

Education tools for GNSS

Gabriella Povero
Istituto Superiore Mario Boella
Politecnico di Torino
Italy



Workshop on the Applications of GNSS – 11/15 May 2009 – Baku

NavSAS research group



NavSAS is a joint research group of *ISMB* and *Politecnico di Torino* University operating in the satellite navigation and localization sectors.

- NavSAS staff consists of 28 researchers.
- Research is focused specifically on advanced technologies for GPS / EGNOS / Galileo receivers and applications.
- See <http://www.navsas.eu> & <http://www.galileoblog.eu>

Outline

1 – Master on Navigation

2 – NAVKIT

3 – Signal Generator / Analysis

4 – Software receiver

5 – SAT SURF / SAT SURFER

Master on Navigation and Related Applications



The one-year Master is a **joint initiative** of



with the **cooperation** of

INRIM Galileo Ferraris

and

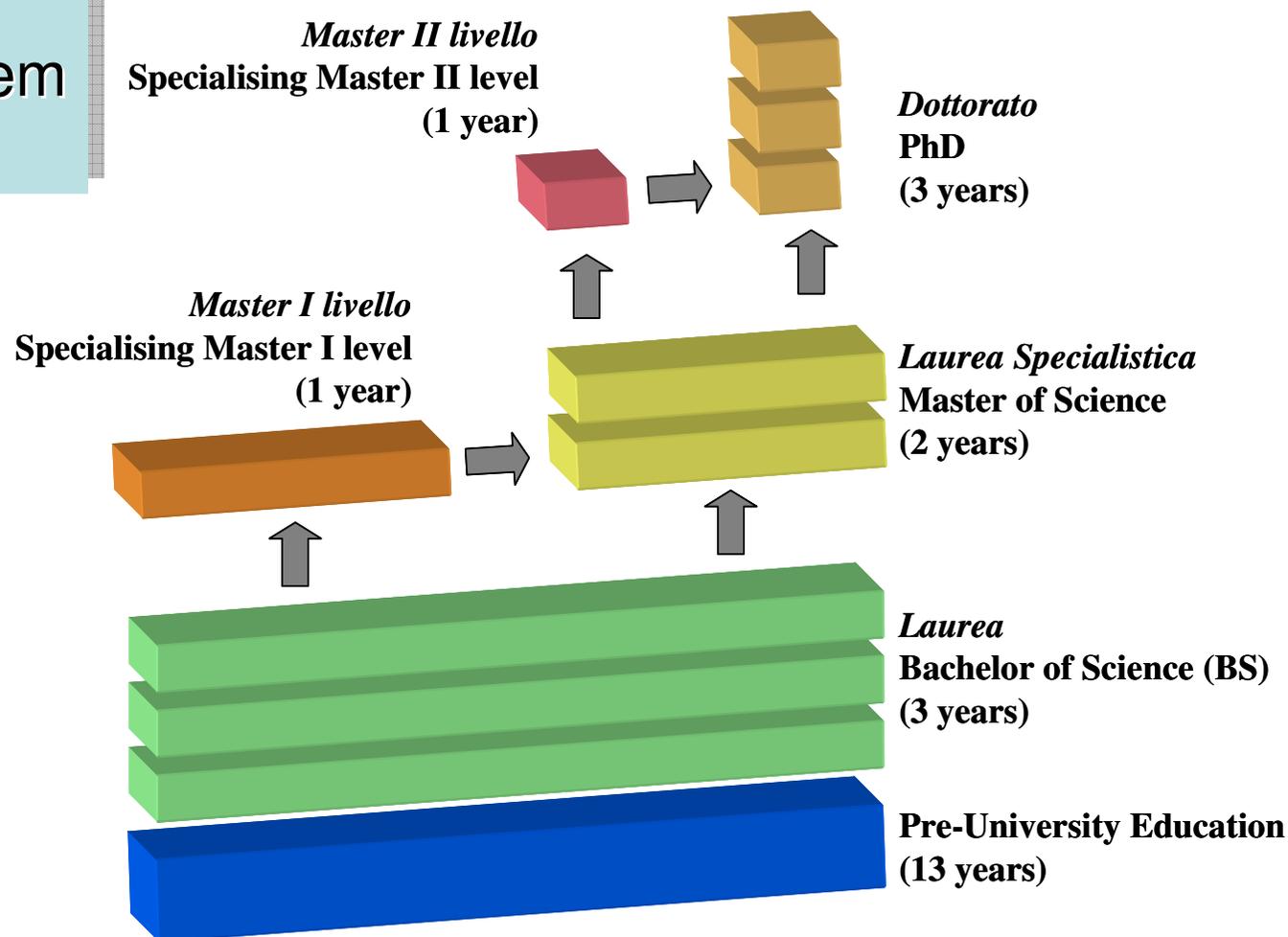
UN OOSA



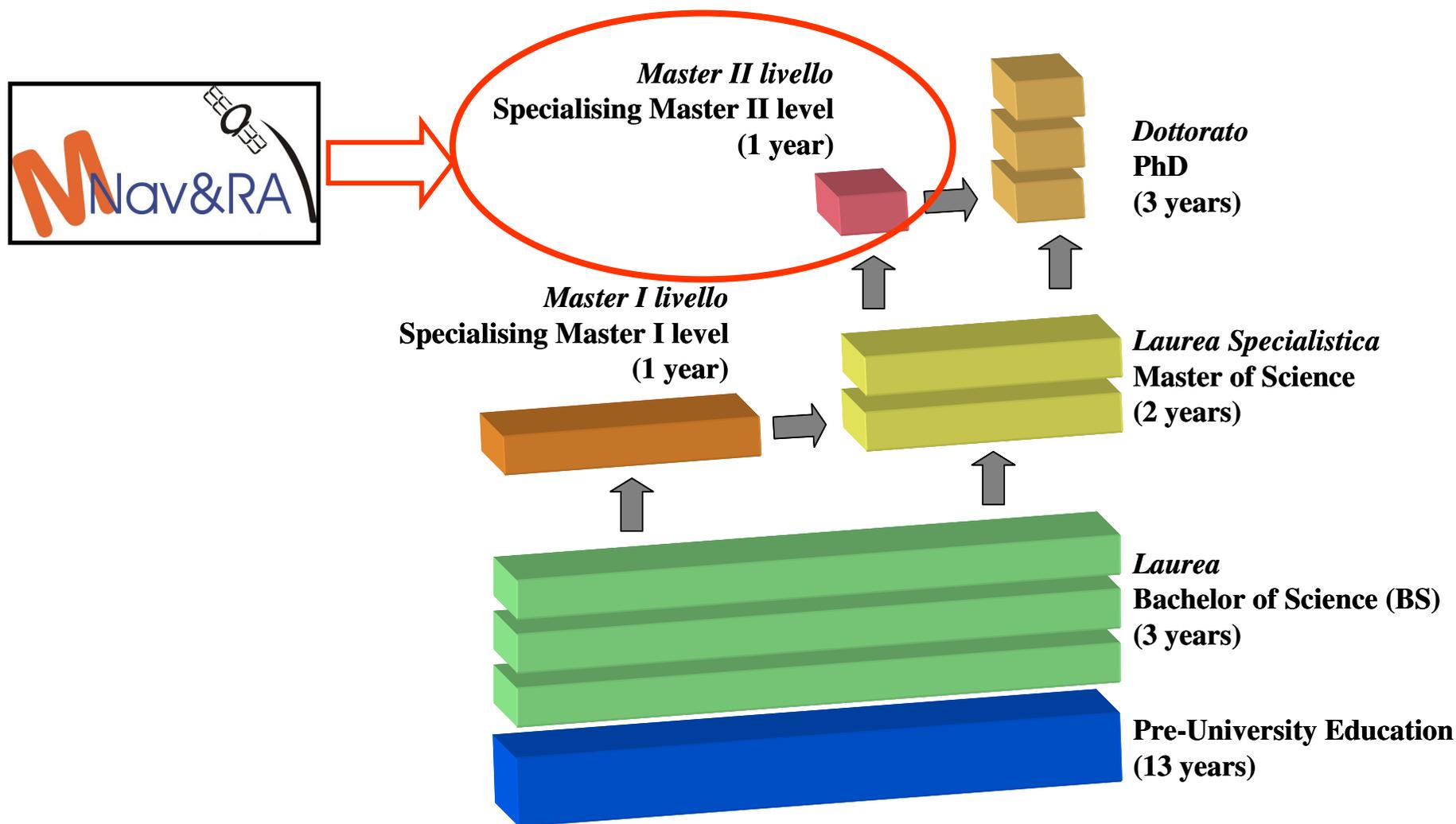
**United Nations
Office for Outer
Space Affairs**

