Track4 "Foot-Mounted IMU (offsite-online)" special features

Organizational aspects:

Database/dataset access

- As initiated in Spain in 2021, Track4 is now an "offsite-online" track. That means, we ask competitors to process data **as if they were in real time**. To do so, an interface based on a web API has been developed: EvaalAPI. This API will be used by competitors for sending position estimates and reading the sensor values: https://evaal.aaloa.org/evaalapi/
- In the context of this EvaalAPI framework, **one** "scoring trial" will be proposed to competitors. **This scoring trial will be usable only once –excepted on justified reasons approved by track chairs**.
- In order to help competitors to be well prepared for the evaluation, a "testing trial" is proposed. This **"testing trial" is fully accessible and reloadable** (i.e. not restricted to a single usage as scoring trials). GroundTruth positions are included in the "testing trial" under the POSI [1]label, for validation purpose.
- Extract from https://competition.ipin-conference.org/current-competition/call-for-competition : "OFFSITE-ONLINE TRACKS : ***Competitors in offsite-online competitions are provided with sensors data and use them to estimate the user position. Competitors calibrate their algorithms in advance using ground truth reference data (testing trials) and compete using new unreferenced data (scoring trials). Competitors run their trials through the EvaalAPI in online mode to emulate the causal, real-time behaviour of onsite Tracks. Scoring trials are run on a Track-specific day. See the paper "Offsite evaluation of localization systems: criteria, systems and results from IPIN 2021--22 competitions" for a conceptual overview. Prizes are awarded for a total worth to be announced.***"

Competitor admission process / Application:

- Admission process: https://competition.ipin-conference.org/current-competition/call-for-competition
- Application page: https://competition.ipin-conference.org/current-competition/application

Submission of the processed results

- As mentioned earlier, results have to be submitted via a web API. See above.

Important deadlines:

• Technical annexes published	**May, 2025**
• "testing trial" is accessible through web API	**July, 2025**
• Application deadline	**August 31st, 2025**
• "testing trial" fully executed with web API	**September 5th, 2025**
• **"scoring trial" will be accessible**	**Sept 8th - Sept. 10th 2025**
• Proclamation of winners	**September 18th, 2025**

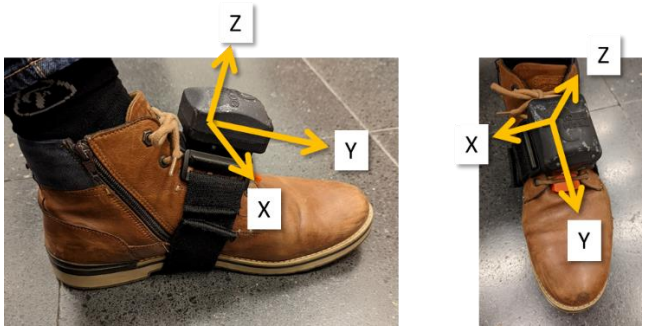
[1] See hereafter in the document, for details

Scope

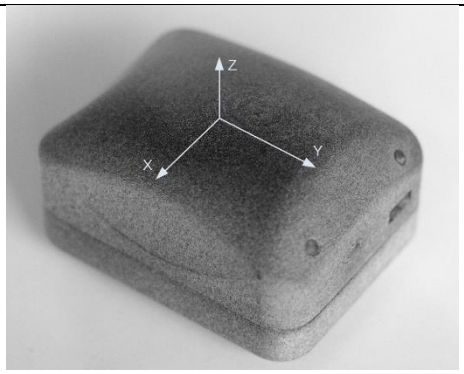
Many indoor navigation systems have been developed for pedestrians and assessing their performances is a real challenge. Benefiting from a reference solution that is accurate enough to evaluate other indoor navigation systems and assist novel research is of prime interest. According to ISO18305:2016 two different ways can be used for assessing indoor localization system: “Off-line surveyed test point” that is commonly used, or “reference system” with an accuracy at least one order of magnitude better the system you want to test. The scope of this track4 is clearly focused on the second way of assessing.
This track4 is based on the same equipment named “ULISS” as it is for several years now.

Competition Goal

The goal of this competition is to evaluate how good up-to-date INS algorithm is. Each competitor will have access to a dataset logged with ULISS (Ubiquitous Localization with Inertial Sensors and Satellites), a state-of-the-art Inertial Navigation System producing IMU data, MAG data, PRESSURE data & GNSS data, without the help of any maps.



