartRail 4.0, that may not be published at this stage.

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2 About this Document

2.1 Purpose

This is the concept of TOPO4. It defines the objectives of the TOPO4-project and describes its approach to achieving them.

2.2 Structure

The concept has the following structure:

- *Section 3* accomplishes the following:
  - it puts the TOPO4-project into the context of SR40,
  - it defines the objectives of the TOPO4-project, and
  - it provides the boundaries of the solution by describing the required data artefacts (TOPO data) and how TOPO4 is embedded in the overall system (premises).
- *Sections 4 and 5* describe the envisioned solution on a conceptual level:
  - *Section 4* shows how the TOPO4 (system and process) will interact with its environment and
  - *Section 5* outlines the approaches to implementing the functionality required for this behaviour.
- *Section 6* sketches the four planned stages of implementation.
- *Section 7* defines the next steps the TOPO4-project plans to take.
- *Section 8* lists the identified open points of the TOPO4 concept.

3 Scope of TOPO4

3.1 Context

Railway traffic management and control comprises everything that is required to plan and safely control movement in an occupancy of tracks (see "SR40 - Programm-Scope und Systemgrenzen"). Information about the current state of the track and track-side infrastructure is clearly a part of this. This information is required by several stakeholders and at all stages of railway traffic management and control (preliminary engineering, implementation, commissioning, operation and maintenance). Some of these stakeholders use this information to make safety critical decisions; therefore it must be correct (i.e. free of errors) and current. Reliable and current information about the state of the track and trackside infrastructure will be referred to as *"TOPO data"*.

The TOPO4-project is the part of SmartRail 4.0 that deals with the acquisition and provision of TOPO data (see "SR40 - Programm-Scope und Systemgrenze" - figure 3", TOPO4 corresponds to "Erfassung der wahren "SIL4" Topologie" in that figure).

The following stakeholders require TOPO data:

- The *ETCS Interlocking (EI)* requires TOPO data as a basic condition for its operation;
- The *Object Controller (OC)* may also require TOPO data for its configuration (if not acquired independently, to be defined);
- The *Accurate Localization Platform (GLAT)* relies on TOPO data for the mapping of track user positions onto the track network;
- The *Traffic Management System (TMS)* uses TOPO data for the automatic planning and control of traffic;
- *The Automated Engineering (AMP)* bases its planning and engineering on TOPO data,
- Other systems such as *(AWAP)* require TOPO data for the correct triggering of trackside warnings.

Independent of the stakeholders, TOPO data must fulfil the following general requirements:

- *Current Data*: The safety-critical production systems (EI, GLAT, etc.) shall be provided by TOPO4 with up-to-date accurate TOPO data at all times. All dangerous discrepancies between the current real topology and the stored TOPO data used by the safety-critical production systems shall be revealed and handled appropriately.

- *Reliable Data:* The TOPO provided by TOPO4 data shall be complete, correct and accurate.

3.2 Objectives

The objectives of the TOPO4-project are:

- To develop a technical system called "TOPO4" that automates the acquisition and provision of TOPO data. Acquisition includes both measurements in the field and aggregation of data from other sources (e.g. from AMP). In order to guarantee sufficient quality of the produced TOPO data, correctness, completeness and accuracy of the acquired data shall be verified.
- To define the related data governance processes required to integrate and operate this system in the environment created by Smart Rail 4.0 (organisation, business processes, IT product landscape, data).

These objectives will be achieved in stages (see EST-682 - TOPO4 Level) and the feasibility of the most critical functionality will first be demonstrated in a Proof of Concept (PoC). Guiding principles in working towards both objectives will be:

- To minimize the need for manual data management by achieving a high grade of process automation,
- To adhere to the SR40 Safety Rules for Safe Systems (SRSS) and to provide data in sufficient quality to enable other stakeholders to do so as well.

3.3 Definition of TOPO data

In order to further refine the scope of TOPO4, the content and stakeholders of TOPO data are defined. Since some of these stakeholders will rely on TOPO data for safety-critical decisions, the content of TOPO data is preliminarily classified into safety-critical and not safety-critical parts.

3.3.1 Content of TOPO data

In general, TOPO data represents the railway infrastructure for SR40 and consists of track descriptions and associated infrastructure objects. Tracks are described by the following characteristics:

- Track axis: actual trajectory of the track according to the alignment as described by absolute coordinates. It consists of the alignment elements such as straights, curves, transition curves and the connecting switches.
- Gradient: inclination of the track
- Radius: actual radius of trajectory elements (infinite radius for straights, start and end radius for transition curves, fix radius value for curves)
- Superelevation: left or right rail superelevation of the track, which is used to compensate the lateral acceleration of vehicles in curves
- Static speed profile: allowed maximum speeds for different train categories

The infrastructure objects, which are relevant for SR40, consist of trackside assets as well as track conditions and can be grouped into the following classes:

3.3.1.1 Movement Restriction Objects

The following objects are required to mark danger points and the start and end of movement permissions:

- ETCS Marker Board
- Dwarf Signal
- Level Crossing Signal
- Stop Post
- Fouling Point

3.3.1.2 Protection Objects

The following protection objects are required to protect from collisions with untrackable moving objects, especially with objects that are not part of the system (e.g. road vehicles):

- Level Crossing
- Derailer

3.3.1.3 Routing Objects

The following objects define the possible routes within the railway network:

- Switch
- Double Slip Switch
- Simple Slip Switch
- Crossing
- Buffer Stop
- Border Node (open Ends, e.g. border of SR40 area or ETCS area)

3.3.1.4 Localization and Transmission Objects

The following objects support the localization of movable objects within the system:

- Occupation Object (e.g. axle counters)
- Balise (fix or transparent: depending on the function, e.g. localization, session management, stop if in shunting)

3.3.1.5 Track Condition Objects

The following objects define properties and possible restrictions during the operational use of the track:

- Powerless section with pantograph to be lowered
- Powerless section with main power switch to be switched off
- Non-stopping area
- Radio hole
- Airtightness area
- Inhibitor of a defined type of brake
- Tunnel stopping area
- Sound horn
- Change of traction system
- Limited clearance area
- Axle load profile section
- Platform
- Tunnel/Open Air area (for GLAT/AWAP)
- Emergency niche (for AWAP)
- Static sectors with environmental hazards
- Bridges
- Non-evacuation areas

3.3.2 Representations of TOPO data

Depending on the specific use case different representations of TOPO data are needed:

- Topography, e.g. for alignment or measurement
- Topology (various levels, e.g. nano, macro), e.g. for engineering or use in production systems

3.3.2.1 Topography

Topography is an exact description of the railway tracks and the positions of trackside assets in an absolute coordinate system. Topographical representations are required in the context of construction and of data acquisition and asset management databases. *Topography* consists of the actual trajectory of track, the gradient, radius and superelevation of the track including the trackside assets such as signals, switches, tunnels or balises. Topographical representations might also include track conditions.

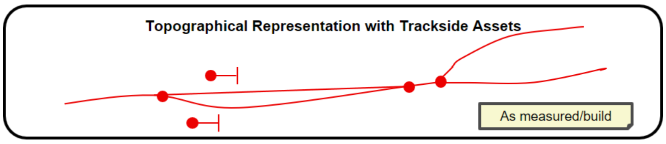

Figure 1 Topology Representation

3.3.2.2 Topology

Topology is an abstract representation of the topographical railway network, usually defined as a mathematical graph (node-edge-model). Typically, infrastructure objects (or only switches) define the nodes. The track conditions and infrastructure objects are positioned along edges (e.g. by distance from start node).
Logical relationships (e.g. track occupation areas, membership of balises in a balise group or UEX) and length information (e.g. length of edges) are represented as information in a topological model.
Note: there will still be a small number of safety-relevant relationships between elements that TOPO4 cannot record but that are represented in topological models and monitored by TOPO4's data governance processes (see also EST-210 - Safety-relevant Relationships).

In addition to the topography, topological models can be enriched with information required for the specific use case, e.g.:

- Navigability/routes: possible routes, which can be used by a railway vehicle, e.g. different navigable routes for simple switch crossings or double switch crossings, represented as sequences of edges
- Trafficability/direct routes: directly trafficable routes without switchback/setting-back of the railway vehicle (no inversion of direction required), also represented as sequences of edges

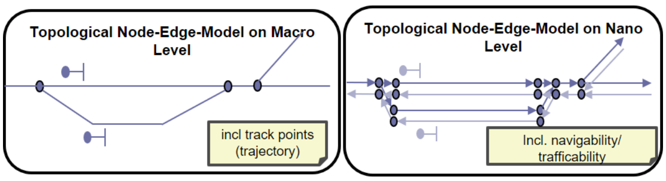

Figure 2 Topology Node-Edge-Model

As shown above, topological models can be defined on various levels:

- Macro level: basic node-edge-model, e.g. for engineering
- Nano level: refines the macro level topology and adds navigability/trafficability information in order to enable an unambiguous interpretation by the production system (such as EI and OC)

3.3.2.3 Topographical Information in Topological Models

Topological representations are abstractions of topographical data that can be interpreted by production systems. Within the scope of TOPO4 the following possibilities for abstraction are considered:

- The exact track axes are modelled with equidistant track points containing absolute coordinates. The track points are positions on the topological edges as virtual infrastructure objects. Hence, absolute coordinates and relative distances are connected, which is an important condition for localization with GLAT.

