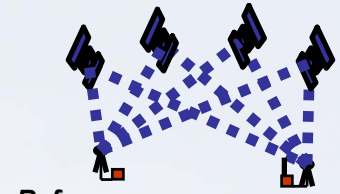


3ème Ecole d'Eté du GRGS

Méthodes et Logiciels pour la Géodésie Spatiale

Forcalquier
du 04/09/06
au 08/09/06

Contacts | Accueil

GPS et GALILEO : statut et evolutions

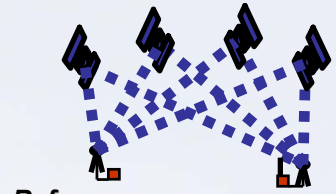
Stavros Melachroinos

Doctorant

GRGS

Groupe de Recherches de Géodésie Spatiale

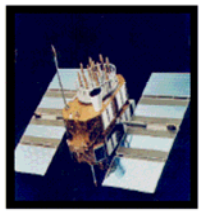
GPS : status



GPS Constellation Status (1)

29 Operating Satellites
(to ensure 24)

- 16 II/IIA satellites operational
- 12 IIR satellites operational
  - Modernizing up to 8 Block IIR satellites
- 1st IIR-M, launched 25 September 2005
  - Set healthy on 16 December 2005
- 2nd IIR-M launch currently scheduled
  - Tentative: 14 September 2006
- 3rd IIR-M launch currently scheduled
  - Tentative: 14 December 2006



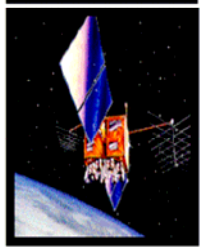
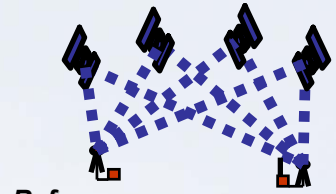