Structure of Education in Italy

The Italian University system after 1999



Specializing Master



Overview of the Master Program

Requirements for Admission

Students with a **5-year** university curriculum

Degree on:

❖ **Information Technology**

➤ Electronic Engineering

➤ Communications Engineering

❖ **Aerospace** Engineering

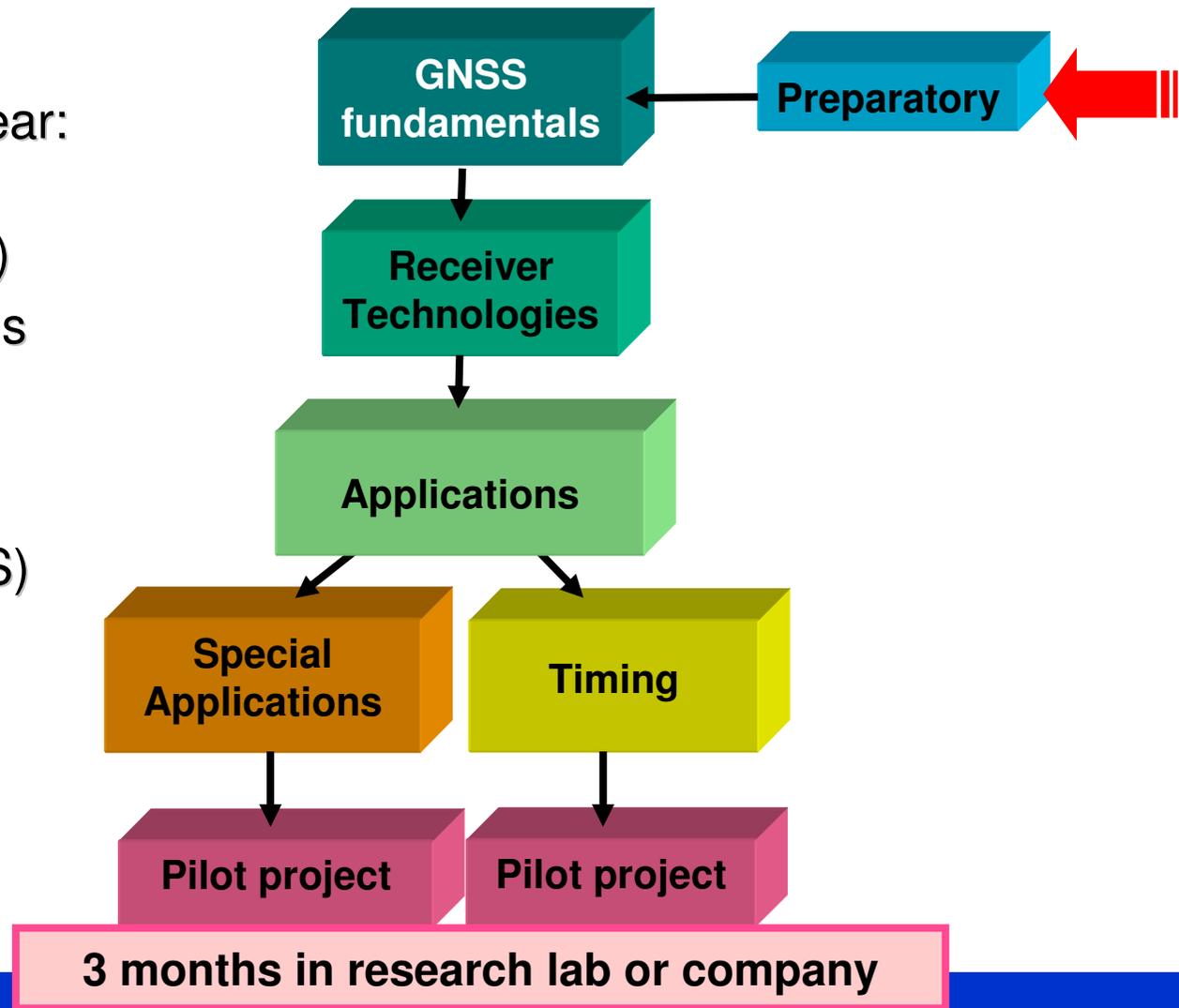
❖ **Environmental** Engineering

Good knowledge of **English language**

Overview of the Master Program

The Masters lasts 1 year:

