Lab Session 5: GNSS Signal Acquisition

Laboratory on real RF navigation signal, correlation and serial acquisition

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Department of Electronics and Telecommunications

GNSS real signals acquisition

Objective:

The goal of this lab session is to implement a more advanced acquisition stage of a GNSS receiver, able to acquire real GNSS signals.

Notes:

Download the additional material from *Portale della didattica*.

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Step 1: parallel acquisition in time domain

TASK
1

Write a Matlab function able to acquire an ideal GPS signal using the **parallel acquisition** in **time domain** scheme.

1. Read the GNSS raw IF samples
2. Generate local carrier and code
3. Perform parallel acquisition
4. Plot cross ambiguity function in the search space

You can use the GPS codes generated in **Lab 3**, as well as the `GenerateLocalCarriers.m` and `GenerateLocalCode.m` functions already written in **Lab 3** and **Lab 4**.

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Step 1: parallel acquisition in time domain

TASK
2

Use the raw IF GNSS signals provided for **Lab 4** to test your acquisition. The signal is ideal (no noise, no navigation message, no front-end input filter).

- **SignalRX_1.bin** contains a **GPS signal**
- **SignalRX_2.bin** contains a **Galileo signal**

Compare the results of the serial and parallel acquisition schemes.

Evaluate the gain in terms of processing time (you can use tic and toc MATLAB functions).

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Step 2: the effect of noise

TASK

1

A new raw IF GPS signal, **SignalRX_3.bin**, is provided. The signal is **ideal** (no navigation message, no front-end filter) but it contains noise. The parameters of the signal are as before.

The file contains signals from **3 different GPS satellites** (PRNs 6, 18 and 21); each one is characterized by a **different Doppler frequency**, **code delay** and $\boldsymbol{C/N_0}$ (45, 50 and 60 dB-Hz, in random order).

Try to process the new signal with the acquisition routine written in the previous steps.

- Can you acquire all the three satellites?
- Why?
- How can you solve the issue?
- Can you match the signals PRN with the C/N_0 value?

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Step 2: the effect of noise

TASK

2

Implement the following strategies, in the **parallel acquisition scheme**, to acquire all the satellites:

- **Non-coherent integration** time extension.
- **Coherent integration** time extension.
- A combination of coherent and non-coherent integration time extension.

Go back to the course material to properly design your code according to the theory.

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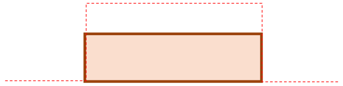
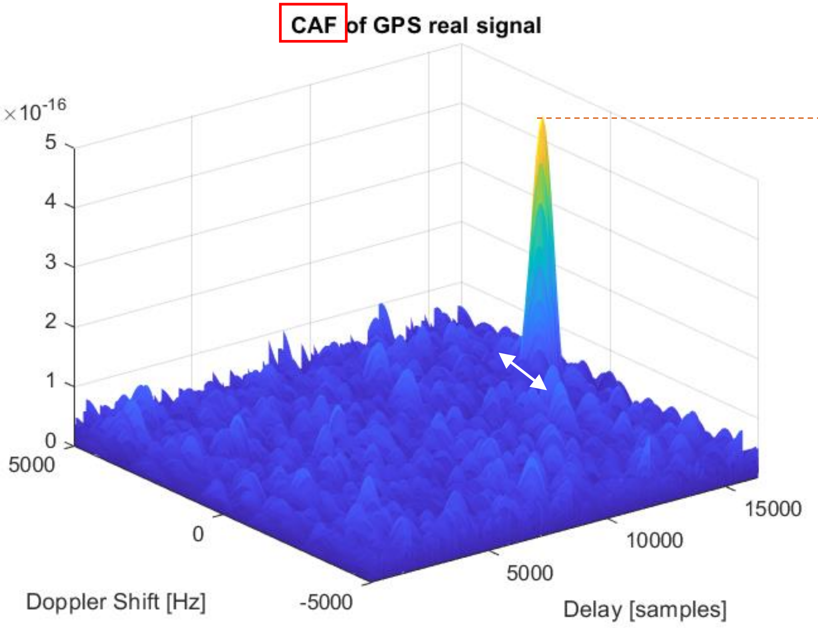
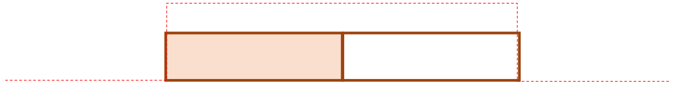
Focus on Coherent Accumulation

