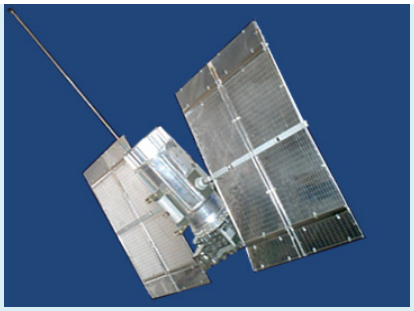
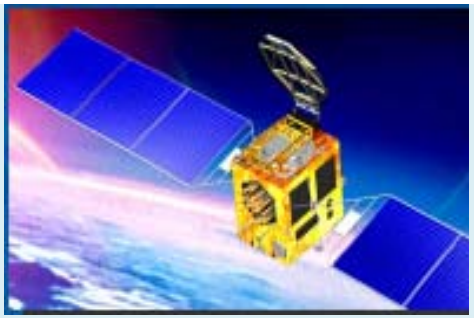




Aktuelle Multi-GNSS Implementierungsszenarien

Sicht der Systembetreiber und des IGS

R. Weber

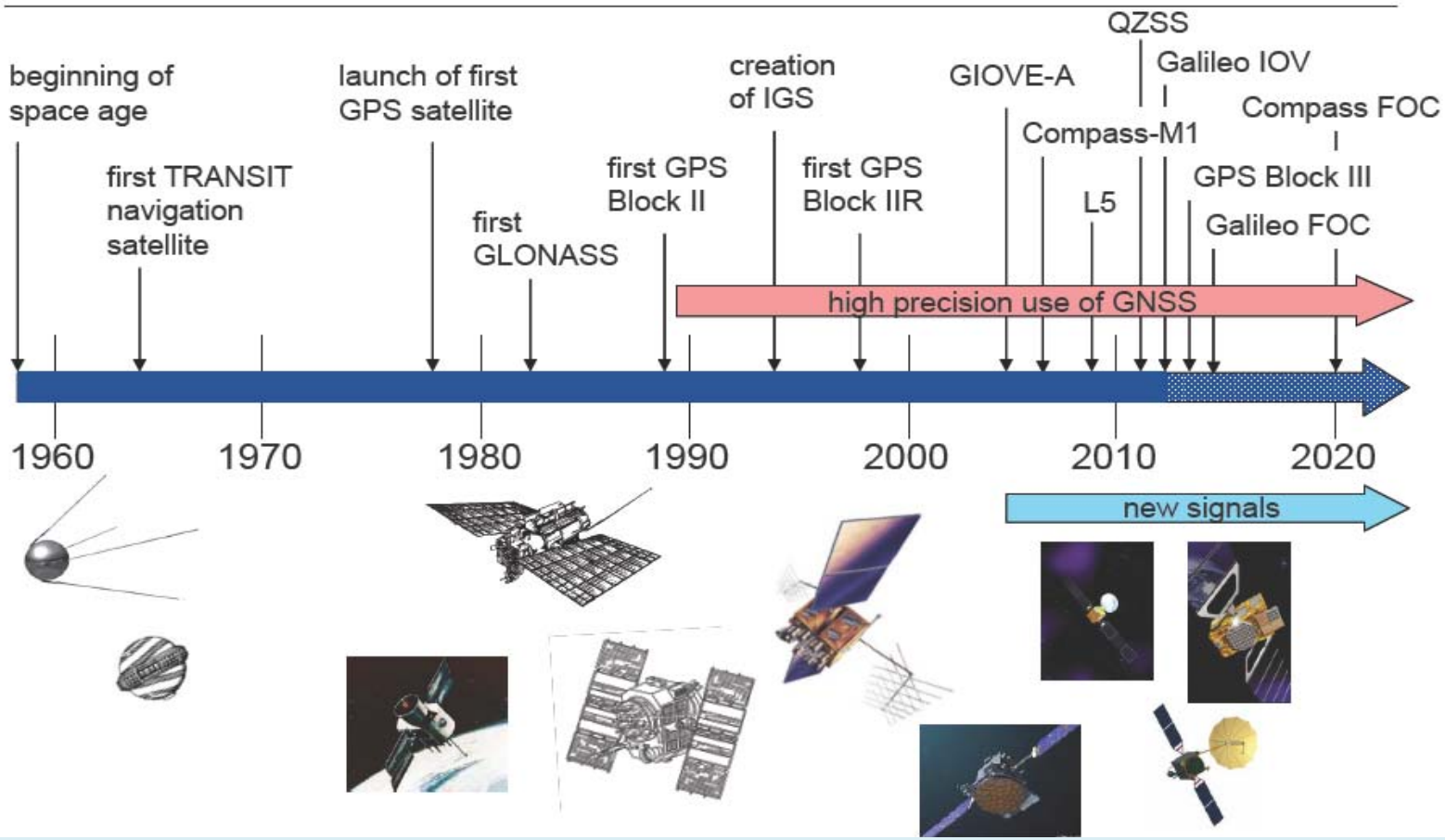
Institut für Geodäsie und Geophysik, TU-Wien

9. Mai 2012, Velden (ÖGT)

Überblick

- Status und Modernisierung GPS, GLONASS
- Galileo
- COMPASS/Beidou II
- Probleme Signalangebot, Biases
- IGS Multi GNSS Global Experiment (MGEX)

Short History of Satellite Navigation



GPS Modernization Program

Increasing System Capabilities • Increasing User Benefit

Block IIA/IIR

Basic GPS

- Standard Service
  - Single frequency (L1)
  - Coarse acquisition (C/A) code navigation
- Precise Service
  - Y-Code (L1Y & L2Y)
  - Y-Code navigation

Block IIR-M, IIF

IIR-M – Basic GPS capability plus

- 2nd civil signal (L2C)
- M-Code (L1M & L2M)

