



GPS/GNSS課程

全球導航衛星系統 (Global Navigation Satellite System)

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全球導航衛星系統(GNSS)

- Global Navigation Satellite Systems
 - Global Positioning System (GPS, USA)
 - GLObal Navigation Satellite System (GLONASS, Russia)
 - Galileo (EU)
 - Beidou/Compass (China)
- Regional Augmentation Systems
 - Quasi Zenith Satellite System (QZSS, Japan)
 - Indian Regional Navigation Satellite System (IRNSS, India)





GNSS發展現況

- Global Constellations
 - **GPS (24+3)**
 - GLONASS (24+)
 - GALILEO (24+3)
 - BDS/BEIDOU (27+3 IGSO + 5 GEO)

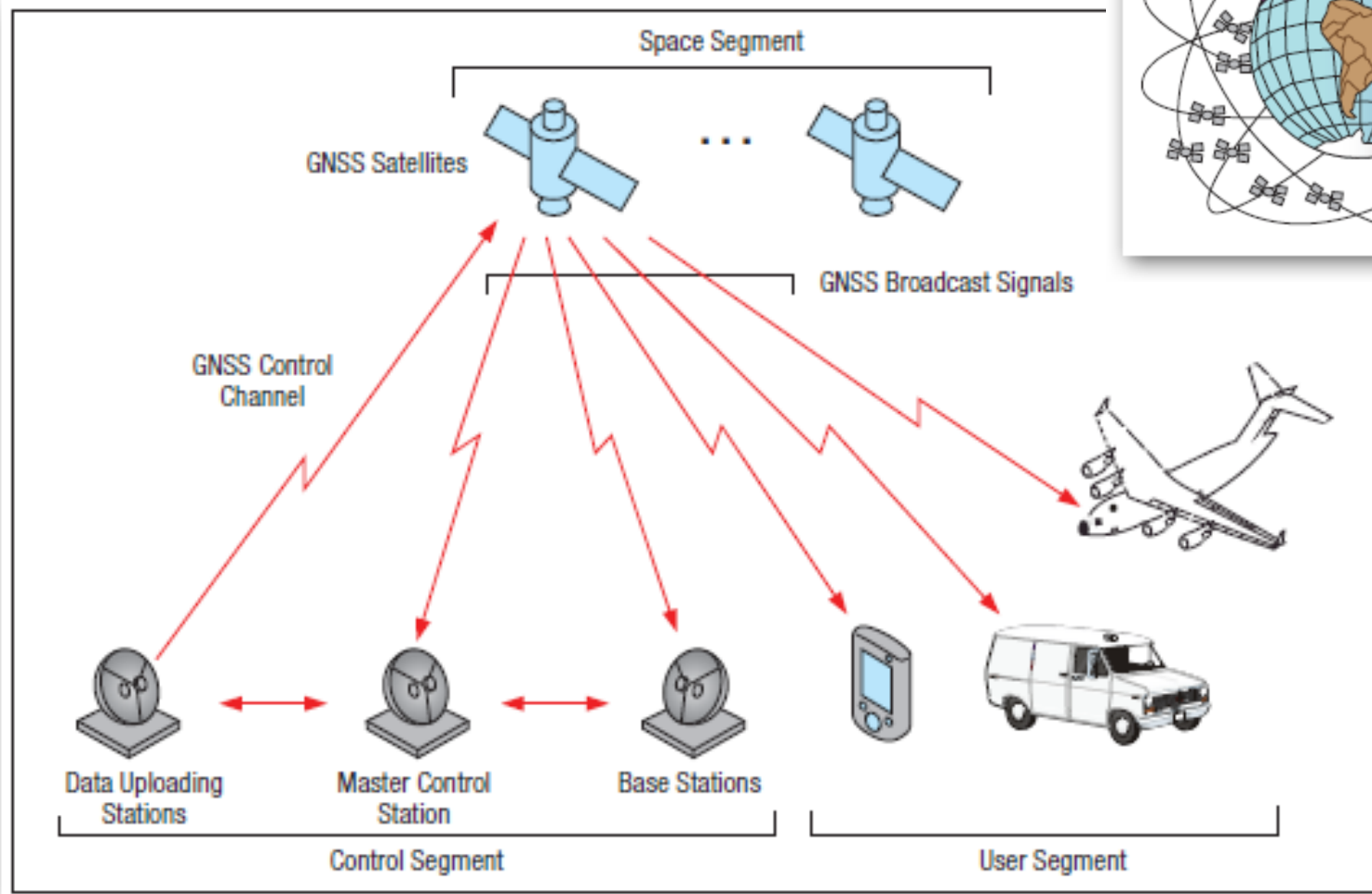
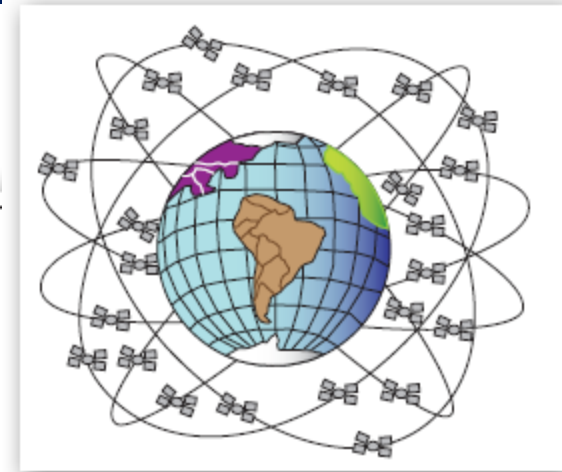


- Regional Constellations
 - QZSS (4+3)
 - IRNSS (7)
- Satellite-Based Augmentations
 - **WAAS (3)**
 - MSAS (2)
 - EGNOS (3)
 - GAGAN (2)
 - SDCM (3)





GNSS運作單元





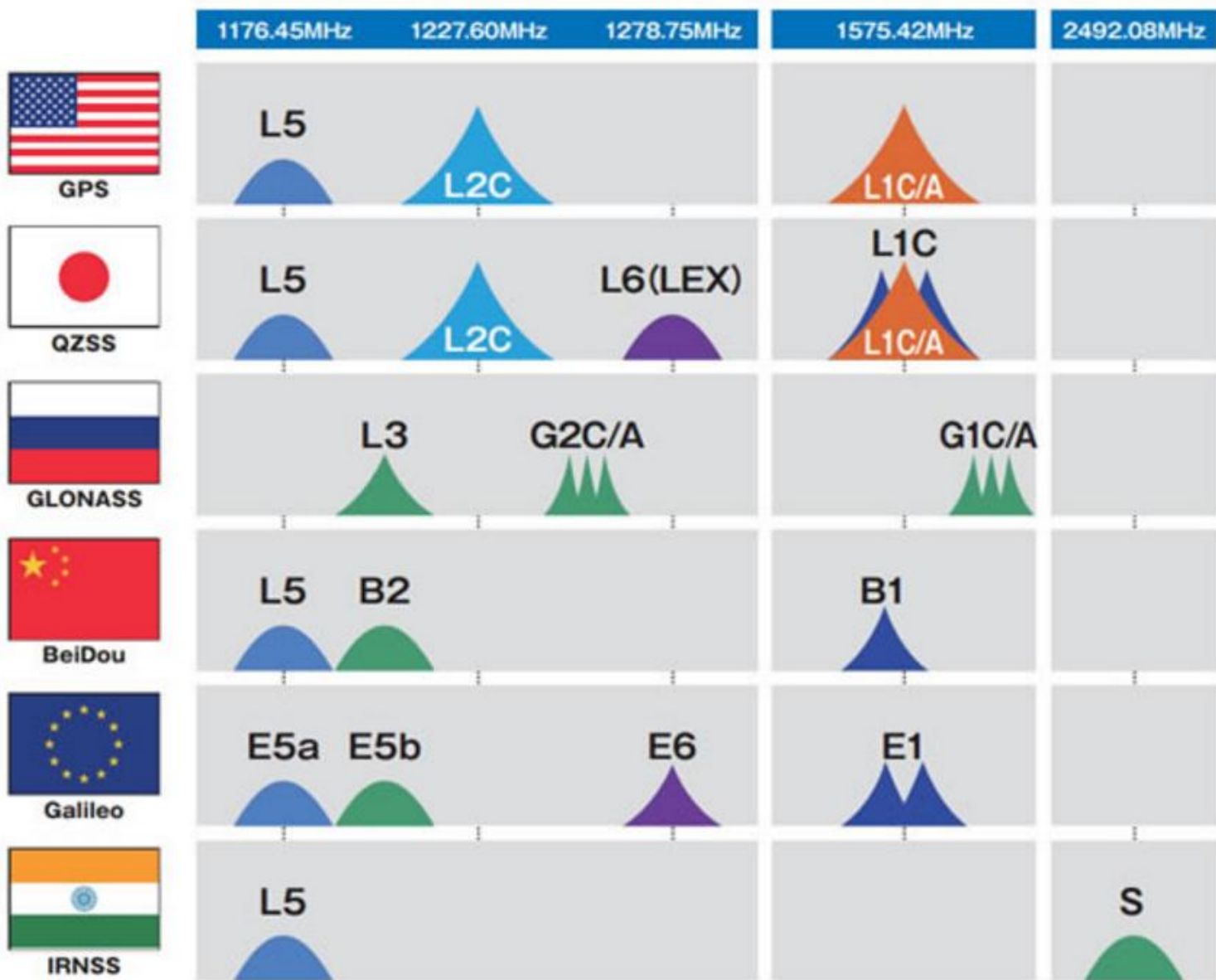
GNSS系統比較

Parameter	GPS	GLONASS	Galileo	BeiDou
Orbital Period	11hrs 58min	11hrs 15mins	14hrs 04mins	12hrs 37min
Orbital Height	22,200 Km	19,100 Km	23,222 Km	21,150 Km
Inclination	55°	64,8°	56°	55°
Number of Orbital Planes	6	3	3	6
Number of satellites	24 operational + 6 spares	21 operational + 3 spares	24 operational + 6 spares	27 MEOs + 5 GEOs + 3 IGSOs
Reference frame	WGS-84	PZ90	GTRF	CGCS 2000
Reference time	GPS Time (GPST)	GLONASS Time (GLONASST)	Galileo System Time (GST)	BeiDou Time (BDT)





GNSS 民用信號







GNSS使用頻道

	L5 / L5OC / E5a / B2a	L2 / L2C / L2OC	E6 / LEX	L1 / L1OC / E1 / B1
GPS	30	30		30
GLONASS	24	24		24
Galileo	30		30	30
BeiDou	35		35	35
QZSS	3	3	3	3
IRNSS	7			
	129			122

← **ARNS* Bands** →

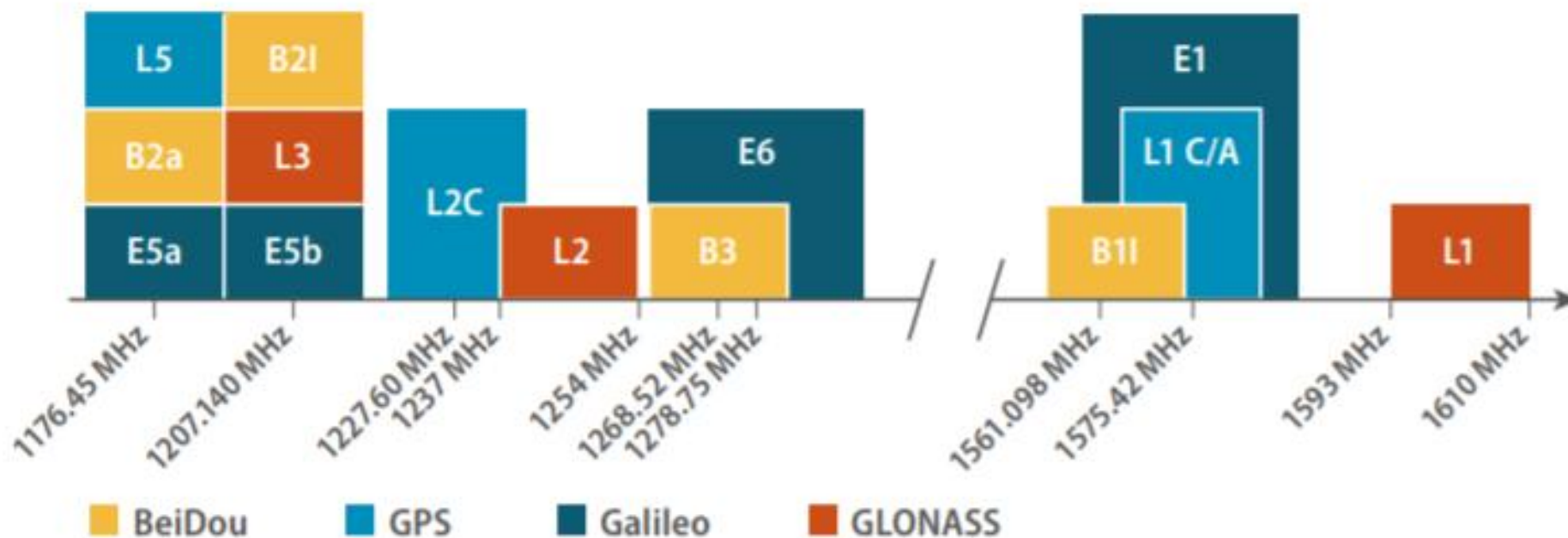
-  Frequency band used by the system, with N = number of satellites
-  Frequency band not used by the system





GNSS頻道分布

GNSS FREQUENCIES IN THE L BAND





日本QZSS與印度IRNSS增益系統

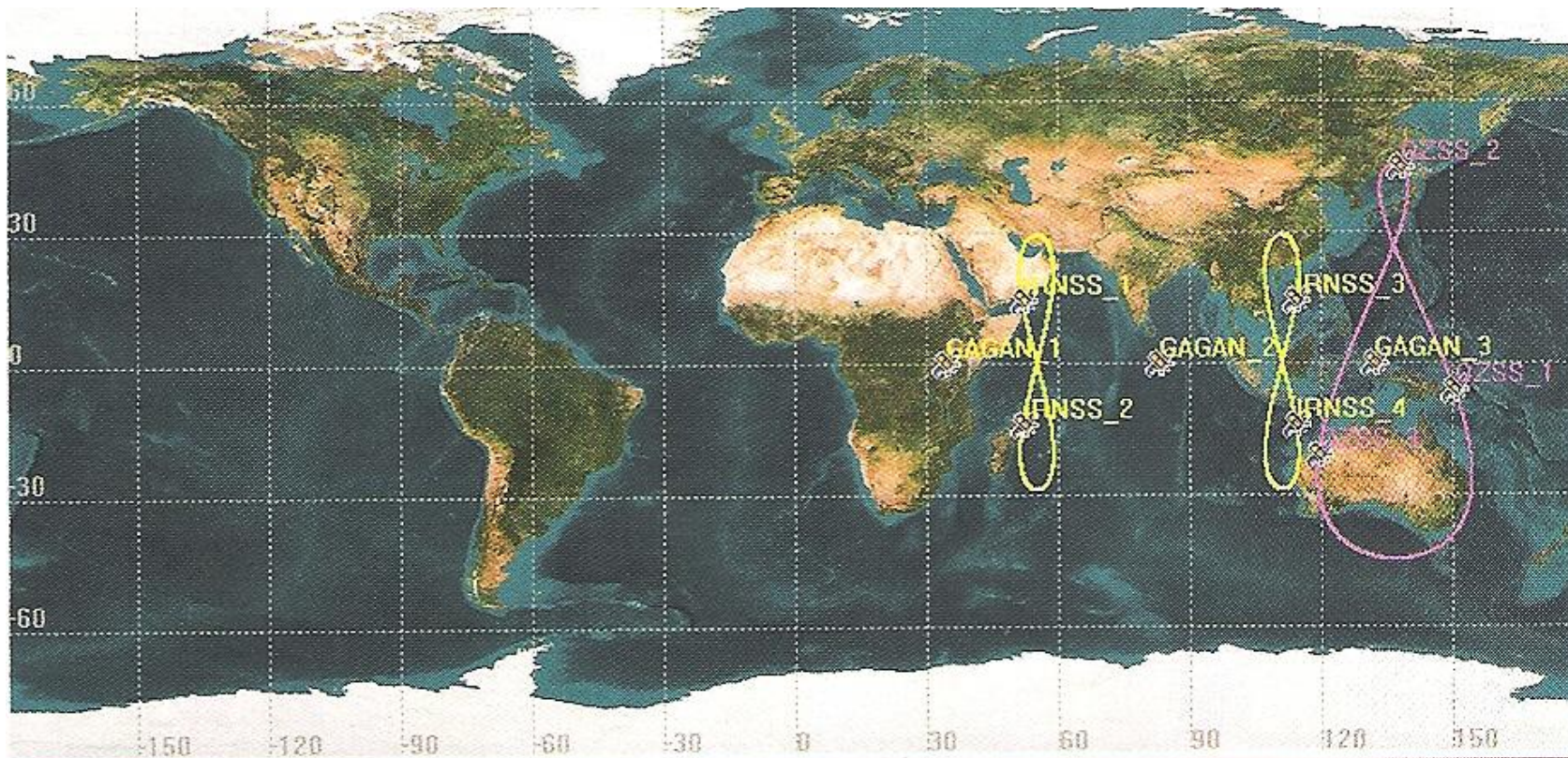


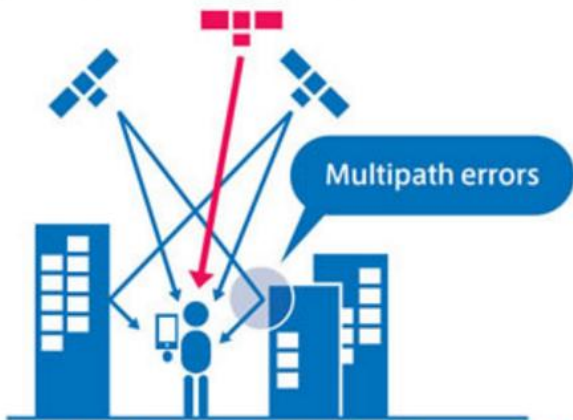
FIGURE 5 Ground Tracks of QZSS and IRNSS.



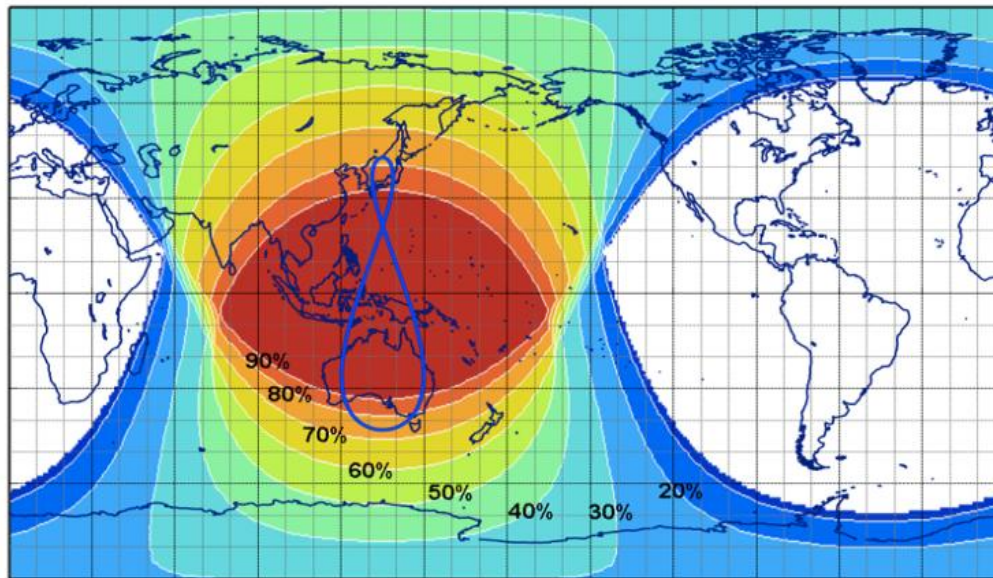


日本QZSS

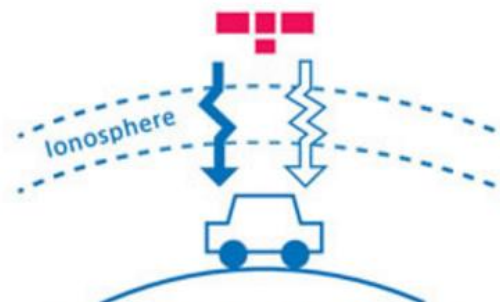
Improved positioning accuracy by multipath reduction



Multipath effects are minimal on satellites with high elevation angles



Satellite signal delays caused by the ionosphere



Improved positioning accuracy through decreased ionospheric errors





印度 IRNSS (NavIC)

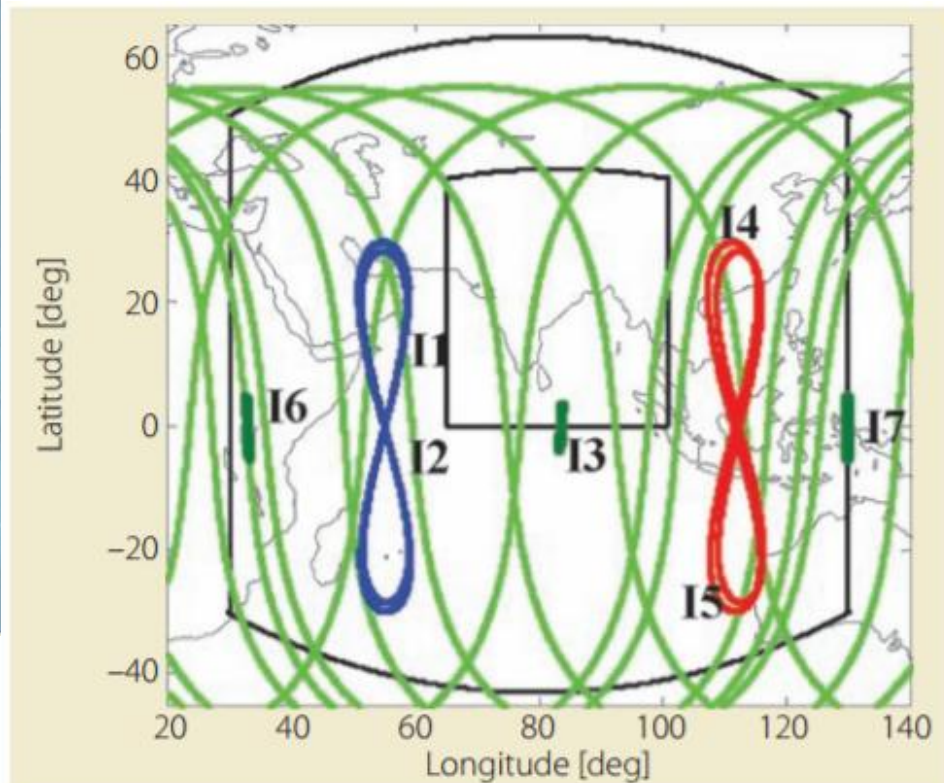


FIGURE 1 Groundtrack of IRNSS and GPS Block IIF (light green) satellites on day of year (DOY) 183 of 2016. The inner and outer black boundaries indicate the border of the IRNSS primary and secondary service areas, respectively.