Illustration reprinted courtesy of the GPS Joint Program Office

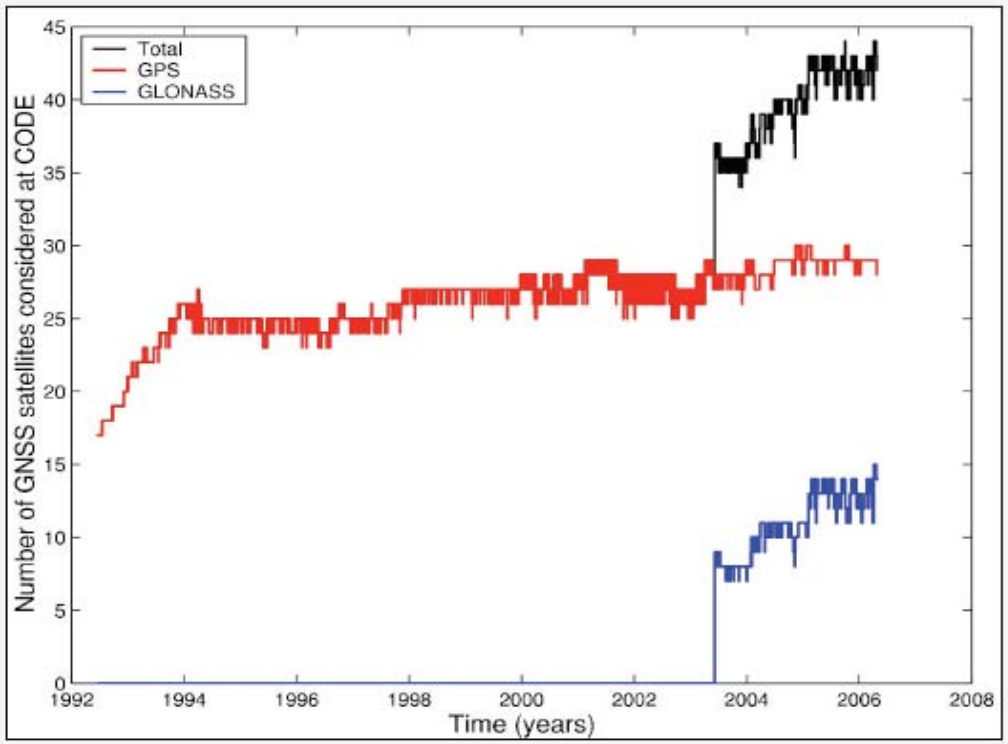
IGS workshop 2006

Demi-grand axe	~26 600 km
Période orbitale	11h58mn ~0.5 jour sidéral
Inclinaison	55 degrés (65 pour les block I)
Oscillateur	Ru (block I), Cs (block II)
Attitude	Pointé Terre et soleil block II-R plus de «Yaw rate »

GPS : status



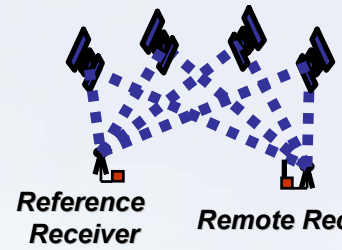
Evolution of GPS/GLONASS Satellite Constellation (2)



IGS WS Darmstadt, DE swisstopo/AIUB | 8-11 May 06 | Slide 6

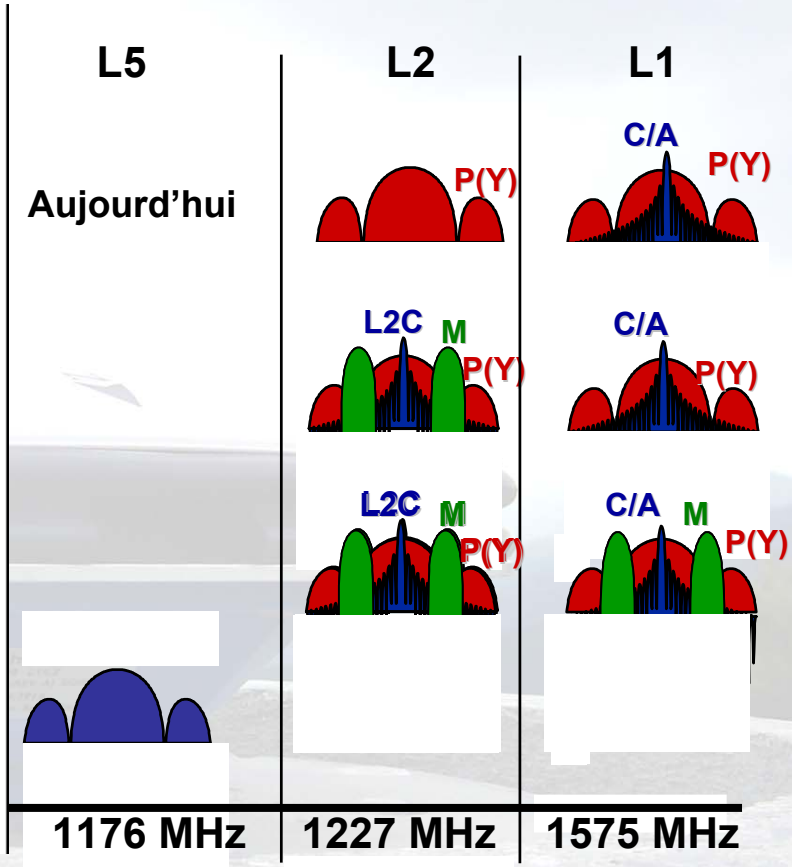
swisstopo

GPS : future



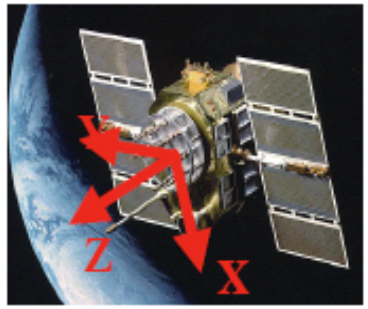
GPS Modernization Program Status

Activity	Implementation Date
SA set to zero	May 2000
GPS IIR-M Enhancements - New L2 civil (L2C) signal - M-code on L1 & L2	1st satellite operational on December 16, 2005 2nd Launch 14 Sept. 2006
GPS IIF Enhancements - L2 civil (L2C) signal - M-code on L1 & L2 - New L5 civil signal	1st launch currently scheduled for May 2008
GPS III Enhancements - L2 civil (L2C) signal - M-code with greater power - L5 - New L1C civil signal	1st launch ~ 2013