ULISS sensor installed on the **left** foot (with axes)

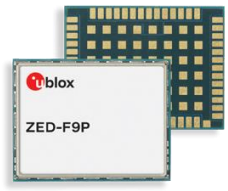


ULISS sensors axes

Description of Datasets

Data is recorded from 3 different sensors:

Xsens Mti-7 	IMU-Mag sensor: -3D accelerometer -3D gyrometer -3D magnetometer https://www.xsens.com/mti-7
BMP280 sensor 	Operation range: Pressure: 300...1100 hPa Absolute accuracy : ~ ±1 hPa Relative accuracy : ± 0.12 hPa (typical) https://www.bosch-sensortec.com/products/environmental-sensors/pressure-sensors/bmp280/
Ublox ZED-F9P dual freq. receiver	Multi GNSS Receiver : BeiDou, Galileo, GLONASS, GPS / QZSS Number of concurrent GNSS 4 Dual GNSS Bands : L1C/A, L2C, L1OF, L2OF, E1B/C, E5b, B1I, B2I

	https://www.u-blox.com/en/product/zed-f9p-module

Unit and meaning of the sensors outputs of ULISS are the following ones:

Column	Xsens MTi-1 (accelerometer)	Comments
1	"ACCE"	Acceleration label
2	GPS Time of Week (ToW) in second	
3	Acc X (m/s²)	Acceleration on X axis
4	Acc Y (m/s²)	Acceleration on Y axis
5	Acc Z (m/s²)	Acceleration on Z axis

Sample strings for accelerometer data

```
ACCE,314410.003952000,-1.25709,-4.34142,8.75831
ACCE,314410.008947000,-1.23771,-4.28408,8.72497
ACCE,314410.013942000,-1.26714,-4.3795,8.72491
ACCE,314410.018937000,-1.26167,-4.29823,8.71566
ACCE,314410.023932000,-1.25662,-4.26479,8.71095
```

Column	Xsens MTi-1 (gyrometer)	Comments
1	"ROTA"	Gyrometer label
2	GPS Time of Week (ToW) in second	
3	Gyro X (rad/s)	Angular velocity around X axis
4	Gyro Y (rad/s)	Angular velocity around Y axis
5	Gyro Z (rad/s)	Angular velocity around Z axis

Sample strings for gyrometer data

```
ROTA,314410.004573000,0.00275338,-0.000805736,0.006387
ROTA,314410.009578000,-0.00576329,-0.00401807,0.00535798
ROTA,314410.014582000,0.00813067,0.00989926,0.00747764
ROTA,314410.019587000,0.00594413,-0.00079453,0.00529695
ROTA,314410.024591000,0.00488472,0.00237882,0.0117271
```

Column	Xsens MTi-1 (magnetometer)	Comments
1	"MAGN"	Magnetometer label
2	GPS Time of Week (ToW) in second	
3	Mag X (a.u.)	a.u. = arbitrary unit according to Xsens.
4	Mag Y (a.u.)	Tips : multiply by 0.49*1000,
5	Mag Z (a.u.)	In order to get milliGauss (mG)

Sample strings for magnetometer data

```
MAGN,314410.005162000,0.224368,0.435266,-1.14962
MAGN,314410.015162000,0.22387,0.434764,-1.14766
MAGN,314410.025162000,0.222876,0.438141,-1.1481
MAGN,314410.035162000,0.223393,0.433828,-1.14817
MAGN,314410.045162000,0.224333,0.431291,-1.1413
```

Column	BMP280 (pressure)	Comments
1	"PRES"	Pressure sensor label
2	GPS Time of Week (ToW) in second	
3	Pressure (Pa)	

Sample strings for pressure data

```
PRES,314410.005162000,101144
PRES,314410.025162000,101152
PRES,314410.045162000,101138
PRES,314410.065162000,101151
PRES,314410.085162000,101151
```

Column	Temperature (temperarure)	Comments
1	"TEMP"	Temperature sensor label
2	GPS Time of Week (ToW) in second	
3	Temperature (Degree Celsius)	

Sample strings for temperature data

```
TEMP,314410.025162000,44.1914
TEMP,314411.025162000,44.1758
TEMP,314412.025162000,44.1758
```

