Specifications for Input Data for the VC Panorama Converter

This specification describes the requirements for input data for a mobile mapping system. The goal is to provide the data in such a way that it can be processed by the converter completely, consistently, and without errors, including for visualization, measurements, and further analysis.

Panoramic images

Panoramic images provide a 360° view of the surroundings and can be captured simultaneously with point clouds. They are used for both visualization and, optionally, analysis.

Recording format and mode

- File format: **JPG/JPEG** or **PNG**
- A single image must be provided for each panorama. Cubemaps or individual images of cube faces are not permitted.
- Horizontal field of view: **360°**
- Vertikal field of view: **180°**
- The pixel ratio of width to height must be exactly **2:1**.
- The converter requires **equirectangular** images.

Recording locations and metadata

- The locations of the panoramic images must be documented in a **CSV file**.
- The first line of the CSV file must contain a **header** with unique, meaningful column names.
- The coordinates of the panoramic images must be specified in the same CRS as the point cloud.
- Each line of the CSV file must contain the following information:
    - **File name** of the panoramic image (unique identifier)
    - **Timestamp** (time of recording in GPS seconds)
    - **X, Y, Z coordinates** of the capture point (center of the image)
    - **Roll angle** in degrees (roll)
    - **Pitch angle** in degrees (pitch)

    - **Yaw angle** in degrees (Heading/Yaw)
- Angles that have already been corrected in the image should be entered as 0.

All coordinate values must use the units of the CRS being used. Elevation above the reference ellipsoid must always be specified in meters. (See Height Reference System)

Model orientation and Euler angles of the panoramic images

The following mandatory guidelines apply to the position and orientation of the panoramic images and the correct projection of point clouds into the panoramic images:

Systems of reference

- **Camera coordinate system (P)**
- The **Y-axis points forward** in the direction of travel
- The axes form a right-handed coordinate system
- **Global UTM System (E)**
- The X-axis points **east**
- The Y-axis points **north**
- The Z-axis points **upward**
- The transformation describes the exact position and orientation of the panoramic camera in the global ENU system.

Position and orientation

Each panoramic camera is described by **three coordinates in the ENU system** and three Euler angles:

- **Translation**: $t_E = (Easting, Northing, Height)$
- **Rotation**: *(Roll, Pitch, Heading)*

Euler angle convention

- The rotation matrix from panorama coordinates to world coordinates is defined in the order **X -> Y -> Z**:
  $\mathbf{R_{P->E} = R_x(Pitch) * R_y(Roll) * R_z(-Heading)}$
- Signs of the angles:
  - **Pitch (X-axis):** positive
  - **Roll (Y-axis):** positive
  - **Heading / Yaw (Z-axis):** negative
- Angles are measured in **degrees**
- This convention defines the extrinsic rotation of the panoramic camera from the local camera coordinate system to the global ENU system.

Elevation reference system and camera height above ground

- All elevation data for point clouds and panoramic images must be in the same **elevation reference system**, with the corresponding EPSG code specified. Automatic transformation between different elevation reference systems is not performed during the calculation. The elevation data is used to ensure the correct positioning and precise display of the panoramic images.
- Official geodata in Germany is generally provided in **normal heights (NHN) in accordance with DHHN2016**. To ensure consistent use and correct spatial referencing, point clouds and panoramic images should be transformed into this elevation reference system using a geoid transformation before processing or calculation in the converter. Only then will the elevation data from the captured data match the elevations of the official geodata when they are merged in a map application.
- The **camera height above ground** must be specified and is set **globally for the entire dataset**. It is used to correctly render the capture locations in the panoramic image. A value of −2.4 indicates that the camera was mounted 2.4 meters above the ground on the mapping vehicle.
- The unit of measurement for elevation is **meters**.

Point Clouds

In general, panoramic images can be processed even without a point cloud. In this case, however, their use is limited to simply viewing panoramic images. Measurements or geometric analyses are not possible. If a point cloud is available, the following requirements must be met.

Taking

- Point clouds can be captured at the same time as panoramic images.
- The recording must be fully georeferenced.

File format

- Accepted formats: **LAS** or **LAZ**.

Georeferencing

- The coordinate reference system (CRS) must have an official EPSG code.
- The EPSG code must be provided.
- The CRS of the point cloud must match the CRS of the panoramic images.
- See notes on the elevation reference system.

Point attributes

Each point in the point cloud must contain at least the following attributes:

- **Coordinate:** According to the specified CRS.
- **Intensity:** An integer between 0 and 65,535.
- **Timestamp:** Time of recording in GPS seconds.