Absolute Track Geometry, what is it and how does it help me?
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**Absolute Track Geometry (ATG)**

**ATG is a very accurate description of the track center line.**

**Absolute** because we can tell you within (H) 3/8” (10 mm) and (V) 19/32” (15 mm) where your track is in space.

We process the data and use a CORS network for positioning.

**Track geometry**, a description of a 3D polyline in predefined horizontal or vertical elements of track center line checked upon compliance to local standards.
Flexible logistic concept
- Piggy bag on revenue trains
- Mounted on dedicated locomotive

Carbon fiber box
GPS/IMU
Laser vision (500 Hz)
Camera’s

Construction approved up to 200 km/h (125 mph)
RILA Track, data of rail and track center line
RILA captures during the survey high resolution video images, which can be used for object identification and asset management.

Add sticky notes to objects in the video when you see something you would normally write down in the field. This allows you to extract a list of notes e.g. for a reconstruction behind your desk instead of going into the track.
Flexible logistic concept
- Mounted on dedicated locomotive

GPS/IMU
Laser scanning (200 HZ, 1 million pps)
Camera’s

Construction approved up to 160 km/h (100 mph)
Typical point cloud of RILA 360, here part of the shunt yard just before entering Eindhoven Central Station.
Developments RILA Track + RILA 360 = RILA 3.0

RILA Track and RILA 360 for detailed information of railway corridor. Detailed engineering scheme.

RILA Track and RILA 360 mounted and ready to go for a survey in the UK.

USA RILA 3.0 with integrated scanner for scanning surroundings.

Fugro RailData: alignment computations based upon RILA Track survey
RILA Technology: **from survey to tamping**

- No staff on or near the track => increased safety performance;
- No possessions required => increased railway capacity;
- Rich data set: Survey once => use many times;
- High accuracy => highest levels of approvals;
- Affordable => cost reductions to 90%.
Check on the input file from the RILA Track survey:

- Completeness
- Units (metric, foot/inches)
- Format
- Sigma's ($\sigma_{xy}$, $\sigma_z$), typically 3/8” H, 19/32” V
- Super elevation (cant or cross level)
- Curvature
- Direction: ascending chainage (mileage)
An alignment is a 3D geometric definition of the track consisting of tangents (straights), curves, spirals (transition curve) and super elevation (cant).

The horizontal alignment (plane view) describes the geometry of the track center line, the vertical alignment (vertical plane) describes the geometry of the lower rail.

An alignment based upon survey data and without any further improvements is a “best fit” or “as built”.

Based upon these H+V alignments quality and safety checks can be done using local standards or regulations.

The alignments can be used to optimize track wear, maintenance operations or as input for a re-design.
KRDZ-file of track center line(s)

Constraints
• S&C
• Platforms
• Level crossings
• Slab track
• OLE
• Bridges/Viaducts

Standards/regulations
• International Standards
• Regional Standards (Europe: TSI INF 1299/2014, US: PGRE Section 6 Railway Track Design)
• Local Standards (OVS)

Complex track situation Rotterdam CS (Netherlands)

European standard for alignment
First step is to determine where curvature, tangent track (straights) and spirals (transition curves) are situated.

For this we use the graph of curvature and super elevation.

The straights and curves are determined using the least square method.

In between straights and curves spirals are computed.

This gives a first draft alignment not taking any constraints into account.

The above steps are integrated into software like Bentley Rail-track or Leica A-track.

In the meanwhile check for location of platforms, crossings, slab track.
In this stage check for:

Maximum slews (especially near platforms, S&C, level crossings, Structures and objects)

In case of crossings, adjacent tracks parallel

Distance between adjacent tracks (UK: SCX)

Does location of spiral equals location of transition of super elevation (runoff)

<table>
<thead>
<tr>
<th>Tabel 10</th>
<th>Horizontal Curves Rh [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min. Values</td>
</tr>
<tr>
<td></td>
<td>Standard Values</td>
</tr>
<tr>
<td>$V_{max} \leq 40$ km/h</td>
<td>$R_a \geq 190$ m</td>
</tr>
<tr>
<td>$V_{max} &gt; 40$ km/h</td>
<td>$R_a \geq 425$ m</td>
</tr>
</tbody>
</table>
Now we’re adding maximal permitted speed and measured averaged super elevation.

This to check some safety parameters.

Super elevation (Cant) is defined by: \[ E_{th} = D_c \times 0.0007 \times V_{max}^2 \]

Due to mixed traffic, not all trains run at the same speed.
Therefore an average speed (equilibrium) is used to determine the super elevation.