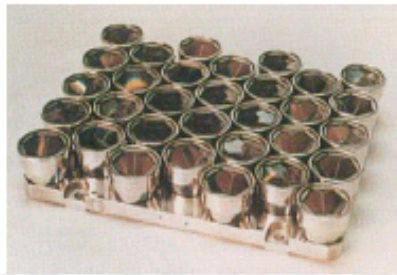


GPS : future

- GPS will lose SLR capability in the near future!
  - SVs 35 and 36 nearing end of life
    - ✓SV 35 - launched August 1993 (12+ years)
    - ✓SV 36 - launched March 1996 (10+ years)



- No plans for Block IIR, IIR-M, or IIF vehicles to carry retro-reflectors
- No existing requirement for GPS III to support laser ranging
  - Consideration pending



IGS workshop 2006

GALILEO

Walker 27/3/1
plus 3 in-orbit spares*

Altitude ~23222 km
Demi-grand axe ~29601 km

30 SV's

inclination 56 deg

Period orbitale ~14h

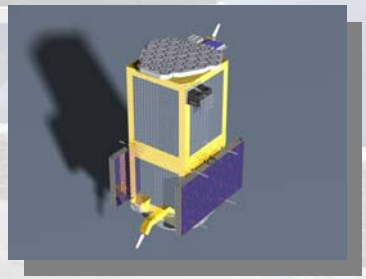
source : ESA

*) passive spares

GSTBV2/GIOVE – A

First GALILEO Test Satellite

Launch 28.12.2005



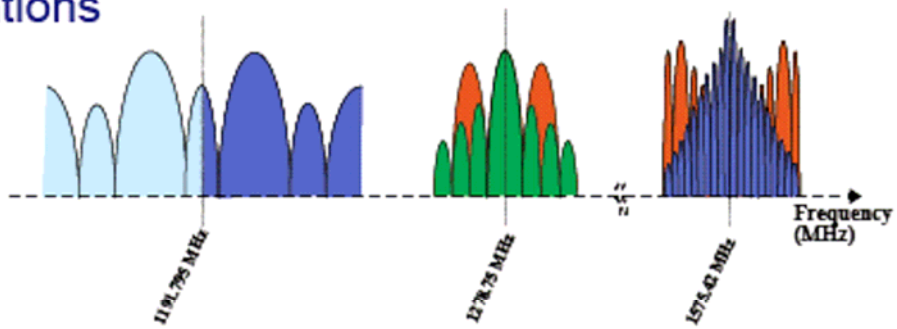
GSTBV2/GIOVE – B

Launch dans 2006 ?

GSTBV2/GIOVE-A

GIOVE-A SIGNAL

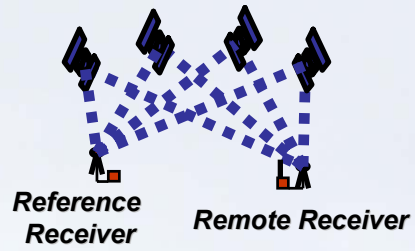
- GIOVE-A SIS is fully representative of GALILEO SIS:
  - RF and Modulations
  - Chip Rates
  - Data Rate



- GIOVE-A can only transmit two signals at a time (L1+E5 or L1+E6)
- GIOVE-A codes are different from GALILEO codes
- GIOVE-A Navigation Message not representative from structure and contents viewpoint (demonstration only purpose)

source : ESA

Galileo project status



- **Critical technology developments completed*:***
  (i.e clocks Rubidium, H-Maser (1ns in 100min), Satellite Navigation Antenna, GSS Antennas, GSS Receiver PreDev, …)