- 12 classes over 3 quarters (50 ECTS)
- The fourth quarter is devoted to an internship to be carried out in a company (30 ECTS)



Details on UN/Italy Fellowship

*“Istituto Superiore Mario Boella (**ISMB**) and **Politecnico** di Torino of Italy have established a Long Term **Fellowship Programme** which will provide scientists and specialists from **developing countries** with an opportunity to receive a **Master Degree in Navigation and Related Applications.**“*

United Nations Vienna, June 2004

The fellowship is therefore the possibility for **students selected by United Nations** to attend the Master

Details on UN/Italy Fellowship

The agreement among Politecnico di Torino, ISMB and UN-OOSA covers the following aspects:

Master Organization

The Masters programme has been organised with the co-operation of officers of UN-OOSA

Contribution to the Master Curriculum definition

The program of the courses has been prepared by the Masters Scientific Committee and discussed with the UN-OOSA representatives

Master Promotion

The Masters and the Fellowship initiatives are promoted through the UN web site and in all the UN Educational Centres in the world

Details on UN/Italy Fellowship

The agreement among Politecnico di Torino, ISMB and UN-OOSA covers the following aspects:

Student Selection

4-5 students are selected yearly by UN through the UN Regional Educational Centres

Financial Support

The students that are selected by UN receive a scholarship by ISMB to attend the Master

The first five editions

UN/ISMB Project

Country - Students	
Algeria - 1	Madagascar - 1
Egypt - 1	Mexico - 1
Georgia - 1	Mongolia - 1
Ghana - 1	Nigeria - 2
Haiti - 1	Pakistan - 3
Iran - 1	Sri Lanka - 1
Jordan - 1	Vietnam - 2

ALPIP-Meftia Projects

Country	
Argentina - 4	Ecuador - 2
Brazil - 2	Mexico - 1
Colombia - 1	Peru - 1

JEAGAL Project

Country
China - 6
Vietnam - 4

Italian National funds

Country	
Bangladesh - 1	France - 2
China - 1	Italy - 16
Colombia - 2	Lebanon - 1
Ecuador - 2	Pakistan - 3

ASIAN-Zhong Guò Projects

Country
China - 3
Indonesia - 1
Vietnam - 1

Some comments...

- Students **actively participate** to the course activities
- Seminars offered by industries and international bodies were **enthusiastically welcome** by the students
- Students coming from so different countries and cultures succeeded in **interact and integrate** their experience with very **positive results** in intellectual and cultural exchanges
- About all the graduated students are now **working** in the field