Super elevation deficiency
- shortfall of super elevation
- Excess of super elevation

Check on length and location of spiral and transition of super elevation and gradient of runoff
Horizontal check on regulations (OVS/CFR)

Minimum length of element

Minimum Radius/Curvature

Comfort parameters like
- sudden changes in lateral acceleration
- tilting speed
- warp

Minimum length depends on speed

<table>
<thead>
<tr>
<th>Spiral [m] acceptable centrifugal forces</th>
<th>Min. Values</th>
<th>Max. Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiral [m] acceptable centrifugal forces</td>
<td>$L \geq \frac{\Delta I \times V_{\text{max}}}{25 \times 3,6}$</td>
<td>$L \geq \frac{\Delta I \times V_{\text{max}}}{70 \times 3,6}$</td>
</tr>
<tr>
<td>Runoff [m] range of change of super elevation</td>
<td>$L \geq \frac{\Delta D \times V_{\text{max}}}{28 \times 3,6}$</td>
<td>$L \geq \frac{\Delta D \times V_{\text{max}}}{35 \times 3,6}$</td>
</tr>
<tr>
<td>Warp (dD/ds)</td>
<td>$L \leq 3,0 \times \Delta D$</td>
<td>$L \geq 0,6 \times \Delta D$</td>
</tr>
</tbody>
</table>

Very comfortable wooden benches
Like the horizontal alignment the first step is to determine where curvature (sags and valleys) and gradients are situated. For this we use the graph of curvature and super elevation.

Again the gradients and curves are determined using the least square method.

This gives a first draft alignment not taking any constraints into account.

The above steps are integrated into software like Bentley Rail-track or Leica A-track.
Take constraints into account
• Platforms
• S&C
• Level crossings
• Slab track

For tamping only lifting of the track is possible, not lowering.

No vertical curves in S&C
Abrupt changes in vertical accelerations:

$$\frac{1}{R_{v, \text{Sag}}} + \frac{1}{R_{v, \text{Valley}}} \leq \frac{1}{0.25 \times V_{\text{max}}^2}$$

When formula is not met a gradient should be applied between summit and valley.

Check for maximum track gradient but also gradients near platforms and shunting yards.

**Table 18**  
**Thresholds for gradients**

<table>
<thead>
<tr>
<th>Max. Values</th>
<th>Standard. Values</th>
<th>Except. Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V \leq 200 \text{ km/h}$</td>
<td>$\leq 5 % (1:200)$</td>
<td>$\leq 25 % (1:40)$ *</td>
</tr>
</tbody>
</table>

* Very steep slope during construction of Railroad in Africa
Although both horizontal and vertical plane are within all thresholds the combination of the two could cause consequential accelerations which exceed comfort parameters.

The combination of a horizontal curve and a gradient will increase resistance which in some cases could lead to more horse power.

<table>
<thead>
<tr>
<th>Tabel 20 Combination of horizontal and vertical curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard. Values</td>
</tr>
<tr>
<td>( \left( \frac{I}{I_{\text{max, norm.}}} \right)^2 + \left( \frac{0.4 \cdot V_{\text{max}}}{R_v} \right)^2 \leq 1 )</td>
</tr>
</tbody>
</table>
Alignment of track center line; Horizontal plane: radius 4825 meter; vertical plane: gradient 0.46 %
Slew and lift for each individual point
For a safe train journey the distance to adjacent track and objects should be large enough to let trains pass.

Depending on speed.

- SC0, distance to objects
- SCP, distance to platform and awnings
- SCX, distance to adjacent track(s)
Input for a new OLE design.

Safety and Asset management:
Height and stagger

Just finished building an OLE design in the Netherlands

Stagger out of thresholds will lead to severe damage to contact wire and droppers
Automated tamping input into WIN-ALC Plasser & Theurer

- **Green** is preferred alignment;
- **Red**: RILA-measurement (current alignment)
- Measuring data coupled to XYZ
- Comparison measurement runs via XYZ

Direct into WIN-ALC

ΔZ (lift)
RILA absolute position tamping:

• No surveyors on or near the track for setting out;
• Track alignments maintained as (originally) approved designs;
• Extended life of track and track components;
• Total cost of ownership significantly reduced.

RILA SURVEY Technology:

• No staff on or near the track => increased safety performance;
• No possessions required => increased railway capacity;
• Rich data set: Survey once => use many times;
• High accuracy => highest levels of approvals;
• Affordable => cost reductions to 90%.
Thank you for your attention

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