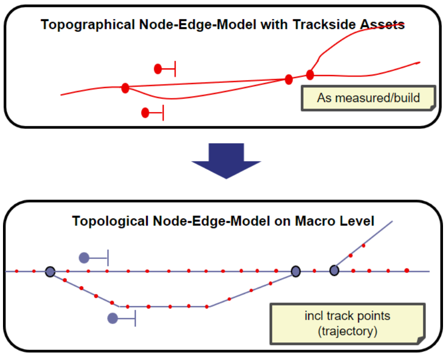

Figure 3 Topological and topographical node-edge-model

- The exact gradient, radius and superelevation is modelled as profile in the topology, while potential simplifications are done to the safe side (e.g. less resolution of gradient sections).

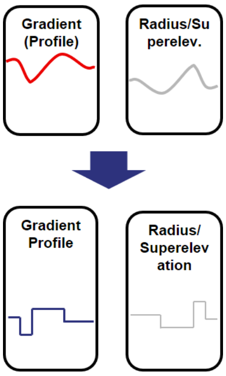

Figure 4 simplification of gradients, radius and superelevation

3.3.3 Safety-relevant TOPO data

Based on the stakeholders' needs and the classification into safety-relevant and not safety-relevant systems the following aspects of TOPO data are considered safety-relevant:

- Tracks on topographical and topological level (including distances)
- Gradient
- Speed Profile
- Trackside Assets
- Safety-relevant Track Conditions (e.g. non-stopping area) - the complete set will be defined in future project phases.
- Safety-relevant relationships between elements (e.g. UEX, balises of balise group)

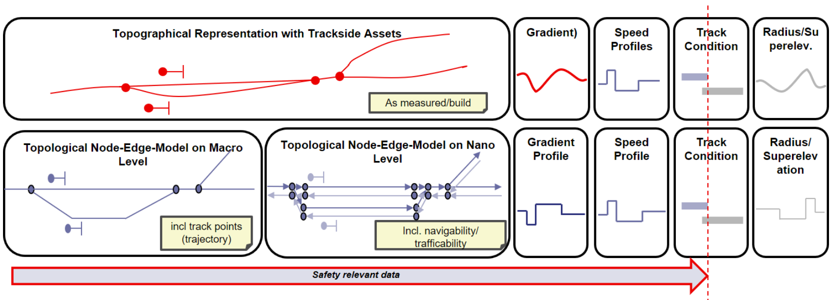

Figure 5 safety-relevant TOPO data

3.3.4 Stakeholders

The following table shows roughly what the stakeholders need to know, i.e. what information TOPO data needs to capture:

Table 1 TOPO requirements of stakeholders

Stakeholder:	EI	GLAT	AWAP	TMS	AMP
TOPO related function	safe operation, meaning safe speeds and distances of all MOBs on the railway network	mapping of MOB positions to the railway network (tracks)	trigger safety critical warnings to the trackside staff at correct location and on time	optimized control for best usage of the railway network	perform engineering on the base of updated data
Safety-relevant system	yes	yes	yes	no	no
Tracks on topographical level	no	no	no	no	yes
Tracks on topological level (incl. trafficability)	yes	yes (including track points)	yes (including track points)	yes (including track points)	yes
Gradient	yes	no	yes	yes	yes
Radius	yes (e.g. as the basis for speed profiles or safety-relevant decisions of the safety manager)	no	no	yes	yes
Superelevation	yes (e.g. as the basis for speed profiles or safety-relevant decisions of the safety manager)	no	no	no	yes (e.g. for speed plausibility check)
Speed Profile	yes	no	yes	yes	yes
Trackside Assets	yes	no	yes	yes	yes
Track Conditions	yes (safety-critical only)	no	no	yes	yes
Relationships between elements	yes (safety-critical only)	no	no	no	no

Regarding OC it is considered, that OC gets TOPO data from other systems (e.g. AMP), if specific TOPO data is required at all for OC configuration. In addition, potential safety-relevant OC configuration data might be part of TOPO4 data governance process (see EST-866).

3.4 General Premises

Based on the general objectives and the definition of TOPO data the following overall premises further refine the scope of TOPO4.

3.4.1 Overall Premises

3.4.1.1 Safety critical TOPO data

The primary responsibility of TOPO4 is the acquisition of all safety-relevant TOPO information. However, potential synergies regarding TOPO data required by not safety-critical systems are considered.

3.4.1.2 System and Process

The TOPO4 system is responsible for the recording of safety relevant objects that are detectable by sensors (incl. object detection based on images / point clouds or addition sensors). The remaining safety relevant objects (e.g. axle load profile, speed profile) are in the scope of the TOPO4 data governance process, that might involve other systems and processes inside and outside SR40.

3.4.1.3 EI Safety Responsibility limited to TOPO4 Geometry

AMP will trigger the application of TOPO4 for the relevant track areas, that will be part of the ETCS Interlocking area. ETCS interlocking will only take over safety responsibility for a track area after it is has been provided TOPO data by TOPO4.
Note: This premise is important to ensure completeness of TOPO data.

3.4.1.4 Position Tolerance in ETCS interlocking

The accuracy of positioning depends on the applied methods. Usually dynamic methods (airborne, trainborne) offer a much better efficiency, but at the cost of worse accuracy. In order to allow highly efficient measurement methods, it is assumed, that the supervision of ETCS interlocking considers a configurable position tolerance. However the value of tolerance is minimized by adequate methods in TOPO4.

3.4.1.5 Application Conditions of TOPO4

TOPO4 is assumed to be applied under various conditions:

1. Areal / corridor based registration with dynamic methods
2. Spot registration with static and dynamic methods (e.g. accompanying construction or during maintenance)

3.4.1.6 Safety-relevant Relationships

Due to the generic approach of the EI (specifically the interlocking logic) it is assumed that very few safety-relevant topological relationships between infrastructure objects or attributes (e.g. UEX) will have to be predefined as part of engineering. Those safety-relevant relationships that will have to be defined will fall into the scope of TOPO4 data governance processes.

3.4.2 Premises for the Acquisition of Topography

3.4.2.1 Reference System

A reference point system (track insurance points) of the exact trajectory of the track is available to support the accuracy of the absolute coordinates appropriately.

3.4.2.2 Alignment data base

The alignment database is the master and supplier for exact topographical information such as alignment elements (e.g. straight, bow and information about switch types) and gradients, radius and superelevation. TOPO4 only checks that this information is current by acquisition of the trajectory.
It is sufficient to assign the values of gradient, radius and superelevation to the segments of the recorded track trajectory according to the topographical situation.
Note: If it should become necessary to know the exact change positions, the acquisition of TOPO4 might be used for the plausibility (actuality) check of the more accurate alignment databases (such as DfA).

3.4.3 Premises for the Acquisition of Topology and Infrastructure Objects

3.4.3.1 Infrastructure Objects (incl. Track Conditions)

The TOPO4 system is responsible for the acquisition of the infrastructure objects that are considered safety-relevant (result of further development phases, e.g. PHA/risk analysis).

3.4.3.2 Classification of Infrastructure Objects

TOPO4 is responsible for the classification of detectable objects into object types (e.g. signal, switches, balise, …).

3.4.3.3 Attributes of Infrastructure Objects

TOPO4 is primarily responsible for the acquisition of safety-relevant position information (coordinate, distance). Further meta-data (e.g. balise telegrams) might be added if the onsite recording is possible (e.g. by synchronized BTM signal). The remaining safety-relevant attributes, that cannot be recorded on site (e.g. object name), are in the scope of the TOPO4 data governance process and might involve other systems as well.

3.4.4 Premises for the Detection of TOPO changes

3.4.4.1 Planned Modifications

For all planned changes with TOPO impact a registration with TOPO4 will be triggered by AMP.

3.4.4.2 Maintenance Task

After all maintenance or reconditioning tasks with potential relevant TOPO impacts, TOPO4 shall be used before the affected section of the line is taken into operation again. Hence, a coordinated, tool supported maintenance process is required to avoid undetected modifications.