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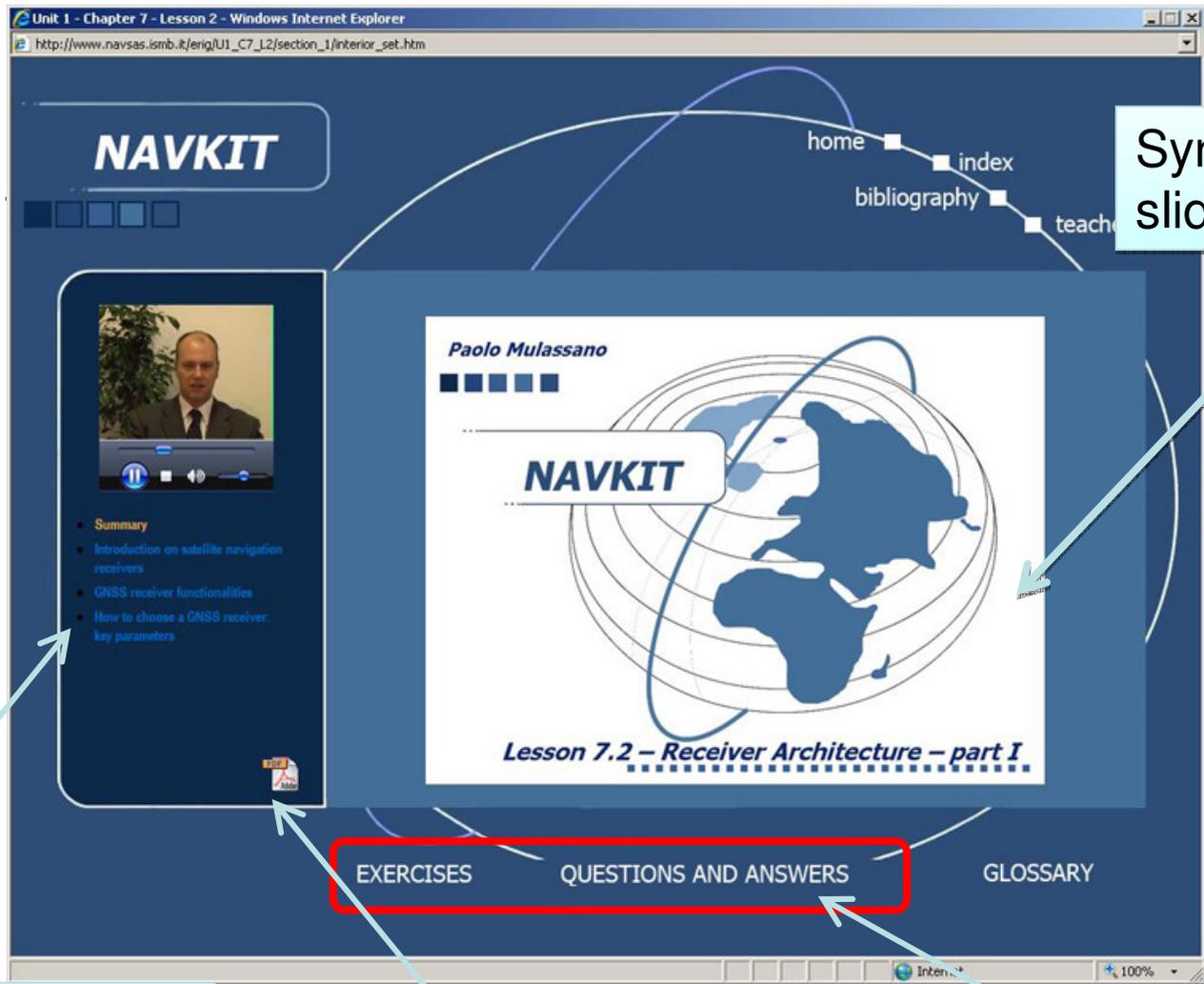
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What is NavKIT

- NAVKIT1.1 is a tool for autonomous training on satellite navigation subjects
- The tool can be accessed via Web (www.navsas.eu) or can be installed as an application on the PC
- NAVKIT1.1 is the output of a task of the **ERIG** project “Education Research and Innovation in GNSS” funded by the GNSS Supervisory Authority within the VI FP





Synchronized slides

Sections can be selected for play and replay

Printable version of slides

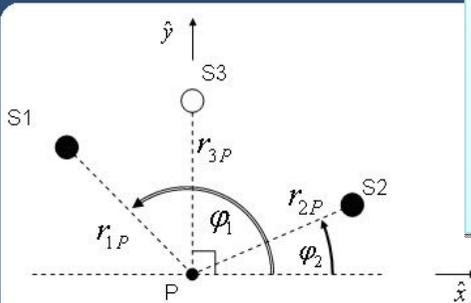
Exercises & Questions



Exercises - Windows Internet Explorer
<http://www.navsas.polito.it/erig/exercises/demo/U1/DoP/DoP.htm>

Dilution of Precision - Exercise 1

A two-dimensional positioning system is implemented by means of three synchronous transmitters S1, S2 e S3, as in Figure.
 Using the two transmitters S1 and S2 and suppose the user has a receiver synchronized with the transmitters:



1. Evaluate the geometric matrix H of the system for a user in P.
2. Evaluate the horizontal dilution of precision HDOP in the following cases:
 $\phi_1 = 3\pi/4, \phi_2 = \pi/4$
 $\phi_1 = \pi, \phi_2 = 0$
3. Justify the results discussing for which case of ϕ_1 e ϕ_2 the minimum value of HDOP is reached.
4. Add the S3 transmitter as in Figure. Supposing the user is not synchronized with the three transmitters, write the H matrix for this case, evaluate the geometric matrix and the HDOP.
5. Verify the results writing a Matlab program for the evaluation of the DOPs.

Internet | Modalità protetta: attivata | 100%

Exercises on positioning problems and processing of satellite signals

2.htm

for a user in P.

in which

k is synchronized with the clocks on the transmitters

$$= \begin{bmatrix} a_{x1} & a_{y1} \\ a_{x2} & a_{y2} \end{bmatrix}$$

$$y_{xj} = \frac{x_j - \hat{x}_u}{\hat{r}_j}$$

and:

$$r_{i,P} = \sqrt{(x_i - x_P)^2 + (y_i - y_P)^2} \text{ for } i = 1,2$$

Internet | Modalità protetta: attivata | 100%

Methodologies for problem solving



Test chapter 3 - Windows Internet Explorer

Test Chapter 3

Summary Results

The white bar (■) shows the time you spent to answer each question.