Column	Ublox F9P GNSS receiver (PVT)	Comments
1	**"GPVT"**	**GNSS Position information label**
2	**GPS Time of Week (ToW) in second**	
3	**ASCII NMEA GGA Message**	**Corresponds to GGA NMEA Message***

*: **https://fr.wikipedia.org/wiki/NMEA_0183**

Sample strings for SBS (SBAS – EGNOS) data

```
GPVT,137598.800000000,$GNGGA,141318.80,6129.67752,N,02346.80402,E,1,12,0.57,106.7,M,19.1,M,,*4C
GPVT,137599.800000000,$GNGGA,141319.80,6129.67750,N,02346.80403,E,1,12,0.60,106.7,M,19.1,M,,*4A
GPVT,137600.800000000,$GNGGA,141320.80,6129.67749,N,02346.80404,E,1,12,0.57,106.7,M,19.1,M,,*4B
```

Column	Ublox F9P GNSS receiver (SBS)	Comments
1	"GSBS"	GNSS SBAS information label
2	GPS Time of Week (ToW) in second	
3	Hexadecimal WORD	Corresponds to EGNOS SBAS Message Format*

*: https://gssc.esa.int/navipedia/index.php/The_EGNOS_SBAS_Message_Format_Explained

Sample strings for SBS (SBAS – EGNOS) data

```
GSBS,315499,9A494C0000000000000400001F00003F80003FC0003FE0001FF0001FF80
GSBS,315618,5363FBFFDC00000000000197BBBAA01848160A0580B185BFDFEF980900
GSBS,315619,9A0A8003FE4027FFBFC7FEFFD4003FEC000003FB8003959559797BA380
```

Column	Ublox F9P GNSS receiver (OBS)	Comments
1	"GOBS"	GNSS Observation label
2	GPS Time of Week (ToW) in second	
3	Observation data	Observation file based on RINEX 3.04 format http://rtcm.info/RINEX_3.04.IGS.RTCM_Final.pdf Only data after header* is used in the context of Track4.

*Header of "OBSERVATION DATA" file under Rinex 3.04 format are given later in each session specific parts (headers are slightly different).

Sample strings for OBS (observation file, based on RINEX 3.04 format) data

```
GOBS,314856.199000000,G04  24066762.037 8 126471694.10925     -3666.900          39.000
GOBS,314856.199000000,G09  21204418.682 8                9     -2579.258          24.000
GOBS,314856.199000000,G06  21843663.561 9                9     -3361.335          14.000
GOBS,314856.199000000,C24  24066200.488 4                9     -1496.777          42.000
GOBS,314856.199000000,C09  41038802.886 9 213699815.76337     -1391.943          30.000
GOBS,314856.199000000,R10  20885796.375 8 111333055.23728     -1125.414          35.000
GOBS,314856.199000000,R17  21027399.505 9 112521861.85837         1.771          31.000
GOBS,314856.199000000,G16  24420695.497 9                9      -607.284          34.000
GOBS,314856.199000000,E25  26416183.541 9                9      1623.139          22.000
GOBS,314856.199000000,R09  23641111.957 9                9     -3901.952          26.000
GOBS,314856.199000000,E24  27240945.515 8                9      -857.287          38.000
GOBS,314856.199000000,E05  27154158.133 8                9     -2871.781          35.000
GOBS,314856.399000000,G04  24066902.088 8 126472426.50726     -3656.825          35.000
GOBS,314856.399000000,G09  21204516.880 8                9     -2576.887          25.000
GOBS,314856.399000000,G06  21843791.401 9                9     -3361.335          14.000
GOBS,314856.399000000,C24  24066258.112 4 125319321.10437     -1491.643          44.000
GOBS,314856.399000000,C09  41038856.136 8 213700093.52228     -1387.629          30.000
GOBS,314856.399000000,R10  20885839.907 8 111333279.85427     -1119.290          37.000

…

GOBS,316465.400000000,G09  22053796.355 9                7     -2965.625          42.000    22053774.011 9
9     -2311.088          23.000
GOBS,316465.400000000,G06  22958748.483 8                9     -3890.580          43.000    22958742.892 9
9     -3018.360          18.000
GOBS,316465.400000000,G04  25190987.721 9                9     -3672.705          35.000
GOBS,316465.400000000,G20  20618874.632 4                9      1326.448          48.000
GOBS,316465.400000000,G07  20956968.745 8                9      -528.696          32.000
GOBS,316465.400000000,C14  26537412.626 9                9     -3269.531          39.000
```