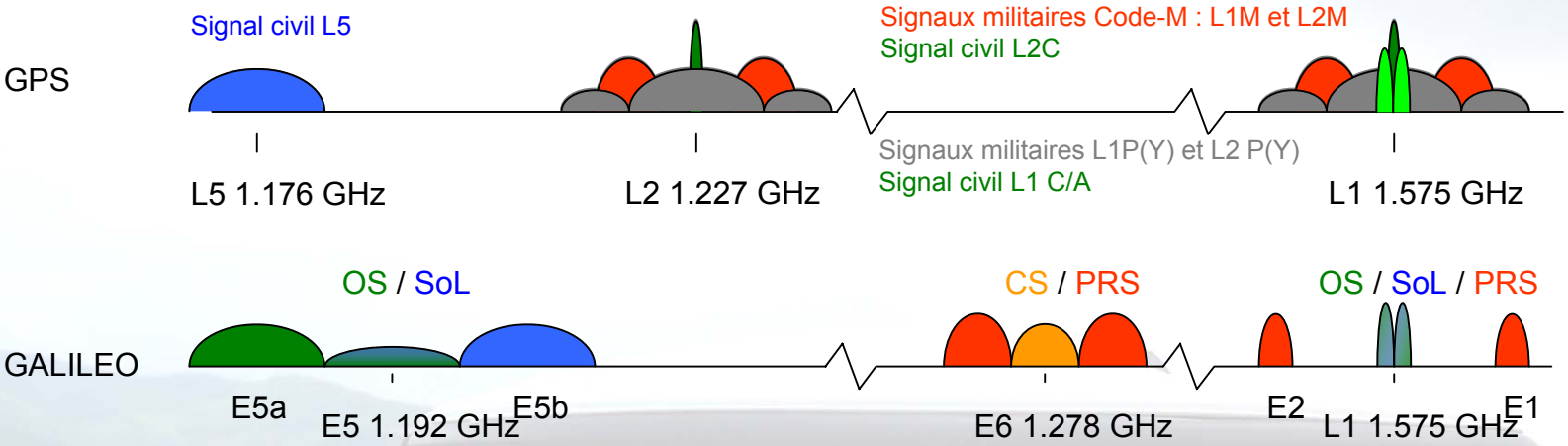
- **Galileo System Test-Bed (GSTB-V1) developed to experiment with Galileo-like processing algorithms based on GPS Observables. Six months of results*.***

- **The GSTB-V2 development was Kicked-off in July 03**
  - Two experimental satellites under development.
  - First experimental satellite was launched at the end of 2005.
  - The GSTB-V2 is planned to be operated for a period of two years after launch (2006 & 2007)

- **In-Orbit Validation Phase on-going.**

source : ESA

Galileo signals

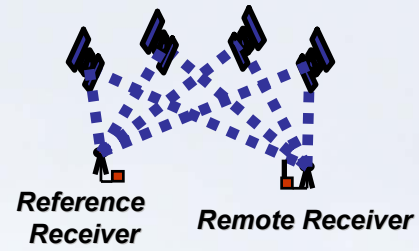


source : CNES

- Four carriers, two common with GPS (E5a and L1)
- Higher signal power (power spectral density located at the lower and upper boundary of the frequency spectrum and not at the center)
- Presence of a pilot (no-data) signal for better carrier phase tracking (no ½ cycle slips possible, gain in tracking robustness).
- Better modulation, with largely reduced tracking noise and multipath errors.
- Better navigation bits encoding (3 levels of error checking)