Number exercise	Time	Result (1pt if correct 0 if incorrect or non-answer)
1	■ 4 sec	1
2	■ 4 sec	1
3	■ 5 sec	1
4	■ 8 sec	1
5	■ 4 sec	1
6	■ 2 sec	1
7	■ 16 sec	0
8	■ 4 sec	1
9	■ 5 sec	1
10	■ 3 sec	1
11	■ 4 sec	1

Repeat the test?

Self-evaluation test for each chapter:

- Number of correct answers
- Time used

For each wrong answer a reference to the proper section of the lessons is provided

Questions and answers - Windows Internet Explorer

Questions and answers



- 1) How does an atomic clock work? (Alain Jorino)
- 2) Which is the GIOVE-A mission? (Manfred Lugert)
- 3) Which will be the services offered by Galileo? (Marco Falcone)
- 4) Which will be the impact of Galileo on the economic development? (Pascal Campagne)



Bibliography - Windows Internet Explorer

Bibliography

Unit 1

- Kaplan, E. D., Hegarty, C. J., *Understanding GPS: principles and applications - 2nd edition*, Artech House, Norwood, MA, 2006
- Parkinson B., Späker J. J., *Global Positioning System - Fundamentals*, American Institute of Aeronautics, Washington
- Misra P., Enge P., *Global Positioning System - Fundamentals*, 2nd edition, Ganga-Jamuna press, Lincoln, M
- Tsui, J. B. Y., *Fundamentals of Global Positioning Systems*, New York, NY, 2005
- Ventura-Traveset, J., Flament, D., *EGNOS - System - A cornerstone of Galileo*, ESA Publications
- <http://www.gps.gov>
- <http://www.glonass-iac.rsa.ru>
- <http://www.gsa.europa.eu>
- http://ec.europa.eu/dgs/energy_transport/galileo/
- <http://www.esa.int/esaNA/index.html>
- <http://www.egnos-pro.esa.int/education/index.html>

Section of questions and answers on general topics related to GNSS
Contributions by experts

Bibliography & Glossary

Glossary - Windows Internet Explorer

GLOSSARY

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

▲ A

Accuracy
 Difference between the measured position at any given time and the actual or true position

ACF
 Auto-Correlation Function

Acquisition
 Operation performed by a GNSS receiver - Initial rough estimate of the delay between the incoming code and the local replica

ADC
 Analog-to-Digital Converter

AGC
 Automatic Gain Control

AltBOC modulation
 Multiplexing technique used for the Galileo signals in E5 frequency band