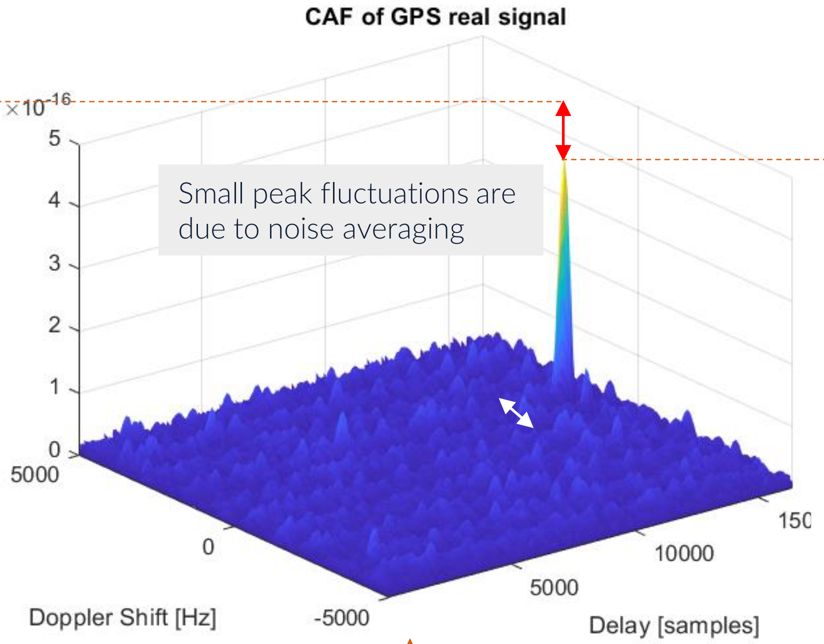


1-ms coherent accumulation

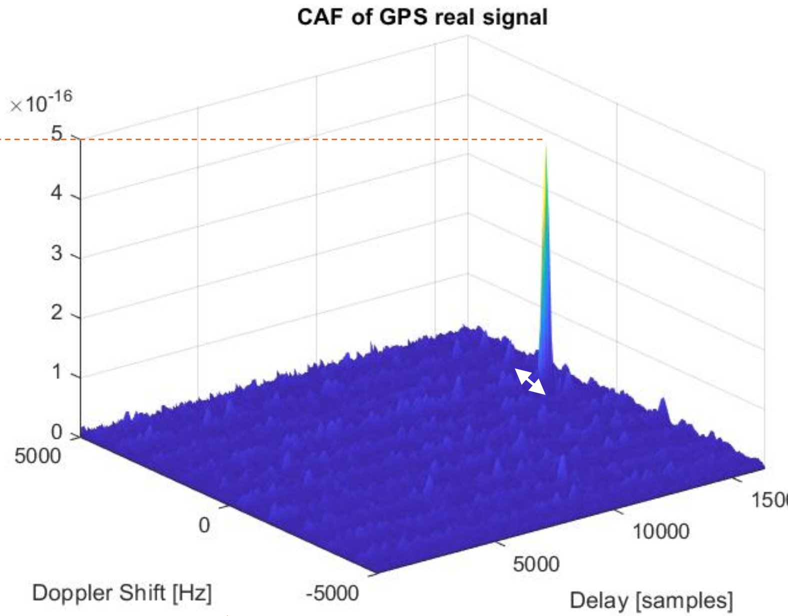




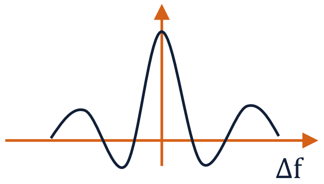
2-ms coherent accumulation
(first replica output)