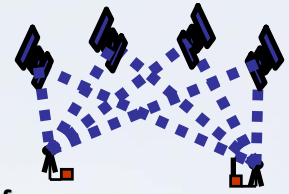
source : ESA

Galileo observables

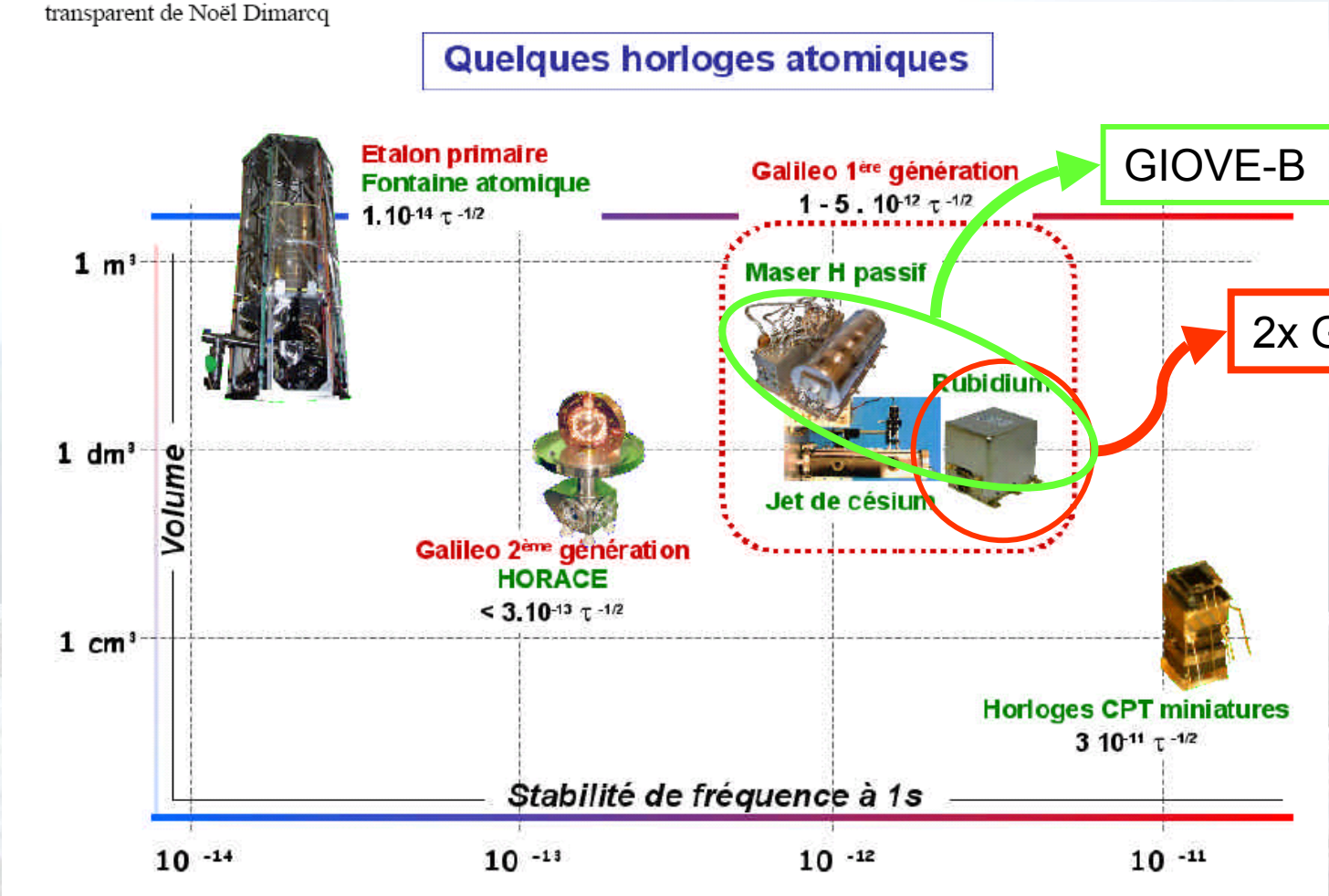


Frequency band	Signal Components code + phase	Comments (Interoperability
E5a	I+Q (data +pilot)	= GPS L5 OS
E5b	I+Q (data +pilot) GIOVE-A	OS, Sol,CS
E5a+b	Alt-BOC E5a + E5b	Very low multipath and tracking noise
E6-A	Data	PRS
E6-BC	B+C (data + pilot) GIOVE-A	CS
E2 (L1-A)	Data, C1A, L1A	PRS
L1-E1 (L1-BC)	B+C (data +pilot) GIOVE-A	= GPS L1 OS,Sol,CS