Satellite	Type	Longitude	Inclination	Launch date
IRNSS-1A (I1)	IGSO	55° E	29.0°	July 2013
IRNSS-1B (I2)	IGSO	55° E	31.0°	April 2014
IRNSS-1C (I3)	GEO	83° E	-	October 2014
IRNSS-1D (I4)	IGSO	111.75° E	30.5°	March 2015
IRNSS-1E (I5)	IGSO	111.75° E	28.1°	January 2016
IRNSS-1F (I6)	GEO	32.5° E	-	March 2016
IRNSS-1G (I7)	GEO	129.5° E	-	April 2016

Table 1 Information on the IRNSS/NavIC satellites (ISRO, 2016).





GNSS透空圖

BASE CONDITION ⊖

Region: **East Asia** ▼

City: **Taipei** ▼

LAT: **25** ° **5** ' **N** ▼

LONG: **121** ° **36** ' **E** ▼

Time: **Current Time**

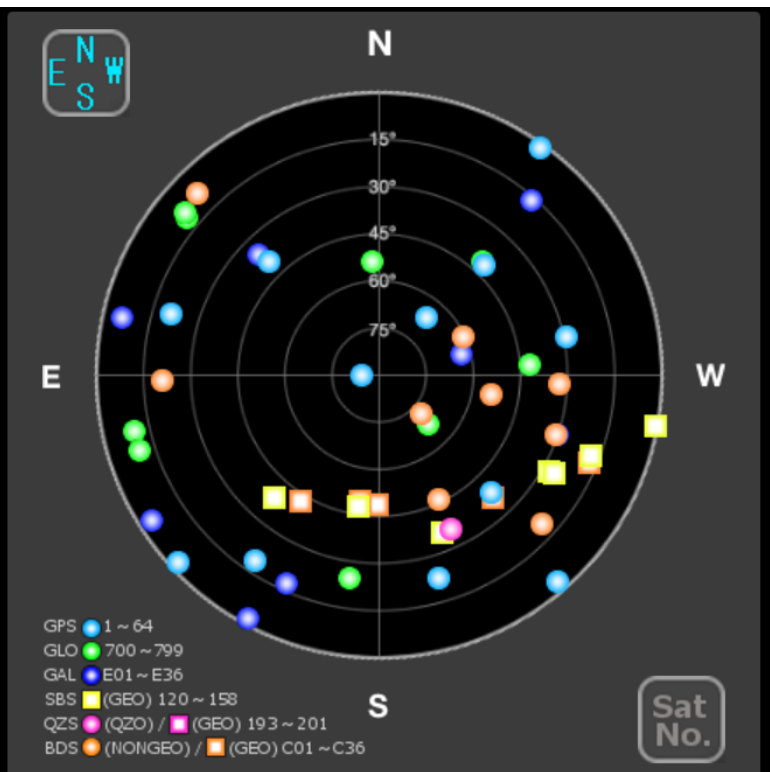
Time Zone: **UTC+08:00** ▼

Year: **2017** ▼ / Month: **04** ▼ / Day: **13** ▼

Hour: **10** ▼ : Minute: **45** ▼ GPS/QZSS Weeks: **920**

Mask Angle: **00** ▼ °

VIEW



DOP Information

HDOP: **0.36**
VDOP: **0.52**

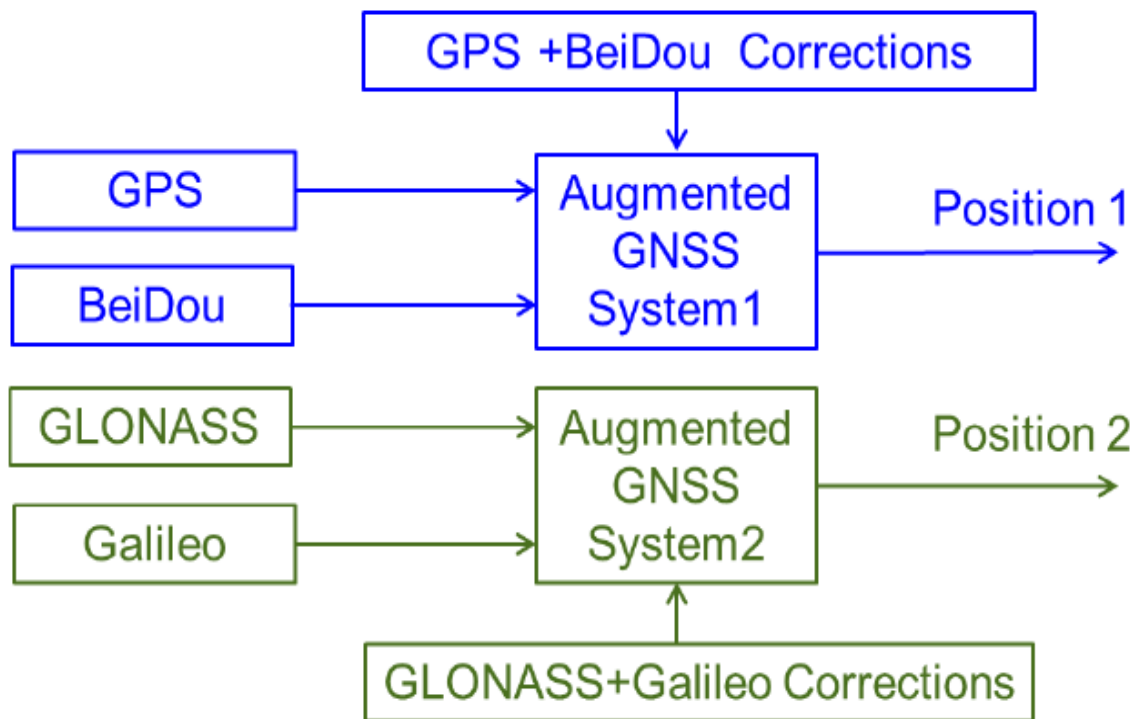
Visible GNSS: **52**

QZS: 1	GPS: 12	GLO: 9
BDS: 14	GAL: 9	SBS: 7





GNSS 定位發展





健行科技大學

Chien Hsin University of Science and Technology

GLONASS衛星系統

Chien Hsin University of Science and Technology
Chien Hsin University of Science and Technology

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GLONASS發展歷程

- 1982年10月GLONASS衛星開始發射
- 1993年開始運作測試
- 1995年24顆衛星布設完成
- 1990年開始財務減縮，導致衛星數銳減
- 2006年開始重新布署
- 2010年底重新布設完成進行運作

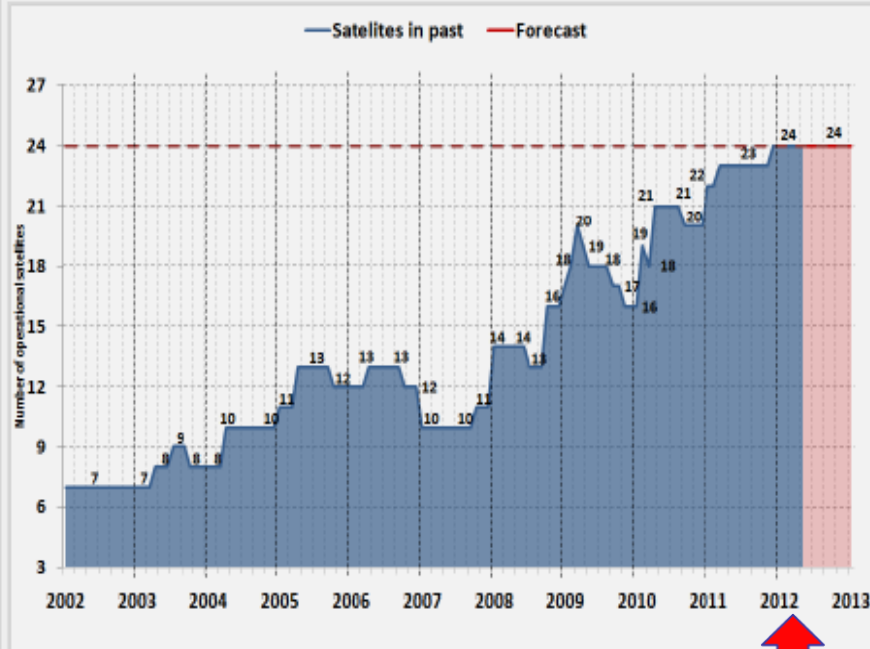




GLONASS表現歷程

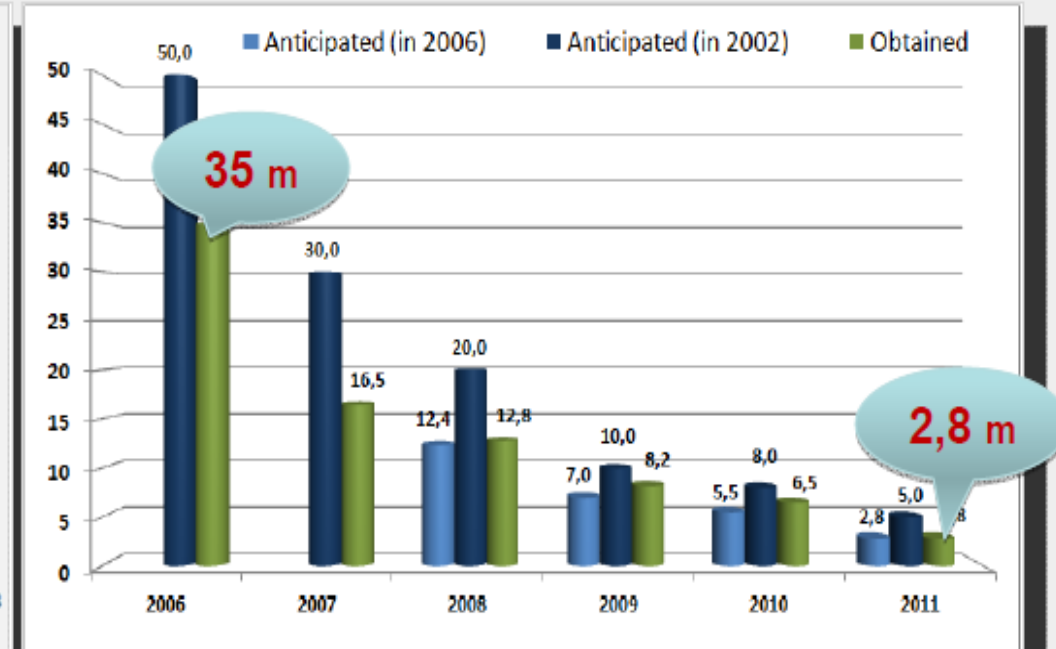
Constellation recovery

Number of operational satellites



Accuracy improvement

User positioning error (RMS, SIS)





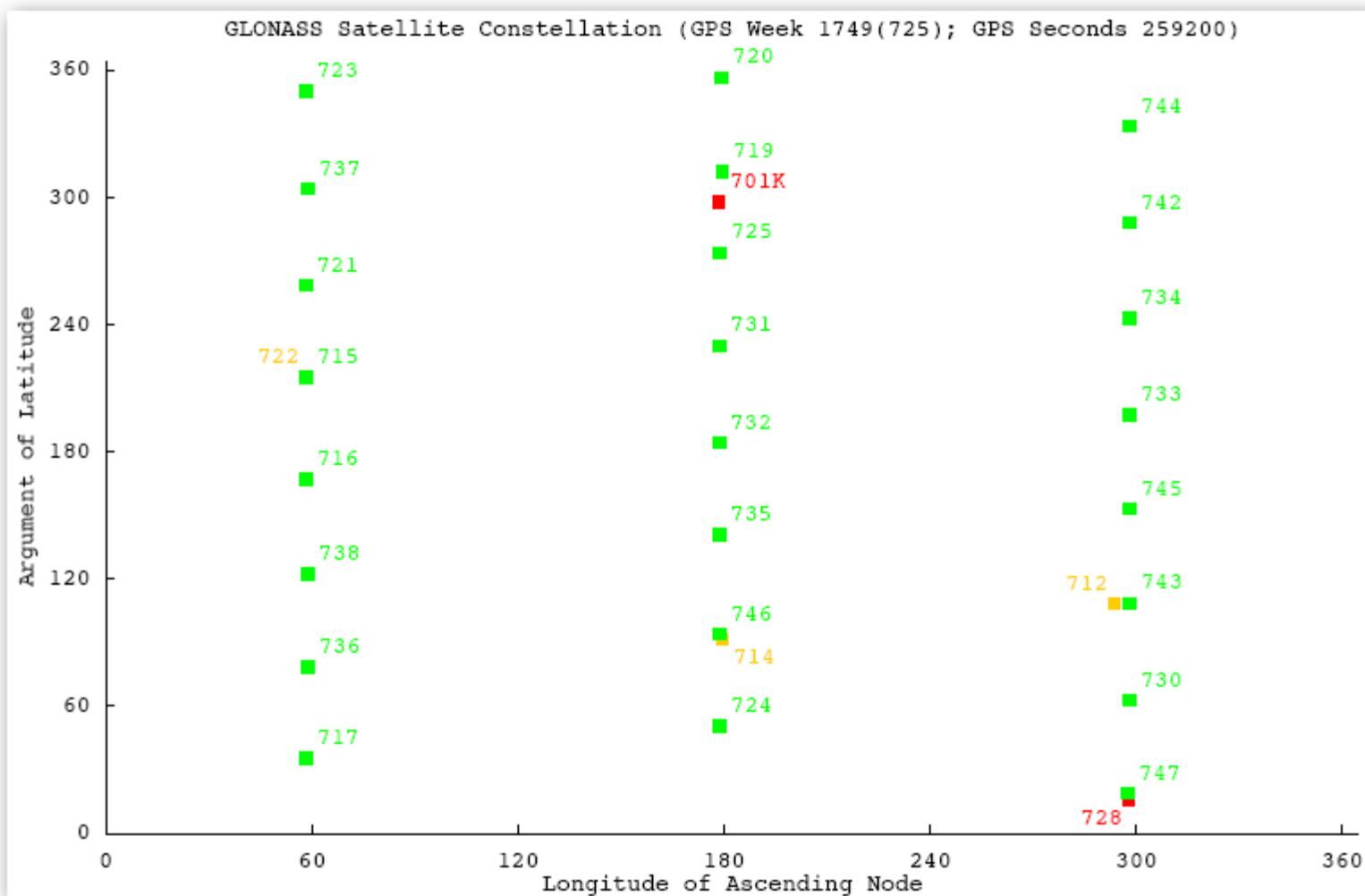
GLONASS衛星現況(2014)

GLONASS number	Cosmos number	Plane/ slot	Frequ. chann.	Launch date	Intro date	Status	Outage date
730	2456	1/01	01	14.12.2009	30.01.2010	operating	.....
747	2485	1/02	-4	26.04.2013	04.07.2013	operating	.....
744	2476	1/03	05	04.11.2011	08.12.2011	operating	.....
742	2474	1/04	06	02.10.2011	25.10.2011	operating	.....
734	2458	1/05	01	14.12.2009	10.01.2010	operating	.....
733	2457	1/06	-4	14.12.2009	24.01.2010	operating	.....
745	2477	1/07	05	04.11.2011	18.12.2011	operating	.....
743	2475	1/08	06	14.11.2011	25.12.2011	operating	.....
736	2464	2/09	-2	02.09.2010	04.10.2010	operating	.....
717	2426	2/10	-7	25.12.2006	03.04.2007	operating	.....
723	2436	2/11	00	25.12.2007	22.01.2008	operating	.....
737	2465	2/12	-1	02.09.2010	11.10.2010	operating	.....
721	2434	2/13	-2	25.12.2007	08.02.2008	operating	.....
715	2424	2/14	-7	25.12.2006	03.04.2007	unusable	11.03.2014
716	2425	2/15	00	25.12.2006	12.10.2007	operating	.....
738	2466	2/16	-1	02.09.2010	12.10.2010	operating	.....
746	2478	3/17	04	28.11.2011	23.12.2011	operating	.....
714	2419	3/18	-6	25.12.2005	31.08.2006	operating	.....
720	2433	3/19	03	26.10.2007	25.11.2007	operating	.....
719	2432	3/20	02	26.10.2007	27.11.2007	operating	.....
725	2443	3/21	04	25.09.2008	05.11.2008	operating	.....
731	2459	3/22	-3	02.03.2010	28.03.2010	operating	.....
732	2460	3/23	03	02.03.2010	28.03.2010	operating	.....
735	2461	3/24	02	02.03.2010	28.03.2010	operating	.....





GLONASS衛星在軌分布(2014)





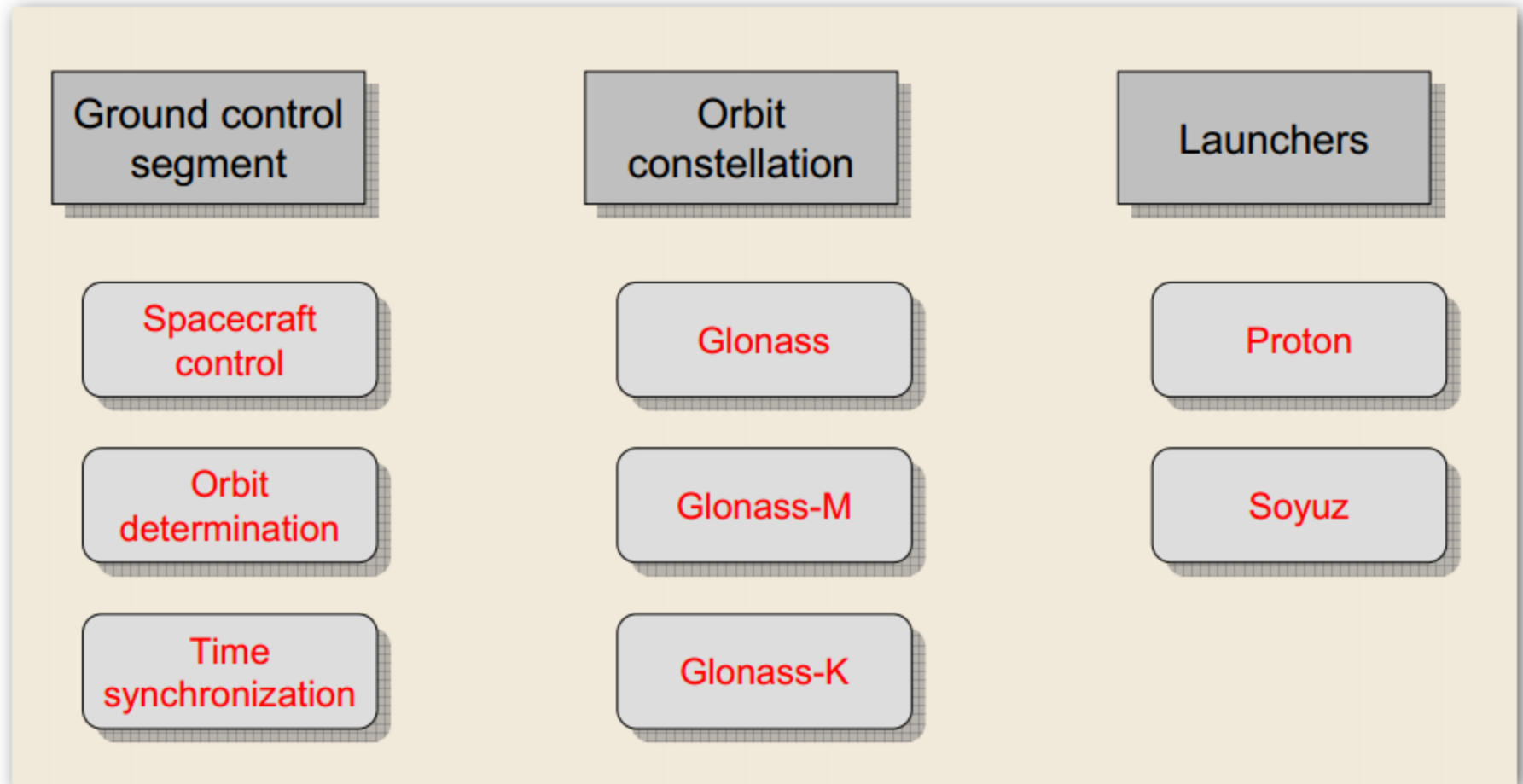
GLONASS發展計畫

- **Constellation sustainment (24 sats with spares)**
 - Glonass-M launches up to 2014
 - Glonass-K launches since 2015
 - 24 satellites transmitting CDMA signals by 2020
- **GLONASS improvement**
 - Constellation (availability)
 - Accuracy of the core system
 - Augmentations development (accuracy, integrity, availability, assisting technologies...)
 - References improvement (geodesy, time, Earth rotation and attitude data...)
- **User segment development**
 - Governmental applications
 - Chips and chipsets, navigation maps
 - Encouraging commercial applications