Important notes on GNSS Receiver data

3 kind of data are now shared to competitors. Track chairs highlight:

- **GPVT is the easiest GNSS data to be used. Because it gives directly positions computed by the RxGNSS (F9P) embedded in ULISS system. However these positions are usually not very accurate.**
- **GOBS is observation data. A specific skill on GNSS signal processing is required in order to be used. If this data is correctly used, then dead-reckoning navigation is enhanced.**
- **GSBS is SBAS data deliver by EGNOS satellite. This data can be used to enhance GOBS data.**

In any case, indoor environments disturbed a lot GNSS signals, so a well-balanced choice is required when using GNSS data.

Column	ground truth position	Comments
1	"POSI"	ground truth position label
2	GPS Time of Week (ToW) in second	
3	WGS84 longitude in decimal degrees	
4	WGS84 latitude in decimal degrees	
5	Floor Number in integer	0 : Ground Floor, -X : for downstairs number X Y : for upstairs floor n° Y
6	POSI number index	**Incremental counter, starting at "1"**

Sample strings for ground truth position data

```
POSI,137766.000,23.780099827,61.494600019,0,1
POSI,137854.505,23.780363395,61.494526707,0,2
```

Note1: POSI frame is only used twice in scoring trials. For the first Key Point (n°1) and the second Key Point (n°2).
Note2: POSI frame is used in testing trial to help competitors to tune their algorithm.

Testing Trial: dataset recorded around 17h00 (local time), the 2nd of June 2025 in Tampere (Finland)

Type	Description	URL to download
Testing Trial	CSV file containing all data as described in section "Description of Datasets". GroundTruth is given inside **IPIN2025**_T4_TestingTrial_v1.txt	**https://data.d4science.net/6aLv**
Ground Truth	Ground Truth of TestingTrial given @60Hz for offline evaluation purpose.	matlab file: **https://data.d4science.net/mLjD** Python file: **https://data.d4science.net/qsMH** kml file: **https://data.d4science.net/ojbY**
Tutorial	Python script given as an example to play with Your specific TestingTrial name (TT) : run **2025**_Track4_EvaalAPI_example.py "TT"	Python files: **https://data.d4science.net/rQ4s**
Allan Variance	static logfile of about 14 hours that can be used for sensors bias estimation.	https://data.d4science.net/3Hyg
Magnetometer Calibration	logfile of about 1 minute that can be used to calibrate the magnetometer sensor	**https://data.d4science.net/Q7U5**
GNSS Navigation file	contains ephemeris data for those who want to use GNSS sensor.(format RINEX 3.04)	**https://data.d4science.net/9Sut**
GNSS Observation header	3.04 OBSERVATION DATA M: Mixed RINEX VERSION / TYPE RTKCONV demo5 b34L 20250623 123852 UTC PGM / RUN BY / DATE format: u-blox UBX COMMENT log: D:\IPIN2025\ULISS\2025.06.02_Testing-1_ULISS\uliss-1-trCOMMENT ace-942\gnss.ubx COMMENT MARKER NAME MARKER NUMBER MARKER TYPE OBSERVER / AGENCY REC # / TYPE / VERS ANT # / TYPE 2792753.7244 1230590.5955 5581951.5895 APPROX POSITION XYZ 0.0000 0.0000 0.0000 ANTENNA: DELTA H/E/N G 8 C1C L1C D1C S1C C2X L2X D2X S2X SYS / # / OBS TYPES R 8 C1C L1C D1C S1C C2C L2C D2C S2C SYS / # / OBS TYPES E 8 C1X L1X D1X S1X C7X L7X D7X S7X SYS / # / OBS TYPES S 4 C1C L1C D1C S1C SYS / # / OBS TYPES C 8 C2I L2I D2I S2I C7I L7I D7I S7I SYS / # / OBS TYPES 2025 06 02 14 13 36.5940000 GPS TIME OF FIRST OBS 2025 06 02 14 34 08.9950000 GPS TIME OF LAST OBS G L1C SYS / PHASE SHIFT G L2X 0.00000 SYS / PHASE SHIFT R L1C SYS / PHASE SHIFT R L2C SYS / PHASE SHIFT E L1X 0.00000 SYS / PHASE SHIFT E L7X 0.00000 SYS / PHASE SHIFT S L1C SYS / PHASE SHIFT C L2I SYS / PHASE SHIFT C L7I SYS / PHASE SHIFT 10 R05 1 R06 -4 R07 5 R13 -2 R14 -7 R15 0 R20 2 R21 4 GLONASS SLOT / FRQ # R22 -3 R23 3 GLONASS SLOT / FRQ # C1C 0.000 C1P 0.000 C2C 0.000 C2P 0.000 GLONASS COD/PHS/BIS END OF HEADER	
RINEX 3.04 spec	Specification of RINEX format version 3.04	https://data.d4science.net/a3Jn