IIF – IIR-M capability plus

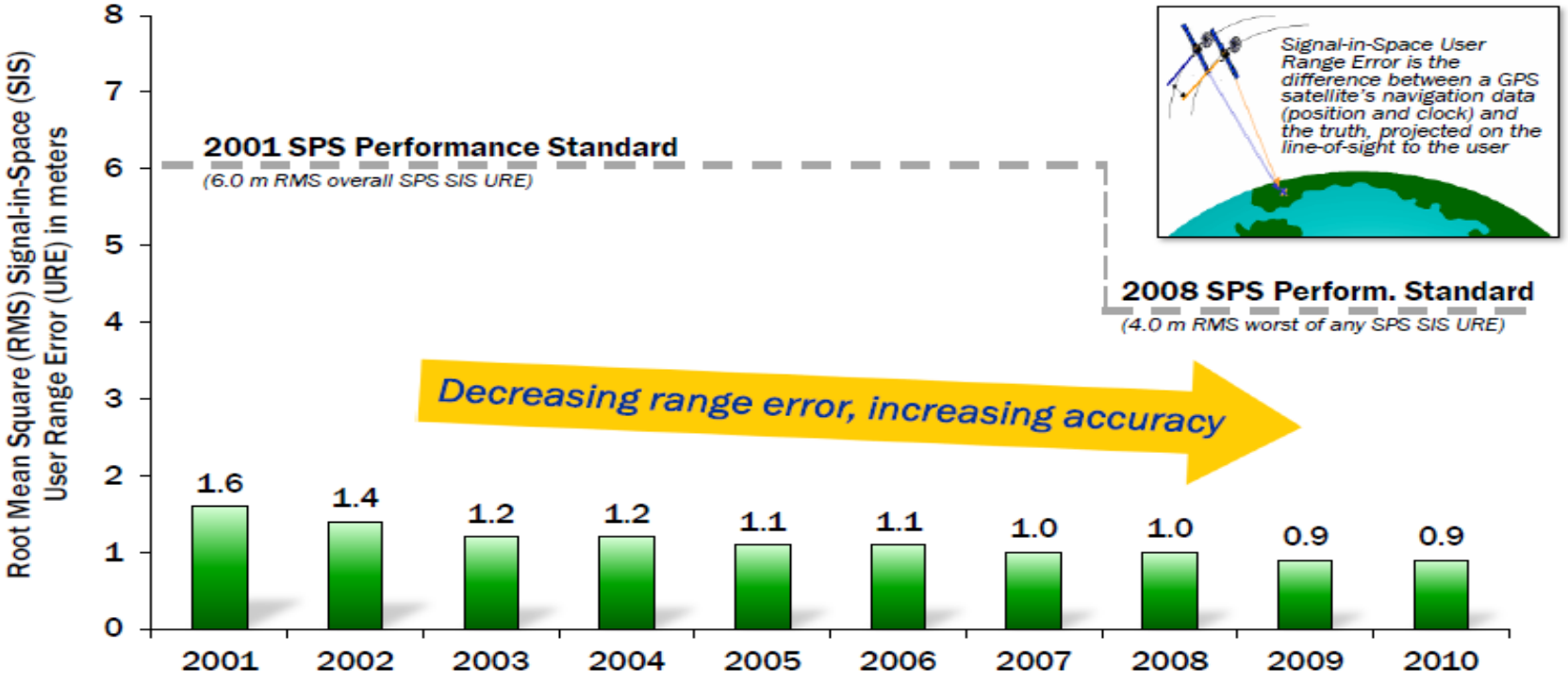
- 3rd civil signal (L5)
- 2 Rb + 1 Cs Clocks
- 12 year design life

Block III

- Backward compatibility
- 4th civil signal (L1C)
- 4x better User Range Error than IIF
- Increased availability
- Increased integrity
- 15 year design life

P1(Y), P2(Y) ab 2020 nicht mehr unterstützt

Standard Positioning Service (SPS) Signal-in-Space Performance



System accuracy exceeds published standard

GLONASS Constellation Status / 10.März 2012

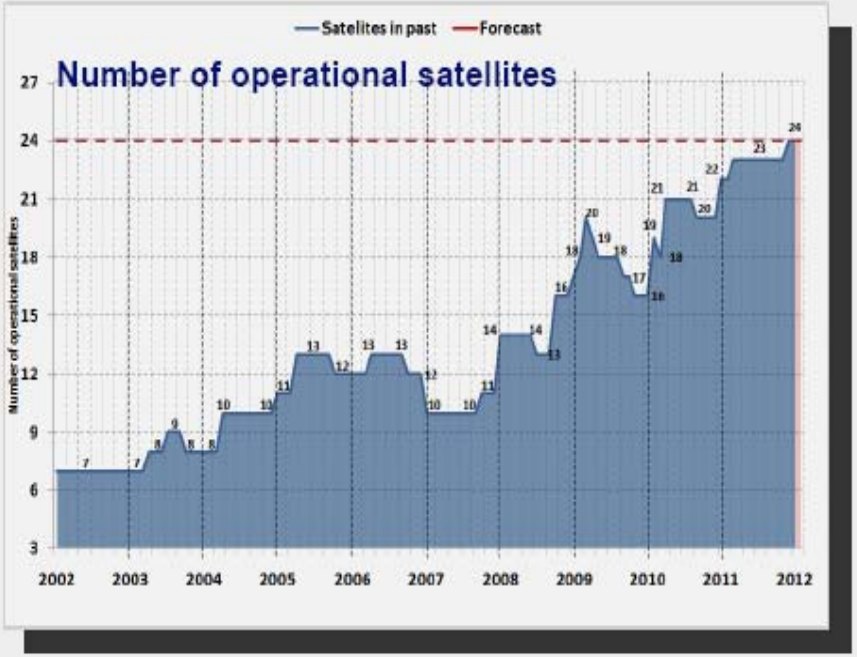
GLONASS constellation status, 10.03.2012