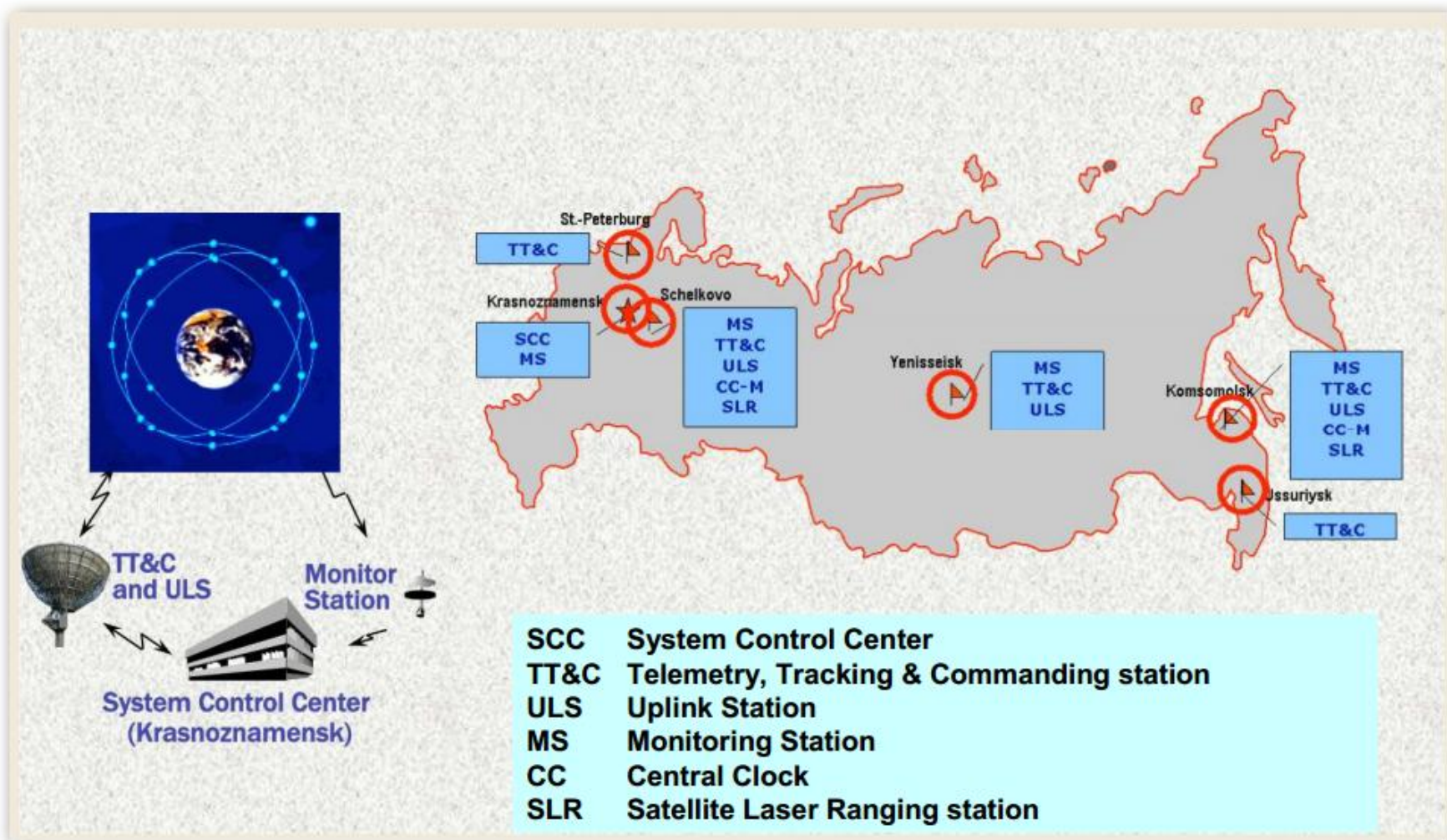


GLONASS系統單元





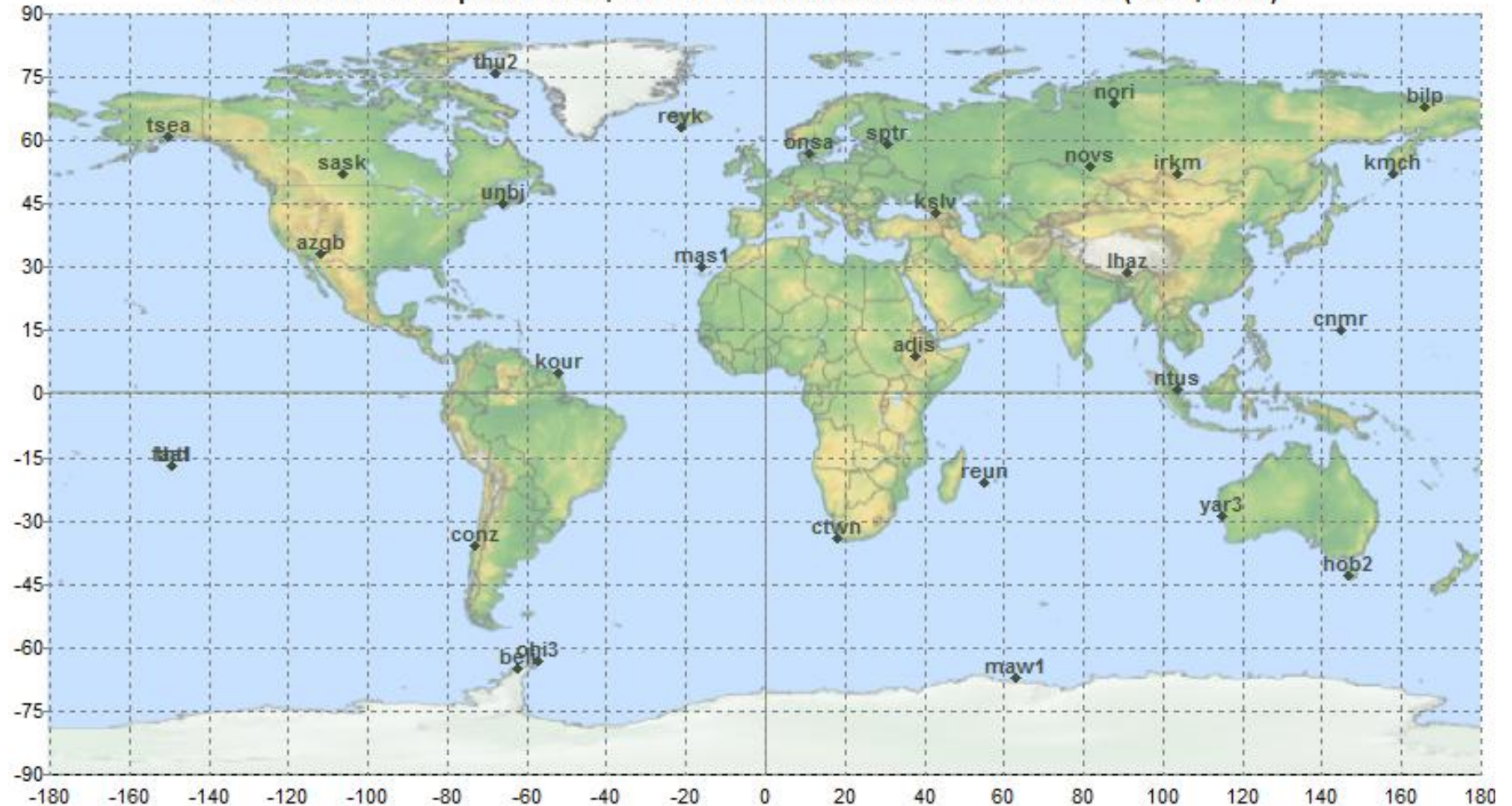
地面監控站





全球監控站位址

Расчетная зона покрытия станций с 19:00 02.06.14 по 20:00 02.06.14 UTC+4 (станций: 30)





衛星類型



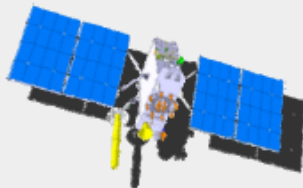

- Glonass (one operational satellite)
- Glonass-M (19 operational satellites)
- Glonass-K (from 2010 onwards)

**New CDMA signals introduced on Glonass-K
Keeping on transmitting the existing FDMA signals**





GLONASS衛星特性

1982	2003	2011	2014
“Glonass”	“Glonass-M”	“Glonass-K1”	“Glonass-K2”
			
<ul style="list-style-type: none">• 3 year design life• Clock stability - 5×10^{-13}• Signals: L1SF, L2SF, L1OF, (FDMA)• Totally launched 81 satellites• Real operational life time 4.5 years	<ul style="list-style-type: none">• 7 year design life• Clock stability 1×10^{-13}• Signals: Glonass + L2OF (FDMA)• Totally launched 36 satellites• Another 12 satellites ordered	<ul style="list-style-type: none">• 10 year design life• Unpressurized bus• Expected clock stability $\sim 10 \dots 5 \times 10^{-14}$• Signals: Glonass-M + L3OC (CDMA) – test• SAR	<ul style="list-style-type: none">• 10 year design life• Unpressurized• Expected clock stability $\sim 5 \dots 1 \times 10^{-14}$• Signals: Glonass-M + full set of CDMA signals• SAR





GLONASS現代化

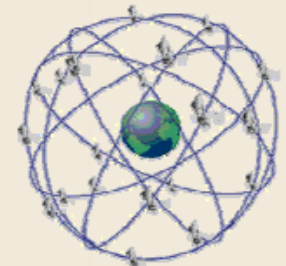
- New (Glonass-K) satellites (from 2010 onwards)
- More satellites (30, probably not before 2015)
- Improved accuracy
- Modernized ground control segment
- New signals:
 - L3 (1201-1212 MHz, to be defined (Galileo E5b 1207.14 MHz))
 - CDMA (on first Glonass-K demonstration satellite in 2010)
- Interoperability with GPS and Galileo





系統諸元

System	Glonass	GPS
Number of satellites	24	30+
Number of orbital planes	3	6
Semi-major axis	25500 km	26550 km
Eccentricity	< 0.01	< 0.01
Inclination	64.8°	55°
Period of revolution	11h16m	11h58m
Repeat period	8 days	1 day





信號電碼

	Glonass	GPS
C/A code		
Frequency	0.511 MHz	1.023 MHz
Chip length	587 m	293 m
P-code		
Frequency	5.11 MHz	10.23 MHz
Chip length	59 m	29 m
Modulation scheme	FDMA	CDMA

FDMA - Frequency Division Multiple Access (Glonass: same code for all satellites, different frequencies)

CDMA - Code Division Multiple Access (GPS: different codes for all satellites, same frequencies)

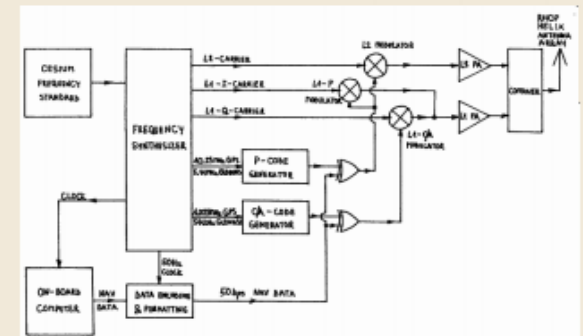


Fig. 6 - GPS/GLONASS satellite block diagram.





FDMA信號頻率

- Nominal carrier frequencies
 - L1: 1602 MHz (GPS: 1575.42 MHz)
 - L2: 1246 MHz (GPS: 1227.60 MHz)
- Satellite specific frequencies
 - $L1_k = L1 + k \times 0.5625$ MHz
 - $L2_k = L2 + k \times 0.4375$ MHz

$k = -7 \dots 13$

Note: $L1_k / L2_k = 9/7$ for all k





CDMA信號頻率

Satellite	FDMA Signals		CDMA Signals		
	L1	L2	L1	L2	L3
«Glonass-M»	L1OF L1SF	L2OF L2SF	-	-	L3OC (c 2014 r.)
«Glonass-K» 1G	L1OF L1SF	L2OF L2SF			L3OC
«Glonass-K» 2G	L1OF L1SF	L2OF L2SF	L1OC L1SC	L2OC L2SC	L3OC

1600.995 MHz

1248.06 MHz

1202.025 MHz





導航訊息

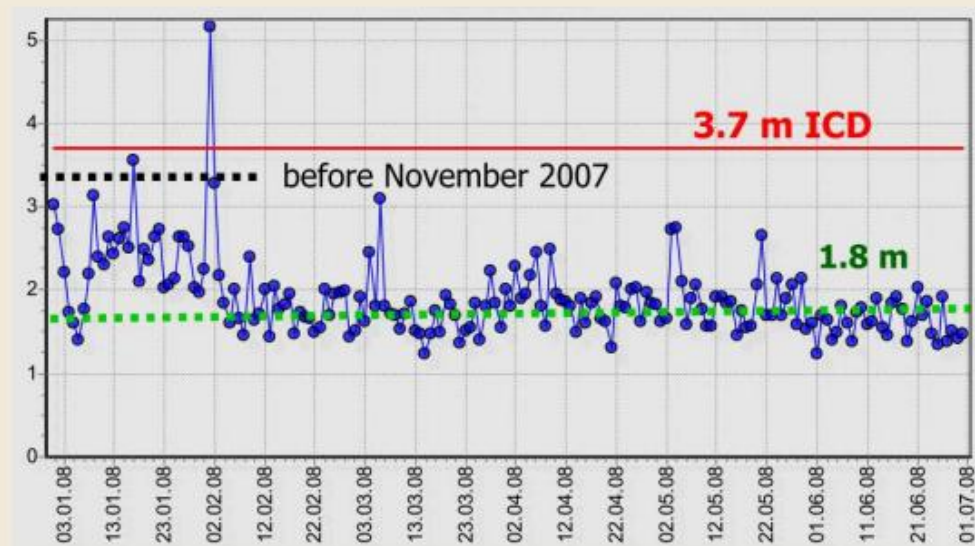
	Glonass	GPS
Orbit	Position, velocity, acceleration at reference time	Keplerian elements and corrections at reference time
Clock	Clock offset and drift at reference time	Clock offset, drift and drift rate at reference time
Update period	30 minutes	Two hours
Almanac	Keplerian elements	Keplerian elements





成果表現

- New geodetic datum
 - Change from PZ90 to PZ90.02 in September 2007
 - PZ90.02, differences with ITRS less than 0.5 m
- User range accuracy
 - ICD 3.7 m
 - Actual 1.8
- Clock stability
 - 10^{-13} s/s

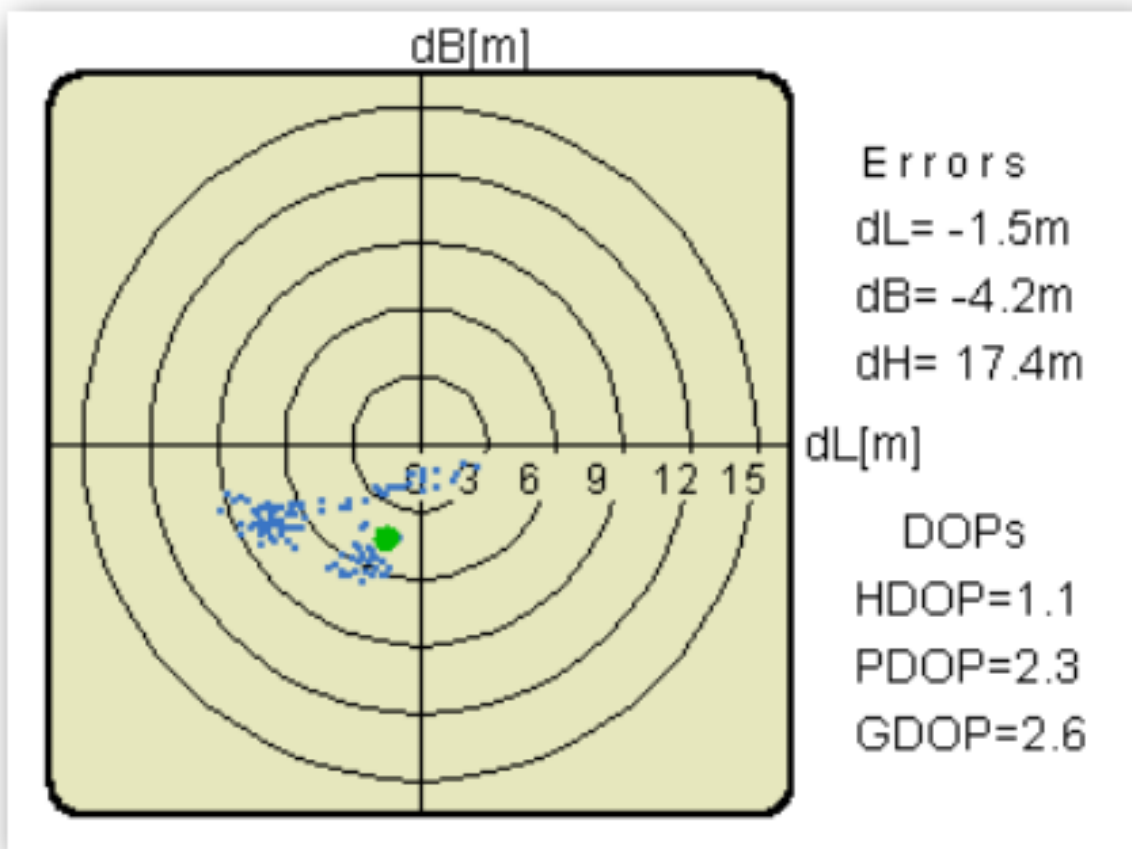


ICD – Interface Control Document



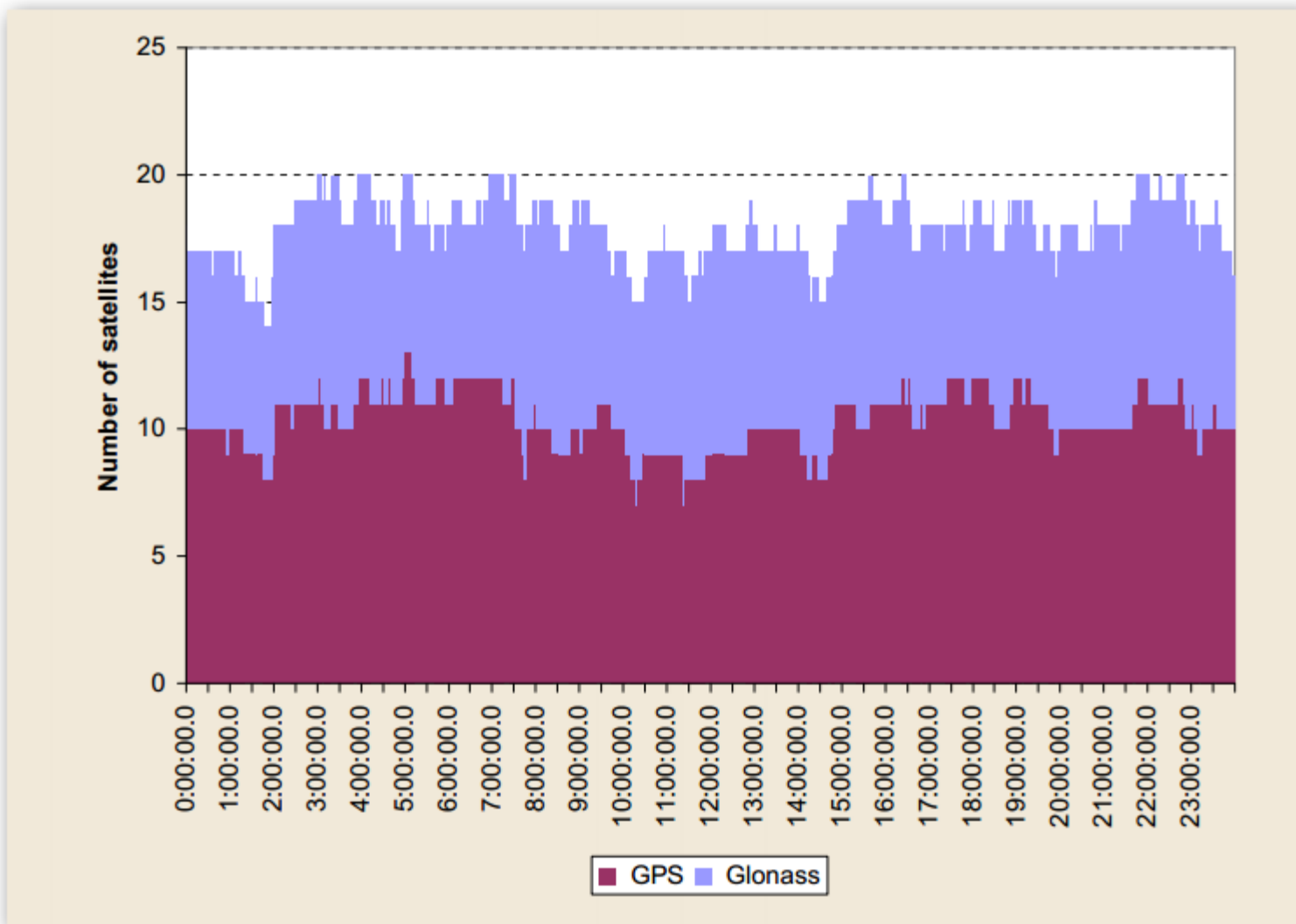


導航定位精度(2014)





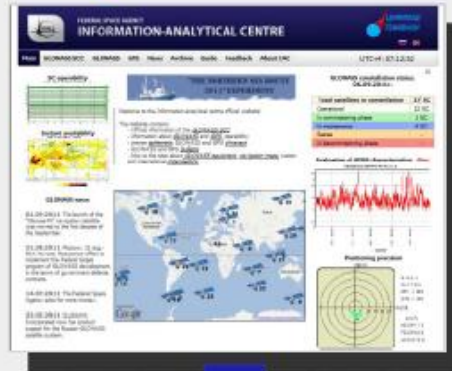
組合衛星數





GLONASS 官網

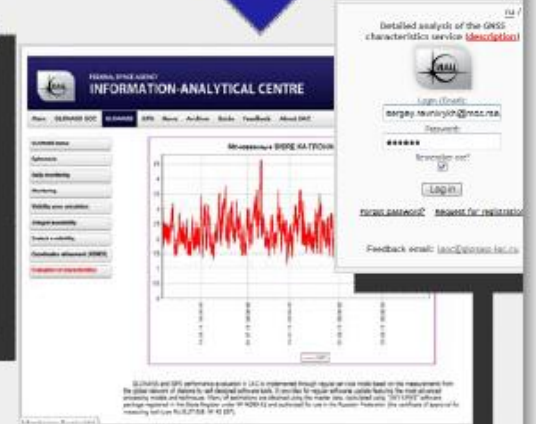
www.glonass-center.ru
(www.glonass-iac.ru)



