Road Design

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10.4. and 17.4. (Lecture and Exercise)

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- Transformation Parameter – Coordinate Systems
- Design Parameter & Definition
- Design Preparation (Leica System1200 OnBoard ATK, Liscad)
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- As Built Check
- Exercise
**Introduction**

**Geodetic Tasks?**

Reference Network, Surveying, DTM, Coord. Transformation, Fixpoints

Data Processing, Planning and Design Preparation

Stake out of math. Elements

As-Built Check

**Measurement System**

- Fixpoint Job
- Trafo Set

- Rotation Ring Laser
- Nivellement (Leveling)
- GNSS
- Total Stations

**Road Design**

- Design Points or Parameter (Formats: TIN, DXF, DBX, XML, D45, ...)  
- Elements: Straight, Arc, Clothoid, Splines  
Road Design Software

**Stake Out**

**As-Built Control**

**Documentation**

**Calculation “Soll-Ist-Vergleich”**
**Introduction Road Construction – Layer**

Layer Description

- Wearing Course (Asphalt)
- Road Base (Asphalt)
- Base Course (Asphalt)
- Subgrade
- Formation (Original Ground)

Curb & Gutter

**Paving**

**Earthworks**

**Introduction**

Stake Out - Road Elements

- Stake Out of a Roundabout
  a) Position to stake out
  b) Stringline to stake out
  c) Centreline
  d) Chainage
  e) ΔChainage
  f) ΔOffset
  g) ΔHeight

Stake Out - Digital Terrain Model

- Offset
- Cross Section
Reference Network

GNSS/TPS/Levelling Adjustment
Alignment Parameter Transformation Parameter DTM

Coordinate Systems – Transformation - Heights

Transformation Approaches
- 3D Helmert (7 parameter, ellipsoid and map projection)
- one Step (height and position transformations separately projected onto a temporary transverse mercator projection and translation, rotation plus scale factor)
Coordinate Systems – Transformation with LGO (3D Helmert)

- Ellipsoid
- 7 Parameter
- Projection

Coordinate Systems – Transformation - LGO one Step Method

One Step (LGO or Onboard)
- 4 Parameter
- Projection: temp. TM

=> Results

=> New Trafo Parameter – new Coordinates System
Coordinate Systems – Transformation - OnBoard one Step Method

One Step (Onboard)
- 4 Parameter
- Projection: temp. TM

Results

= New Trafo Parameter – new Coordinaten System

Coordinate Systems – Transformation - OnBoard one Step Method

Exercise:

One Step (Onboard)
- 4 Parameter
- Projection: temp. TM
Exercise:
Start GNSS Simulator
- Check TPS and GNSS Fixpoint Jobs
- Start Onboard Application
- Select Jobs
- Define Method
- Match Points

- Calc

=> Similar Coord. System @ the GNSS & TPS Sensor
Road Design Parameter and Definition

Types:
- 2D- or 3D-Polyline(s) plus Slope Parameter
- 3D Grid
- DTM (TIN, Grid, …)
- Profiles (X-Section)

Road Design - Parameter and Definition

Deutsch | English
---|---
Designlinie (Stringline) | Stringline
Querprofil (Rampenband) | X-Slope
Längsprofil (Rampenband) | "Rainfall"
Quer & Längsneigung | Roll & Pitch
Krone | Crown
Schicht | Layer
DGM | DTM
Stationierung | Chainage (Stationing)
horizontale Strassentrasse | Horizontal Alignment
vertikale Strassentrasse | Vertical Alignment
Querprofil | Cross Section (X Section)
Road Design - Parameter and Definition

A digital elevation model (DEM) is a digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM). A DEM can be represented as a raster (a grid of squares) or as a triangular irregular network (TIN).
**Road Design – Elements**

Stake Out of Roundabout
a) Position to stake out
b) Stringline to stake out
c) Centre line of the layer is not used for the individual stringline
d) Chainage
e) ΔChainage
f) ΔOffset
g) ΔHeight

**Road Design – D45**

eg. the D45 Model

Coordinate:
(Easting, Northing, Height)
Road Design

The Horizontal Alignment

The horizontal alignment defines the road axis of a project. The constituting elements of a horizontal alignment are:

- straights (tangents)
- curves (arcs)
- spirals (clothoid or cubic parabola).