3.4.4.3 Ad hoc environmental influences

Changes due to ad hoc environmental influences (e.g. the detection of avalanches, landslides) are not in the scope of TOPO4.
Note: These influences might be detected by other, external systems and possibly processed in TMS. TOPO4 would recognize these changes too late.

3.4.4.4 Gradual environmental influences

Changes due to gradual environmental influences (like changing the railway loading gauge) are not in the scope of TOPO4. However, potential synergies are evaluated under the condition of an automated evaluation.
Note: However the data of diagnostic trains might be used for the tracking of TOPO changes.

3.4.4.5 Security/Vandalism

The detection of wilful damage or security-related changes to the TOPO is not in the scope of TOPO4.

3.4.5 Premises for the Comparison of Data

3.4.5.1 Topographical Input Data

The imported data (means import data for the comparison) must contain topographical information, including the track trajectory (radius and gradient) and absolute positions of all relevant object types (for detailed information see EST-774 - Representations of TOPO data) .

3.4.5.2 Accuracy of Input Data

The accuracy of the input data must be known. The largest possible tolerance, which is acceptable from a functional point of view by EI and GLAT, must be known by TOPO4 .

3.4.5.3 Balise information

The affiliation of balises to a balise group must be known.

3.4.5.4 Timestamp

For the purpose of unambiguous identification as well consideration of time dimension during the validation the input data will have a unique versioning and/or time stamp information.

3.4.5.5 Engineering Errors

TOPO4 system checks the correct implementation according to the engineering data. The check of design rules is not in the scope of TOPO4 system. Hence, it is assumed, that the remaining design rules are applied correctly to the engineering data. The remaining safety critical engineering rules must be considered by TOPO4 data governance.

3.4.5.6 TOPO related Engineering Data

It is assumed that the engineering data of the specific application of EI does contain TOPO data only. This excludes configuration data without relation to the TOPO, which will be part of the generic application or controlled by data governance processes.

3.4.5.7 Independence from IDs/Name Attributes

The merging of TOPO data streams should not have dependencies on IDs or names (including GUID). The comparison should only be done with detectable information present in all input data streams (lowest common denominator): e.g. position, object type.
Note: However, a central ID configuration management system, valid for all systems, should be introduced.

3.4.6 Premises for the Output Data

3.4.6.1 Distribution of TOPO data

It is assumed that TOPO4 pushes new versions of topological data to the EI, if relevant TOPO changes occur (e.g. triggered by AMP). EI handles the request for update and the distribution of TOPO data to EI internal stakeholders (e.g. OM) as well as external stakeholders (e.g. TMS).
Note: The flow of TOPO data is to be defined and coordinated with all relevant systems

3.4.6.2 Tolerances

EI can handle location tolerances and evaluates them according to the operational situation to the safe side (analogue to Q_LOCACC for ETCS, but for all object distances and lengths).
For example: A signal position can be assumed by the EI within the tolerance area so that it fits the operational situation (e.g. by calculation of min safe front end or max safe front end of train).
Note: TOPO4 will not be able to preselect the safe side of each discrepancy or inaccurate distance/length information in a static way. Usually the operational context must be taken into account for a proper decision.

3.4.6.3 Processing of Inacceptable Discrepancies

Procedure before commissioning:
In case of inacceptable discrepancies between compared data sets the negative results will be processed by AMP based on the information of the error protocol and AMP will trigger appropriate reactions (e.g. re-measurement or re-arranging of object in engineering or at trackside).
Procedure after commissioning (during operation):
In case of detected unacceptable discrepancies, a warning message will be generated by TOPO4 and will be send to all stakeholder (especially EI), that are using the affected TOPO data.

4 Scenarios and System Use Cases of TOPO4

4.1 Scenarios

The following table shows the scenarios in which TOPO4 is applied. This serves to further refine the scope of TOPO4 from a practical process point of view and to determine the application conditions.

Table 2 Scenarios and use cases

Scenario	Description	TOPO4 Use Case
Preliminary Engineering	Support of TOPO4 during the preliminary engineering phase, e.g. check of inventory data against reality (inventory data vs. actual TOPO)	"Check inventory TOPO"
Implementation Phase	Support of TOPO4 during the construction/implementation, i.e. updating the status of the installed objects or onsite validation of correct installation according to planning (actual TOPO vs. planned TOPO (AMP-TOPO) including pre-validated data by data governance)	"Check implemented/build TOPO" and "Detect relevant TOPO changes"
Commissioning Phase	Support of TOPO4 during the commissioning, i.e. a final check of implementation and generate EI-TOPO. EI-TOPO is the TOPO data required of EI and the connected stakeholders GLAT/AWAP and TMS-L (and OC, if not acquired independently and OC-TOPO is provided by EI) .	"Provide EI-TOPO"
Operation/ Maintenance	Support of TOPO4 during the operation or maintenance, i.e. check of constant TOPO after maintenance work (actual TOPO vs. EI-TOPO)	"Detect relevant TOPO-changes"

From the above table, four possible use cases for TOPO4 can be derived:

- Check inventory TOPO
- Check implemented/build TOPO
- Provide EI-TOPO
- Detect relevant TOPO-changes

The use case "Detect relevant TOPO-changes" is divided in two cases, since it will be implemented in two very different ways:

- Detect relevant TOPO-changes – onsite check
- Detect relevant TOPO-changes – permanent infrastructure acquisition

The difference between these two use cases will be explained in more detail in the following chapters.

4.2 Actors and Interfaces of TOPO4

The following actors influence the TOPO4 system (also valid for the following description of the sub systems of TOPO4):

Table 3 Interests of actors

Actors	Description	Interest of Actor	Interest of TOPO4
AMP	engineering process and system, primarily for the engineering of the EI (also for remaining engineering activities of TMS and OC)	Get actual TOPO data for engineering and Checking of engineering data Get installation status of the trackside infrastructure objects	Trigger of TOPO4 application, especially during engineering (plan and build) phases and Get precise alignment data incl. radius, superelevation, gradient (topography)
EI	EI requires the TOPO data for the (safe) operation and the geometrical safety logic.	Get updated and reliable (validated) TOPO data	EI handles the distribution and activation of the transmitted TOPO and EI stores the current valid TOPO data for the usage within EI
Data Governance Staff	Monitoring of specified processes for achieving data safety / data quality	Compliance with the prescribed processes	Use of prescribed processes to maintain data quality/data safety
Survey Staff	Operator of TOPO4 system	use and coordinate TOPO4 acquisition	apply the TOPO4 application
Installation Staff	Operator of TOPO4 system	Use TOPO4 for updating the installation status and for an onsite check	apply the TOPO4 application during construction phase
Maintenance Staff	Operator of TOPO4 system	Use TOPO4 for updating the installation status and for checks after maintenance work	apply the TOPO4 application during operation phase
GLAT	serves for the exact localization of moveable objects	Get updated and reliable TOPO data as reference map for a reliable localization to map the identified MOBs to it	-
AWAP	Correct triggering of trackside warnings	Get updated and reliable TOPO data	-
TMS	Traffic management system (includes TMS-L and TMS-PAS)	Get updated TOPO data for long-term/short-term traffic planning and control	-
OC	Object controller: the connector between EI and the infrastructure objects	Get actual TOPO data for construction phase (if not acquired independently)	-
Infrastructure (Topology and Topography)	Recorded infrastructure data	-	Record relevant objects and track data

4.3 Overall Use Cases

The following diagram shows the overall use cases (blue) of the system and processes of TOPO4 and which stakeholders use each use case. It also shows how these use cases are related, that is to say, what functionality they share: each requires some form of acquisition and comparison of TOPO-data. It also shows where human actors (staff) have interactions with the TOPO4 system and processes.

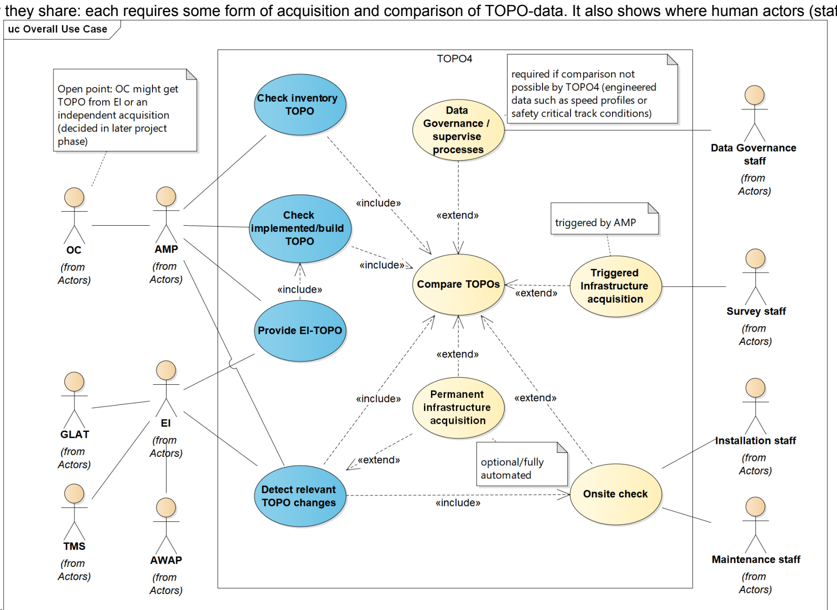

Figure 6 Overall Use Cases of TOPO4

4.4 Description of TOPO4 Use Cases

In this chapter the above identified use cases are explained in detail.