GLONASS News



GLONASS and GPS
Status & Feedback



GLONASS and GPS
Performances





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發展Galileo的思考

- 以軍事用途為主的衛星導航系統，並無法保證提供其連續不斷的系統服務
- 衛星定位已成為載具導航的標準方法，一旦衛星信號被人為關閉，則回復傳統定位方法會有困難
- 1990年代歐洲委員會（EC）認為歐洲需要發展一套自主的全球定位系統
- 歐洲太空局（ESA）開始推動Galileo衛星系統，以求建置全世界第一個完全以**民用**為目的之導航衛星，並保證其全天候、全時程的服務提供





Galileo的發展考量

- 配合GPS與GLONASS衛星系統的交互運作，Galileo將可完成GNSS的布建
- Galileo可使導航衛星數量增加一倍，使得地球上的大多數地方(如城市)能有精確定位的功能
- Galileo設計比GPS衛星更大的傾角軌道，使其能在高緯度區域(如北歐)提供更佳的覆蓋面
- Galileo可使歐洲各國全面擴展相關的商機(如接收器製造, 供應, 服務)，進而創造全新的商業機會





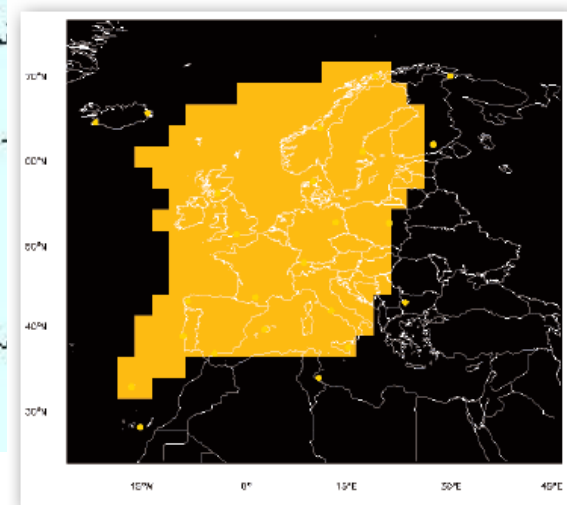
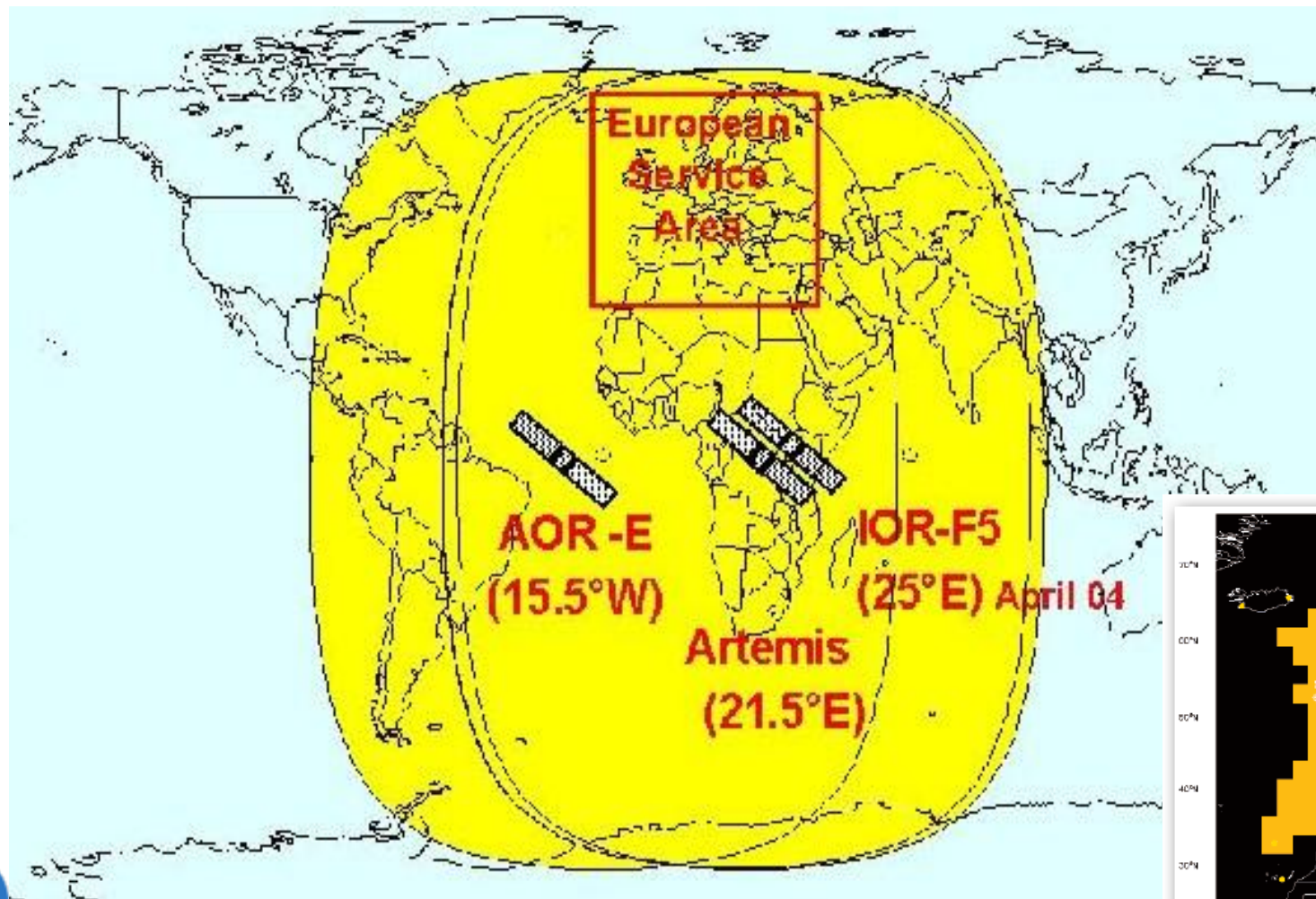
Galileo發展歷程(GNSS-1)

- GNSS-1衛星計畫(1995-2004)稱為EGNOS (European Geostationary Navigation Overlay Service) ，目前已投入運行中
- EGNOS可提供空中和地面服務外，還包括相關技術基礎及對衛星導航系統的瞭解
- EGNOS是在GPS衛星的L1頻率中傳送完整的即時定位資訊信號，以補強GPS和GLONASS定位功能
- EGNOS含三個地球同步衛星，涵蓋範圍含整個歐洲，並可延伸至美洲、非洲、以及部份的亞洲及澳洲地區





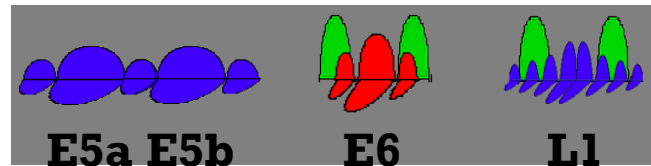
EGNOS作業涵蓋區





Galileo發展歷程(GNSS-2)

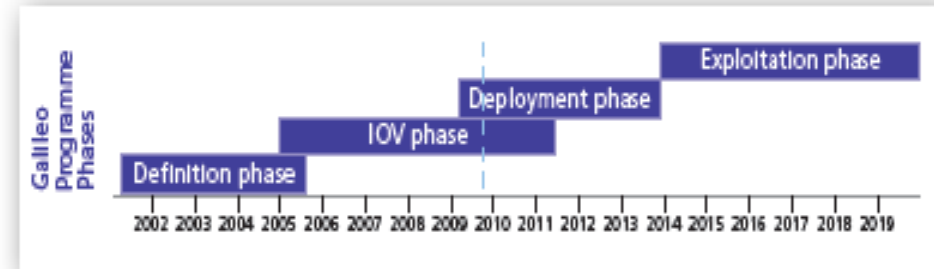
- GNSS-2衛星計畫(1999-2008)稱為Galileo，它將是歐盟所發展的最先進導航衛星系統，並可與GPS與GLONASS同時提供高精度的導航定位服務
- Galileo所設計的特殊規格(如三頻觀測量)，將可有效提高其在全球導航定位系統中的重要性
- Galileo能與GPS及GLONASS實現資訊互通，任何使用者皆可使用一個定位儀來接收各個導航衛星系統所傳送的信號資料，並經由各系統信號觀測資料的組合來完成較高精度的定位





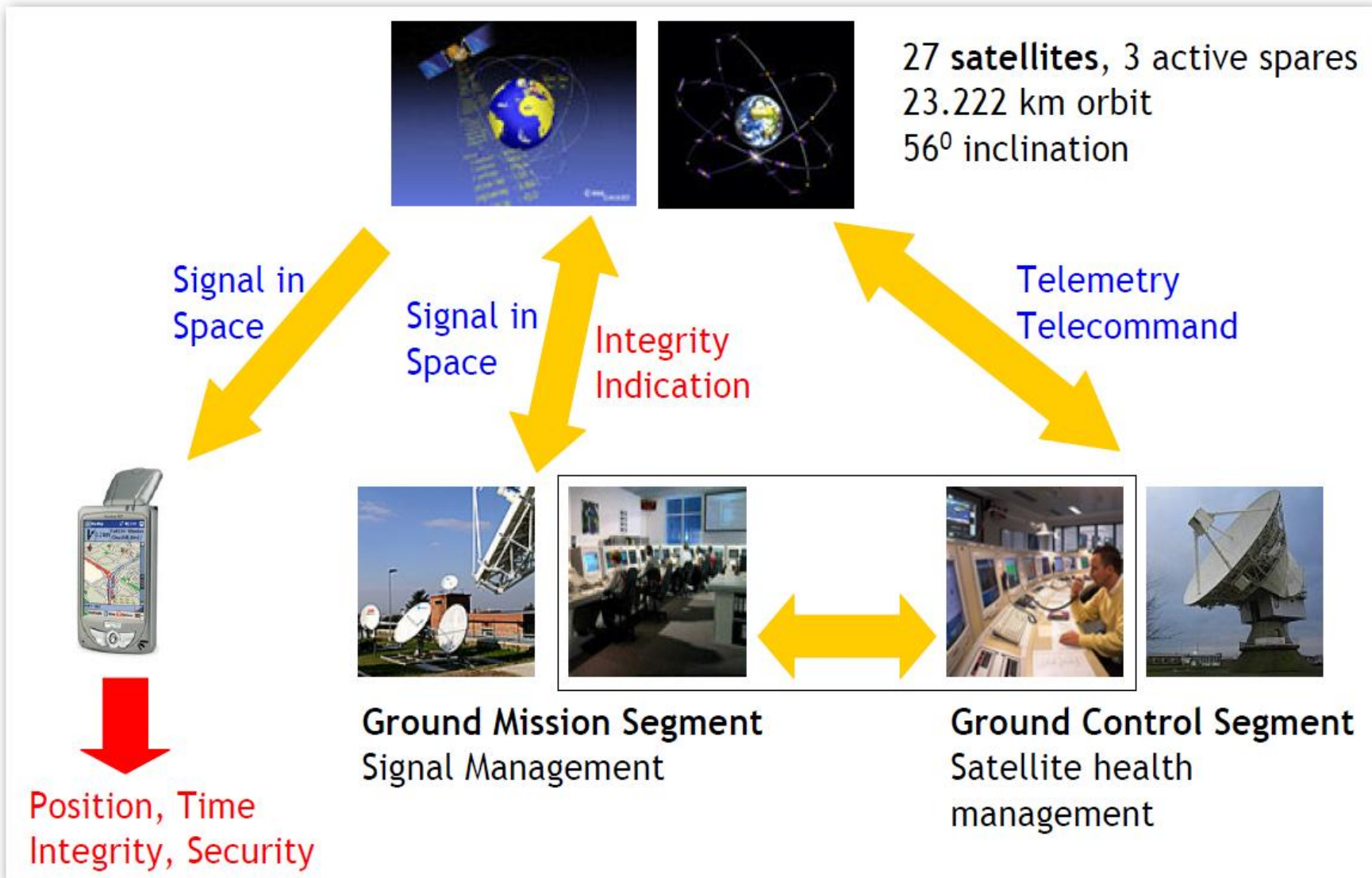
Galileo計畫推動程序

- 4 Phases:
 - **Definition Phase (定義階段)**
 - up to end 2005.5
 - Initial definition of the GAL
 - **In-Orbit Validation (驗證階段)**
 - 2005 through 2011.5
 - Consolidation of Mission Requirements
 - Development of satellites and ground based components
 - In Orbit validation
 - **Deployment (部署階段)**
 - 2009 through 2014
 - Construction and launch of satellites
 - Installation of complete ground segment
 - **Exploitation (運作階段)**
 - 2014 onwards





Galileo系統架構





Galileo太空單元

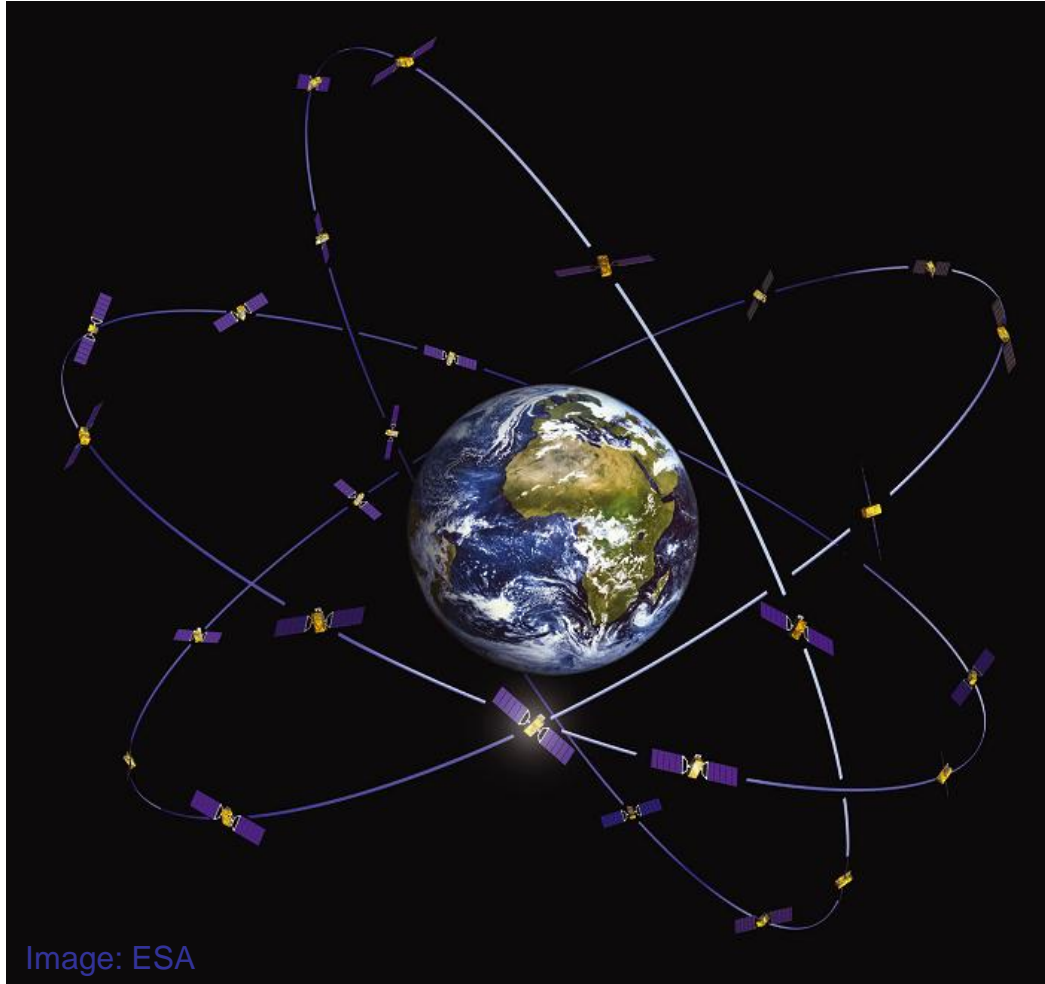


Image: ESA

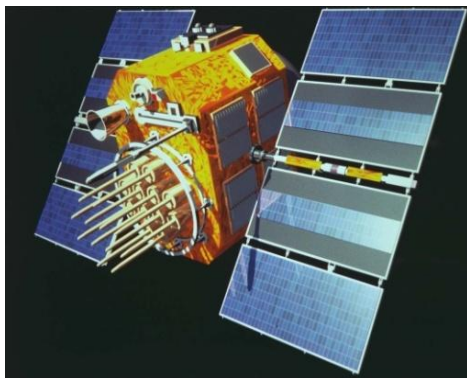
- ▶ Walker 27/3/1
+3 Active Spares
- ▶ Inclination 56°
- ▶ 29600.318 km Radii
- ▶ Period 14hr 4m 42s
Ground Track Repeat
10 days /17 Orbits
- ▶ 2 Rubidium, 2 PHM





Galileo衛星運作歷程

2003



GPS
Constellation



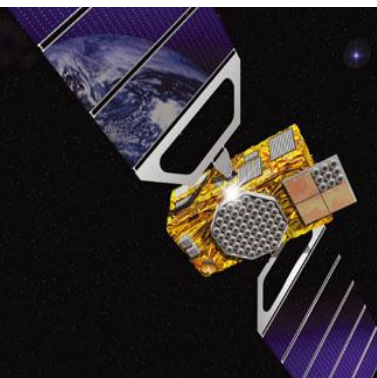
2005



Galileo Exp. SV
(2)



2008



Galileo In Orbit
Validation
Const. (4)



2014

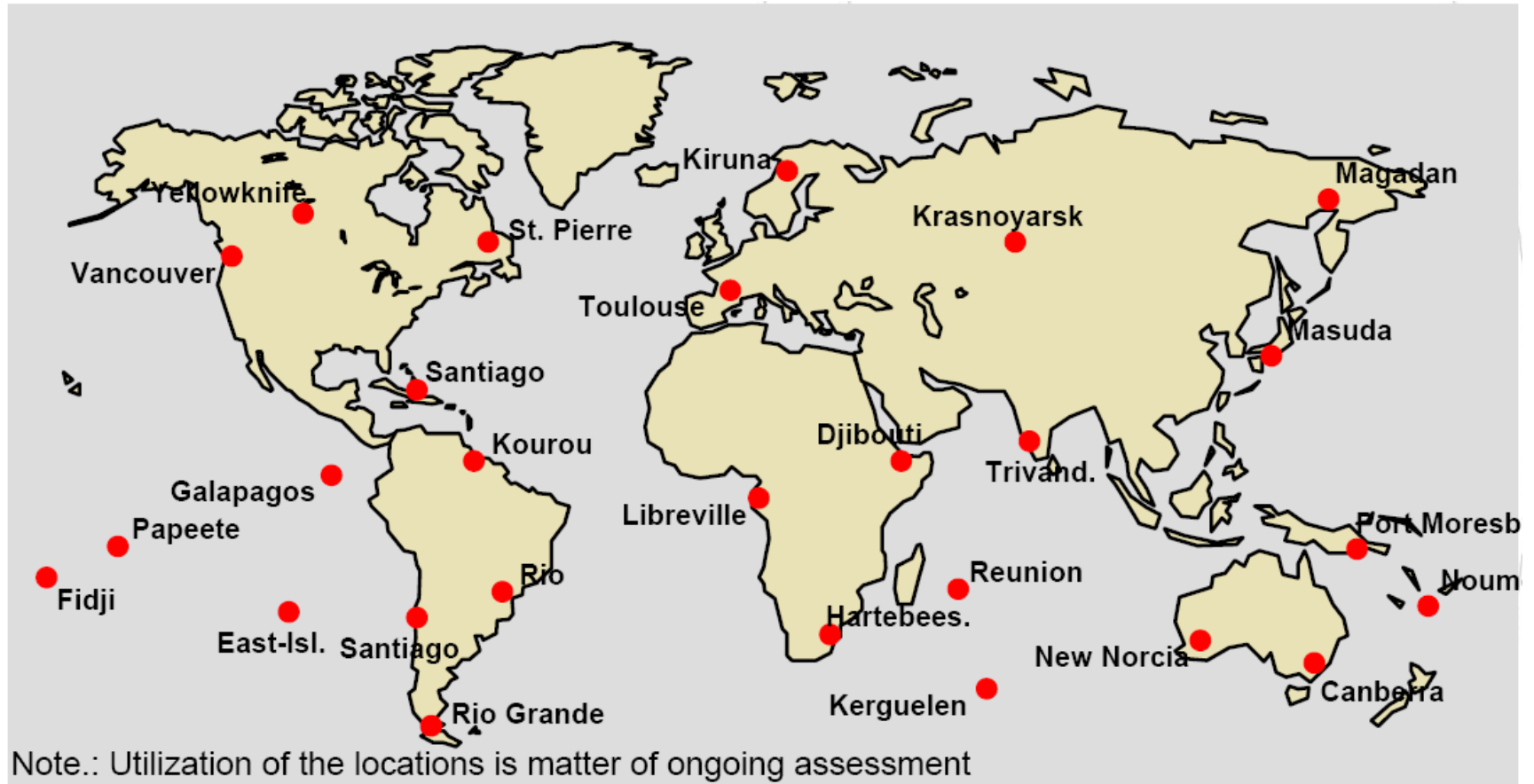


Galileo Full
Operational
Const. (30)