Each constituting element is defined by individual horizontal design elements such as chainage, easting, northing, radius and parameter \( A^2 = R \times L \).

Elements:

The Tangent - straight line between two points. Its end point is identical with the beginning of a curve or spiral. The tangent is perpendicular to the radius of the curve.

The Curve (Arc) - circular curve with constant radius.

Spiral in - spiral transition from tangent to curve.  
Spiral out - spiral transition from curve to tangent.
**Road Design**

**The Vertical Alignment**
The vertical alignment gives information about the pattern of heights of the road axis as it is defined in the horizontal alignment.
The constituting elements of a vertical alignment are:

- tangents (straight segments)
- curves
- parabolas.

Each constituting element is defined by individual vertical design elements such as easting, northing, radius and chainage.

**Cross Section**
A cross section gives a profile view. It requires vertical alignment or actual elevation on each station.
The constituting elements are straight elements. The points are called vertices.
You may optionally define slopes at the vertices most left and most right.

Points are defined by:
- $\Delta H$ and $\Delta V$
- $\Delta H$ and slope in percentage
- $\Delta H$ and slope ratio
$\Delta H$ horizontal distance from the centre line
$\Delta V$ vertical distance from the centre line (vertical alignment or actual elevation mandatory) – $\Delta V$
**Road Design - Station Equation**

Re-calculation

**Road Design – Elements**

Δ Offset, Δ Height
Cross Slope

- A clockwise rotation about the axis of the machine in the direction of travel is a positive cross slope.
- An anti-clockwise rotation the axis of the machine in the direction of travel is a negative cross slope.
### Road Design – Slope Definition

- **Long Slope**
  - *A clockwise rotation about the cross-axis of the machine, viewed from left-side of machine, is a POSITIVE long slope.*
  
  - *An anti-clockwise rotation about the cross-axis of the machine, viewed from left-side of machine, is a NEGATIVE long slope.*

### Road Design – Definition of Elevation Offsets

<table>
<thead>
<tr>
<th>Positive Offset from design or Negative Correction</th>
<th>Negative Offset from design or Positive Correction</th>
</tr>
</thead>
</table>

A down arrow will be displayed in the Corrections dialog and the As-built Log

An up arrow will be displayed in the Corrections dialog and the As-built Log
**Road Design – Definition of Steer Offsets**

- A negative Offset or deviation from the design
- Or a positive Correction

A right hand arrow will be displayed in the Corrections dialog and the As-built Log

- A positive Offset or deviation from the design
- Or a positive Correction

A left hand arrow will be displayed in the Corrections dialog and the As-built Log

**Road Design – Elements**

- Straight (Tangent)
- Curve
- Spiral
- Clothoid
- ...

Initialisation of the calculation (Find the elements)

Interpolation
Parking Lot
Only one stringline (object) can be selected at a time
All the objects can be on the same layer

Gap in the Polyline, two Stringlines
Extrapolation
**Design Preparation - CAD Applications**

- Design data format
  (different types depending on country, CAD system / design software program, user, file type etc)
- Many different CAD / design software packages and applications exist
- Common CAD / design software packages are:

![Software Logos]

- Novapoint
- Autodesk
- Bentley
- Carlson
- Chaos
- Liscad
- Syngis
- Geopak Survey
- SiteVision Office
- Topcon SiteLINK

**Design Preparation - CAD Applications**

- Each of these CAD software packages will output at least one of the following file types

![File Types]

- DXF
- ASCII
- LandXML
**Design Preparation - Leica**

In the Leica DataFlow following options are possible

- System 1200 (TPS & GNSS) ATK Onboard Tool
- Data Conversion via LGO (Design-to-Field or SiteManager)

**Design Preparation - LandXML Files**

- LandXML is an emerging standard for civil engineering survey and design supported by many companies and manufacturers.
  - Currently there are ~45 software products registered as LandXML compliant
  - Website: [www.landxml.org](http://www.landxml.org)

- There are 2 types of LandXML files:
  - **X-Slope**, a template based design file based on cross sections (not usually used for paving)
  - **String** based
    - These are transformed differently
**Design Preparation - LandXML**

- DBX is a database structure, common to Leica System 1200
- Leica Survey refers to this as “X-Function”

**Design Preparation - Leica**

- Leica is using the DBX file structure
  - DBX is a database structure, common to Leica System 1200
  - Leica Survey refers to this as “X-Function”

- Fixpoint Job (XYZ, Code, Measurement Elements, Time & Date)
- DTM Job (3D Terrain Models)
- Tunnel Job
- Rail Job
- Road Job (Alignments)

Leica uses the concepts of Projects and Jobs.