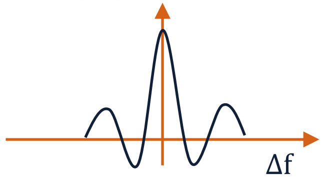


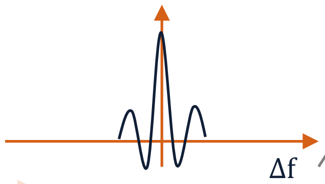
3-ms coherent accumulation
(first replica output)



Single-period coherent CAFs
Can be averaged to obtain
non-coherent accumulation







Δf must be set according to the coherent integration time.

Peak shrinking in the Doppler domain
(larger rectangular window, narrower sync function)

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Step 3: real GNSS signals

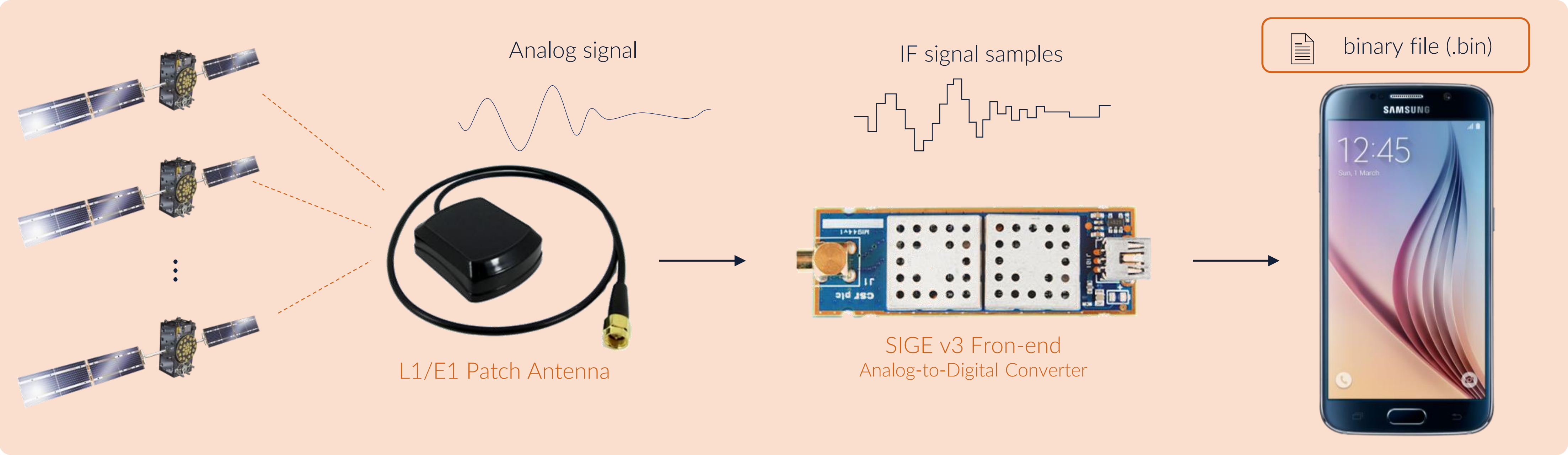
Live Recording of raw signal samples

Real GNSS signals are being collected during an on-field real data collection at **Politecnico di Torino**, by means of a patch antenna, a USB front-end and a PC/smartphone.

SIGE v3 Front-end | Output Data format

Signal type	int8
Sampling frequency	16.368 MHz
IF frequency	4.092 MHz
Bandwidth	L1

⋮



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Step 3: a real GNSS signal

TASK

1

Perform **GPS L1** and **Galileo E1b** signal acquisition on the real dataset by using the functions written in the previous steps and comment the results on the basis of the environmental conditions of the data collection.