Galileo地面單元








- 全球布建30~40個監測站，將觀測資料透過通信網路傳至控制中心





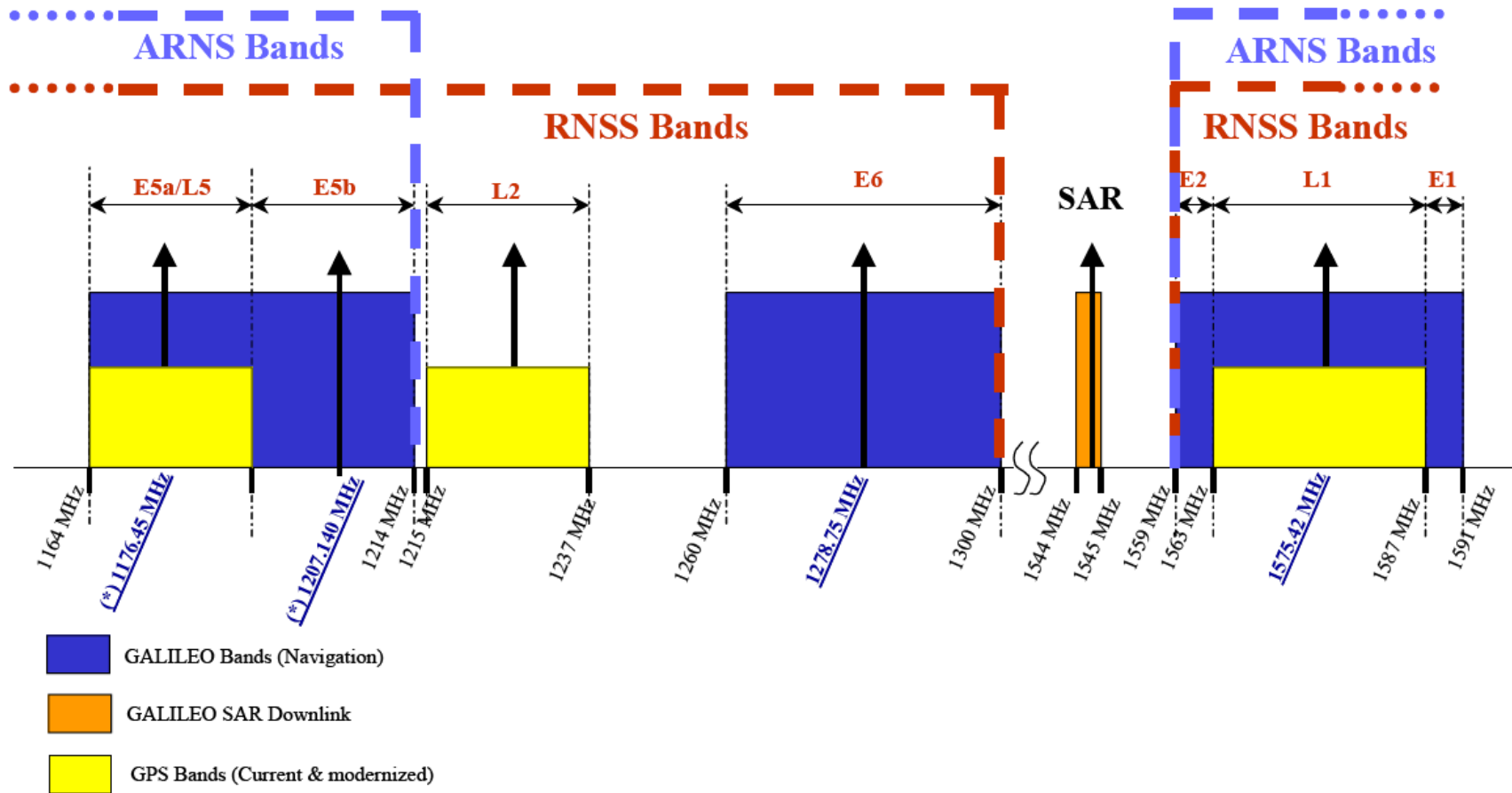
Galileo服務項目

Navigation	Open Service	Free service ; Mass market;	
	Commercial	Encrypted; sub metric accuracy (dedicated signals in E6 band); Guaranteed service-data via Internet	
	Safety of Life	Open Service + Integrity and Authentication of signal. Guaranteed service	
	Public Regulated	Encrypted; Integrity; Continuous availability	
SAR	Search and Rescue	Near real-time; Precise; Return link feasible	





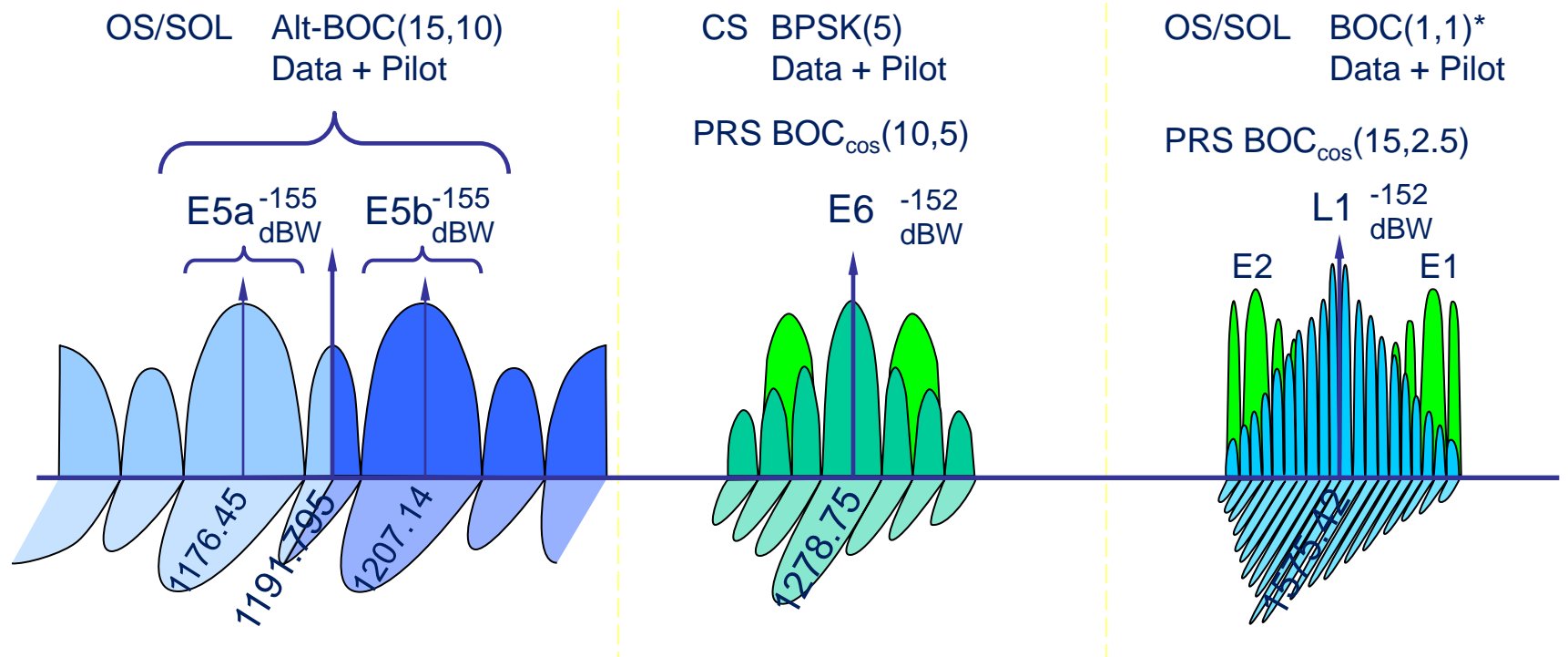
Galileo信號頻率





Galileo信號

➤ 10 Navigation Signals - Right Hand Circularly Polarised



Commercial Service (CS)
Open Service (OS)

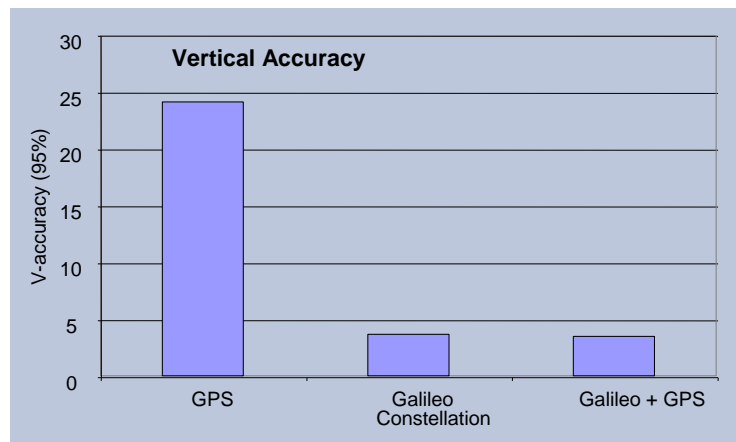
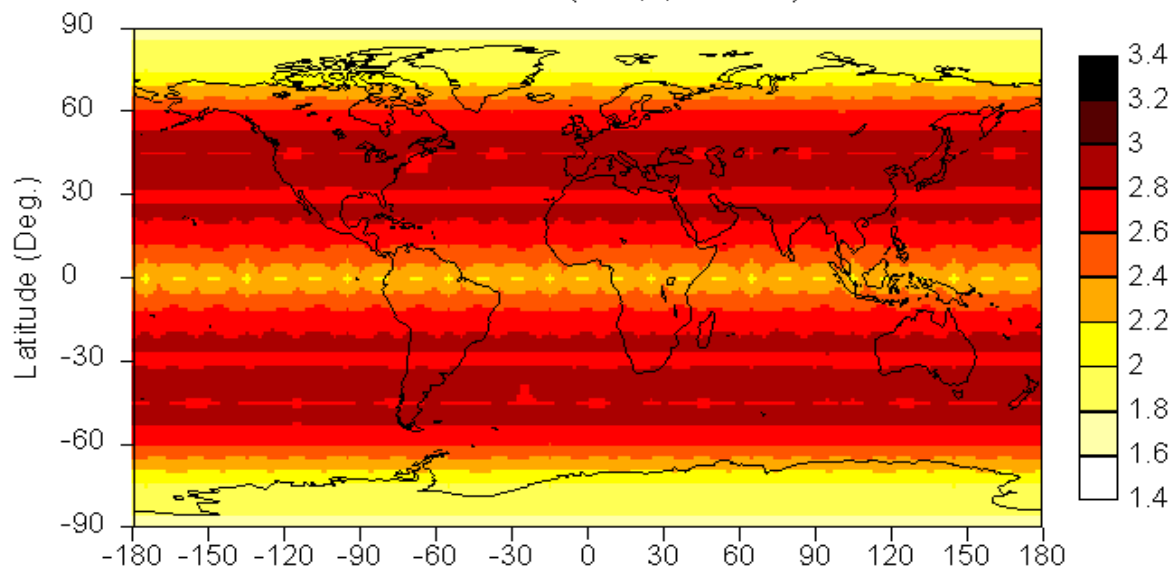
Public Regulated Service (PRS)
Safety Of Life Service (SOL)

* BOC(1,1) or Optimised CBCS





Galileo預期定位精度



Horizontal Accuracy

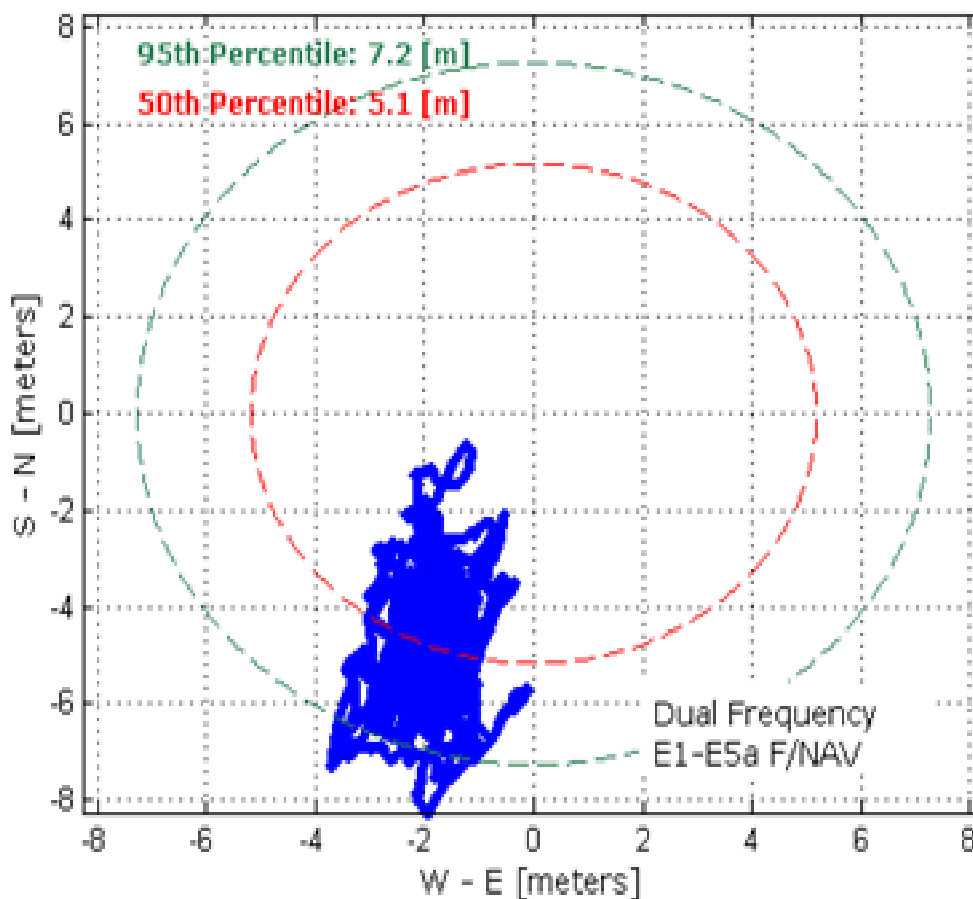
	1 frequency	2 frequencies
Horizontal Positioning (95%)	15 [m]	4 [m]
Vertical Positioning (95%)	35 [m]	8 [m]
Velocity (95%)	0.5 [m/sec]	0.2 [m/sec]
Timing with respect to UTC	30 [nsec]	30 [nsec]
Global availability	99.8 %	99.8%





第一組定位測試資料(歐洲)

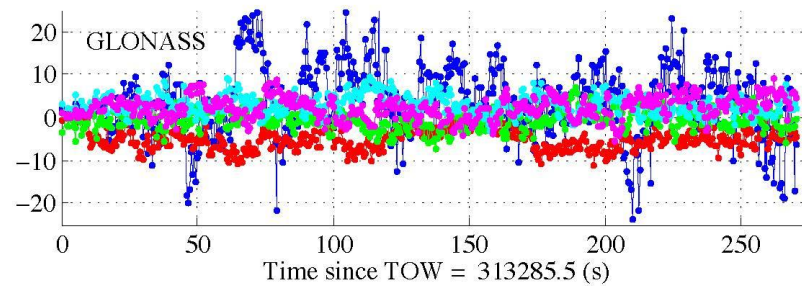
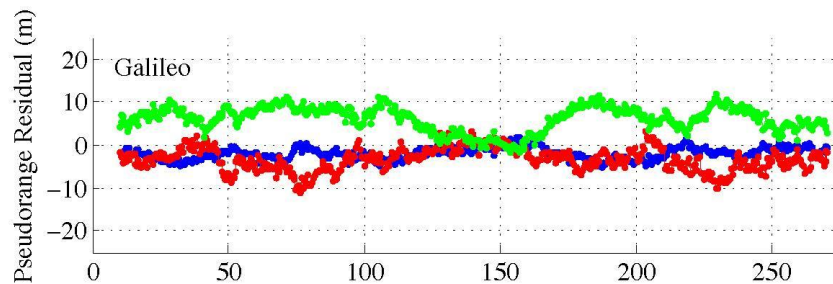
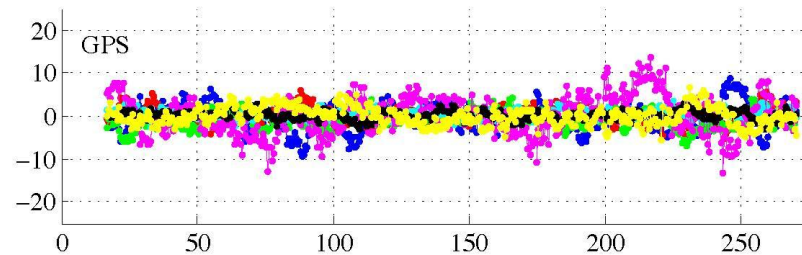
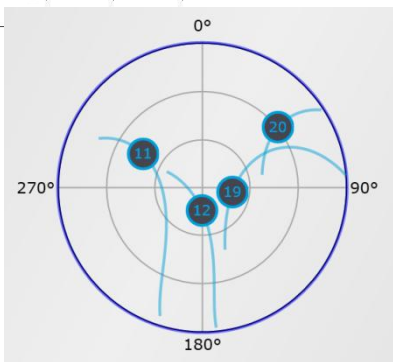
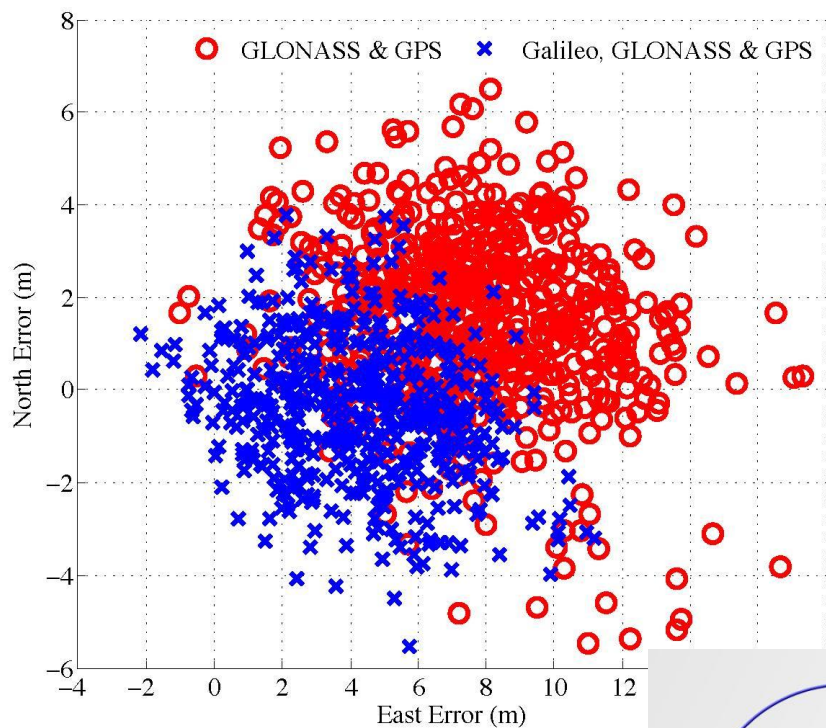
- 2013/3/12 – Noordwijk, the Netherlands





第一組定位測試資料(北美)

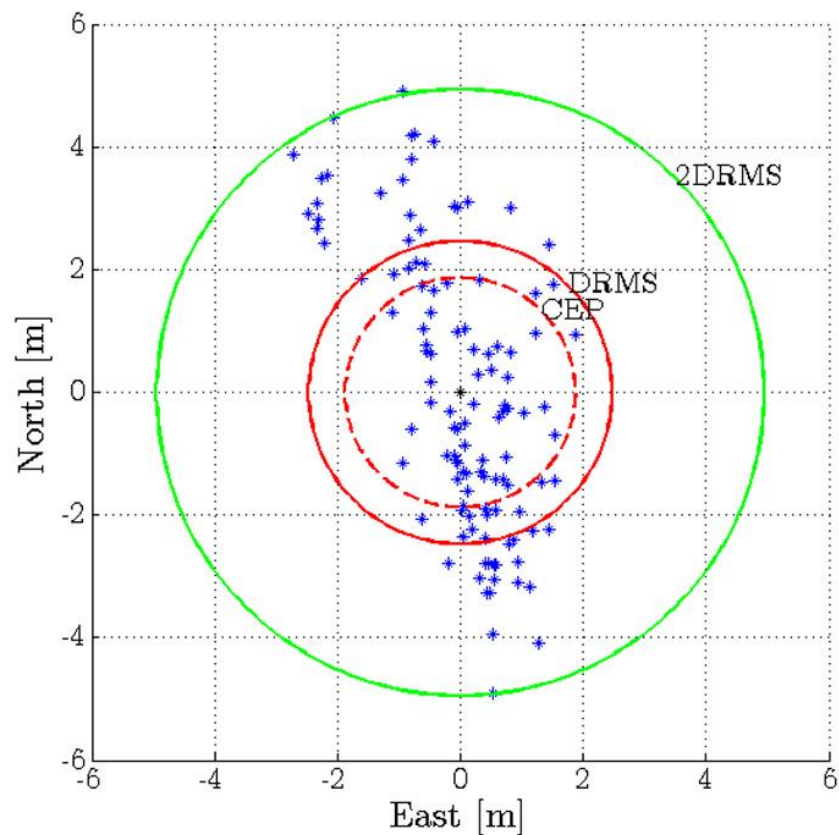
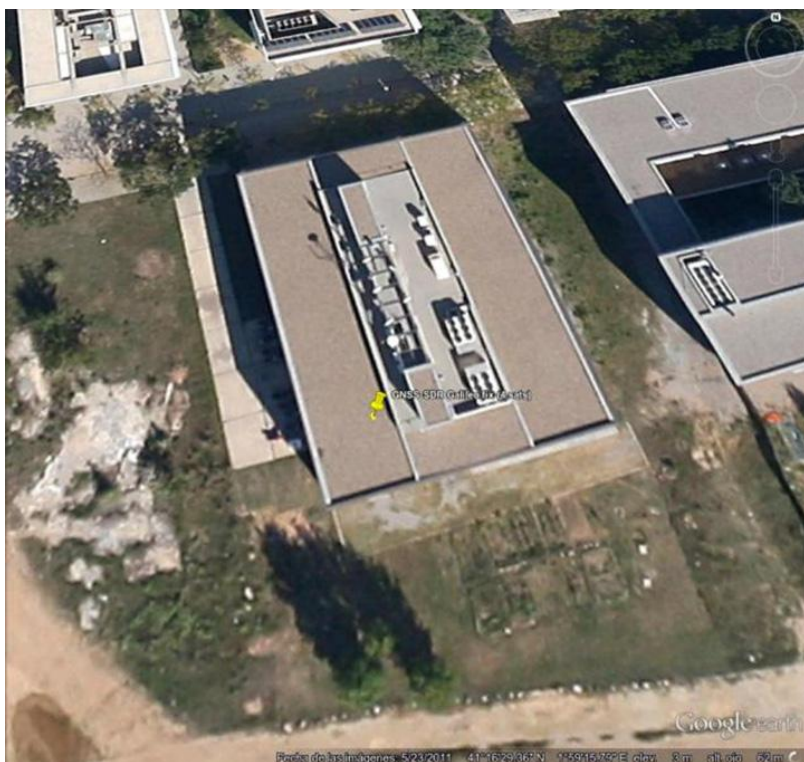
• 2013/3/12