4.4.1 Check Inventory TOPO

The check of inventory TOPO has the following purpose:

- Comparing of inventory TOPO and actual TOPO
- Informing AMP about the results of the comparison
- Supporting AMP in creating the basis for the engineering phase

The following diagram shows the activity chart of the use case "Check inventory TOPO" including the basic activities of the process:

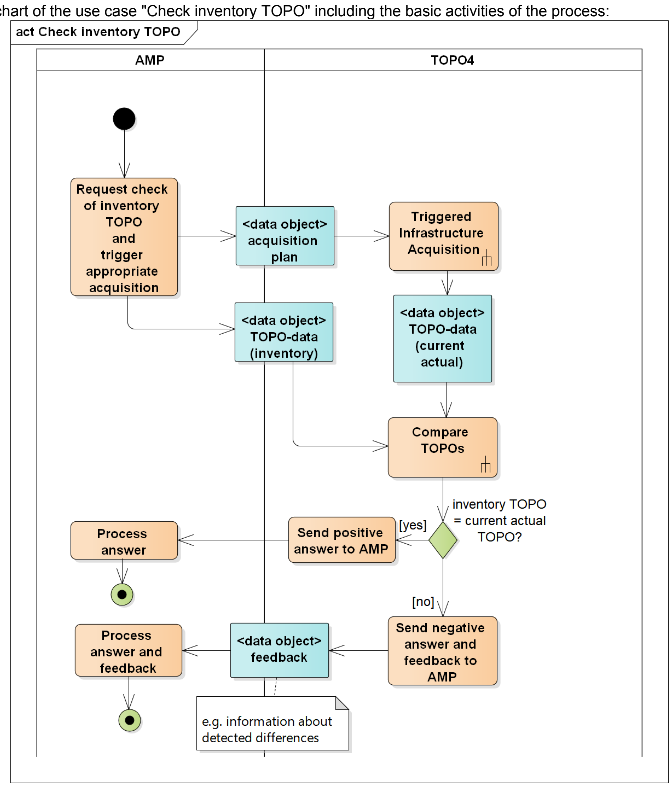

Figure 7 Activity Chart- Check Inventory TOPO

Request check of inventory TOPO and trigger appropriate acquisition
AMP sends a request to TOPO4, asking it to check some inventory data and to acquisition the TOPO-data required for that check.
Data Object: acquisition plan
For the acquisition of actual TOPO, TOPO4 needs information about the section that needs to be acquired.
Triggered Infrastructure Acquisition
After receiving the input for the affected section (acquisition plan), TOPO4 can prepare the acquisition of the actual TOPO. The activities during the acquisition are described in more details in chapter EST-673 - Triggered Infrastructure Acquisition .
Data Object: TOPO data (current actual)
After acquisition TOPO4 is in possession of actual TOPO data. These data serve as one of two inputs for the comparison.
Data Object: TOPO-data (inventory)
To check inventory data TOPO4 needs the data from AMP as input for the comparison.
Compare TOPOs
Based on the actual acquired TOPO and the received inventory data a comparison of these data is carried out.
The activities during the comparison are described in more details in chapter EST-671 - Compare TOPOs .
Send positive answer to AMP
Based on a positive comparison, TOPO4 send an answer to AMP with the information that the comparison was successful.
Process answer
After receiving a positive answer, AMP can start the engineering phase based on checked and actual inventory data.
Send negative answer and feedback to AMP
Based on a negative comparison, TOPO4 send an answer to AMP with the information that the comparison was not successful. The transmitted data object includes some information about the discrepancies discovered in the comparison.
Data object: feedback
Some Information about the discrepancies between inventory data and actual acquired data.
Process answer and feedback
After receiving a negative answer, AMP should process the information gained (e.g. by replacing the inventory data by the actual acquired data).

4.4.2 Check implemented/build TOPO

The check of implemented/build TOPO has the following purpose:

- Comparing of planned TOPO and actual TOPO
- Handling of TOPO data (not checked by TOPO4) by data governance/process supervising
- Identifying any discrepancies between planned and actual TOPO
- Informing AMP about the results of the comparison
- Process supervision of data that cannot be checked by TOPO

The following diagram shows the activity chart of the use case "Check implemented/build TOPO" including the basic activities of the process:

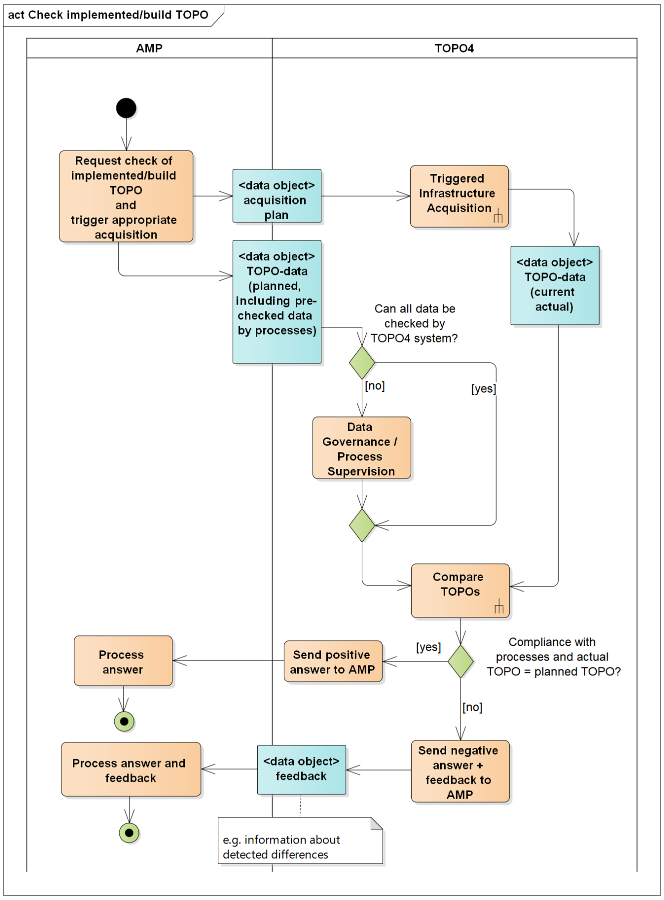

Figure 8 Activity Chart - Check implemented/build TOPO

Request check of implemented/build TOPO and trigger appropriate acquisition
AMP send a request to TOPO4 asking it to check some implemented/build TOPO against the planned TOPO to acquisition the TOPO-data required for that check.
Data-object: acquisition plan
For the acquisition of actual TOPO, TOPO4 needs an instruction/plan (means: information about the section to be acquired for the check of inventory data).
Data-object: TOPO-data (planned, including pre-checked data by processes)
To check the implemented/build TOPO, TOPO4 needs the planned TOPO from AMP as input for the comparison. The data object might contain data that requires safe processes (e.g. speed profile or safety relevant trakc conditions) in addition to the data, that can be compared to recorded data.
Triggered Infrastructure Acquisition
After receiving the input for the affected section (acquisition plan), TOPO4 can prepare the acquisition of the actual TOPO. The activities during the acquisition are described in more details in chapter EST-673 - Triggered Infrastructure Acquisition .
Data Object: TOPO data (current actual)
After acquisition TOPO4 is in possession of actual TOPO data. These data serve as one of two inputs for the comparison.
Data Governance / Process Supervision
Based on input data that cannot be checked by TOPO4, TOPO4 should ensure that the pre-validated input data is not changed by TOPO4. TOPO4 must comply with the prescribed processes for obtaining data safety. The topic data governance is described in more detail in chapter EST-740 - Data Governance .
Compare TOPOs
Based on the input data (planned TOPO and actual recorded TOPO-data), TOPO4 performs a comparison of these data.
The activities during the comparison are described in more details in chapter EST-671 - Compare TOPOs .
Send positive answer to AMP
Based on a positive comparison, TOPO4 sends an answer to AMP with the information that the check of implemented/build TOPO was successful.
Process answer
After receiving a positive answer, AMP can complete the implementation process and start the commissioning phase.
Send negative answer and feedback to AMP
Based on a negative comparison, TOPO4 sends an answer to AMP with the information that the comparison was not successful. The transmitted information includes some Information about the discrepancies identified in the comparison.
Data object: feedback
Includes information about the identified discrepancies between the planned and the actual TOPO.
Process answer and feedback
After receiving a negative answer, AMP should process the information (e.g. checking the planning data).