- How many and which PRNs can you acquire in the different scenarios?
- Can you improve the results by employing integration time extension?
- Which are the limitations of the real case with respect to the ideal case?

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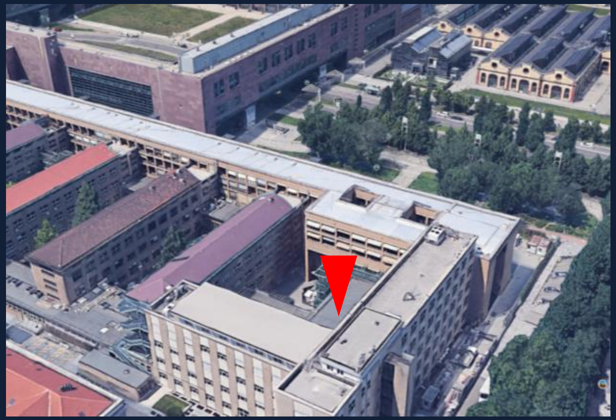
Examples of real data collections

- Time: ~ (?), Date: (?), Location: (?) | Signals: L1/E1 bandwidth (GPA L1 C/A and Galileo E1bc signals)
- 3 datasets, 1-second long
  - (A) Open Sky
  - (B) Mild Urban
  - (C) Urban Canyon

According to the satellites visibility (check on one of the online GNSS planners), provide comments on the way urban environment can affect satellite visibility and more specifically signal quality at the acquisition stage

