IPIN 2021
ELEVENTH INTERNATIONAL CONFERENCE ON
INDOOR POSITIONING
AND INDOOR NAVIGATION
29 Nov. – 2 Dec. 2021, Lloret de Mar, Spain

Version 2.0 (September 30th, 2021)

Track4 "Foot-Mounted IMU based Positioning (off-site)" special features

Organizational aspects:

Database/dataset access

- This year we decided to change a little bit rules: even if Track4 is still an off-site track, we will ask to competitors to process data as if they were in real time. To do so, a new 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 readouts:
  https://evaal.aaloa.org/evaalapi/
- Participants can still download data usable for sensors bias estimation. Files will be accessible at the following URL:
  http://evaal.aaloa.org/images/2021/track4/ (coming soon)
- For information, competitors can find training datasets of previous Track4 edition on Zenodo:
  IPIN2018-Track4: https://zenodo.org/record/3228012
  IPIN2019-Track4: https://zenodo.org/record/3937220
  IPIN2020-Track4: https://zenodo.org/record/4668618

Submission of the processed results

- As mentioned earlier, results have to be submitted via a web API. See above.
- A participant team can run the process up to 2 times. This lets a chance to catch-up if any issues happen. Although the competition organizers will evaluate the two trials, only the best one will be considered for the contest. For the first evaluation, dataset of session1 will be used. For the second trial, dataset of session2 will be used. These two datasets correspond to two different data collection performed on the same path but not at the same time.

Important deadlines:

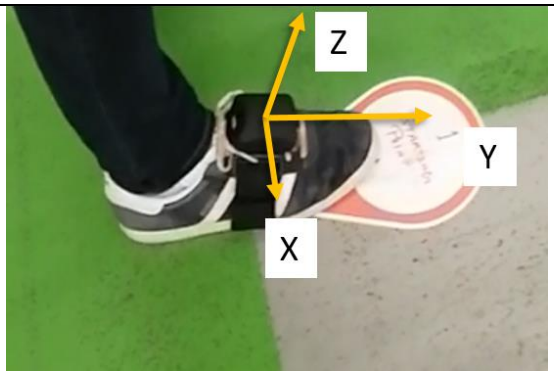
- Data will be published, and accessible through web API the: **OCTOBER 4th 2021**
- **The deadline** for submitting the post-processed results is: **NOVEMBER 18th 2021**
- Proclamation of winners: **DECEMBER 2nd 2021**

Scope

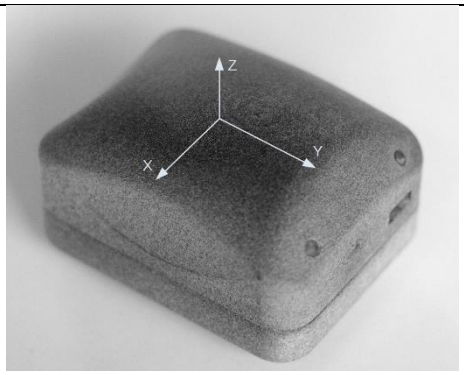
Many indoor navigation systems have been developed for pedestrians and assessing their performances is a real challenge. Benefiting from a reference solution that is accurate enough to evaluate other indoor navigation systems and assist novel research is of prime interest. According to ISO18305:2016 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 material as previous competitions hold during IPIN2018, IPIN2019 and IPIN2020.

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 (Ubiquituous 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.



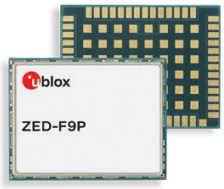
ULISS sensor installed on the right foot (with axes), on the starting point.