Galileo : time

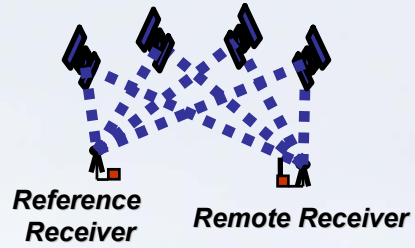


transparent de Noël Dimarcq



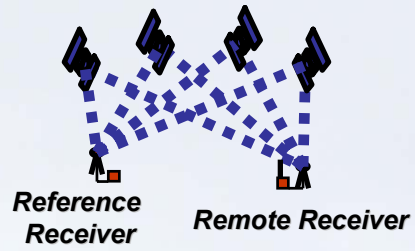
Source : colloque GALILEO, MESR : Inside GNSS

Galileo and GPS : time



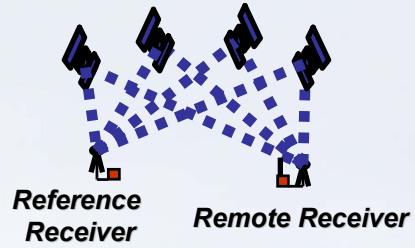
- Galileo and GPS work on the basis of accurate measurement of difference in time – need a reference scale (system time) upon which to base these measurements.
- Each system has its own system time.
- To combine measurements from Galileo and GPS need to know offset between these system times 'Galileo GPS Time Offset' (GGTO).
- Galileo and GPS will calculate and broadcast this GGTO value as part of its navigation message.
- GGTO accurate to 5ns (2 sigma) – 1.5m

Galileo and GPS : GGSP



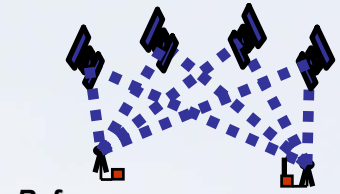
- Galileo and GPS need a Global Coordinate System upon which to reference its satellites.
- International Terrestrial Reference System (ITRS) is basis for both Galileo and GPS.
- Realisation of Reference System creates Reference Frame.
- Galileo and GPS will have independent realisations and this will introduce small differences between the two.
- Galileo will minimise the effect of this by:
  - - Maintaining its Terrestrial Reference Frame accuracy to 3cm (2 sigma) of the latest International Standard (ITRF).
  - - Broadcast transformation parameters to other Reference Frames if need be (WGS-84, PZ-90…).

Galileo and GPS : benefits



- **In Triple frequency geometry-free, iono-free combinations (both phase and code) we will have an independent set of multipath and tracking errors.**
- **Multi-system Multi-frequency ambiguity resolution**
  - combining frequencies from the 2 systems
  - all other ambiguities are dependent from the initial 2 in the combination ex. Galileo receiver : only one phase out of three is lost and recovered, the new ambiguity can be immediately recomputed.
  - Triple frequency constraints will help limit the complexity of the search process
- **Phase mutlipath (bud for high frequency positionning, cf. TP-BRETAGNE)**
  - Simple linear combination of three phase differences shall contain no ionosphere delays
  - The same principal goes for ranges and Doppler measurements
  - Provides single-station absolute information which is not available in today's two-frequency GNSS except for variations between stations and multipath values only for one code. In the case of Galileo the big number of frequencies L1,E5a,E5b,E5AltBOC,E6 provides large number of combinations.
  - Information on phase multipath shall become available through single-satellite single-station measurements.
- **Code multipath (bud for high frequency positionning, cf . TP-BRETAGNE)**
  - In today's GNSS, absolute values of mutlipaths are unknown, only variations are available, and they can only be estimated over periods of continuous tracking. With triple-frequency code combination we can have multipath values for non continuous tracking due to the constant combinations of receiver-side and satellite-side biases.
  - Relationship between code biases at different frequencies. It means that if timing group delays are known for two frequencies, they can be simply computed for all other frequencies.

And what about GLONASS ?