Total satellites in constellation	31 SC
Operational	24 SC
In commissioning phase	1 SC
In maintenance	2 SC
Spares	3 SC
In flight tests phase	1 SC

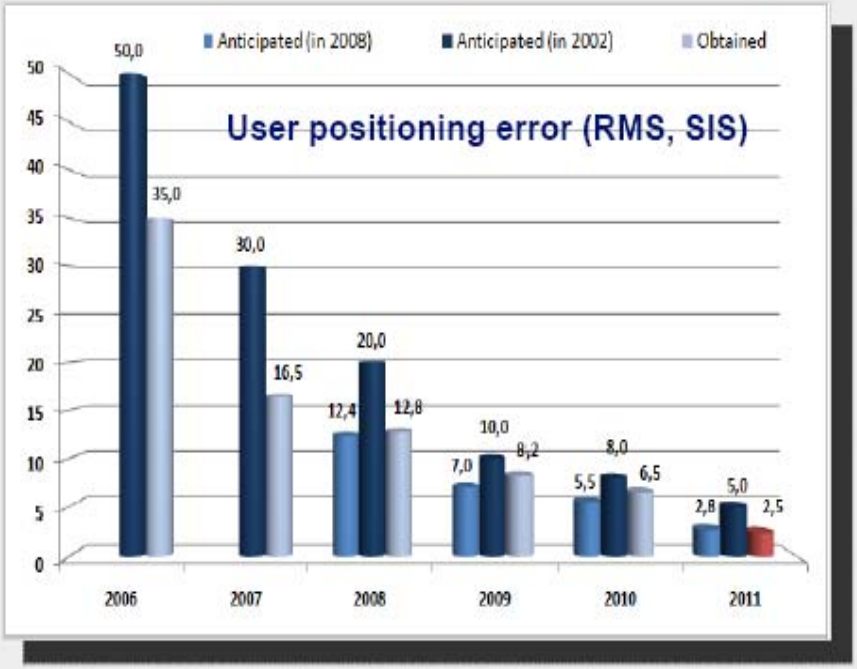
GLONASS Constellation Status at 10.03.2012 based on both the almanac analysis and navigation messages received at 12:00 10.03.12 (UTC) in IAC PNT TsNIImash

Orb. slot	Orb. pl.	RF chnl	# GC	Launched	Operation begins	Operation ends	Life-time (months)	Satellite health status		Comments
								In almanac	In ephemeris (UTC)	
1	1	01	730	14.12.09	30.01.10		26.9	+	+ 12:00 10.03.12	In operation
2	1	-4	728	25.12.08	20.01.09		38.5	+	+ 12:00 10.03.12	In operation
3	1	05	744	04.11.11	08.12.11		4.2	+	+ 12:01 10.03.12	In operation
4	1	06	742	02.10.11	25.10.11		5.3	+	+ 12:01 10.03.12	In operation
5	1	01	734	14.12.09	10.01.10		26.9	+	+ 10:59 10.03.12	In operation
6	1	-4	733	14.12.09	24.01.10		26.9	+	+ 10:59 10.03.12	In operation
7	1	05	745	04.11.11	18.12.11		4.2	+	+ 10:59 10.03.12	In operation
8	1	06	729	25.12.08	12.02.09		38.5	+	+ 10:59 10.03.12	In operation
9	2	-2	736	02.09.10	04.10.10		18.2	+	+ 10:59 10.03.12	In operation
10	2	-7	717	25.12.06	03.04.07		62.5	+	+ 10:59 10.03.12	In operation
11	2	00	723	25.12.07	22.01.08		50.5	+	+ 12:00 10.03.12	In operation
12	2	-1	737	02.09.10	12.10.10		18.2	+	+ 12:00 10.03.12	In operation
13	2	-2	721	25.12.07	08.02.08		50.5	+	+ 12:00 10.03.12	In operation
14	2	-7	715	25.12.06	03.04.07		62.5	+	+ 10:59 10.03.12	In operation
15	2	00	716	25.12.06	12.10.07		62.5	+	+ 10:59 10.03.12	In operation
16	2	-1	738	02.09.10	11.10.10		18.2	+	+ 10:59 10.03.12	In operation
17	3	04	746	28.11.11	23.12.11		3.4	+	+ 11:00 10.03.12	In operation
18	3	-3	724	25.09.08	26.10.08		41.5	+	+ 12:00 10.03.12	In operation
19	3	03	720	26.10.07	25.11.07		52.5	+	+ 12:01 10.03.12	In operation
20	3	02	719	26.10.07	27.11.07		52.5	+	+ 12:00 10.03.12	In operation
21	3	04	725	25.09.08	05.11.08		41.5	+	+ 10:59 10.03.12	In operation
22	3	-3	731	02.03.10	28.03.10		24.3	+	+ 10:59 10.03.12	In operation
23	3	03	732	02.03.10	28.03.10		24.3	+	+ 10:59 10.03.12	In operation
24	3	02	735	02.03.10	28.03.10		24.3	+	+ 10:59 10.03.12	In operation
2	1	-4	743	04.11.11			4.2			Commissioning Phase
21	3		701	26.02.11			12.4			Flight Tests
14	2		722	25.12.07	25.01.08	12.10.11	50.5			Spares
7	1		712	26.12.04	07.10.05	14.12.11	86.5			Spares
17	3		714	25.12.05	31.08.06	19.12.11	74.5			Spares
3	1		727	25.12.08	17.01.09	08.09.10	38.5			Maintenance
22	3		726	25.09.08	13.11.08	31.08.09	41.5			Maintenance