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	GPS Time of Week (ToW) in second	GPS Time of Week (ToW) in second
2	Nano part of GPS Time of Week	Full GPS ToW = col1 + col2 / 1E9
3	Acc X (m/s²)	
4	Acc Y (m/s²)	
5	Acc Z (m/s²)	

Sample strings for accelerometer data

```
314410,3952000,-1.25709,-4.34142,8.75831
314410,8947000,-1.23771,-4.28408,8.72497
314410,13942000,-1.26714,-4.3795,8.72491
314410,18937000,-1.26167,-4.29823,8.71566
314410,23932000,-1.25662,-4.26479,8.71095
```

Column	Xsens MTi-1 (gyrometer)	Comments
1	GPS Time of Week (ToW) in second	GPS Time of Week (ToW) in second
2	Nano part of GPS Time of Week	Full GPS ToW = col1 + col2 / 1E9
3	Gyro X (rad/s)	
4	Gyro Y (rad/s)	
5	Gyro Z (rad/s)	

Sample strings for gyrometer data

```
314410,4573000,0.00275338,-0.000805736,0.006387
314410,9578000,-0.00576329,-0.00401807,0.00535798
314410,14582000,0.00813067,0.00989926,0.00747764
314410,19587000,0.00594413,-0.00079453,0.00529695
314410,24591000,0.00488472,0.00237882,0.0117271
```

Column	Xsens MTi-1 (magnetometer)	Comments
1	GPS Time of Week (ToW) in second	GPS Time of Week (ToW) in second
2	Nano part of GPS Time of Week	Full GPS ToW = col1 + col2 / 1E9
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

```
314410,5162000,0.224368,0.435266,-1.14962
314410,15162000,0.22387,0.434764,-1.14766
314410,25162000,0.222876,0.438141,-1.1481
314410,35162000,0.223393,0.433828,-1.14817
314410,45162000,0.224333,0.431291,-1.1413
```

Column	BMP280 (pressure)	Comments
1	GPS Time of Week (ToW) in second	GPS Time of Week (ToW) in second
2	Nano part of GPS Time of Week	Full GPS ToW = col1 + col2 / 1E9
3	Pressure (Pa)	

Sample strings for pressure data

```
314410,5162000,101144
314410,25162000,101152
314410,45162000,101138
314410,65162000,101151
314410,85162000,101151
```

Column	Temperature (temperarure)	Comments
1	GPS Time of Week (ToW) in second	GPS Time of Week (ToW) in second
2	Nano part of GPS Time of Week	Full GPS ToW = col1 + col2 / 1E9
3	Temperature (Degree Celsius)	

Sample strings for temperature data

```
314410,25162000,44.1914
314411,25162000,44.1758
314412,25162000,44.1758
```

Column	Ublox F9P GNSS receiver (SBS)	Comments
1	GPS Week number	
2	GPS Time of Week (ToW) in second	

3	PRN (sat number)	EGNOS Satellite Id
4	-	Not used
5	Constant value ":"	
6	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

```
2175 315499 123 18 : 9A494C0000000000000400001F00003F80003FC0003FE0001FF0001FF80
2175 315618 136 24 : 5363FBFFDC00000000000197BBBAA01848160A0580B185BFDFEF980900
2175 315619 136  2 : 9A0A8003FE4027FFBFC7FEFFD4003FEC000003FB8003959559797BA380
```

Ublox F9P GNSS receiver (OBS)	Comments
GNSS observation data	Observation file based on RINEX 3.04 format http://rtcm.info/RINEX_3.04.IGS.RTCM_Final.pdf