4.4.3 Provide EI-TOPO

The provision of EI-TOPO has the following purpose:

- Final check of implemented TOPO against planned TOPO
- Provide reliable and actual EI-TOPO to EI (EI-TOPO), that includes all TOPO data relevant to EI, GLAT/AWAP and TMS(-L)

The following diagram shows the activity chart of the use case "Provide EI-TOPO" including the basic activities of the process:

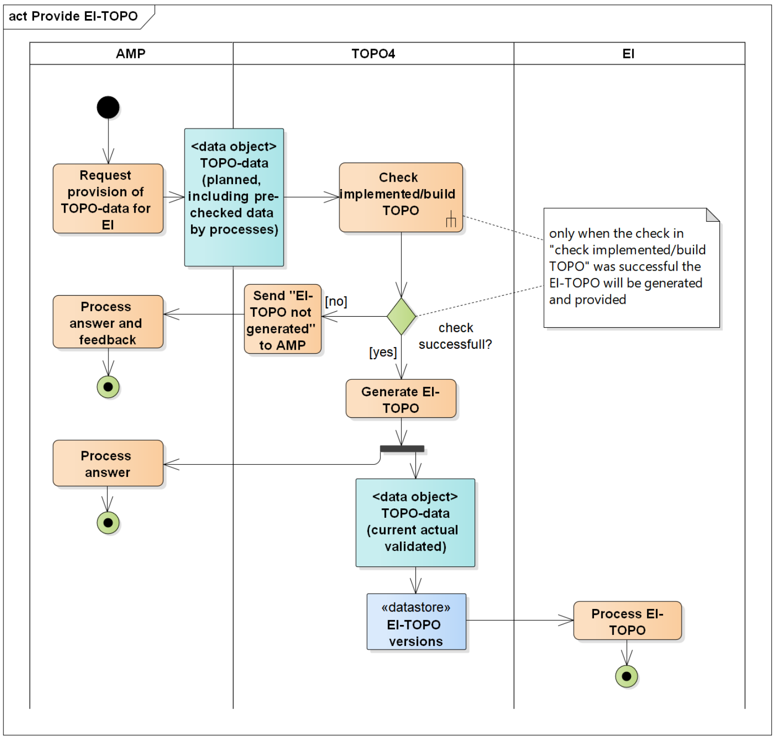

Figure 9 Activity Chart - Provide EI-TOPO

Generate EI-TOPO
Based on a successful check of the implemented/build TOPO and the request of AMP for provision of EI-TOPO, TOPO4 generates the EI-TOPO based on the imported planned TOPO-data.
Note: The generation of EI-TOPO basically is a data transformation of the planned TOPO into the format of EI-TOPO. Any manipulation of planned TOPO must be excluded.
Data-object TOPO data
TOPO4 provides the EI-TOPO (that includes all relevant TOPO data for EI, GLAT and TMS).
Data-store EI-TOPO versions
The checked TOPO-data is stored to a persistent database, in combination with checksum/hash for unambiguous identification and to protect against manipulation.
Process answer
After receiving a positive answer, AMP can complete the commissioning phase.
Send "EI-TOPO not generated" to AMP
Based on a negative comparison of the check implemented/build TOPO, TOPO4 sends an answer to AMP with the information that the EI-TOPO is not generated.
Process answer and feedback
After receiving a negative answer, AMP should process the information (e.g. checking the planning data or correct the implementation).

4.4.4 Detect relevant TOPO changes

As already mentioned above, the use cases are required during installation as well as maintenance activities and are divided in two parts:

- Detect relevant TOPO changes – onsite check
- Detect relevant TOPO changes – permanent infrastructure acquisition

4.4.4.1 Detect relevant TOPO changes - onsite check

The detection of relevant TOPO changes via onsite check has the following characteristics:

- Support of Installation and Maintenance Staff during the implementation and operation phase
- Record the current state and position after the installation or maintenance of an infrastructure object
- Detect intended TOPO changes during the planning phase
- Detect unintended TOPO changes during maintenance activities

The following diagram shows the activity chart of the use case " Detect relevant TOPO changes – onsite check " including the basic activities of the process:

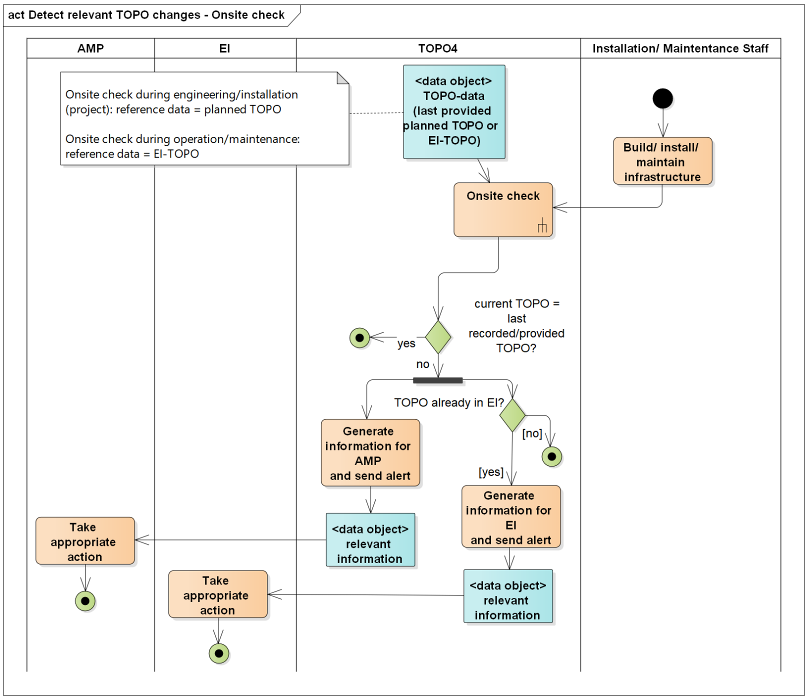

Figure 10 Activity Chart - Onsite Check

Build/Install/Maintain Infrastructure
Installation or maintenance of infrastructure during the implementation or operation phase.
Data-object: TOPO-data (last provided planned TOPO or EI-TOPO)
Provide the currently available planned TOPO for the onsite check during engineering phase. Provide the currently valid EI-TOPO for the onsite check during operation phase.
Onsite Check
The onsite check is used after modifications on the infrastructure (e.g. installation of new infrastructure or maintenance of infrastructure) to check that the changes were made correctly. The onsite check includes the acquisition of positions of the changed infrastructure element and the comparison of the new acquired TOPO with the currently valid EI-TOPO.
The actions during the onsite check are described in detail in chapter EST-672 - Onsite check .
Generate information for AMP and send alert
Based on a non-successful onsite check, TOPO4 generates Information about the found discrepancies for AMP.
Generate information for EI and send alert
If the checked TOPO is already used by EI: Based on a non-successful onsite check, TOPO4 generates an information for EI with the results of the check including the information that the checked section/TOPO is not safe.
Data object: relevant information (AMP)
Providing information about the found discrepancies.
Data-object: relevant information (EI)
Providing information about not safe TOPO sections.