Operationelle Satelliten

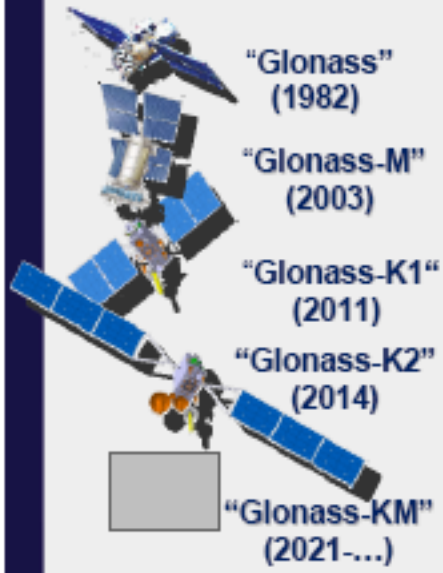


Positionierung



GLONASS Signals Modernization

РОСКОСМОС



L1	L2	L3	L1, L2	other	Status
L1OF, L1SF	L2OF, L2SF	–	–		Done
L1OF, L1SF	L2OF, L2SF	–	–		Done
L1OF, L1SF	L2OF, L2SF	L3OC test	–		Done
L1OF, L1SF	L2OF, L2SF	L3OC	L1OC, L1SC, L2SC		2014
L1OF, L1SF	L2OF, L2SF	L3OC	L1OC, L1SC, L2SC	L1OCM, L2OC, L5OC	Under development after 2015

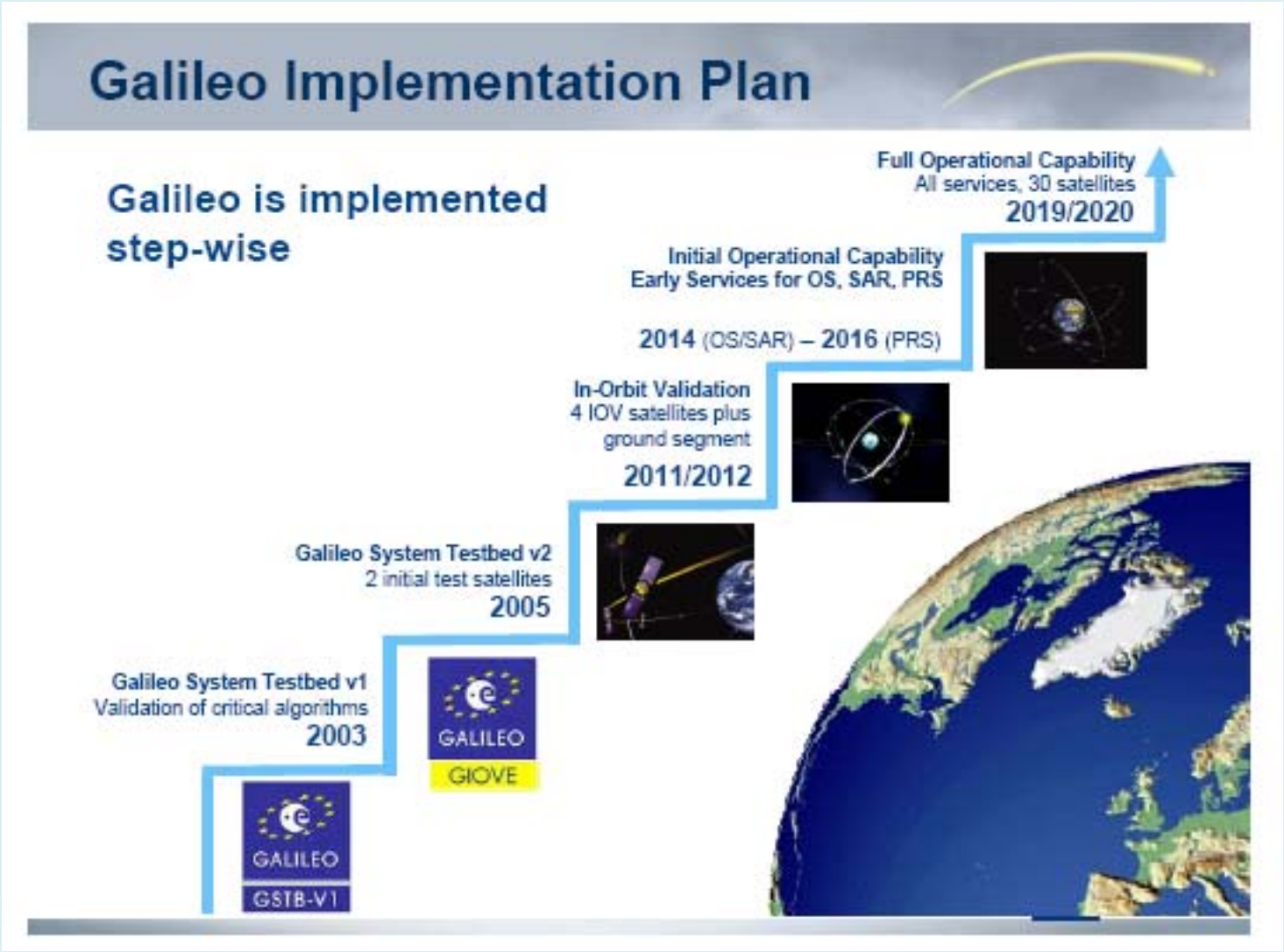
FDMA signals CDMA signals

GLONASS will introduce new CDMA signals
GLONASS will continue transmitting existing FDMA signals

13

GLONASS CDMA Signale L1 = 1575.42 MHz L2 = 1242 MHz

L3 = 1207.14 MHz L5 = 1176.45 MHz



Commercial Service : Optionen werden evaluiert;
SoL Service (Integrity): nur über SBAS

Erfolgreicher Start der ersten beiden GALILEO-IOV Satelliten am 21. Oktober 2011 (Kourou/Soyuz)