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

```
     3.04           OBSERVATION DATA    M: Mixed            RINEX VERSION / TYPE
RTKCONV demo5 b34c                      20210923 145112 UTC PGM / RUN BY / DATE
format: u-blox UBX                                          COMMENT
log: D:\IPIN2021\DataCollection\2021.09.23_verif with FranceCOMMENT
                                                            MARKER NAME
                                                            MARKER NUMBER
                                                            MARKER TYPE
                                                            OBSERVER / AGENCY
                                                            REC # / TYPE / VERS
                                                            ANT # / TYPE
  4337849.4702  -123594.0862  4658735.5346                  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    7 C2I L2I D2I S2I C7I D7I S7I                          SYS / # / OBS TYPES
  2021    09    15    15    20    09.1990000     GPS         TIME OF FIRST OBS
  2021    09    15    16    03    42.4000000     GPS         TIME OF LAST OBS
G L1C                                                       SYS / PHASE SHIFT
G L2X -0.25000                                              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
 11 R01  1 R02 -4 R08  6 R09 -2 R10 -7 R11  0 R12 -1 R17  4 GLONASS SLOT / FRQ #
    R18 -3 R23  3 R24  2                                    GLONASS SLOT / FRQ #
 C1C    0.000 C1P    0.000 C2C    0.000 C2P    0.000       GLONASS COD/PHS/BIS
                                                            END OF HEADER
> 2021 09 15 15 27 36.1990000  0 12
G04  24066762.037 8 126471694.10925     -3666.900          39.000
G09  21204418.682 8                9     -2579.258          24.000
G06  21843663.561 9                9     -3361.335          14.000
C24  24066200.488 4                9     -1496.777          42.000
C09  41038802.886 9 213699815.76337     -1391.943          30.000
R10  20885796.375 8 111333055.23728     -1125.414          35.000
R17  21027399.505 9 112521861.85837         1.771          31.000
G16  24420695.497 9                9      -607.284          34.000
E25  26416183.541 9                9      1623.139          22.000
R09  23641111.957 9                9     -3901.952          26.000
E24  27240945.515 8                9      -857.287          38.000
E05  27154158.133 8                9     -2871.781          35.000
> 2021 09 15 15 27 36.3990000  0 12
G04  24066902.088 8 126472426.50726     -3656.825          35.000
G09  21204516.880 8                9     -2576.887          25.000
G06  21843791.401 9                9     -3361.335          14.000
C24  24066258.112 4 125319321.10437     -1491.643          44.000
C09  41038856.136 8 213700093.52228     -1387.629          30.000
R10  20885839.907 8 111333279.85427     -1119.290          37.000

…
```

```
> 2021 09 15 14 20 21.8070000  0 18
G07  24638128.012 4                9      2275.081          43.000
G09  22424741.675 4         -0.500 9      -955.661          50.000
G03  26674681.751 4 140176422.500 6     -3636.344          47.000    26674678.108 9                9     -
2804.250          25.000
G04  24071769.440 4 126498007.31728     -3013.200          48.000    24071770.003 9                7     -
2347.817          27.000
C24  26416433.672 2 137557308.209 7       754.198          49.000
C14  25849654.595 2 134605934.893 6     -2756.586          46.000    25849646.713 8                9     -
2131.866          31.000
C09  42560860.631 4                9     -1445.346          40.000
R17  24946541.057 9                9      3115.864          24.000
R08  22003634.282 8                7     -1828.522          45.000
R07  25163827.512 2 134703975.099 8     -3711.899          44.000    25163831.604 9                9     -
2882.884          26.000
R01  22197721.649 9                9      1128.883          25.000
G20  25637162.698 9                9      2762.477          20.000
G26  27350146.151 9                9      -313.516          30.000
R10  24027352.119 4 128079371.572 7      2280.223          43.000
R09  24316162.257 4 129846945.75628      -999.930          41.000
E05  27654623.458 4 145326026.91917     -2614.866          46.000    27654624.165 8 111353711.57017     -
2002.352          28.000
E03  25494806.465 9 133976111.99018      -446.883          43.000
E24  29961715.263 4                9      1027.975          42.000    29961716.223 8                9
790.388          26.000
```

Inputs given to competitors

The materials and methods provided by the competition organizers are:

- **Datasheet of each individual sensors can be downloaded here:**
  - Xsens MTI-1 : http://evaal.aaloa.org/images/2021/track4/MTi-7_Leaflet.pdf
  - Ublox ZED F9P GNSS Receiver: http://evaal.aaloa.org/images/2021/track4/ZED-F9P_ProductSummary_(UBX-17005151).pdf

    http://evaal.aaloa.org/images/2021/track4/RINEX_3.04.IGS.RTCM_Final.pdf
- **LogFiles to download and to use before evaluation (for both session 1 and 2)**:
  - 2021.09.02_ULISS_AllanVariance.zip : static logfile of more than 15 hours that can be used for sensors bias estimation http://evaal.aaloa.org/images/2021/track4/2021.09_ULISS_AllanVariance.zip :
    - acceleration.csv
    - rotation.csv
    - magnetic.csv
    - pressure.csv
    - temperature.csv
  - 2021.09.15_ULISS_MagCalib.zip : logfile of about 1 minute that can be used to calibrate the magnetometer sensor http://evaal.aaloa.org/images/2021/track4/2021.09.15_ULISS_MagCalib.zip
    - acceleration.csv
    - rotation.csv
    - magnetic.csv