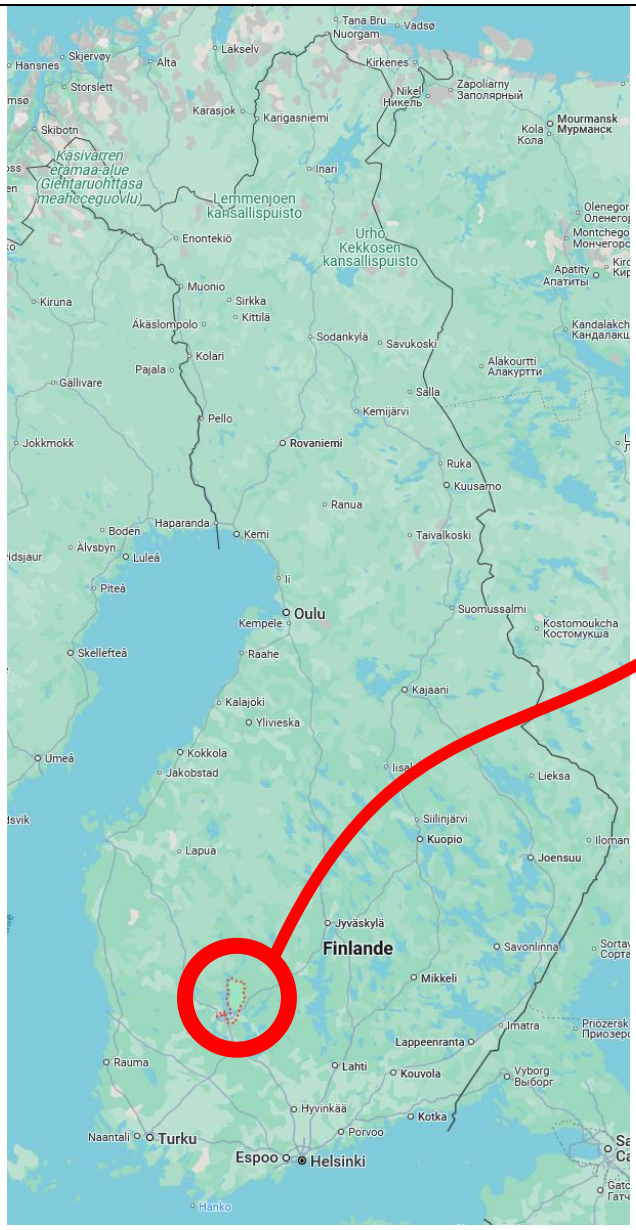
- **Note about Maps use**
  - Usage of maps as an input for the computation of position estimates is **not allowed**. Track chairs, in such a case, could cancel contributions of competitor.
  - Algorithms are not supposed to embed or access maps to enhance positioning. However, maps can still be used in the scope of auto-assessment during the preparation phase (Testing Trial).