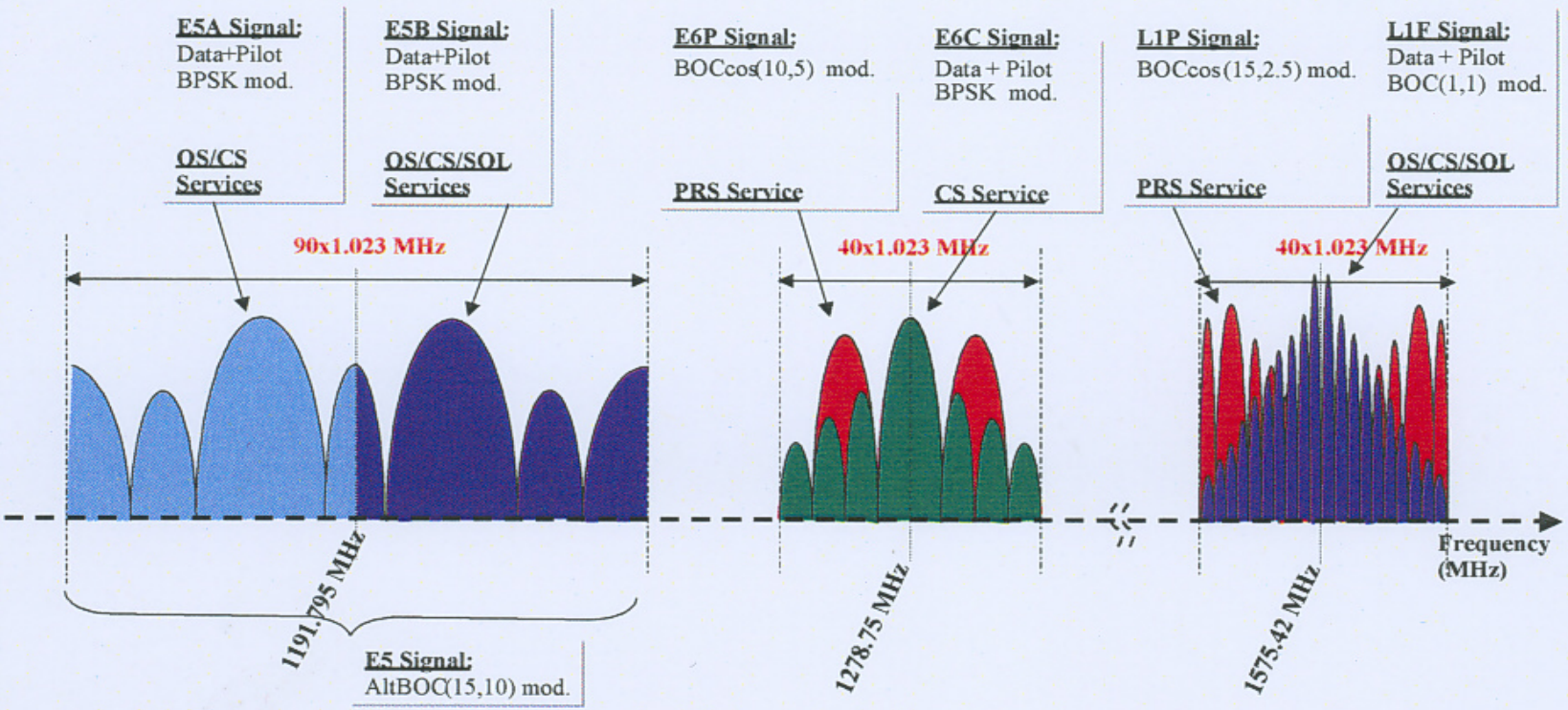
Constellation Deployment in Progress

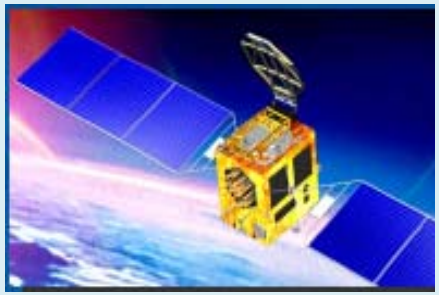
21/10/2011, Kouru, SOYUZ dual satellite launch

- 2 more spacecrafts will be launched in 2012
- 14 additional satellites are under construction
- 6 additional satellites under procurement