- **GNSS Navigation files that contain ephemeris for those who want to use GNSS sensor**:
  - session1_gnss.nav: GNSS Navigation file for session1 (format RINEX 3.04) http://evaal.aaloa.org/images/2021/track4/session1_gnss.nav
  - session2_gnss.nav: GNSS Navigation file for session2 (format RINEX 3.04) http://evaal.aaloa.org/images/2021/track4/session2_gnss.nav
- **Coordinates of Key Point n°1 (same for both session 1 and 2):**
  - WGS84 longitude in decimal degrees: *-1.6313191524195993*
  - WGS84 latitude in decimal degrees: *47.22617430160391*
  - Floor Number in integer: *-1*
- **Coordinates of Key Point n°2 (same for both session 1 and 2):**
  - WGS84 longitude in decimal degrees: *-1.631060453984984*
  - WGS84 latitude in decimal degrees: *47.22612380681056*
  - Floor Number in integer: *-1*
- **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.

Session 1: dataset recorded around 15h30, the 15th of September

- **Timing of expected Key Points**:
  - 83 key points will be evaluated in Track4 : from 3 to 85
  - Key Points timestamps are expressed in GPS Time of Week in milliseconds (ms), hereafter in the table.

Key Point	GPS Time of Week (ms)	Key Point	GPS Time of Week (ms)	Key Point	GPS Time of Week (ms)
1*	308945294	**30**	309778168	**59**	310502561
2*	308960836	**31**	309881752	**60**	310567480
3	308976111	**32**	309893883	**61**	310580113
4	308990088	**33**	309906198	**62**	310592378
5	309002014	**34**	309917817	**63**	310601509
6	309014780	**35**	309972535	**64**	310615558
7	309022926	**36**	309984353	**65**	310628286
8	309029910	**37**	309993111	**66**	310676329
9	309039174	**38**	310002843	**67**	310688873
10	309145224	**39**	310024502	**68**	310699335
11	309186323	**40**	310039365	**69**	310783689
12	309202144	**41**	310054263	**70**	310810773
13	309207260	**42**	310071496	**71**	310823555
14	309225605	**43**	310087427	**72**	310980767
15	309250396	**44**	310106513	**73**	311008253
16	309263674	**45**	310173810	**74**	311035611
17	309279550	**46**	310183035	**75**	311052397
18	309291084	**47**	310205504	**76**	311064380
19	309305375	**48**	310258708	**77**	311094500
20	309320843	**49**	310293343	**78**	311282676
21	309330410	**50**	310306095	**79**	311361069
22	309512491	**51**	310324789	**80**	311390255
23	309527796	**52**	310343358	**81**	311412163
24	309556105	**53**	310353269	**82**	311418497
25	309568216	**54**	310363170	**83**	311428756
26	309594479	**55**	310372852	**84**	311439655
27	309677148	**56**	310446256	**85**	311460997
28	309755879	**57**	310476495		
29	309768646	**58**	310485099		

*: coordinates given (see above)

GPS time of week being the same as ones used in datasets, expect that unit here is millisecond (ms).

The output format is described in the chapter “Description of the Output File” here after.

Session 2: dataset recorded around 17h15, the 15th of September

- **Timing of expected Key Points**:
  - 83 key points will be evaluated in Track4 : from 3 to 85
  - Key Points timestamps are expressed in GPS Time of Week in milliseconds (ms), hereafter in the table.