第一組即時定位資料(歐洲)

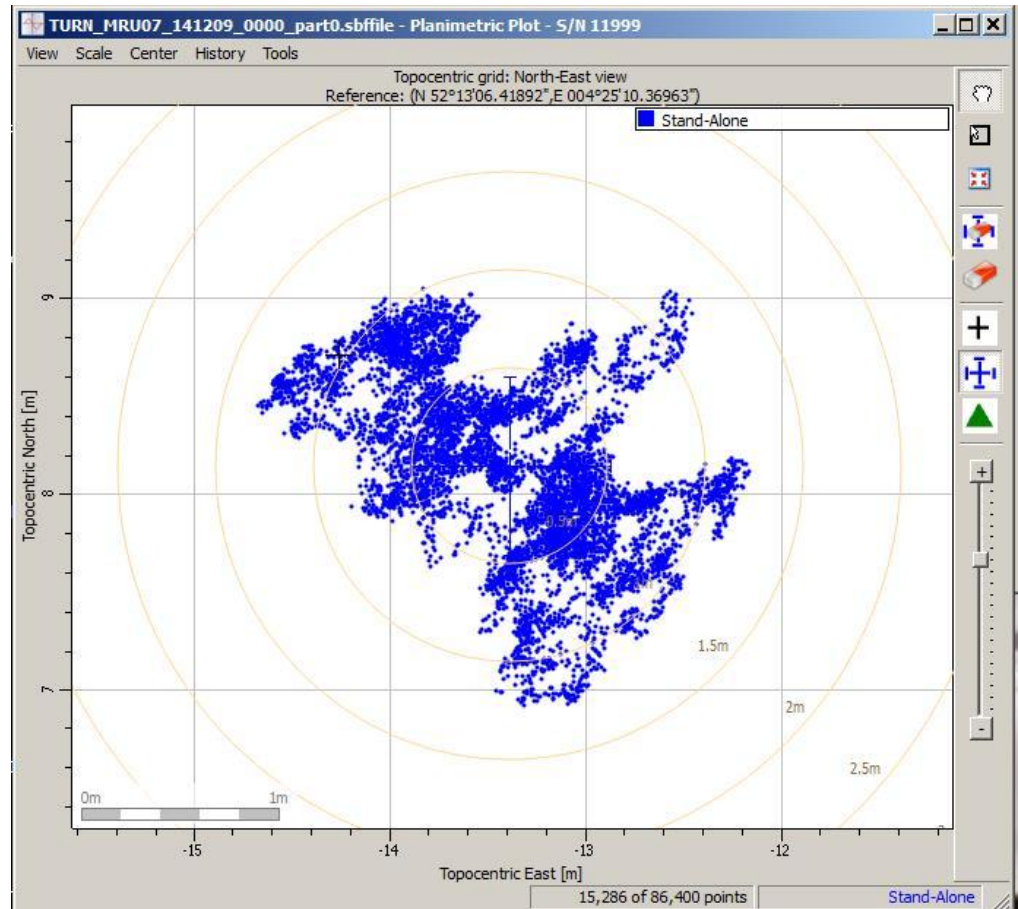
- 2013/11/10 15:52:14 UTC





加入第五顆(修正軌道)衛星定位

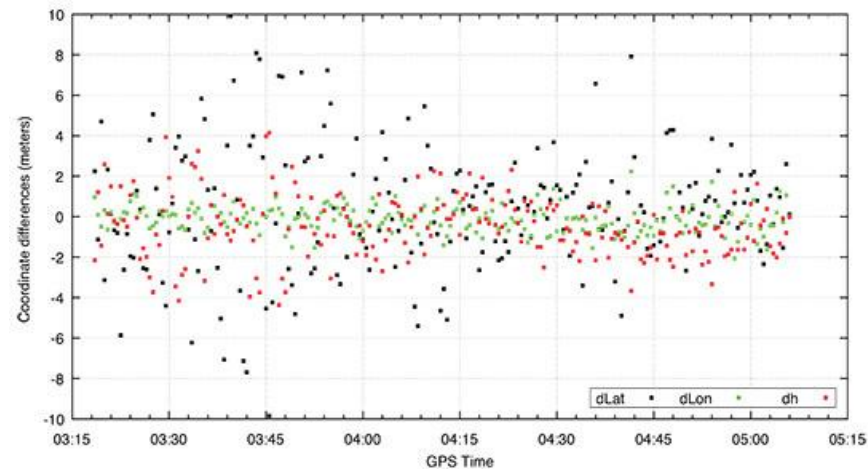
- Position fixes made by France's CNES space agency in Toulouse, France, on 9 Dec. 2014 with Galileo's fifth satellite, recently salvaged from the wrong orbit to begin navigation testing (better than 2 m).



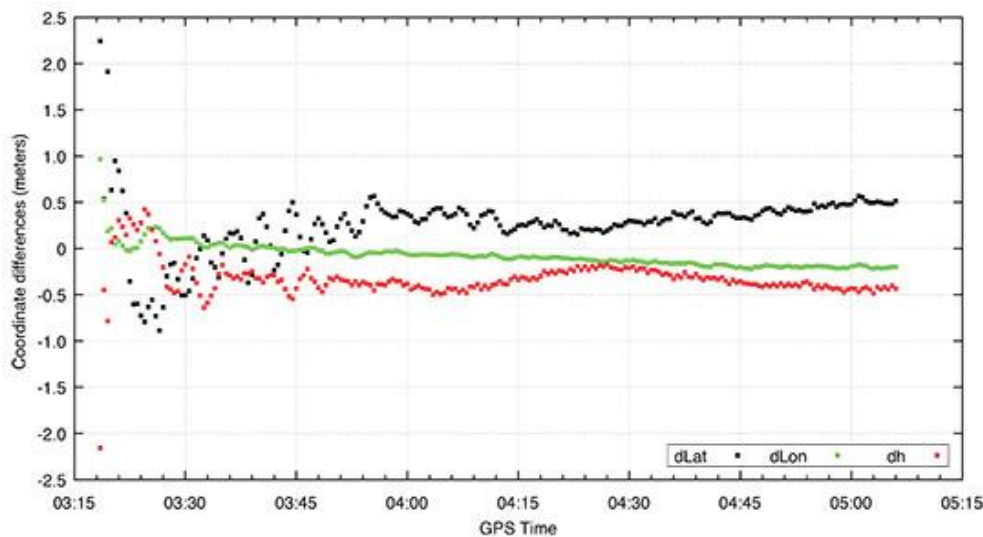


單點定位成果

Solution	Latitude [m]	Longitude [m]	Height [m]
Code only	3.084	0.658	1.617
Code and phase (PPP)	0.422	0.150	0.389
Phase only (from known point)	0.041	0.009	0.045



code only



code and phase





艱困環境定位測試

	Urban Canyon #1	Urban Canyon #2
GPS	331.9m	76.2m
GPS+GLONASS	42.9 (13%)	7.6m (10%)
GPS+Galileo	10.7 (3%)	5.4m (7%)
GPS+GLONASS+Galileo	43.0 (13%)	24.7m (32%)
<i>Positive numbers indicate improvement over GPS.</i>		

	Indoor #1	Indoor #2
GPS	278.7m	70.3m
GPS+GLONASS	68.4m (25%)	11.8m (17%)
GPS+Galileo	24.6m (9%)	10.1m (14%)
GPS+GLONASS+Galileo	64.0m (23%)	15.8m (23%)
<i>Positive numbers indicate improvement over GPS.</i>		





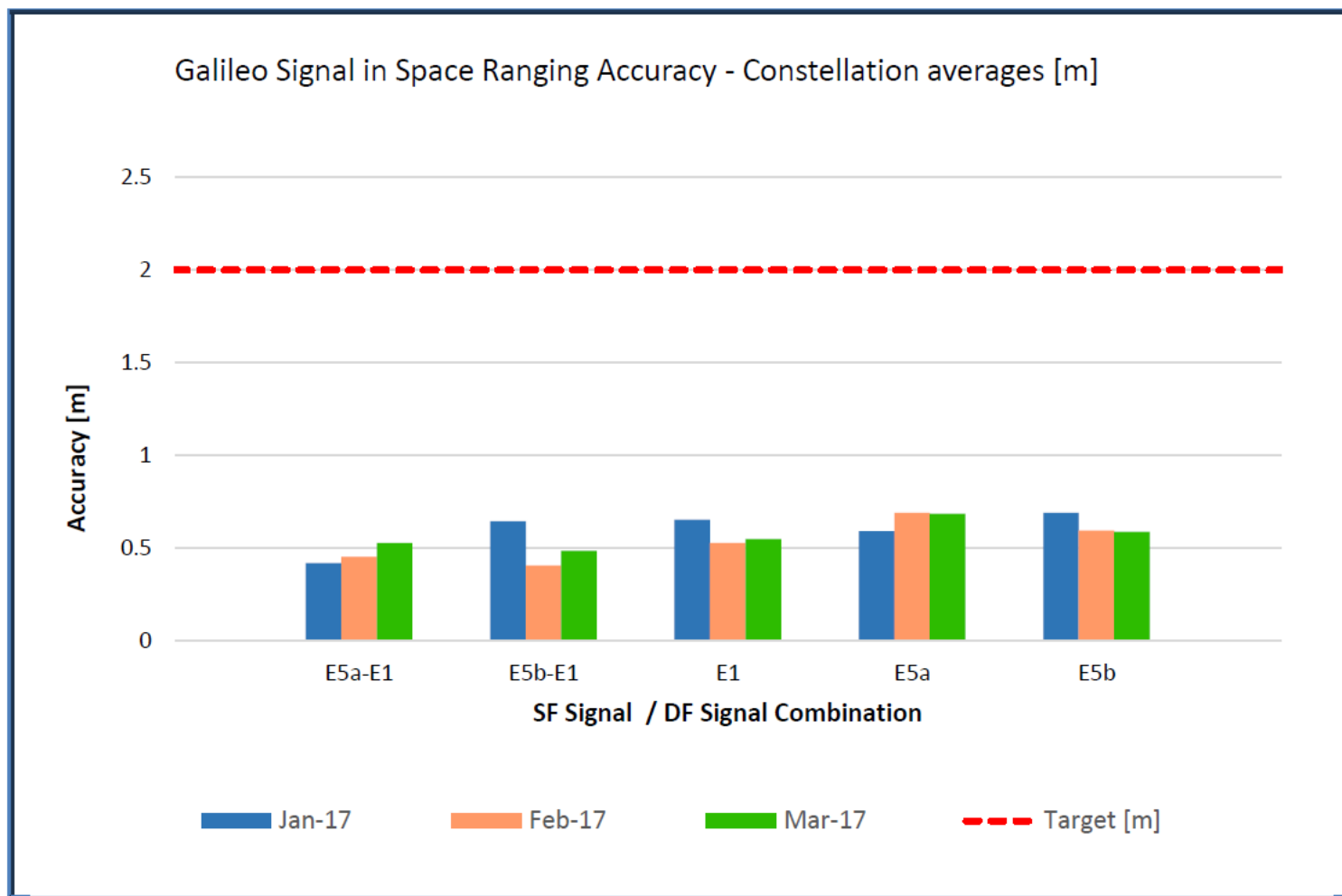
2017年Q1-IOC階段(衛星數)

Satellite Code	SV ID (PRN)	CCSDS ID [hex]	Orbital Slot	Status
GSAT-0101	11	3A5	B05	Available
GSAT-0102	12	3A6	B06	Available
GSAT-0103	19	3A7	C04	Available
GSAT-0203	26	263	B08	Available
GSAT-0204	22	264	B03	Available
GSAT-0205	24	265	A08	Available
GSAT-0206	30	266	A05	Available
GSAT-0208	8	268	C07	Available
GSAT-0209	9	269	C02	Available
GSAT-0210	1	26A	A02	Available
GSAT-0211	2	26B	A06	Available





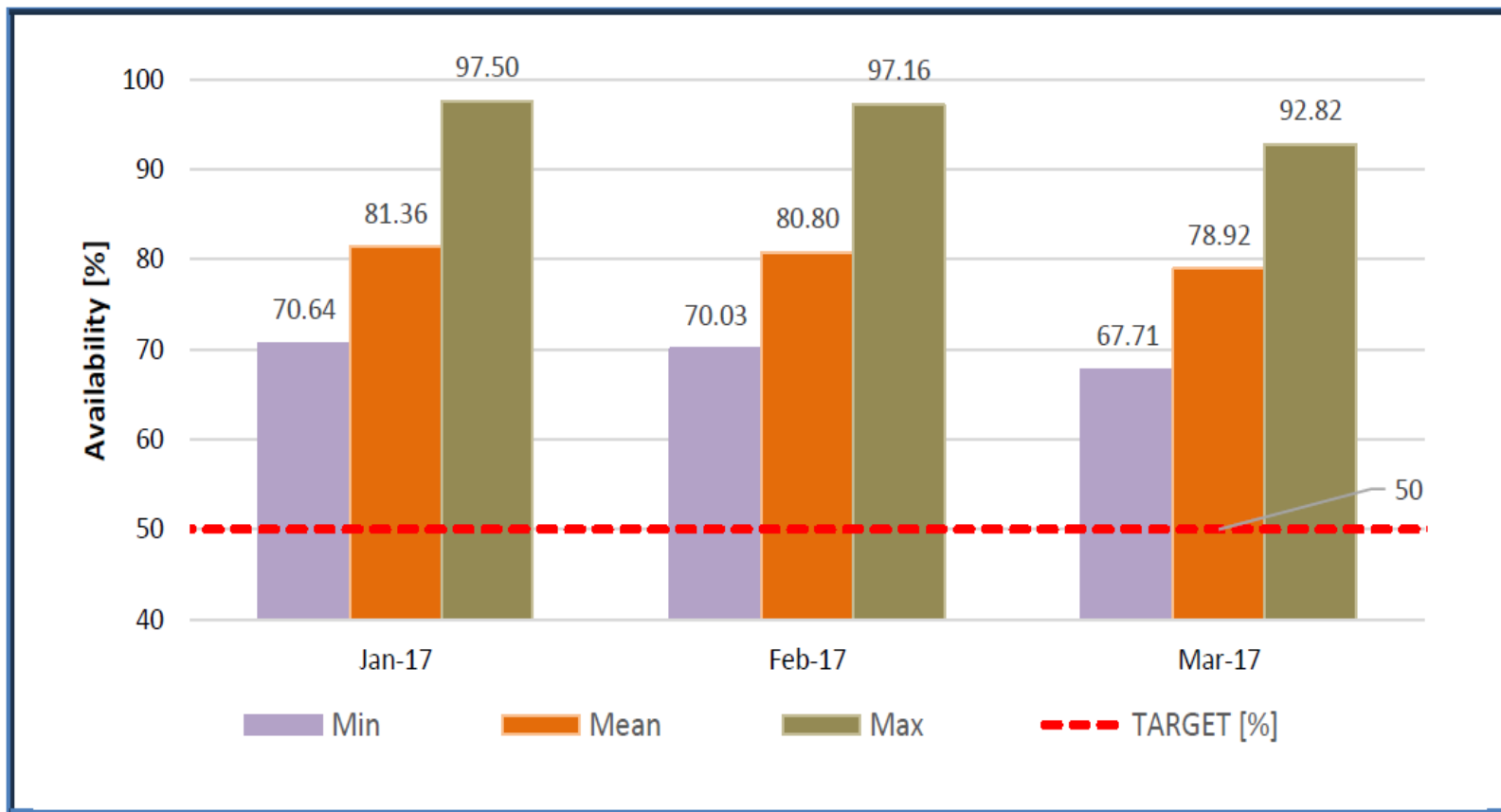
2017年Q1-IOC階段表現(SIS距離)





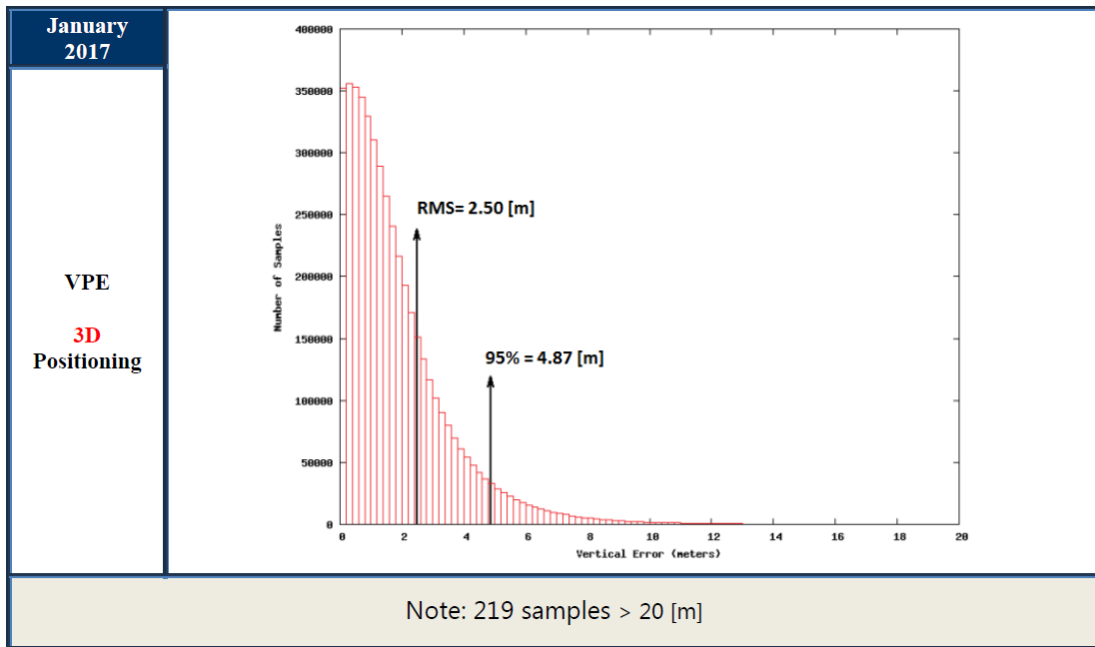
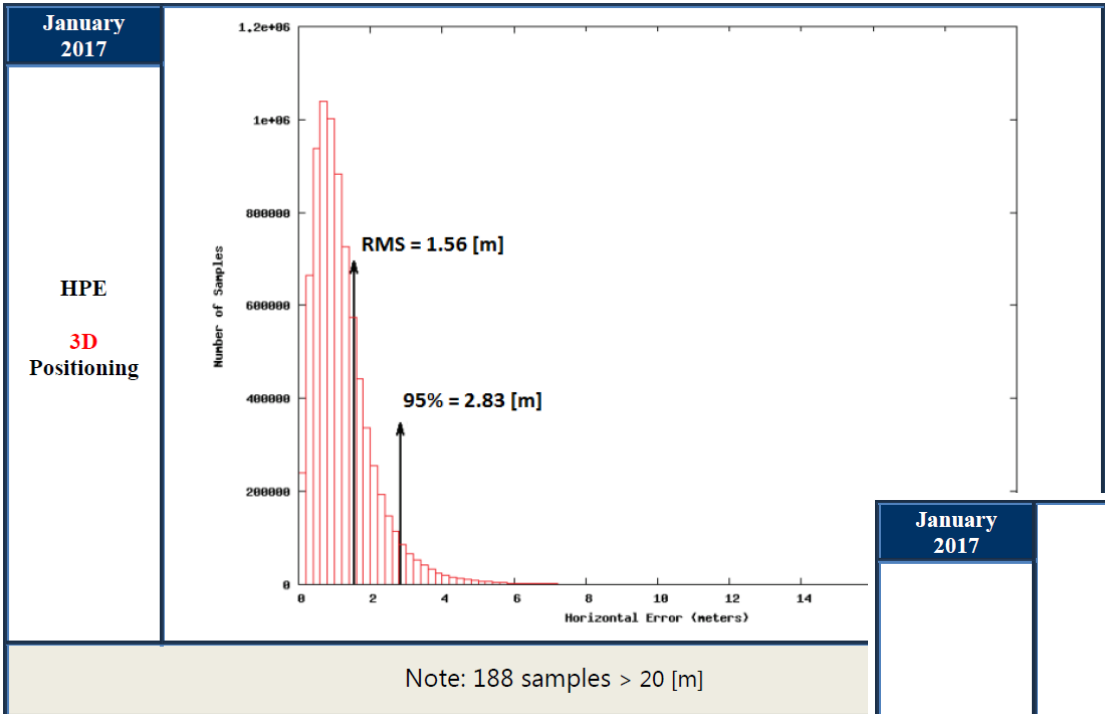
2017年Q1-IOC階段表現(可用性)

HDOP<5





2017年Q1-IOC階段表現(定位精度)





健行科技大學
Chien Hsin University of Science and Technology

北斗導航衛星系統

Chien Hsin University of Science and Technology
Chien Hsin University of Science and Technology

好學  有禮



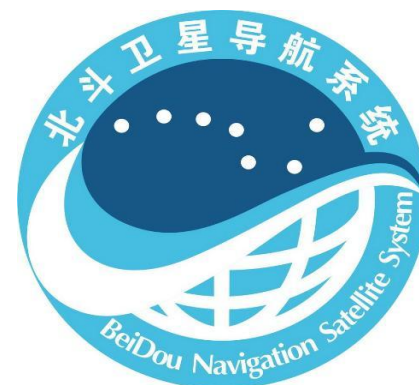


北斗導航衛星系統

Beidou Satellite Navigation System (BDS)

- 中國大陸自主發展、獨立運行的全球衛星導航系統。
- 系統建設目標：建成獨立自主、開放相容、技術先進、穩定可靠、覆蓋全球的衛星導航系統，可促進衛星導航產業鏈形成，形成完善的衛星導航應用產業，推動衛星導航在各行業的廣泛應用。

<http://www.beidou.gov.cn/>





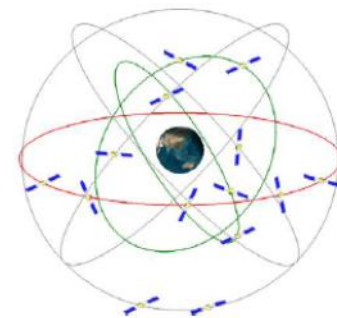
建置原則

- 開放性：北斗衛星導航系統的建設、發展和應用將對全世界開放，為全球用戶提供高品質的免費服務，積極與世界各國開展廣泛而深入的交流與合作，推動衛星導航技術與產業的發展。
- 自主性：自主建設和運行北斗衛星導航系統，北斗衛星導航系統可獨立為全球用戶提供服務。
- 相容性：在全球衛星導航系統國際委員會（ICG）和國際電信聯盟（ITU）框架下，使北斗衛星導航系統與世界各衛星導航系統實現相容與互操作，使所有用戶都能享受到衛星導航發展的成果。
- 漸進性：積極穩妥地推進北斗衛星導航系統的建設與發展，不斷完善服務品質，並實現各階段的無縫銜接。