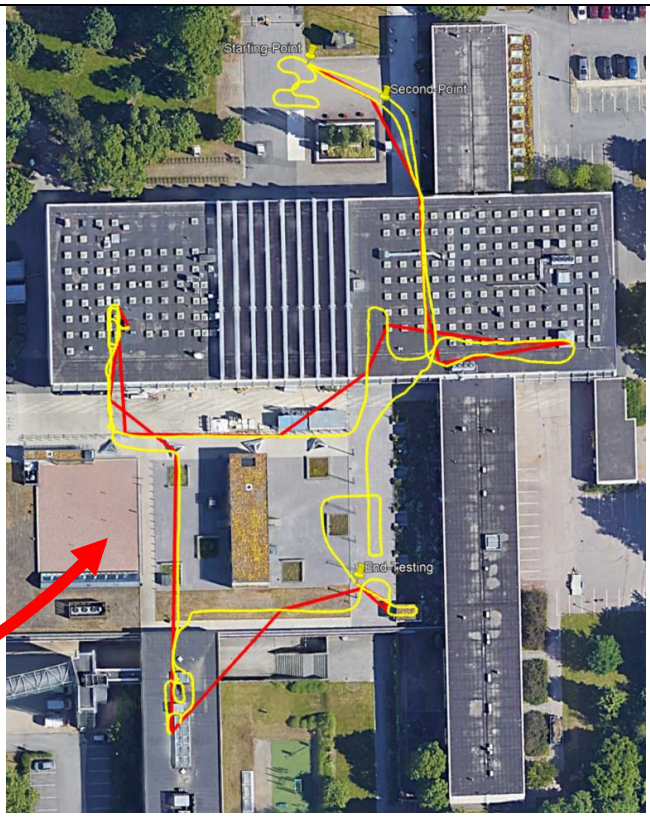
- **Key Points**:
  - All reference points are given at a sampling rate ~60Hz, for offline evaluation purpose.
  - **34** ground truth key points will be given as POSI lines through EvaalAPI.
  - Among them the two first are important, because they can be used to compute a good heading like for "Scoring Trial" sessions (see Key Point n°1 and Key Point n°2 below).
  - Evaluation is based like other Tracks: i.e. position estimates have to be computed and sent twice a second (~2Hz; i.e. EvaalAPI horizon of 0.5s), synchronized with the evaal data stream, and thus corresponding to the end of each dataset window of 0.5s.
  - The output format is described in the chapter "Description of the Output File" here after.

- **Points given in order to get a good first heading:**
  Two reference points are given to competitor in order to help them.
  - **Coordinates of Key Point n°1 (starting point):**
    - **GPS Tow : 137766.000 s**
    - **longitude: 23.780054845 °**
    - **latitude : 61.494621014 °**
    - **Floor Nb : 0**
    - Corresponding POSI line:
      POSI,137766.000,23.780054845,61.494621014,0,1
  - **Coordinates of Key Point n°2 (at less than ~10m far from starting point):**
    - **GPS Tow : 137854.505 s**
    - **longitude: 23.780294812 °**
    - **latitude : 61.494559522 °**
    - **Floor Nb : 0**
    - Corresponding POSI line:
      POSI,137854.505,23.780294812,61.494559522,0,2

- **Coordinates of Key Point n°34 (ending point):**
  - **GPS Tow : 138507.533 s**
  - **longitude: 23.780239010 °**
  - **latitude : 61.493687427 °**
  - **Floor Nb : 0**
  - **Corresponding POSI line: POSI,138507.533,23.780239010,61.493687427,0,34**

- **Bird view:**





Legend:

- yellow = ground truth @60Hz for post-process evaluation (matlab & kml files)
- red = sub sample (32 key points) of ground truth given as POSI lines through EvaalAPI

Scoring Trial: dataset recorded around XX h XX (local time), the XX of June 2025 in Tampere

Type	Description	URL to download
Scoring Trial	SCORING TRIAL is only accessible via EvaalAPI	coming later
Allan Variance	static logfile of about 14 hours that can be used for sensors bias estimation.	coming later
Magnetometer Calibration	logfile of about 1 minute that can be used to calibrate the magnetometer sensor	coming later
GNSS Navigation file	contains ephemeris data for those who want to use GNSS sensor.(format RINEX 3.04)	coming later
GNSS Observation header	coming later	
RINEX 3.04 spec	Specification of RINEX format version 3.04	https://data.d4science.net/a3Jn