GALILEO EGNOS

GALILEO Signals Overview

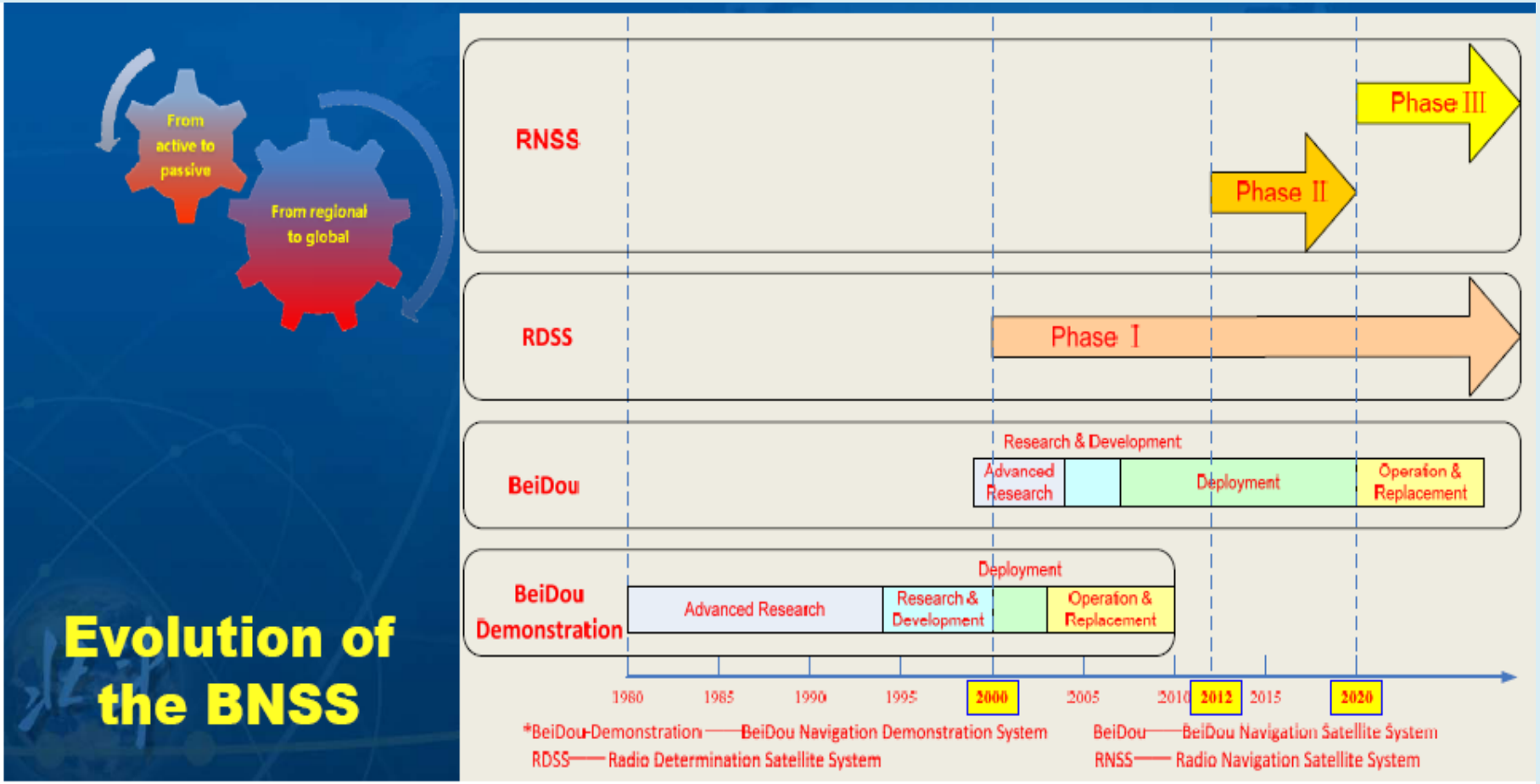




BNSS –

Beidou Navigation Satellite System

Beidou = der Große Bär



Beidou 2 : derzeitiges Raumsegment

Launches

Satellite	NORAD ID	Int'l code	Status	Launch date	Launch centre	Launch vehicle	Orbit
Compass-M1	31115	2007-011A	Operational	14 Apr 07	Xichang-LC1A	CZ-3A	MEO ~21,500km
Compass-G2	34779	2009-018A	Failed	15 Apr 09	Xichang-LC1B	CZ-3C	GEO
Compass-G1	36287	2010-001A	Operational	17 Jan 10	Xichang-LC1B	CZ-3C	GEO 144.5°E
Compass-G3	36590	2010-024A	Operational	2 June 10	Xichang-LC1B	CZ-3C	GEO 84.7°E
Compass-IGSO1	36828	2010-036A	Operational	1 Aug 10	Xichang-LC1A	CZ-3A	GSO, 55° incl.
Compass-G4	37210	2010-057A	Operational	1 Nov 10	Xichang-LC1B	CZ-3C	GEO 160°E
Compass-IGSO2	37256	2010-068A	Operational	18 Dec 10	Xichang-LC1A	CZ-3A	GSO, 55° incl.
Compass-IGSO3	37384	2011-013A	Operational	10 Apr 11	Xichang-LC1A	CZ-3A	GSO, 55° incl.
Compass-IGSO4	37763	2011-038A	Operational	27 July 11	Xichang-LC1A	CZ-3A	GSO, 55° incl.
Compass-IGSO5	37948	2011-073A	Operational	2 Dec 11	Xichang-LC1A	CZ-3A	GSO, 55° incl.