Scenario A

Scenario B



Scenario C

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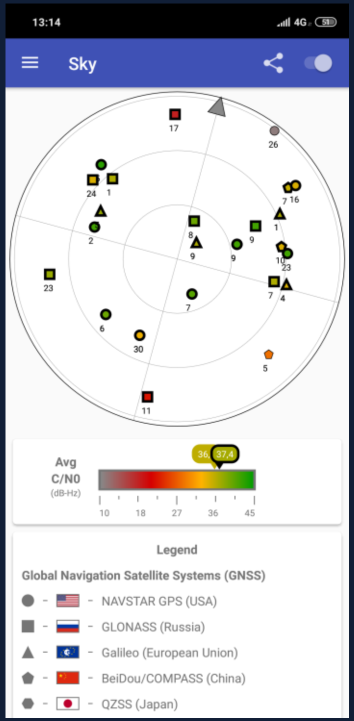
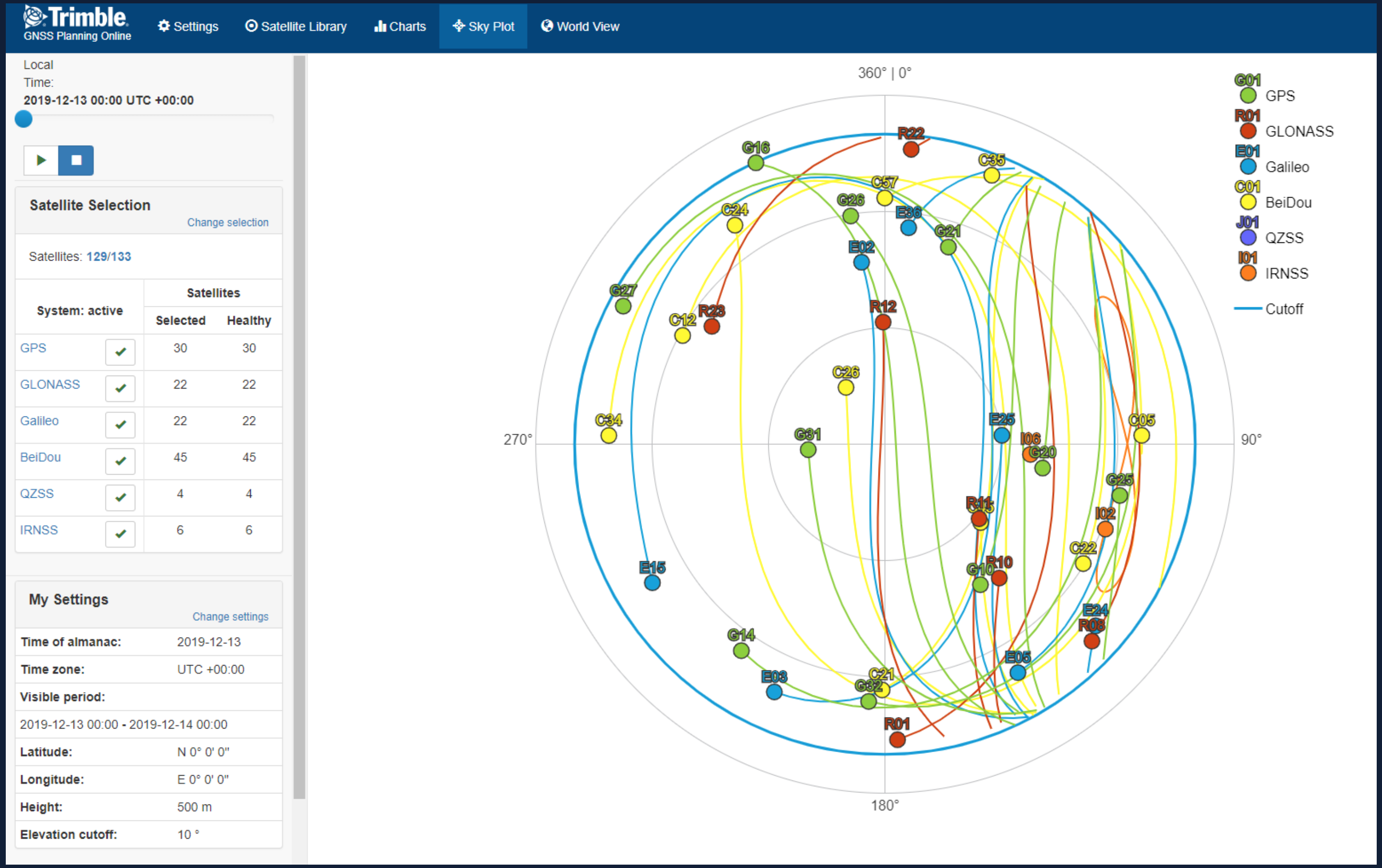
Check actual satellites

- Through the **smartphone apps**
- Through an online **GNSS planner**
- Through **Orbitron**





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Reminder: how to read IF samples data

```
fileName = '…';
[fid, message] = fopen(fileName, 'rb');

samplesToRead = ...;
[rawData, cntData] = fread(fid, samplesToRead, 'int8');
fclose(fid);
```


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Description of the backup real data collection

If weather conditions are not so good for live data collection ...

- **Time: ~ 14:30, December 13, 2019**
- L1/E1 bandwidth (GPA L1 C/A and Galileo E1bc signals)
- 3 datasets, 1-second long
  - **`d01_openSky.bin`** acquired in the parking area in front of Laib building (Via Boggio), in open sky conditions.
  - **`d02_mildUrban.bin`** acquired in the gate area close to the Laib building with partial sky occlusion.
  - **`d03_urbanCanyon.bin`** acquired in narrow street close to Politecnico (i.e., Via Andrea Vochieri)

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Description of the backup real data collection

If weather conditions are not so good for live data collection ...

- **Time: ~ 13:00, December 14, 2018**
- L1/E1 bandwidth (GPA L1 C/A and Galileo E1bc signals)
- 3 datasets, 1-second long
  - **`fante.bin`** acquired in front of the statue, in Piazzale Duca d'Aosta, good open-sky conditions
  - **`entrance.bin`** acquired at Politecnico main entrance, sky-view partially obstructed by Politecnico building
  - **`indoor.bin`** acquired at the main entrance, below the rectorate's ceiling, very limited sky-view