AOA
 Angle Of Arrival



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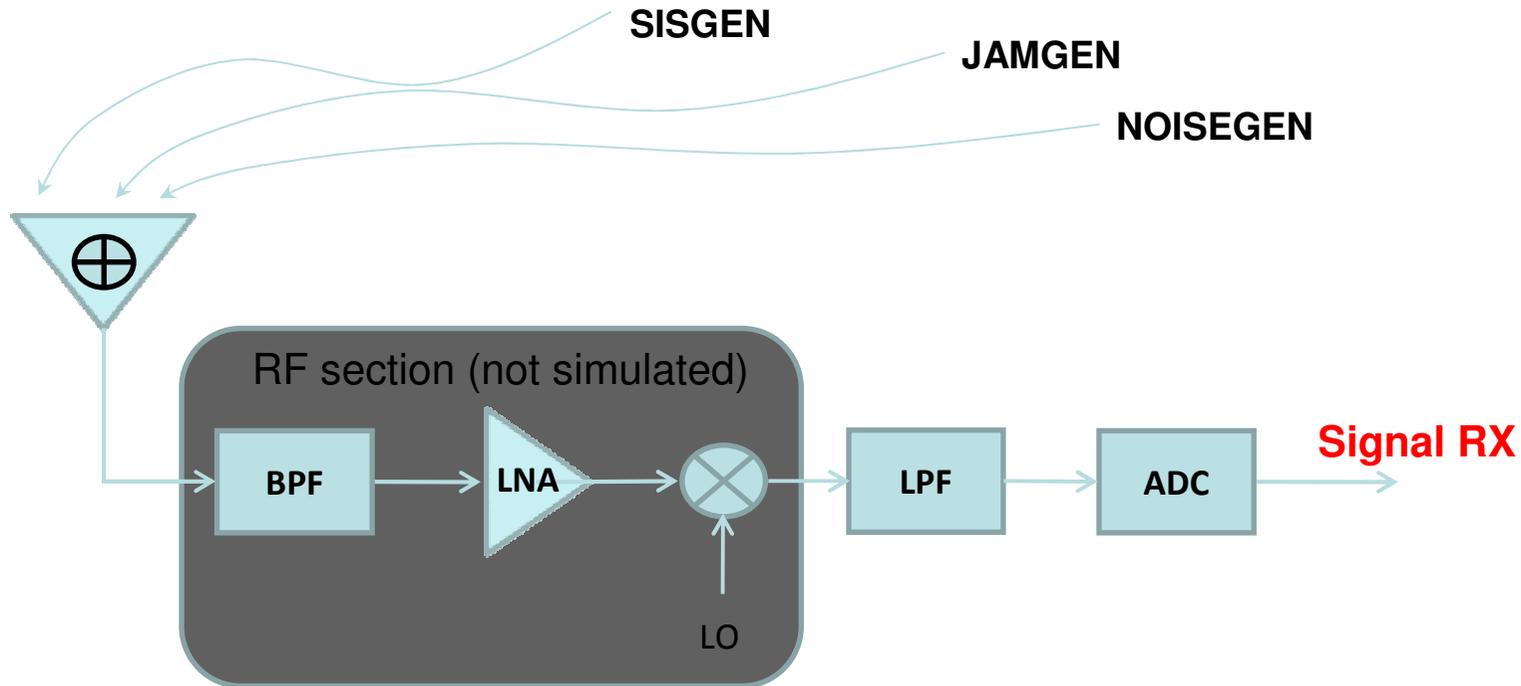
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SW package: Signal Generator



The signal generator is a software package which simulates the **received signal** at the output of the front-end analog to digital converter

SW package: Signal Generator

SIS Modulations

- GPS

- L1
- L2
- L5
- L1C
- L2C

- Galileo

- E1-BOC
- E1-MBOC
- E5
- E6

- EGNOS

Analysis Tools

Interference

- **Intra/Inter-system interference (IS):** one or more signals among GPS, Galileo, and EGNOS;
- **Multipath (MP):** one or more attenuated and delayed versions of the SIS;
- **Narrowband interference (CW):** continuous wave (CW) signal;
- **Wideband interference (WB):** wideband signal modeled as filtered white noise.

Signal generator (student edition)

The student edition of the Signal generator is available **free of charge!**

Please contact Davide Margaria
(davide.margaria@polito.it)