4.4.4.2 Detection of relevant TOPO changes - permanent acquisition

The detection of relevant TOPO changes via permanent infrastructure acquisition has the following purpose:

- Permanent acquisition of actual TOPO
- Permanent check of TOPO change
- Usually applied during operation phase to detect unintended TOPO changes
- Requires highest degree of automation

This use cases requires a certain degree of technical development of TOPO4 system and the TOPO4 process. The details of the development of TOPO4 are described in more detail in chapter EST-682 - TOPO4 Level .
The following diagram shows the activity chart of the use case "Detect relevant TOPO changes – permanent infrastructure acquisition" including the basic activities of the process:

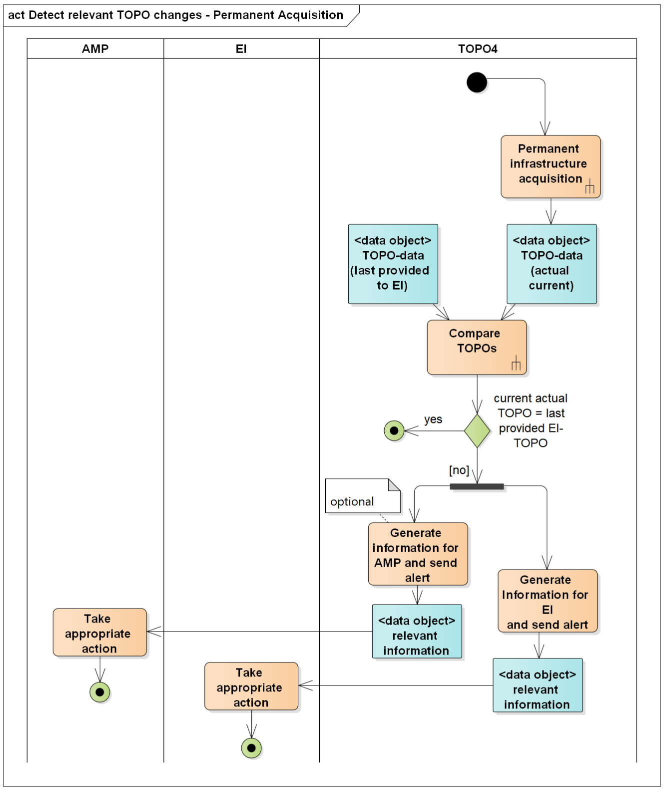

Figure 11 Activity Chart- Permanent Acquisition

<u>Permanent Infrastructure acquisition</u>
In permanent acquisition TOPO4 is continuously recording actual data of the infrastructure.
The activities during the permanent acquisition is described in more detail in section EST-674 - Permanent Acquisition .
<u>Data-object: TOPO-date (actual EI-TOPO)</u>
Provide the actual EI-TOPO for the comparison.
<u>Data-object: TOPO-date (actual recorded)</u>
Provide the actual recorded TOPO data for the comparison.
<u>Compare TOPOs</u>
Based on the input data (actual EI-TOPO and actual recorded TOPO-data), TOPO4 performs a comparison of these data.
The activities during the comparison are described in more details in chapter EST-671 - Compare TOPOs.
<u>Generate Information for EI and send alert</u>
Based on a negative result of the comparison (e.g. detection of discrepancies) TOPO4 generates an information/feedback for EI that some EI-TOPO is not safe and not actual anymore.
<u>Data-object: relevant information of comparison</u>
Provide the generated information for EI.
<u>Optional: Generate Information for AMP and send alert</u>
Based on a negative result of the comparison (e.g. detection of discrepancies) TOPO4 generates an information/feedback for AMP that some EI-TOPO is not safe and not actual anymore.
<u>Take appropriate action</u>
Based on the information about TOPO changes, the EI (and optionally AMP) should process the information and take further steps.

5 Approach

The acquisition is the central and most complex function of TOPO4 and is divided in three technically-different acquisition systems:

- triggered infrastructure acquisition,
- permanent infrastructure acquisition,
- onsite check.

Two other main aspects of TOPO4 are

- Compare TOPO and
- the data governance process.

The following chapter is to describe approaches for these.

5.1 Triggered Infrastructure Acquisition

The *triggered infrastructure acquisition* is intended for the acquisition of large track sections (e.g. initial acquisition of the entire railway network or acquisition of complete SR40 segment and also for maintenance activities during the operation phase and has the following characteristics:

- The acquisition is triggered by AMP(*Note: The acquisition can also be triggered by other systems reporting an invalid TOPO (e.g. EI or OC: during the registration of OC) and also by data governance (e.g. if the data is not trusted due to a detected process error / process violation)* .
- Post processing and analysis of measurement data required (including quality check)
- Import and processing of alignment data or correction points to enhance accuracy of absolute coordinates
- Identification of relevant infrastructure objects (find all relevant objects)

- Classification of relevant infrastructure objects (determine object type)
- Determine absolute object positions (coordinates)
- Identify tracks (I.e. track trajectory, gradient, optional superelevation)
- High processing efficiency due to automation and integrated tool chain without manual data transfers
- Build TOPO model from acquisition
- Merge acquisitioned TOPO with long term TOPO data (I.e. in order to detect changes)

5.1.1 Acquisition Methods

In order to determine the best possible technique and methods for TOPO acquisition, an analysis will be carried out taking into account the following influencing factors:

- Identified requirements from the use cases (e.g. triggered infrastructure acquisition)
- State of the art of data acquisition technology
- External influences, such as weather conditions, light influences, etc.
- Constraints, such as object catalogue, specific railway conditions or grade of automation

The acquisition methods must meet the following requirements:

- Acquisition during operation (no traffic interruptions)
- Use in (nearly) all weather conditions (e.g. waterproof/ splash-proof system), if possible by suitable combination of methods. However, the planning of the triggered areal acquisitions of TOPO4 can consider the weather conditions.
- Application in tunnels and at night-time (e.g. use of laser scanner or additional mounting of spotlights)
- Efficient acquisition due to high measurement speeds and no traffic interruptions for long track corridors
- Sufficient methods for accompanying on-site as well as areal measurements

The following technologies for infrastructure and localization recording were identified as possibilities (also a combination of these technologies):

<u>Recording of infrastructure:</u>

- Laser: laser point cloud based distance measurement at every direction in order to rapidly get the surface shape of objects, buildings or landscapes
- Radar: uses radar pulses to image the environment or subsurface (ground penetrating radar)
- Photogrammetric: videos or images with depth information of the pixels, which allows to identify and measure element positions in combination with synchronized localization data

<u>Recording of Localization:</u>

- GNSS: global navigation satellite system in order to measure absolute coordinates
- IMU: inertial measurement unit, combination of accelerometers and gyroscopes, sometimes also magnetometers in order to measure relative distances during movement
- Odometer: distance measurement during movement, e.g. based on wheel sensors or laser scanning of rail

The following methods for using these techniques were identified and will be examined in detail in an "Method Analysis":

- Railbound Systems, e.g. mounted on trains or on other vehicles
- Airbone Systems, e.g. drones, airplanes
- Static Measurement Systems

5.1.2 Activity Diagram

The following diagram shows the activities of the triggered infrastructure acquisition.

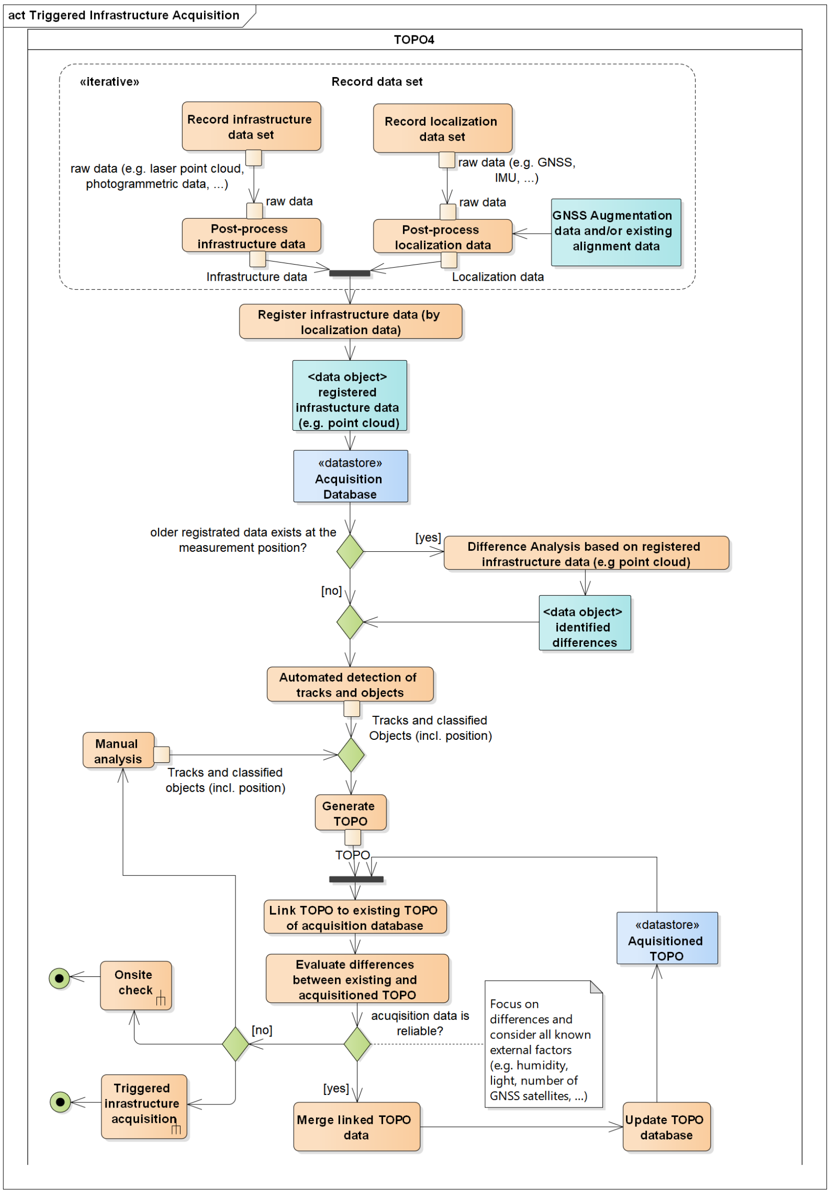

Figure 12 Activity Chart - Triggered Infrastructure Acquisition

<u>Record data set (iterative)</u>

The start trigger for the triggered data acquisition comes from AMP. After the trigger starts an iterative acquisition of infrastructure data in combination with localization data.