Key Point	GPS Time of Week (ms)	Key Point	GPS Time of Week (ms)	Key Point	GPS Time of Week (ms)
1*	314464119	30	315298217	59	316002074
2*	314479680	31	315405177	60	316067544
3	314494550	32	315417901	61	316079626
4	314508178	33	315430545	62	316092067
5	314519029	34	315441137	63	316100796
6	314531177	35	315498639	64	316115968
7	314539394	36	315511795	65	316131648
8	314546146	37	315523122	66	316177077
9	314554692	38	315534042	67	316189403
10	314653472	39	315556677	68	316200670
11	314690208	40	315573167	69	316284229
12	314704715	41	315588007	70	316309169
13	314709778	42	315603373	71	316319587
14	314726705	43	315617840	72	316477414
15	314751531	44	315636094	73	316506845
16	314763828	45	315683853	74	316534418
17	314779473	46	315695036	75	316550102
18	314791153	47	315718421	76	316559894
19	314805333	48	315766314	77	316587909
20	314820570	49	315799477	78	316791764
21	314830328	50	315812175	79	316885342
22	315014273	51	315830200	80	316909820
23	315029267	52	315846496	81	316926458
24	315059662	53	315855041	82	316933781
25	315071840	54	315863442	83	316944035
26	315092353	55	315872961	84	316955015
27	315196607	56	315947424	85	316976482
28	315276853	57	315974505		
29	315288742	58	315984551		

*: coordinates given (see above)

GPS time of week being the same as ones used in datasets, expect that unit here is millisecond (ms).

The output format is described in the chapter “Description of the Output File” here after.

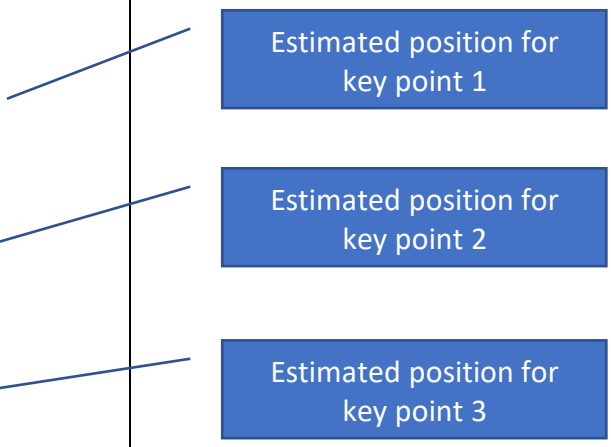
Description of the Output stream to return by competitor

For each trial, competitor is asked to give processed data with the following format:

- 5 fields :
  - Field 1: Timestamp in ms
  - Field 2: WGS84 longitude in decimal degrees with at least 9 decimal digit resolution
  - Field 3: WGS84 latitude in decimal degrees with at least 9 decimal digit resolution
  - Field 4: Floor Number in integer (0 : Ground Floor, -1, 1, 2)
  - Field 5: index in integer (key point number from 1 to N. 0 represents no key point. Each specific integer represents the specific key point)
- Comma (“,”) used as data delimiter

Example :

```
314479680,141.346908569,43.070758819,-1,0
314531177,141.346893310,43.070755004,-1,0
314704715,141.346893310,43.070755002,-1,0
314805333,141.346893308,43.070755003,-1,0
315014273,141.346893310,43.070755004,-1,1
315071840,141.346908569,43.070758819,0,0
315276853,141.346908570,43.070758817,0,0
315405177,141.346908579,43.070758819,0,0
315534042,141.346908569,43.070758815,1,2
315573167,141.346908565,43.070758819,1,0
315695036,141.347000132,43.070770263,1,0
315830200,141.347000142,43.070770261,2,0
315947424,141.347000152,43.070770262,2,3
316100796,141.347000162,43.070770263,2,0
```



Evaluation will only take into account the estimated position at each indexed key point position, so that each track is considered as a series of key point positions (from 1 to N).
In others words : column 1 will not be assessed, and thus can be slightly different from the expected time.
What is important is to put correctly the right key point id in field n°5.

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 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.

- $\mathrm{Distance}(R_i, E_i)$ 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	September 3rd	Initial Submission
Version 2.0	September 30th	Change from PERSY sensor to ULISS sensor. New data, and its format are described. Clarification on the two different sessions that will be proposed to competitors.