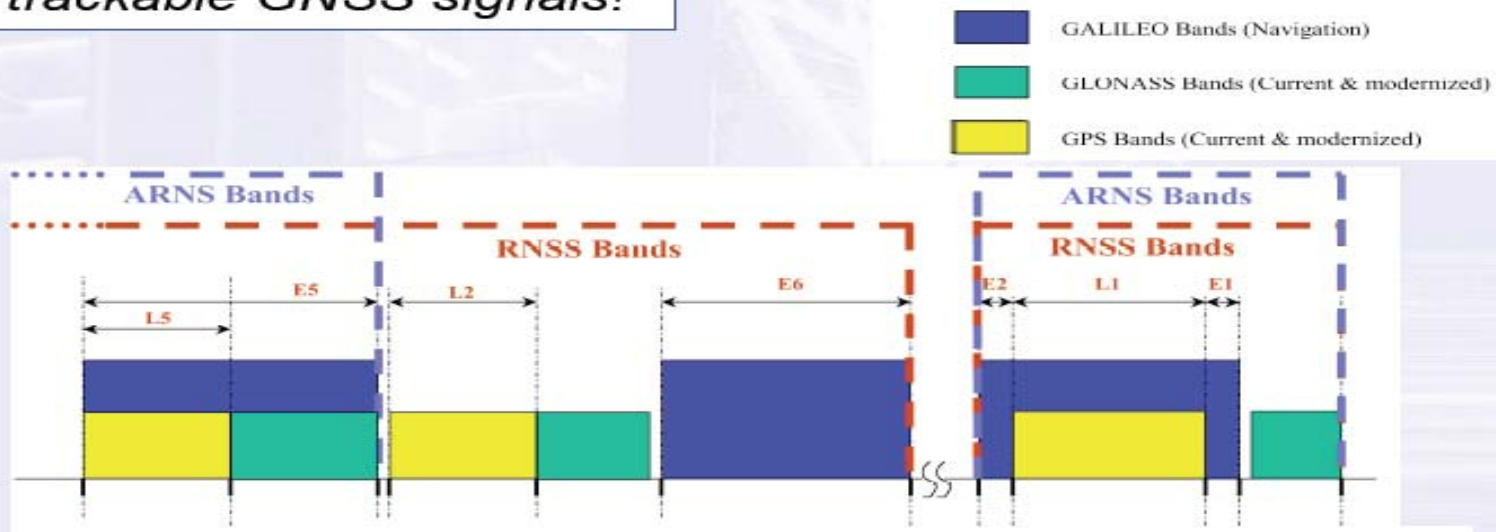


IGS Workshop, 8 - 11 May 2006, Darmstadt, Germany

Frequencies…GPS, GALILEO & GLONASS

4 frequency 'bands'

Many trackable GNSS signals!



SSIS School of Surveying and Spatial Information Systems

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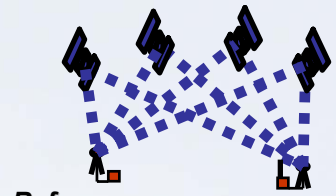
Galileo and GPS : RINEX




```
|                        OBSERVATION DATA FILE - EXAMPLE                        |
3.00           OBSERVATION DATA    M (MIXED)           RINEX VERSION / TYPE

MIXED FILE GPS/SBAS/GALILEO/GLONASS                     COMMENT
G    8 C1P L1P C2C C2P L2P C5Q L5Q S1P                  SYS / # / OBS TYPES
S    2 C1C L1C                                          SYS / # / OBS TYPES
E    4 C1C L1C C5Q L5Q                                  SYS / # / OBS TYPES
R    4 C1P L1P C2P L2P                                  SYS / # / OBS TYPES
P-code based L2 phases of six GPS satellites in half wavel. COMMENT
G  L2P   6 G14 G15 G16 G17 G18 G19                      SYS / HALF CYCLES
P-code based L1 phases of all GPS satellites in half wavel. COMMENT
G  L1P                                                  SYS / HALF CYCLES
E   10   2 L1C L5Q                                      SYS / SCALE FACTOR
05  3 24 13 10 36.0000000  0  3G12S20E11R21                    -.123456789
  21456789.123            .123 7  21456789.231    21456789.321          -.123 7
  21456789.312            .321 7       123.213
  40123456.789           -.987 8
4  3
```