組成單元



- 北斗衛星導航系統由空間段、地面段以及用戶段三部分組成
- 空間段包括5顆地球靜止軌道衛星(GEO)、3顆傾斜軌道同步衛星(IGSO)以及27顆非靜止中軌道衛星(MEO)
- 地面段包括主控站、注入站和監測站等若干個地面站
- 用戶段包括北斗用戶終端以及與其他衛星導航系統相容的終端





空間星座

- 5顆地球靜止軌道衛星(GEO): 定點於東經 58.75° / 80° / 110.5° / 140° / 160°
- 3顆傾斜軌道同步衛星(IGSO): 軌道高度36,000公里, 均勻分布在3個軌道, 傾角 55° , 星下點軌跡重合, 交叉點於東經 118° , 相位差 120°
- 27顆非靜止中軌道衛星(MEO): 軌道高度21,500公里, 均勻分布在3個軌道, 傾角 55°





地面控制

- 主控站：收集監測站觀測數據，進行數據處理，生成衛星導航電文、廣域差分及完整性訊息，任務調度，運行控管
- 注入站：上傳衛星導航電文、廣域差分及完整性訊息，進行有效載荷控管
- 監測站：衛星連續追蹤監測，接收導航信號，資料回傳主控站





時間及坐標基準

- 時間基準：BDT（北斗時）
 - 起始曆元：2006年1月1日 UTC 00:00:00
 - 時間聯繫：UTC (NTSC) 中國科學院國家授時中心
 - 錶差：導航電文播報
- 坐標基準：CGCS2000（中國2000大地坐標系統）
 - 長半徑：6378137.0 m
 - 扁率：1/298.257222101





規劃歷程

BDS-1
2000

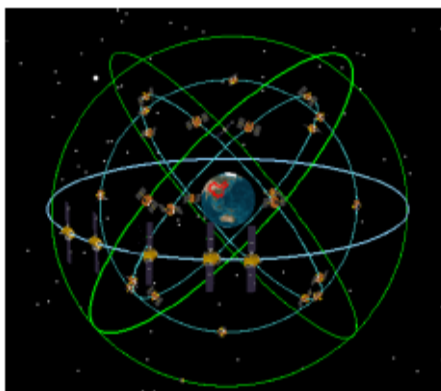
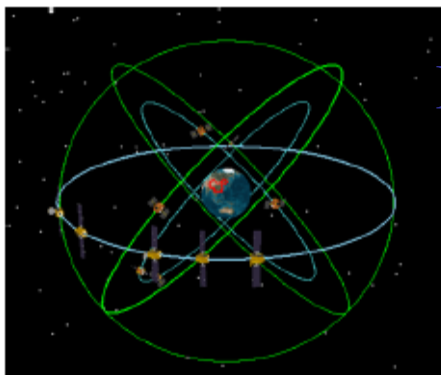
- 1994年啟動試驗系統建設

BDS-2
2012

- 2000-2003年發射試驗衛星
- 2004-2012年啟動系統工程建設
- 2012年，公布空間信號接口控制文件 (ICD B1I)

BDS
2020

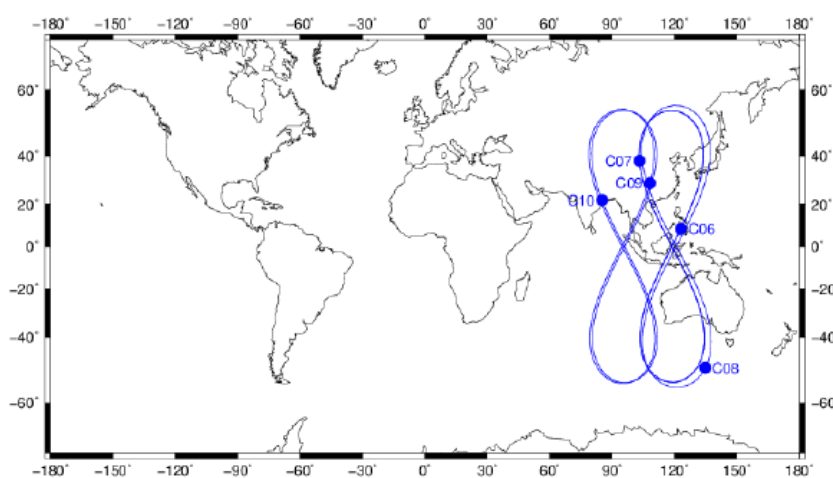
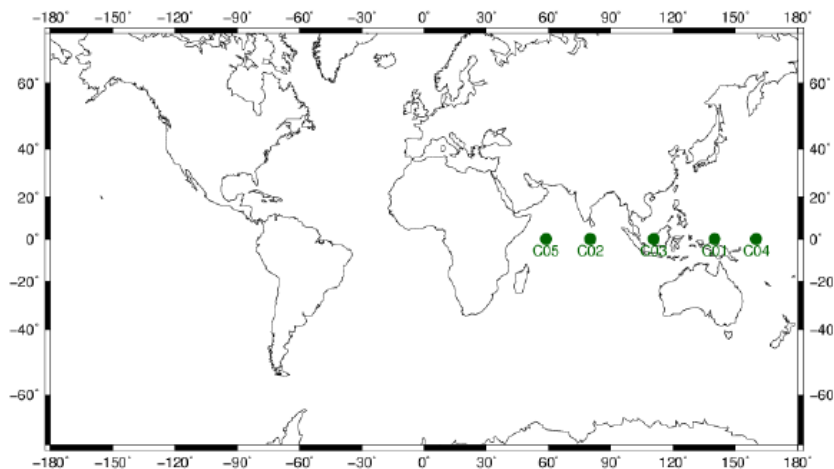
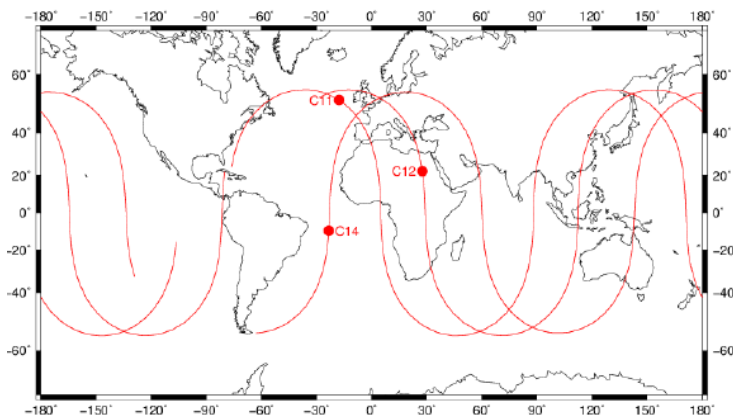
- 2012年，系統將首先具備覆蓋亞太地區的定位、導航和授時以及短報文通信服務能力 (5 GEO + 5 IGSO + 4 MEO)





規劃歷程

- 2013年，公布空間信號接口控制文件 2.0版(ICD B1I/B2I)及公開服務性能規範1.0版
- 2020年，建成覆蓋**全球**的北斗衛星導航系統 (3 GEO + 3 IGSO + 24 MEO)





北斗系統功能

- 四種類型服務：
 - 開放服務
 - 授權服務
 - 廣域差分服務
 - 短報文通信服務
- 開放服務：向全球用戶免費提供定位、測速和授時服務，定位精度10米，測速精度0.2米/秒，授時精度20奈秒。
- 授權服務：向中國及周邊地區用戶提供定位精度優於1米之廣域差分服務，120個漢字/次之短報文通信服務。





優勢潛力

- 可同時具備定位與通訊功能，無需其他通訊系統支援
- 可覆蓋中國及周邊國家和地區，具24小時全天候服務功能，無通訊盲區
- 特別適合用戶進行大範圍監控與管理，以及用戶資料之傳輸應用
- 可融合導航衛星和增益系統兩大資源，提供更豐富的增值服務
- 具自主、安全、可靠、穩定之系統設計，特別適合關鍵部門加以應用





信號設計(2010/06)

5 free “open services”

Signal	Carrier frequency (MHZ)	bandwidth (MHz)	PRN code chip rate (Mcps)	Signal modulation	Navigation data bit rate (bps)
B1	1561.098	4.092	2.046	QPSK	I: GSO: 500 NGSO: 50 Q: 500
B1-2	1589.742	4.092	2.046	QPSK	
B2	1207.14	24	10.23	QPSK	
B3	1268.52	24	10.23	QPSK	
B1-BOC	1575.42	16.368	1.023	MBOC (6, 1, 1/11)	50
B2-BOC	1207.14	30.69	5.115	BOC (10, 5)	
B3-BOC	1268.52	35.805	2.5575	BOC (15, 2.5)	
L5	1176.45	24	10.23	QPSK	





公開信號特性

- B1I 公開服務信號 ICD-B1I (1.0 版)
- 頻率：1561.098 MHz
- 信號調制：正交相移鍵控 (QPSK)
- 信號發射：右旋圓極化 (RHCP)
- 接收電平：-163 dBW
- 信號複用：碼分多址 (CDMA)
- 工作帶寬：(1 dB) 4.092 MHz
(3 dB) 16 MHz





公開信號特性

- B2I 公開服務信號 ICD-B2I (2.0 版)
- 頻率：1207.140 MHz
- 工作帶寬：(1 dB) 20.46 MHz
(3 dB) 36 MHz

B1、B2 信號由 I、Q 兩個支路的 “測距碼+導航電文”
正交調製在載波上所構成





導航電文

- 依據速率和結構不同，導航電文分為D1導航電文和D2導航電文
- D1導航電文速率為50bps，並調製有速率為1kbps的二次編碼，內容包含基本導航資訊（本衛星基本導航資訊、全部衛星曆書資訊、與其它系統時間同步資訊）
- D2導航電文速率為500bps，內容包含基本導航資訊和增強服務資訊（差分及完好性資訊和格網點電離層資訊）
- MEO/IGSO衛星的B1I和B2I信號播發D1導航電文，GEO衛星的B1I和B2I信號播發D2導航電文





導航電文主要內容

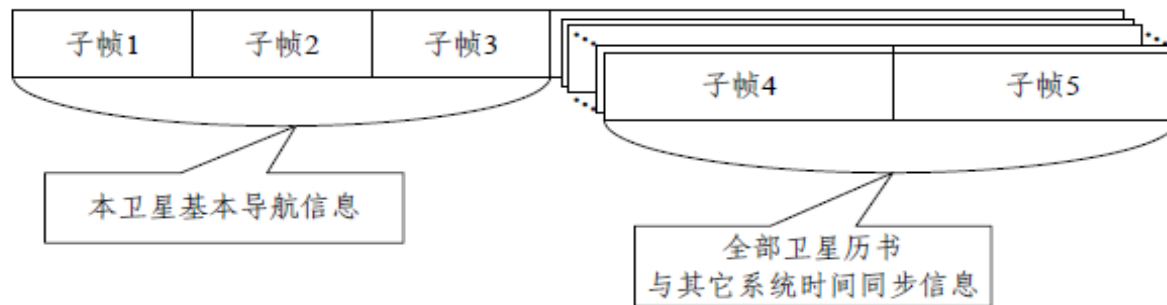
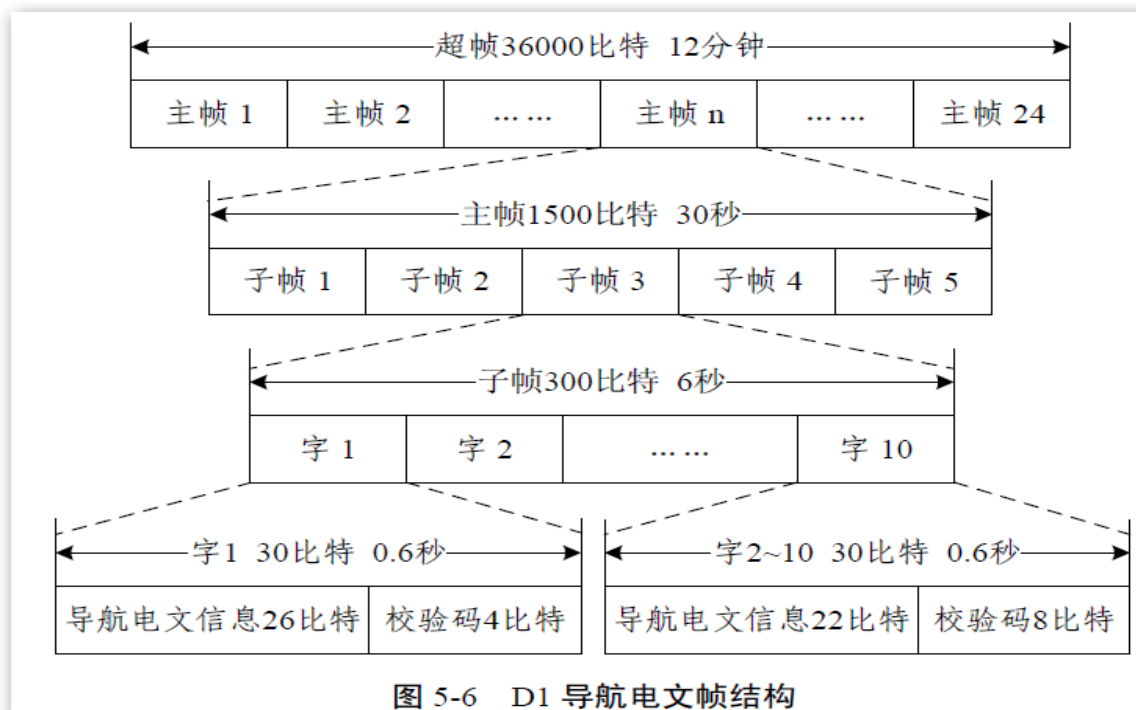
- 衛星星曆參數；
- 衛星鐘差參數；
- 電離層延遲模型改正參數；
- 衛星健康狀態；
- 用戶距離精度指數；
- 星座狀況（曆書資訊）等。





D1 導航電文

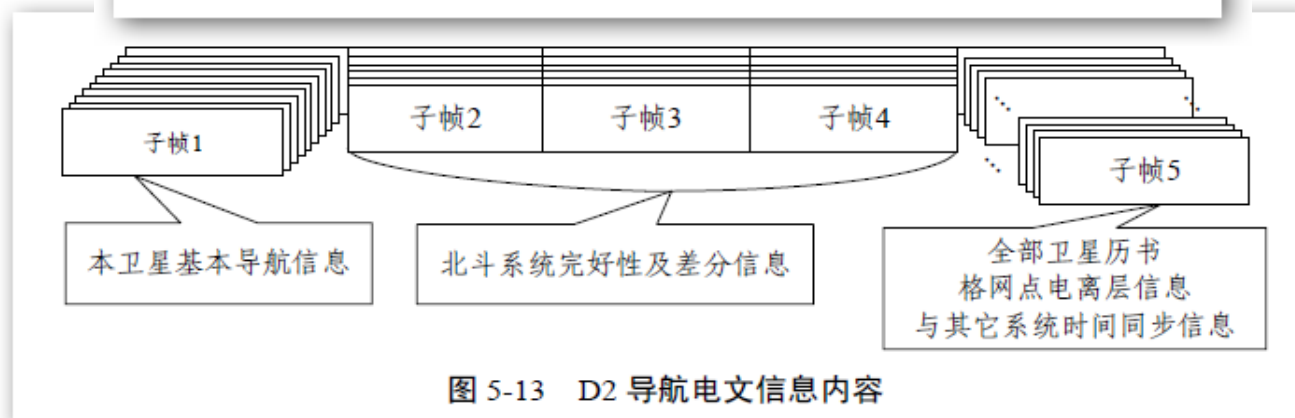
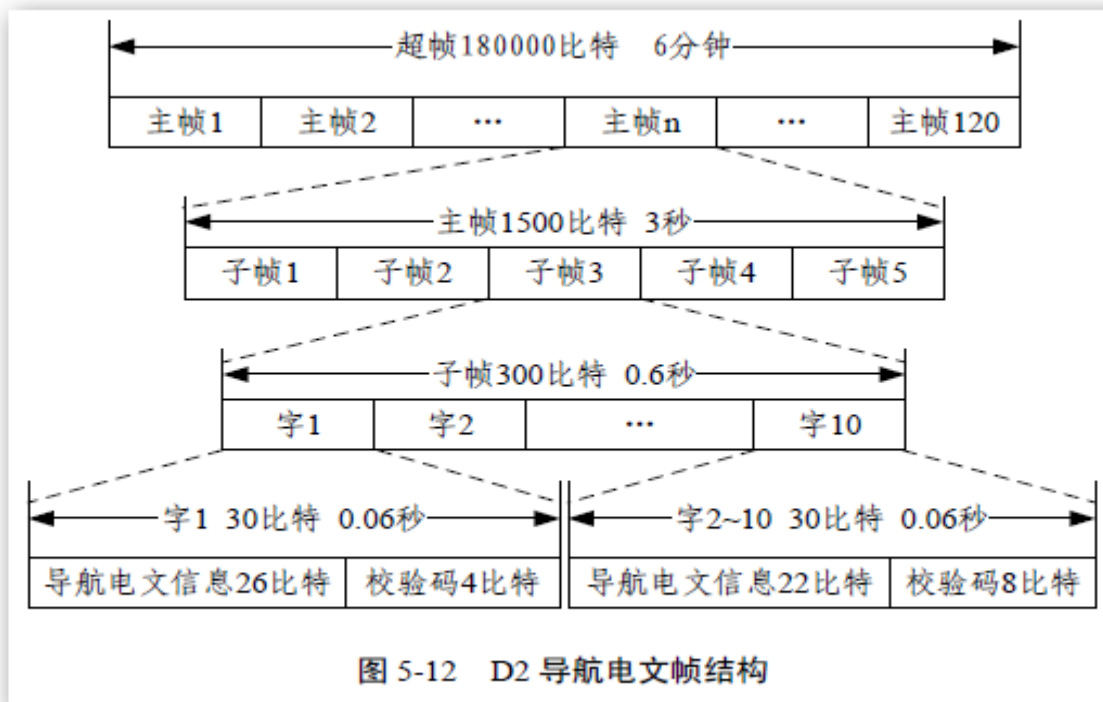
- MEO/IGSO 衛星 B1I 信號發送
- D1 提供衛星基本導航訊息
- 可供開放服務用戶使用





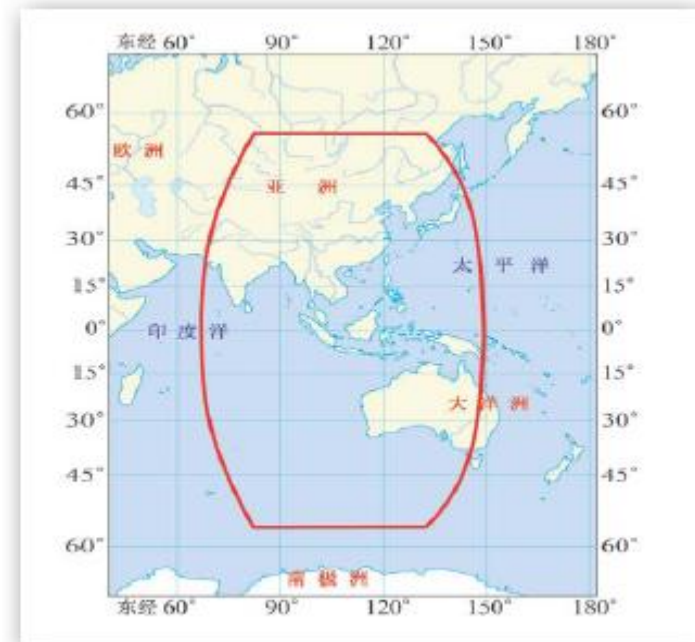
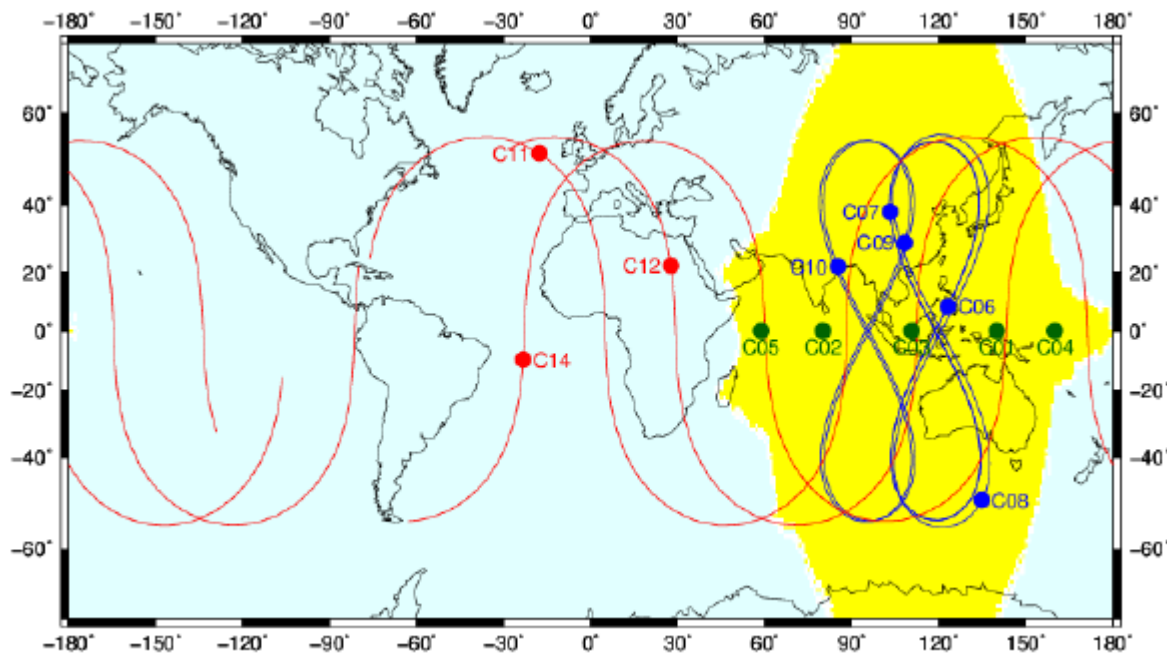
D2 導航電文