6 weitere MEO Starts in 2012 geplant

Im Endausbau : 5 GEO+5 IGSO + ca. 25 MEO

Aktuelle Situation

- Neue und modernisierte Systeme werden operabel

  COMPASS/BeiDou, QZSS, GIOVE/Galileo,

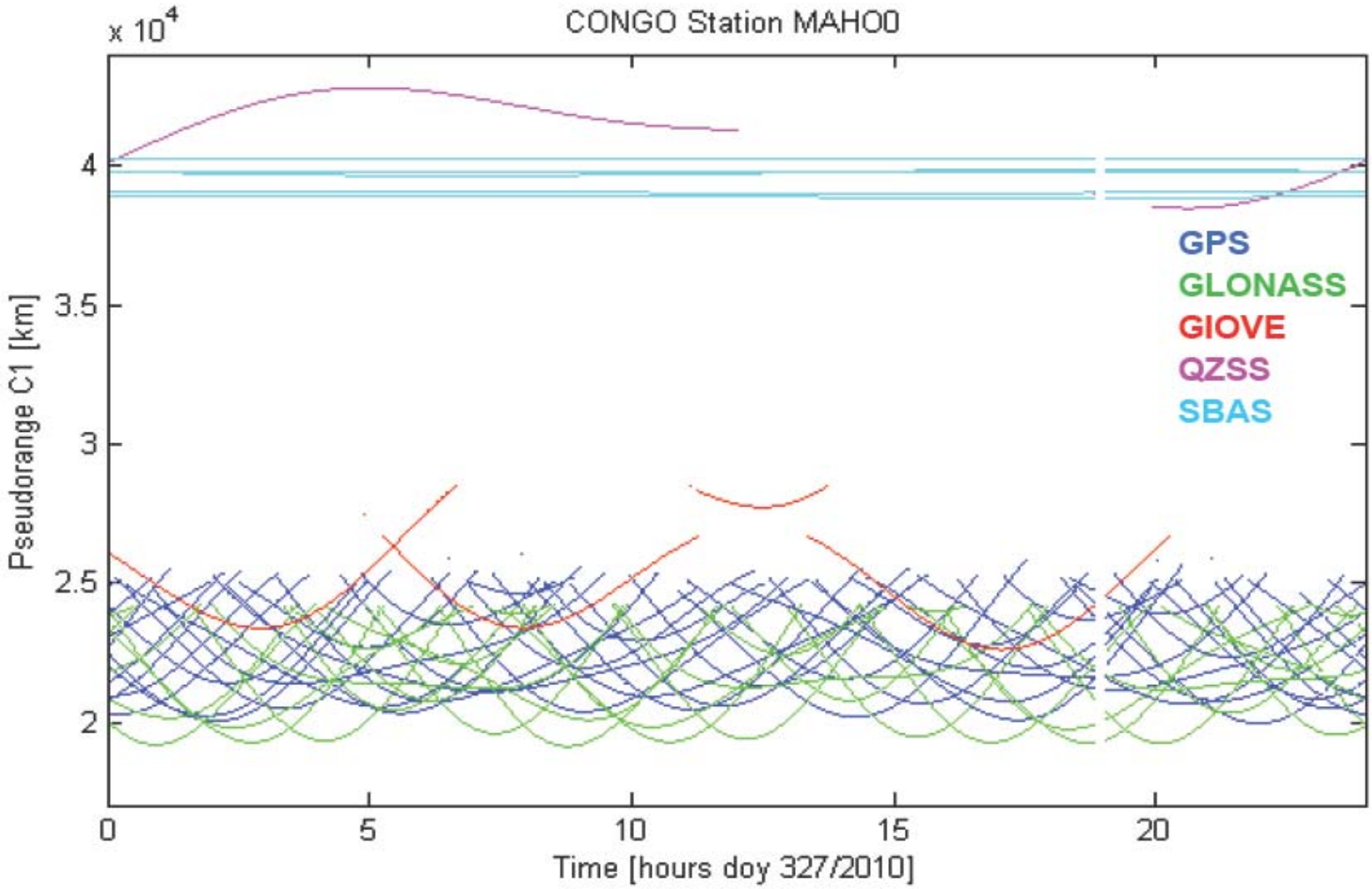
  plus Modernisierung von GPS & GLONASS,

  plus SBAS
- Empfänger unterstützen heute multi-GNSS tracking
- IGS muss für diese Situation Vorsorge treffen (neue GNSS)
- Empfehlungen des Newcastle 2010 IGS Workshops :

  Vorbereitung eines Call for Participation für ein

  IGS Multi-GNSS Global Experiment

Observations of Different Satellite Systems



Quelle: U.Hugentobler (TUM)

Galileo Signals

Galileo	E1	1575.42	A PRS	C1A	L1A
			B I/NAV OS/CS/SoL	C1B	L1B
			C no data	C1C	L1C
			B+C	C1X	L1X
			A+B+C	C1Z	L1Z
	E5a	1176.45	I F/NAV OS	C5I	L5I
			Q no data	C5Q	L5Q
			I+Q	C5X	L5X
	E5b	1207.140	I I/NAV OS/CS/SoL	C7I	L7I
			Q no data	C7Q	L7Q
			I+Q	C7X	L7X
	E5 (E5a+E5b)	1191.795	I	C8I	L8I
			Q	C8Q	L8Q
			I+Q	C8X	L8X
	E6	1278.75	A PRS	C6A	L6A
			B C/NAV CS	C6B	L6B
			C no data	C6C	L6C
			B+C	C6X	L6X
			A+B+C	C6Z	L6Z

Novatel 15A

JPS
Delta-G2T

Septentrio
GeNeRx1 *)

Leica
GRX1200
GGPRO

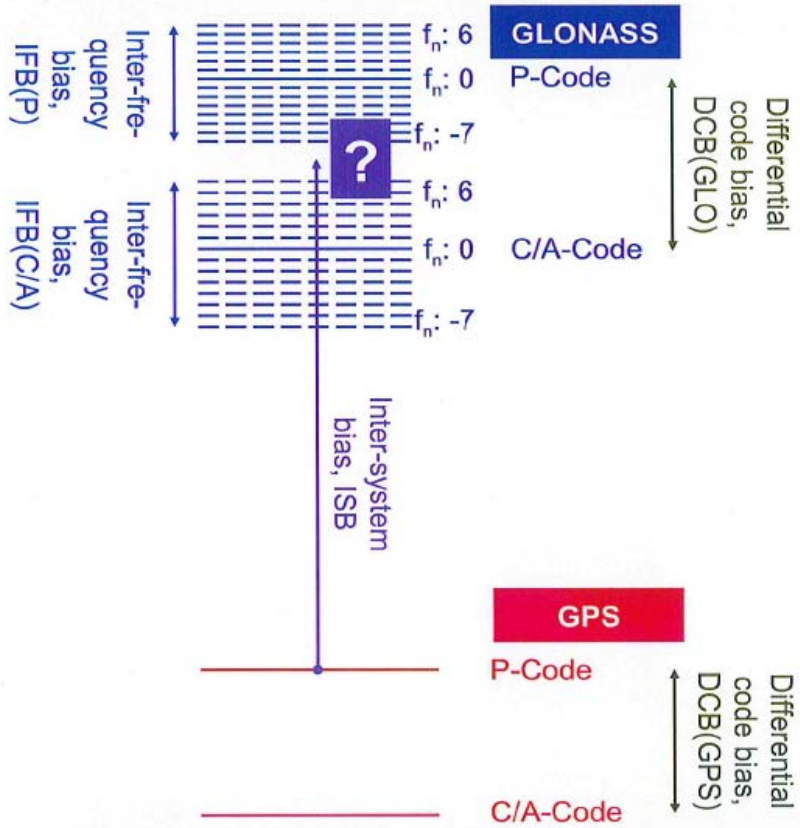
*) depending on receiver configuration

Quelle: U.Hugentobler (TUM)

Intra- und Intersystem Biases

- Satellite biases
  - GPS/GLONASS/GALILEO/... Inter-frequency biases
  - GPS/GLONASS/GALILEO/... System Time biases
  - Antenna phase center offsets and variations (frequency dependent)
  - Satellite phase biases (UPD)
- Station biases
  - Antenna phase center offsets and variations
  - Receiver specific intersystem biases
  - Receiver phase biases (UPD)

Biases in GPS/GLONASS (Clock) Processing



- **DCB: differential code bias**
  different hardware delays for P– and C–Code
- **ISB: inter–system bias**
  different hardware delays for measurements of different GNSS
- **IFB: inter–frequency bias**
  frequency–dependent hardware delays for the different GLONASS–signals

We can only extract the sum of delays from a GPS/GLONASS data processing.

