



GPS Constellation Update and International Cooperation



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GPS



- **System Is Constant and Reliable**
 - Constant Upgrades
 - U.S. Air Force is the Steward... 24/7
 - Resolution is 6 Meters Contractual, Less than 1 Meter in Practice
 - Improved Performance Through Augmentation Systems
- **Interoperability a Key Feature**



Overview



- **System Improvements & Modernization**
 - – GPS Constellation Status
 - Next Steps for Space and Control Segments
- **Interoperability & International Collaboration**
- **Summary**



GPS Constellation Status as of 9 Mar 07



29 Healthy Satellites

Baseline Constellation: 24

- 14 Block IIA satellites operational
- 12 Block IIR satellites operational
- 3 Block IIR-M satellites operational
 - 5 additional IIR-M satellites to launch
- Since Dec 93, U.S. Government met/exceeded civil GPS service performance commitments
 - SPS Performance Standard (PS)
- U.S. committed to superior GPS service





IIR-15(M) Launch & ISS View

25 September 2006





IIR-16(M) Launch 17 November 2006





GPS constellation – Delivering excellent performance



	Orbital Slot	SVN	PRN	Block	URE
A-plane	A-1	39	9	IIA	1.11
	A-2	25	25	IIA	2.61
	A-2	52	31	IIR	0.14
	A-3	38	8	IIA	0.36
	A-4	27	27	IIA	2.13
B-plane	B-1	56	16	IIR	0.45
	B-2	30	30	IIA	2.06
	B-3	44	28	IIR	0.68
	B-4	35	5	IIA	0.6
	B-5	58	12	IIR	0.16
C-plane	C-1	36	6	IIA	1.05
	C-2	33	3	IIA	0.36
	C-3	59	19	IIR	0.38
	C-4	53	17	IIR	0.21
	C-5	37	7	IIA	0.69

	Orbital Slot	SVN	PRN	Block	URE
D-plane	D-1	61	2	IIR	0.6
	D-2	46	11	IIR	0.22
	D-3	45	21	IIR	0.69
	D-4	34	4	IIA	1.29
	D-6	24	24	IIA	1.08
E-plane	E-1	51	20	IIR	0.33
	E-2	47	22	IIR	0.5
	E-3	40	10	IIA	0.45
	E-4	54	18	IIR	0.49
F-plane	F-1	41	14	IIR	0.17
	F-2	26	26	IIA	0.09
	F-3	43	13	IIR	0.43
	F-4	60	23	IIR	0.23
	F-5	29	29	IIA	0.52
	F-6	32	1	IIA	1.08

Average URE from 30 GPS SVs: 0.71 m

NASA JPL data on Wed Feb 21 17:46:02 2007 (UTC)



Overview



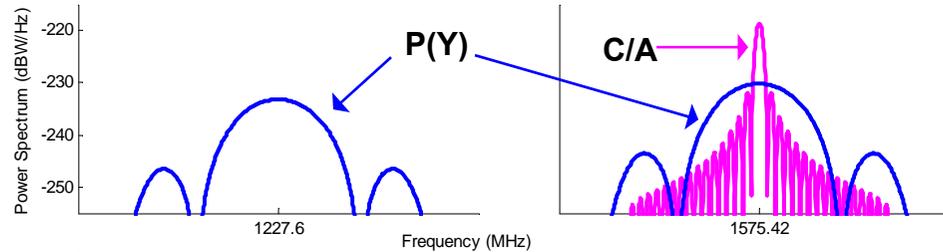
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GPS Modernization – Spectrum