- **Note about Maps use**
    - Even if maps may be allowed in others tracks, for this one, **it is NOT**. Track chairs, in such a case, could cancel contributions of competitor.
    - Algorithms are not supposed to embed or access maps to enhance positioning.
- **Key Points**:
    - Only 2 ground truth key points will be given as POSI lines through EvaalAPI (see Key Point n°1 and Key Point n°2 in the Bird View below).
    - Evaluation is based like other Tracks: i.e. position estimates **have to** be computed and sent twice a second (~2Hz), synchronized with the evaal data stream, and thus corresponding to the end of each dataset window of 0.5s.
    - Based on previous point, Track4 is now able to assess all estimations computed by competitors. Thus, last editions, for instance, more than 3000 key points were evaluated for each run of competitors.
    - The output format is described in the chapter "Description of the Output File" here after.
- **Points given in order to get a good first heading:**
  Two reference points are given to competitor in order to help them.
    - **Coordinates of Key Point n°1 (starting point):**
        - GPS Time of Week in seconds: coming later
        - WGS84 longitude in decimal degrees: coming later
        - WGS84 latitude in decimal degrees: coming later
        - Floor Number in integer: coming later
        - Corresponding POSI line: coming later
    - **Coordinates of Key Point n°2 (at less than ~10m far from starting point):**
        - GPS Time of Week in seconds: coming later
        - WGS84 longitude in decimal degrees: coming later
        - WGS84 latitude in decimal degrees: coming later
        - Floor Number in integer: coming later
        - Corresponding POSI line: coming later

- **Bird view:** coming later

Description of the Output stream to return by competitor

For each scoring trial, competitor is asked to give processed data inside the field "position estimates" of the *GET /TRIAL/nextdata* EvaalAPI request. The string "position" has to be composed of the 4 following fields:

- Field 1: WGS84 longitude in decimal degrees with at least 9 decimal digit resolution
- Field 2: WGS84 latitude in decimal degrees with at least 9 decimal digit resolution
- Field 3: Floor Number in integer. 0 for Ground Floor, -X for downstairs number X, Y for upstairs floor n° Y
- Field 4: Incrementing counter starting from 1. 1 being the first point computed by competitor, 2 being the second, and so on…

Comma (",") has to be used as data delimiter.

Assessment will take into account the PTS (timestamp relative to the last position) return by *GET /TRIAL/estimates* EvaalAPI request.

Examples of successive string "position estimates" included in *GET/TRIAL/nextdata* requests:

```
-1.542614572,47.217689856,0,1
-1.542614573,47.217689855,0,2
-1.542614574,47.217689854,2,3
…
```

Corresponding example of *GET/TRIAL/estimates* request:

```
pts,c,h,s,pos
217034.000,0.000,0.000,45.000,-1.542614572,47.217689856,0,1
217034.500,1662121746.081,0.500,43.762,-1.542614572,47.217689856,0,1
217035.000,1662121747.877,0.500,45.000,-1.542614573,47.217689855,0,2
217035.500,1662121749.670,0.500,45.000,-1.542614574,47.217689854,2,3
…
```

Evaluation criterion

The final metric will be based on the accuracy for the correct floor detection and the horizontal positioning error. In particular, the score for comparing the different location systems will be based on the following equations:

$$\textbf{Accuracy Score} = \text{3rdQuartile}\{\text{SampleError}(R_i, E_i)\}, \forall \text{ groundtruth reference in all final test sets}$$

$$\text{SampleError}(R_i, E_i) = \text{Distance}(R_i, E_i) + (\text{penalty} \times \text{floorfail})$$

where:

- "3rdQuartile" is the third quartile error, in meters, of a cumulative error distribution function, i.e., the error value that includes 75% of estimations (sample errors) with a lower error.
- R_i is the actual position (ground truth).
- E_i is the predicted position estimate by the method proposed by the contest participant.
- floorfail is the absolute difference between actual floor and the predicted one.
- penalty is used to penalize errors in estimating the floor. penalty is set to 15 m.
- $\text{Distance}(R_i, E_i)$ calculates the Euclidean distance between coordinates (longitude and latitude) of R_i and E_i.

The team with the lower "Accuracy Score" wins.

Contact points and information

For any further question about the database and this competition track, please contact to:

- Miguel Ortiz (miguel.ortiz@univ-eiffel.fr) at the University Gustave Eiffel, France.
- Ni Zhu (ni.zhu@univ-eiffel.fr) at the University Gustave Eiffel, France.

Introduced changes

For any further question about the database and this competition track, please contact to:

Version 1.0	May 24th , 2025	First version. Including Testing Trial of previous 2024 edition. 2025 new Testing Trial (from Tampere) will come later.
Version 2.0	**June 19th , 2025**	**-Replacement of 2024-Testing Trial by the new Testing Trial recorder in Tampere in June 2025.** **-Add of a new kind of data: GPVT that is the position computed by the GNSS receiver embedded inside ULISS.**