Note: For the preparation of the triggered acquisition basic data for the measurement scope is collected (e.g. line sections to be acquisitioned). This is important to ensure completeness. In case of dynamic measurements, the preparation requires the coordination of the measurement run with the commercial operation on the track. Temporary installations on trains might require some additional installation efforts for each campaign.

<u>Record localization data set</u>

The acquisition of localization data takes place during normal operation. For this purpose, the acquisition equipment is either mounted on a locomotive or it is an already permanently installed system on a locomotive or it is used independently from the railway network in case of airborne measurements. In addition, the acquisition data might be complemented by static measurements

<u>Record infrastructure data set</u>

The acquisition of infrastructure data takes place during normal operation. For this purpose, the acquisition equipment is either mounted on a locomotive or it is an already permanently installed system on a locomotive or it is used independently from the railway network in case of airborne measurements. In addition, the acquisition data might be complemented by static infrastructure recordings (e.g. laser scanner).

<u>Post-Process localization data</u>

Following the acquisition of localization, the data are post processed in order to improve the data (e.g. by augmentation data or existing alignment data or correction points) and to clean it up (e.g. cutting sections without localization receipt and replace insufficient localization data).
The result of the Post-Processing is an optimized localization data stream.

Note: Due to the dynamic measurement approach the existing alignment data is required for an exact trajectory incl. gradient radius, superelevation. However, the post-processing algorithm must check, if the alignment data fits to the acquisition. In case of to large discrepancies an error message should occur.

<u>Post-Process infrastructure data</u>

Following the infrastructure acquisition, the data are post processed in order to improve them (e.g. the trajectory by augmentation data or input of alignment database) and clean it up (e.g. cutting uninteresting point cloud sections).
The result of the Post-Processing is an optimized infrastructure data stream (possibly contains several measurements of the same topographic situation).

<u>Register infrastructure data</u>

Following the post-processing, the localization data and the infrastructure data are merged into one registered data stream. The connection of localization and recorded infrastructure data is accomplished using the recorded timestamp. The result might be a registered point cloud of laser scanners.

Acquisition Database
The data base serves as storage for the acquisitioned and registered infrastructure data (e.g. point cloud). The infrastructure data is stored in order to accomplish differential analyses after future measurements.

Difference Analysis based on registered infrastructure data (e.g. point cloud)
In order to support (e.g. by focusing) the following automated object detection, this step is based on the registered infrastructure data (e.g. point clouds) and does preliminary difference analysis with this data (e.g. changed points).

Automated detection of tracks and objects (incl. positions)
The data evaluation is applied with the already processed and registered acquisition data and consists of the following steps:

- Get track axis/trajectory
- Identification and classification of infrastructure objects
- Determine object positions
- Assign objects to track axis
- Assign gradient data to track axis

Note: The highest possible degree of automation is aimed for.

Generate TOPO
Following the analysis, the topographical acquisition data sets are transformed into a common topological model. This is required as condition for the following linking procedure with older acquisition data. This step includes the following tasks:

- Set nodes and edges (including the navigability/routing information)
- Set objects and its topological positions in the node edge model (start node/ end node)
- Gradients of tracks are simplified by sliding average and introduction of break points (or nodes) for gradient changes equal or higher than e.g. 2 per mill.

Link TOPO to existing TOPO data of acquisition data base
In order to update the TOPO database with the newly acquired TOPO data, the linking between new and existing TOPO data is defined. In this step, the edges and objects of the TOPO data sets (old and new) are linked to each other.
The approach for the linking is described in chapter EST-423 - Linking of topology and objects.

Evaluate differences between existing (old) and acquisitioned (new) TOPO data
If an edge and/or an object in one of the data sets could not be linked to a corresponding edge or object in the other data set (e.g. due to new/missing objects or position difference > tolerance) an appropriate message is generated. During this step all messages are analysed. In addition, the overall quality of measurement data (including environmental factors) is evaluated, especially in case of discrepancies. Based on this analysis the reliability of the acquisition data is derived. If further evidence is required, three possibilities are offered:

- Repeated triggered infrastructure acquisition
- Onsite check
- Manual analysis of tracks and objects from point cloud and/or video.

Note: The definition of the required reliability of acquisition data is part of the following development phases, taken into account the requirements of the TOPO stakeholders (i.e. position tolerance of EI, GLAT) on the one side and the technical parameters of the applied combination of methods (e.g. accuracy, application conditions) on the other side.

Merge linked TOPO data
Following the linking process, in this step all data sets (are merged into one. The approaches for the merging are described in chapter EST-255 - Merging of linked acquisition data sets .

Update Acquisitioned TOPO database

After or during the merge process the single TOPO data stream is used to update the "Acquisitioned TOPO" database.

Acquisitioned TOPO database
The data base serves as storage for the acquisitioned TOPO data. The TOPO data is stored in order to accomplish differential analyses after future measurements. In addition, the TOPO data is stored for the further checking activities.

5.1.3 Linking of topology and objects

5.1.3.1 Linking of topology

Before any linking of objects is carried out, the edges in the different data sets should first be linked.
In this linking of edges, the lengths of the edges are not considered due to the influence of measurement error, which might be higher than the length difference between parallel tracks.

In general, the edges in different datasets can be linked in two ways:

- Topologically by considering the branch directions
- Topographically by considering the nearest track points

Topological approach

For a unique linking of the edges, the branch directions (right/left/straight) are required.
The following figure shows the linking of two data sets. The start nodes are linked by their topographical position and the connected tracks by their branch direction. For the selected start node of dataset 1 the corresponding node of dataset 2 is searched for within the circular area around the geographic coordinate of the node of dataset 1. The radius of the circular search area is defined by the sum of measurement inaccuracies of both compared data sets. After the definition of the start node the node edge model is navigated along the connected track edges. In case of several branches, the branch direction information is considered.

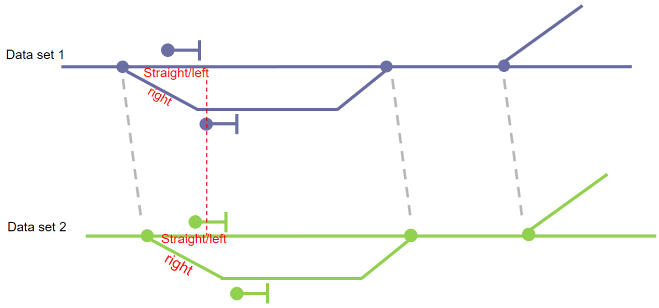

Figure 13 Linking of Topology

Note: In order to ensure completeness in the linking, the search must be executed both from data set 1 to data set 2 and vice versa.

Topographical approach

The topographical approach compares the points on track trajectories of the compared datasets. Two tracks are linked, if the sum of deviation between the absolute coordinates of all analysed track points is minimal. The advantage of this approach is, that the branch directions are not required, which safes effort during the topology generation. The disadvantage is, that this approach depends strongly of the absolute accuracy of the track trajectory in order to allow an unambiguous linking even in large switch areas of stations. Therefore the first topological approach seems to be more robust and is preferred.

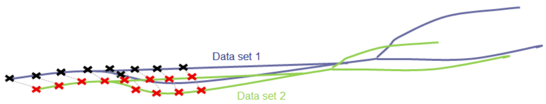

Figure 14 Linking of Topography

5.1.3.2 Linking of objects

After the linking of the edges of the data sets is completed, the objects of the two data sets can be linked.
To be able to compare the objects of the data sets later, it must be decided which objects from data set 1 correspond to which objects from data set 2.
The following criteria should support the assignment. The criteria are AND-linked criteria and are queried in the following sequence:

1. Object Type: Is the type of object X in data set 1 the same as object Y in data set 2?
2. Object Direction: Does object X of data set 1 has the same direction as object Y of data set 2?
3. Object Location: Can object Y (in data set 2) be found within the circular area around the geographical coordinate of Object X (data set 1), while the radius of the circle is defined by the sum of assumed measurement inaccuracies?
4. Object Sequence: If several objects of the same type have been found within the tolerance range, the order of the objects are taken into account.