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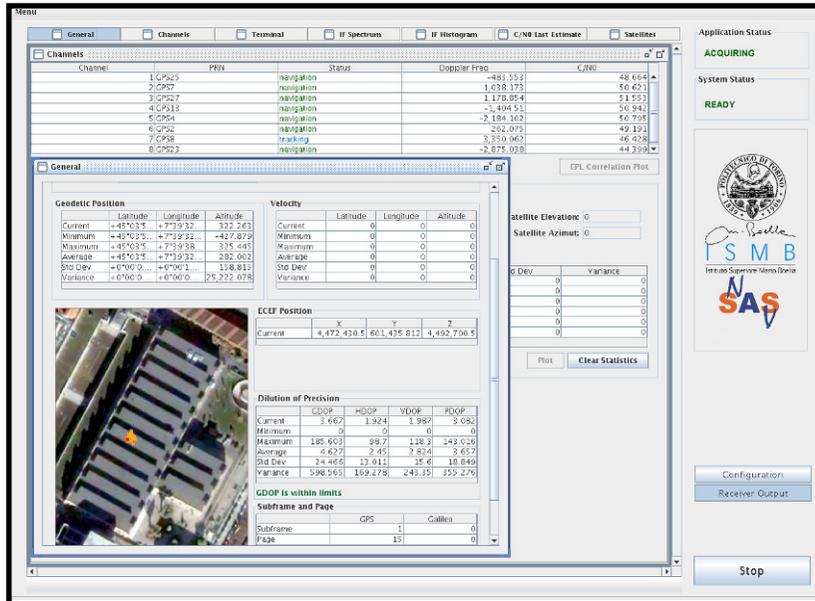
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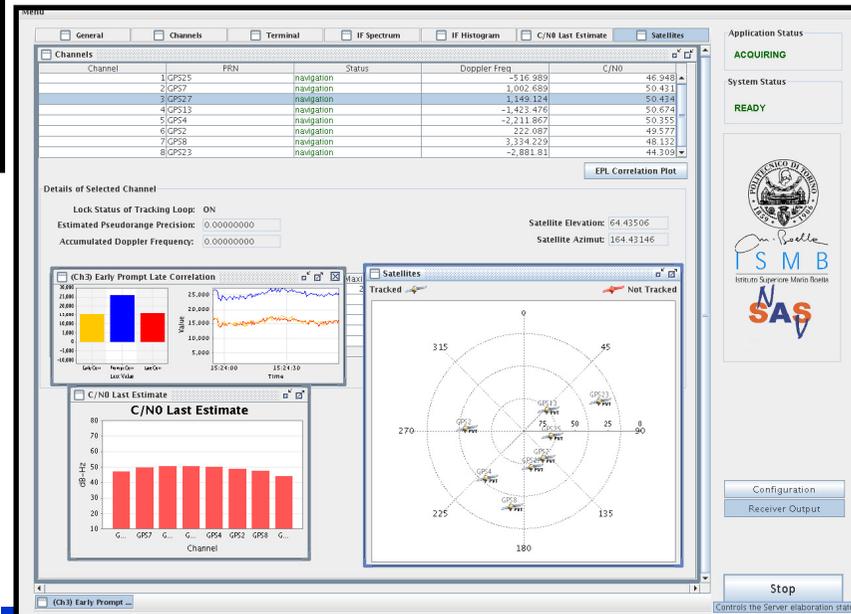
5 – SAT SURF / SAT SURFER

N-GENE Software Receiver



- Position Accuracy: r.m.s < 10 m using code-based measurements and without applying carrier smoothing techniques
- Time to First Fix in Cold Start mode lower than 45 seconds
- Up to 20 channels

- GPS L1 8 bits quantization at a sampling rate of 17.5103 MHz
- Galileo E1, GIOVE-A & GIOVE-B signals, upgradable to Multiplexed Binary Offset Code (MBOC) easily
- EGNOS, WAAS & A-GPS



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SAT-SURF & SAT-SURFER

A Tool for Hands-On Training on
Satellite Navigation



SAT-SURF & SURFER Features



1 – It allows to log all the raw GPS and GSM data (both binary and NMEA Protocols)

2 – It embeds different GPS modules depending on the user needs:

- uBlox Modules
- SiRF Modules

3 – Equipped with a quad-band GSM/GPRS modem (worldwide coverage) for NAV/COM integration

4 – Raw data storage in the various file formats for an easy post-processing:

- ASCII, Excel® & MATLAB® files
- RINEX 2/3 Log

The screenshot displays the SAT-SURFER software interface. It features a menu bar (File, Commands, Configuration, View, Help) and a toolbar with buttons for Disconnect, Restart, Receiver Requests, Start Ntrip, Stop Ntrip, and Log Directory. The main window is divided into several sections:

- Navigation Data:** Shows position (X: 4472416.63, Y: 601433.6, Z: 443280.93), velocity (0 m/s), error (443269175362081 m), latitude (45°354.972), longitude (7°39'32.297), and speed (0). It also displays DOP data (GDOP: 1.97, HDOP: 1.08, VDOP: 1.35) and GNSS time data (WN: 1504, TOW: 488085.001, Leap Seconds: 14).
- Satellites Data:** Shows 12 satellites in view and 11 satellites in fix. A list of satellites in view includes PRN, Pseudorange, Doppler, Carrier Phase, CNO, TOW, and wN.
- Receiver Raw Data:** A table with columns for S/wid (PRN), Pseudorange [m], Doppler [Hz], Carrier Phase [Cycles], CNO [dBHz], TOW [s], and wN. The data shows various satellite signals being received.
- Messages:** A section for receiving messages, currently empty.
- Application Messages:** A section for application messages, currently empty.

The interface also includes a logo for 'Sat-Surf' and a globe icon. The status bar at the bottom indicates 'uBlox Connected Ntrip Disconnected'.

Contacts

Gabriella Povero
gabriella.povero@ismb.it

www.navsas.eu

**Visit our non-official blog on
Galileo!**

www.galileoblog.eu



Thank you!