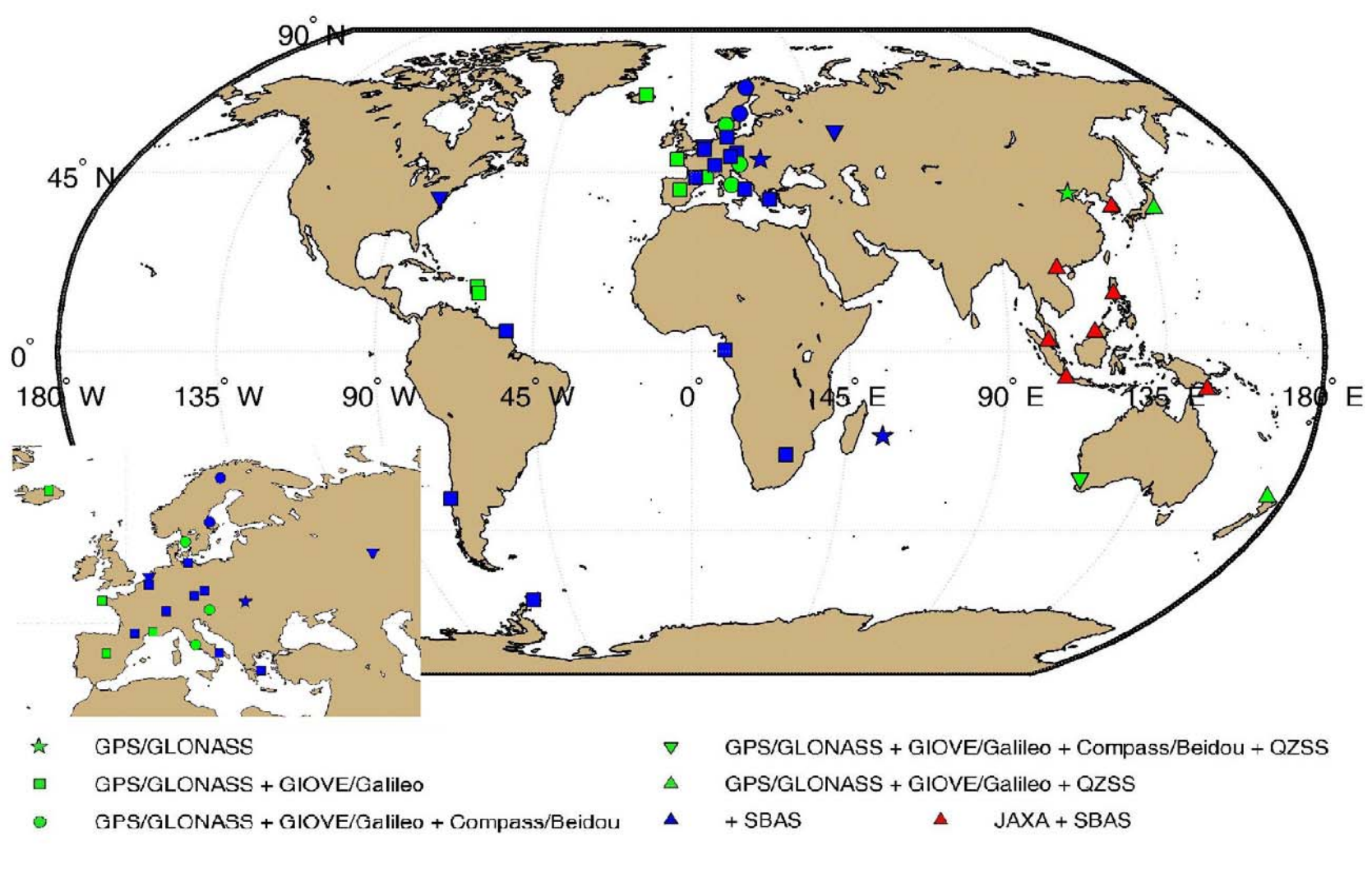
Quelle: R.Dach, M.Meindl, S,Schär (AIUB)

Folge : IGS startet ein

‘Experiment to operate an expanded network of new receivers capable of tracking new signals in addition to GPS&GLONASS’

IGS Multi-GNSS Global Experiment (IGS M-GEX)

M-GEX Stationen (Stand April 2012)



IGS Multi-GNSS Global Experiment 2012

Zusammenfassung

- Zentrale Aufgaben des Experiments
  - Aufbau eines kleineren Beobachtungsnetzwerkes mit Multi-GNSS Empfängern (40-60 Stationen)
  - sammeln und frei zur Verfügung stellen von RINEX Beobachtungsdaten
    (RT-Datenpolitik wird noch definiert)
  - Test des Datenaustausches
  - Qualifizieren von Equipment und Signalen

- Künftige Aufgaben (mittelfristig)
  - upgrade des gesamten IGS Netzwerkes auf ein Multi-GNSS Netzwerk
  - Generierung von Multi-GNSS Produkten

Danke für Ihre Aufmerksamkeit

Für weitere Informationen :
Besuchen Sie unseren Stand
hier auf der Fachmesse