The following figure shows the linking of signals from data set 1 to signals in data set 2 by using the first three criteria. While the left signal allows an unambiguous assignment with three criteria, the right signal requires the fourth criteria (sequence of objects).

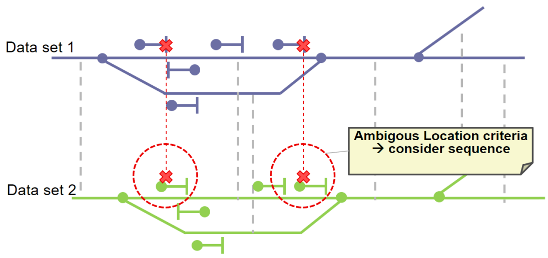

Figure 15 Linking of Objects

Note: In order to ensure completeness in the linking, the search must be proceeded both from data set 1 to data set 2 and vice versa.

5.1.4 Merging of linked acquisition data sets

The precondition for the merging of data sets is a successful linking of data sets. During the merge process the distance (incl. length) and absolute coordinates are summarized to get the values of the single output data stream.

Merging of distance data
The distance data of each dataset are described as statistical values, since the input topographic coordinates are statistical information. Hence, each distance is defined as an expectancy value with a standard deviation (for a defined significance level) according to the provided accuracy of the underlying topographical data.
In case of two-dimensional coordinates, the accuracy of the measurement hardware is usually defined by the circular error probability (CEP). CEP describes the radius around the actual coordinate, while the measured coordinate lays within this circle with a specific probability. Depending on the required probability, which is also known as significance level, the following CEP values (which can be derived from each other) are used:

- CEP50: 50% of the measured coordinates are within the defined circle
- CEP95 = 2,08 * CEP50: 95% of the measured coordinates are within the defined circle
- CEP99 = 2,58 * CEP50: 99% of the measured coordinates are within the defined circle

During acquisition, topographical input data is transformed into topological models (topology generation). In this process the geographical coordinates of objects and discrete points of the track trajectory are transformed into track edge lengths and distances of objects. The relation between the accuracy of absolute coordinates and topological distances depends on the availability of an absolute positioning system (e.g. GNSS) during the measurement.
For the merging of several data sets there are some mathematical applicable approaches. These approaches will be analysed in the further phases (system definition phase).

Merging of absolute coordinates
The absolute coordinates (e.g. track points) are merged in an analogue way according to the principles of merging distance data. Since there is no safe side of position error for the track points the demanding systems should consider the measurement inaccuracies.

5.2 Permanent Acquisition

The permanent acquisition is the desired optimal target of TOPO4 acquisition. It is the further development of the triggered acquisition and implies a fully automated analysis process. Instead of a trigger by AMP the acquisition might be applied in regular time intervals, e.g. by several trains.

5.3 Onsite check

The Onsite Acquisition is part of the activity "Onsite Check" in the use case "Detect relevant TOPO changes - onsite check".
The onsite check is part of the implementation and operation phase. It serves as support for the installation and the maintenance teams. With the onsite check the installation and/or maintenance team can check their work directly onsite.
This will be done using a tablet (e.g. using the GLAT tablet). The team has to record the changed elements with the tablet (only position, kind of element and status of element) and then the system compares this data with the planned TOPO (in the case of installation) or the validated EI-TOPO (in the case of maintenance).
After the comparison the tablet sends the results to the affected systems (e.g. AMP and EI, see also activities in use case "Detect relevant TOPO changes - onsite check") which then have to process/ evaluate the results.

The onsite acquisition has the following characteristics:

- Used for selective acquisition of infrastructure objects
- No post processing required (human as sensor for object identification)
- Measurement of absolute object positions
- No measurement of track trajectory or gradients

5.4 Compare TOPOs

The comparison of TOPO data is a main function of TOPO4 and based on the linked input datasets.
The following diagram shows the steps during the comparison.

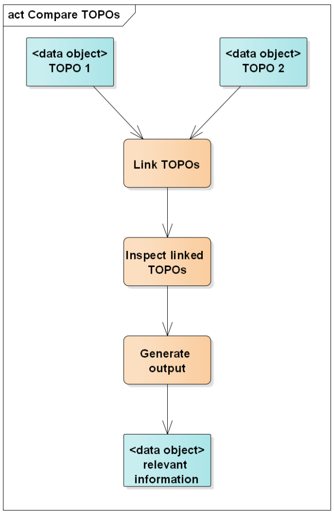

Figure 16 Steps of comparision

data-object :TOPO1
Provides one of the input datasets to be compared (e.g. planed data by AMP or inventory data by AMP).

data object: TOPO2
Provides the input data that serves as a basis for comparison (e.g. actual recorded data by TOPO4)

Linking of TOPOs
In this step, the edges and objects of the data sets are linked to each other.
The approach for the linking is described in chapter EST-423 - Linking of topology and objects.
An error message is generated if edges and/or objects in one the data sets could not be linked to a corresponding edges or objects in the other.

Inspect linked TOPOs
Based on the linked datasets, the linked edges and objects of the datasets are compared to each other.
If the comparison is not successful (means e.g. the position of linked objects are different to each other and the discrepancies are outside the tolerance range) an feedback has to be generated.

Generate output
If the comparison and evaluation was successful, i.e. no discrepancies between the linked datasets were identified, a positive feedback is generated. In this case, the imported reference TOPO (e.g. planned TOPO) does comply with the acquisitioned TOPO and might be used as verified TOPO.
If the comparison and evaluation was not successful, i.e. some discrepancies between the linked dataset were identified, a negative feedback is generated including the Information about the identified discrepancies.

data-object: relevant information
Provides Feedback in form of relevant information for the other systems (e.g. AMP).

5.5 Data Governance

Some information contained in TOPO data cannot be verified by TOPO4, i.e. speed profiles and safety critical track conditions. If this information is to be used by safety-critical systems, it must be safely generated before being read in by TOPO4. This safety can only be guaranteed by applying appropriate processes. The processes must apply equally to everyone and their compliance must be checked regularly by a data governance team.
The topic data governance will be analysed in more detail in further steps following the concept phase.

6 TOPO4 Level

The eventual objective of TOPO4 is for the acquisition to be fully automated and permanently active. Obviously, this objective will not be reached immediately. Rather, the following four successive levels of implementation are planned:

Table 4 TOPO4 levels

Level	Description	Grade of Automation	Infrastructure Objects Recorded	Safety Critical Output	Stakeholder
1	Initial recording of the complete infrastructure to provide a basis for the training and qualification of the algorithms of the TOPO4 system. This initial recording will probably rely heavily on manual actions.	low	all (SR 40 relevant)	no	TOPO4 intern
2	Repeated recordings of parts of the infrastructure to provide TOPO-data during the migration period and for rollout planning. TOPO change detection will be applied at this level to increase confidence in the data quality. These recordings will probably still require some manual actions.	medium	all (SR 40 relevant)	no	TMS, MTC
3	Repeated recordings of parts of the infrastructure to generate TOPO-data in sufficient quality to be used by safety critical systems. These recordings will probably still require some manual actions. Data Governance will be required at this stage.	medium	all (SR 40 relevant)	yes	SR40 (EI, GLAT/AWAP, AMP,TMS)
4	Fully automated continuous recording of the complete infrastructure, maintaining current TOPO-data in sufficient quality to be used by safety critical systems.	high	minimum amount, level crossings and switches (SR40 A4)	yes	SR40 (EI, GLAT/AWAP, AMP,TMS)

7 Next Steps

This chapter lists the next steps following the concept phase.

- Coordination of a holistic data model/ data flow
- Method analysis of TOPO4 data acquisition
- Definition and execution of Proof of Concept (PoC): based on the selected methods a proof of concept should be carried out.
- Implementation of a PHA to identify the safety critical functions/sections of TOPO4 (part of the approval concept)
- Definition of Data Governance for TOPO4

8 Open Issues

8.1 OC configuration process

The following open issues regarding OC configuration need to be clarified with respect to TOPO4:

- It is assumed that the OC configuration is based on generic TOPO data and therefore does not require specific TOPO4 data. If specific TOPO is required, it might be provided by AMP.
- The specific configuration data of OC must be defined. Safety-relevant configuration data of OC might be into the scope of TOPO4 data governance process.

8.2 Safety-critical Objects

It has to be discussed whether the following objects should become part of the safe EI-TOPO or are only relevant for TMS (not-safe TOPO):

- Position of ZKE facilities
- danger zones / construction sites of third parties