- GEO 衛星 B1I 信號發送
- D2 提供基本導航訊息及增強服務信息
- 可供授權服務用戶使用





區域性服務範圍





性能指標

- 覆球範圍內（高度1000km）100%
- 用戶最低接收功率大於-161dBW
- $URE \leq 2.5m$

表8 北斗系統服務區內公開服務定位/測速/授時精度指標

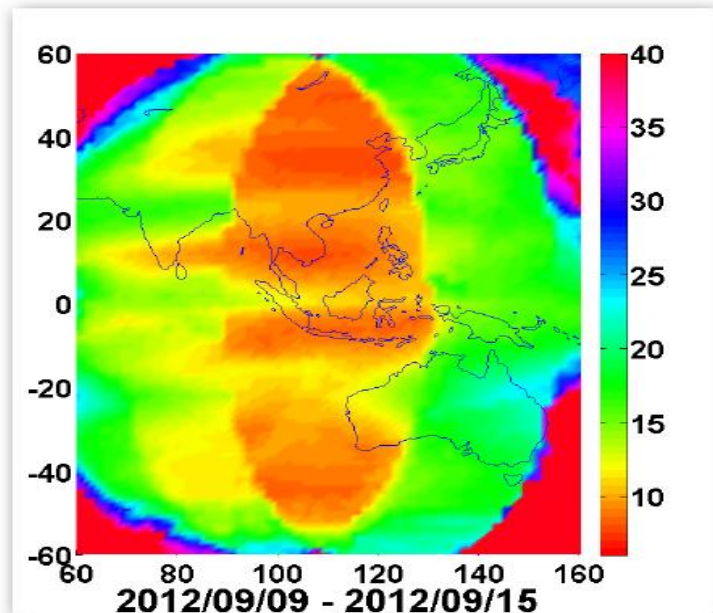
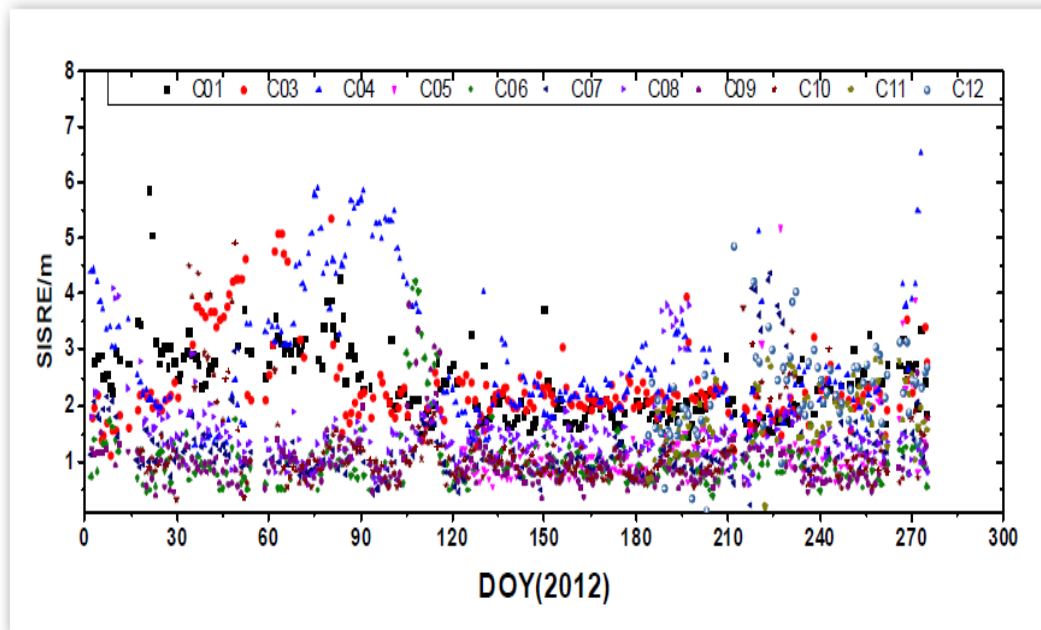
服務精度		參考指標 (95%置信度)	約束條件
定位 精度	水平	$\leq 10m$	服務區任意點 24 小時的定位/測速/ 授時誤差的統計值。
	垂直	$\leq 10m$	
測速精度		$\leq 0.2m/s$	
授時精度（多星解）		$\leq 50ns$	





測距精度(2013/05)

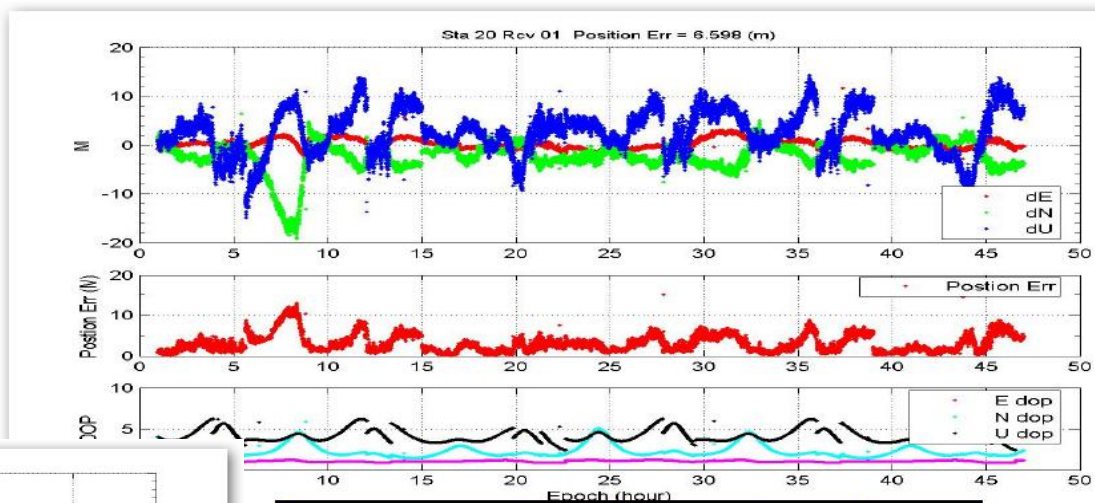
- URE = 1.2 - 1.4 m





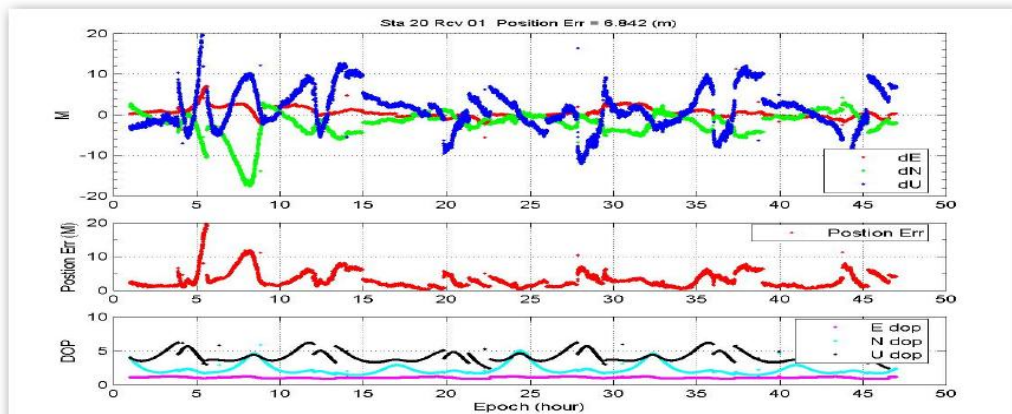
導航定位測試精度

D1單頻信號定位



RMS (m)	North	East	Up	3D
Open service	3.86	1.04	5.25	6.60
Authorized user	0.82	0.31	1.37	1.63

D1/D2雙頻信號定位

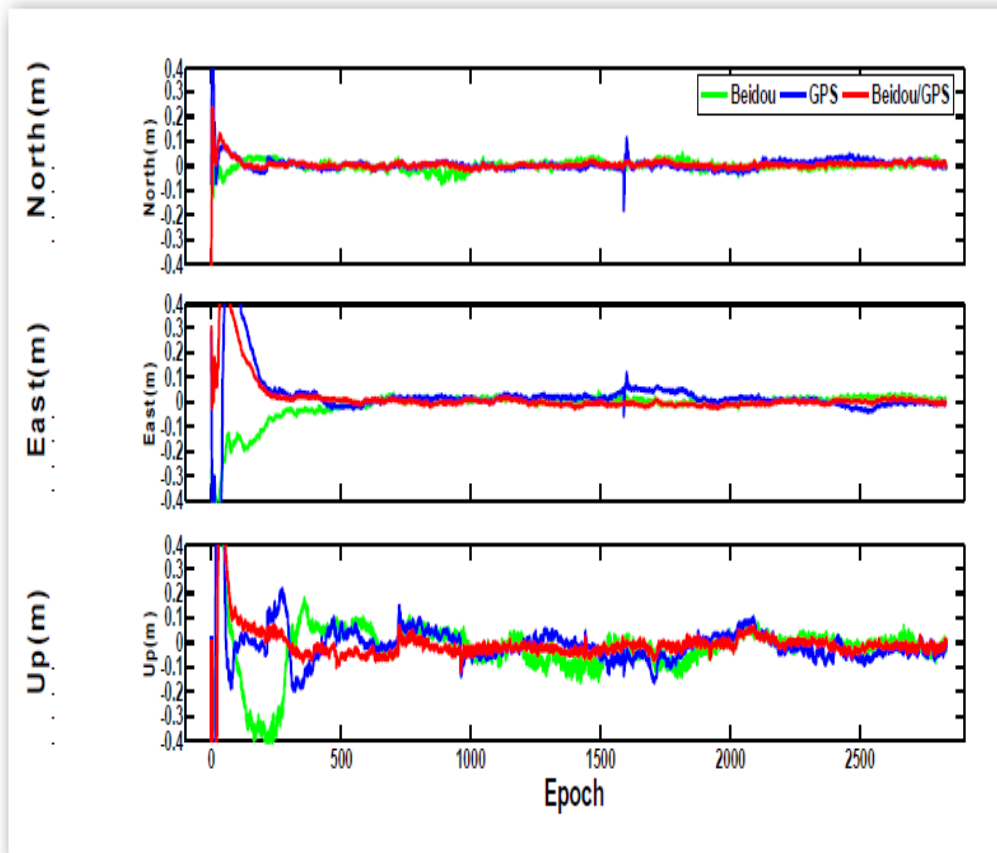


RMS (m)	North	East	Up	3D
Open service	3.85	1.31	5.51	6.84
Authorized user	1.81	0.48	3.55	4.02

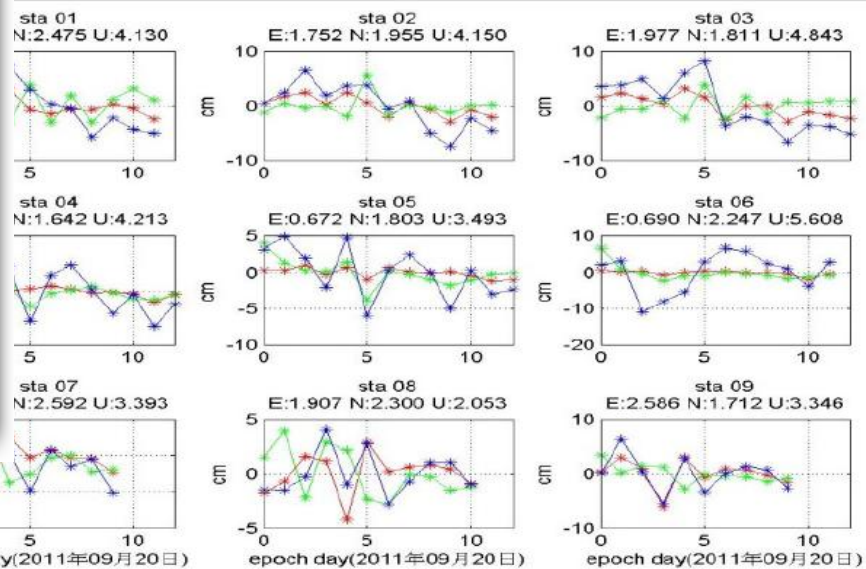




精密定位測試精度



即時動態定位(RTK)



精密單點定位(PPP)

	North	East	Up	3D
Repeatability(cm)	2.05	1.23	4.41	5.07





海外測站測試精度

- 2013/2/15 導航定位解
- 利用廣播星曆及全球電離層改正模型計算

Station (ID, Receiver)		GPS L1	GPS L1/L2	BDS B1	BDS B2	BDS B3	BDS B1/B2	BDS B1/B3	PDOP BDS
Singapore (SIN1,NetR9)	E	0.70 m	0.85m	0.78 m	0.89 m	0.90 m	1.36 m	1.14 m	
	N	0.87 m	0.59 m	0.98 m	1.35 m	1.22 m	0.93 m	1.13 m	
	U	1.71 m	2.04 m	2.16 m	3.50 m	3.52 m	2.34 m	3.13 m	
	3D	2.04 m	2.29 m	2.50 m	3.86 m	3.83 m	2.86 m	3.52 m	1.9





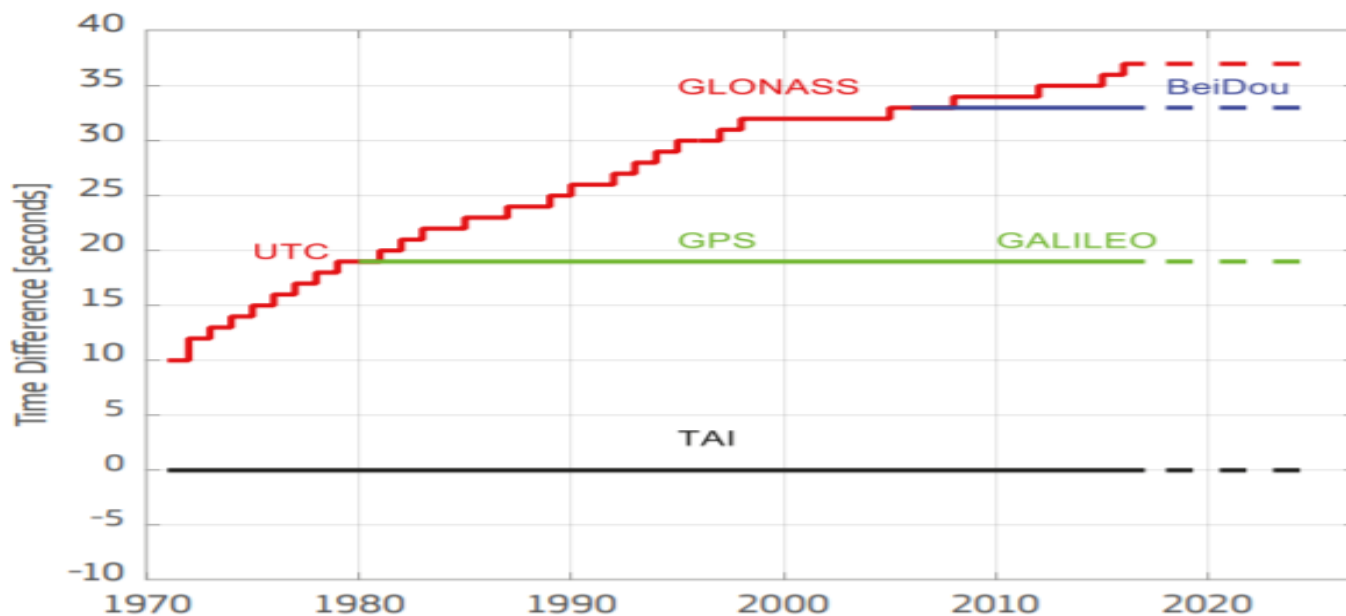
與GPS系統比較

Standard	GPS	BeiDou
URE accuracy	6m 95% ZAOD 7.8m 95% all AODs	2.5m ZAOD 95%
URRE accuracy	0.006m/s 95%	0.006m/s 95%
URAE accuracy	0.002mm/s 95%	0.002mm/s 95%
UTC OE	40ns 95%	2ns 95%
Continuity Unscheduled	0.9998/h	0.994/h
Advance Notice	NANU 48 hr	n/a
Unscheduled Notice	As soon as possible after event	n/a
Baseline Slot Availability	0.957	n/a
PDOP > 6	98% global 88% worst site	98% global
Horizontal Availability	17m 99% global 90% worst site	95% global
Vertical Availability	37m 99% global 90% worst site	95% global
Horizontal Accuracy 95%	9m	10m
Vertical Accuracy 95%	15m	10m
Time Transfer 95%	40ns	50ns





時間系統比較



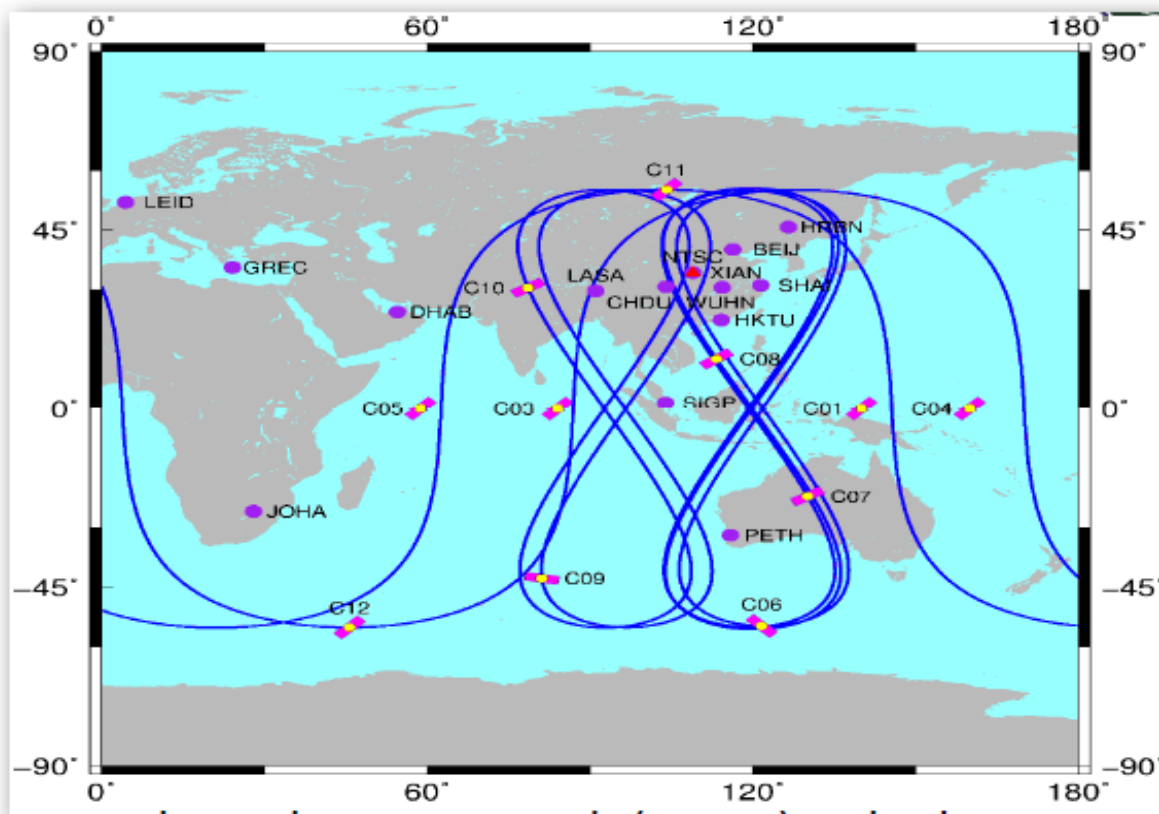
Systems	Relationship
GPST - TAI	$TAI = GPST + 19s$
GST - TAI	$TAI = GST + 19s$
GLONASST - TAI	$TAI = GLONASST - 3h + leapsecond_{UTC-TAI}$
UTC - TAI	$UTC = TAI - leapsecond_{UTC-TAI}$
BDT-TAI	$TAI = BDT + 33s$





國際合作

- Experimental Tracking Network
- 側重東協
- 巴基斯坦-監測站
- 泰國-CORS站
- 寮國-CORS站





十二五發展計畫

- 導航與位置服務科技發展專項
- 重點目標：核心技術、應用示範、體系框架、創新平台

类别↕	序号↕	指标↕	属性↕
科技↕	1.	完成一批关键技术、设备和系统 ↕ 定位/地圖/服務	約束性↕
	2.	为国家定位导航授时体系建设提供技术支撑↕	
	3.	申请 300 项专利↕	
经济↕	4.	直接形成 1000 亿以上的规模产业↕	预期性↕
社会↕	5.	初步建立 5 个高新技术产业化基地↕	約束性↕
	6.	培育 30 家创新型企业↕	
	7.	形成 10 个左右的示范和试验应用↕	

四、重点任务





發展訊息

- 完成北斗基礎產品(晶片、天線、OEM板)比測
- ICG-8C會議提報資訊發布及教育訓練議題
- 訂定2013-2015為產業挑戰期，年增長訂為35%，
五項重點領域：汽車前裝、智慧手機、高精度應用、
天地基一體、室內外融合
- 高通與三星結合之北斗定位智慧手機
- 高通4G LTE北斗定位晶片
- 完成海上搜救資訊系統示範工程





發展訊息

- 著手啟動高精度增益系統「中國精度(China CM)」計畫(北京合眾思壯科技公司負責)，建置全球參考站網，2015年提供公尺級精度免費服務，2017年提供公分級精度授權服務
- 公布「國家衛星導航產業中長期發展規劃」，訂定2020年產業規模達4000億人民幣，境內市場貢獻率60%，應用領域達80%





發展訊息

- 發布「室內外定位白皮書」，發展「羲和系統」，協助北斗進行高精度區域定位改正，建構用戶位置服務產品應用平台
- 此為十二五計畫成果之一，可應用在交通、物聯網、智慧城市、緊急救援等領域，目標在2020年達100個城市及2億用戶
- 機載抗干擾北斗衛星導航接收裝置通過技術鑑定