- A Project is a collection of designs, alignment references and localization sets specific to a job.
- A Project can support multiple Jobs
- Jobs are groupings of data to fulfill a specific application.
- Each Job is collection of Reference Lines
Leica DBX File Structure

Binary Code (Type is not displayed)

Design Preparation – Leica Liscad (TIN)

Definition of a Project, Units, ...

Creating a TIN Job
The Alignment Tool Kit application supports these alignment types:

- Horizontal alignments
- Vertical alignments
- X-section
- Chainage (Stationing)

A'' (ENh) Point on horizontal alignment
A (ENh) Point on real surface
A''' (ENh) Point on vertical alignment
- Horizontal alignment (A''-B'')
- Projection of the horizontal alignment onto the real surface (A'-B')
- Vertical alignment (A'''-B''')

The angle between the horizontal and the vertical alignment is the grade (α).
**Design Preparation – Leica Onboard Application ATK**

Create a new Job in the ATL Application

![ATL Application screenshot](image1)

Design Preparation – Leica Onboard Application ATK

Create a new Job in the ATK Application

![ATK Application screenshot](image2)

**Design Preparation – Leica Onboard Application ATK**

Chainage

![Chainage screenshot](image3)

The data representing a link between two existing nodes is used during your tutorial.
Create and Edit a Alignment

Create in CF Card\Data/XML\ Example ATK.xml

Design Preparation – Leica Onboard Application ATK

Horizontal Alignment

From Fixpoint Job or measure

Add point

Institute for Geodesy and Photogrammetry - Prof. Dr. H. Ingensand
ETH Zürich
**Design Preparation – Leica Onboard Application ATK**

**Horizontal Alignment**

- delete point => Chainage

**Vertical Alignment**

- Parameter
  - Straight
  - Parabola (Grade In/Out, 2:1 hv)
  - Curve (Sag or Crest)
Exercise
Create a Design
with the ATK Tool

Points:

1. ID: 1  
   E = 100 m  
   N = 100 m  
   H = 100 m

2. ID: 2  
   E = 120 m  
   N = 100 m  
   H = 100 m

3. ID: 3  
   E = 140 m  
   N = 80 m  
   H = 100 m

4. ID: 4  
   E = 140 m  
   N = 60 m  
   H = 110 m

5. ID: 5  
   E = 160 m  
   N = 60 m  
   H = 110 m

6. ID: 6  
   E = 160 m  
   N = 120 m  
   H = 90 m

Length = 31.416 m
The X-Section Templates

A X-Section gives a profile view. It requires vertical alignment or actual elevation on each chainage. The constituting elements are straight elements. The points are called vertices. You may optionally define slopes at the vertices most left and most right. Points are defined by:

- ΔH and ΔV
- ΔH and slope in percentage
- ΔH and slope in ratio

The X-Section Assignments

One X-section is valid until a new one is defined at a chainage ahead. X-section definition can be at any chainage. The chainages need not necessarily correspond to chainages where a design element starts or ends.
**Design Preparation – Leica Onboard Application ATK**

**The Chainage equation**

Chainage Equations define adjustments for the chainage values in the horizontal alignment. These adjustments may be necessary when the horizontal alignments have been **modified** by inserting or removing a constituting element and the chainage in the horizontal alignment were not recomputed.

This can be the case when editing manually or with a program which does no automatic recomputation.

**Convert to RoadRunner Job**

ATK creates a log file during the conversion.

The file `LandXml2Dbx.log` can be found in the `\Data\XML` folder on the CF Card.

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**Design Preparation – Leica Onboard Application ATK**

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**Convert to RoadRunner Job**

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**Vertical Alignment**

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**Information:**

Conversion to <EGL_II_RR>

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**OK**