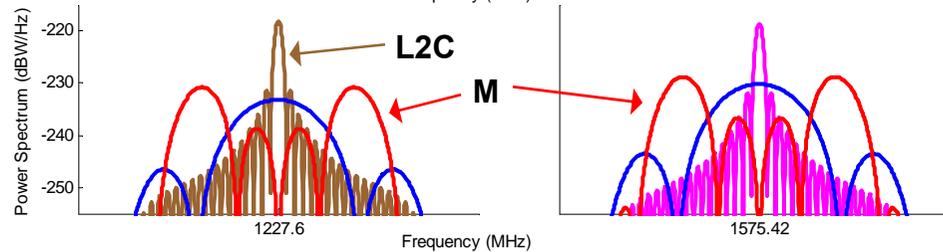
previous →



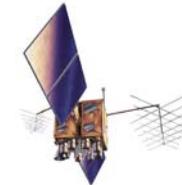
Block IIA, 1990



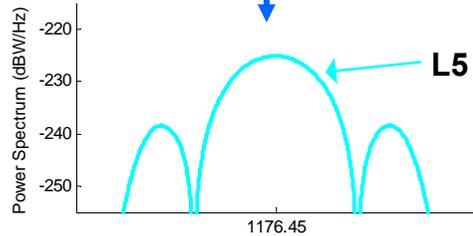
as of Dec 2005 →



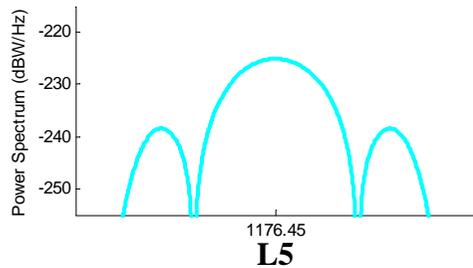
Block IIR-M, 2005



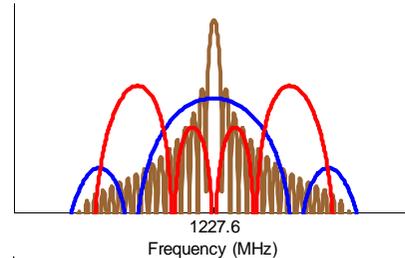
planned ↓



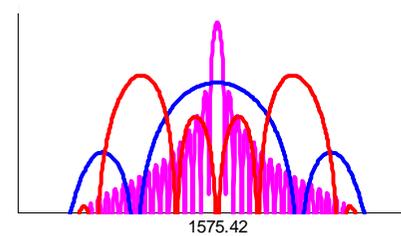
Block IIF, 2008



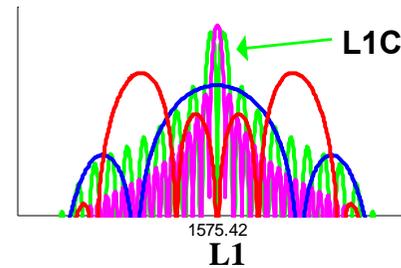
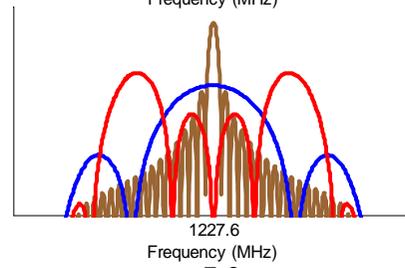
ARNS Band



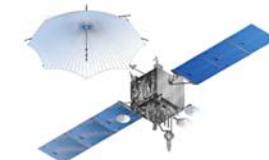
RNSS Band



ARNS Band



Block III, 2013



(artist's concept)



GPS Evolutionary “System-of-Systems” Programs



Space Segment

Legacy (Block IIA/IIR)

- Std Service (≤ 6 meters RMS SIS SPS URE)
 - Single frequency (L1)
 - Coarse acquisition (C/A) code navigation
- Precise Service (≤ 2.6 m 95% URE PPS at Zero AOD)
 - Y-Code (L1Y & L2Y)
 - Y-Code navigation

Modernized (Block IIR-M)

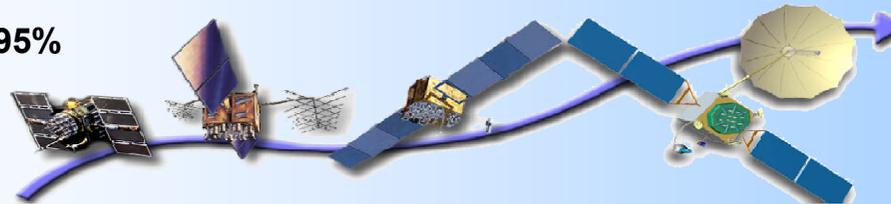
- 2nd civil signal (L2C)
- M-Code signals (L1M, L2M)
- Anti-jam flex power

Modernized (Block IIF)

- 3rd civil signal (L5)

GPS III (Block III)

- Increased accuracy
- Increased A/J power
- Signal integrity
- Search and Rescue
- L1C civil signal common w/Galileo, QZSS, & possibly GLONASS



Ground Segment

Legacy

- TT&C
- L1 & L2 monitoring



Upgraded (AEP)

- IIR-M IIF TT&C
- WAGE, AII, LADO
- NMCS/AMCS

Modernized (OCX V1)

- New Architecture
- Signal Monitoring

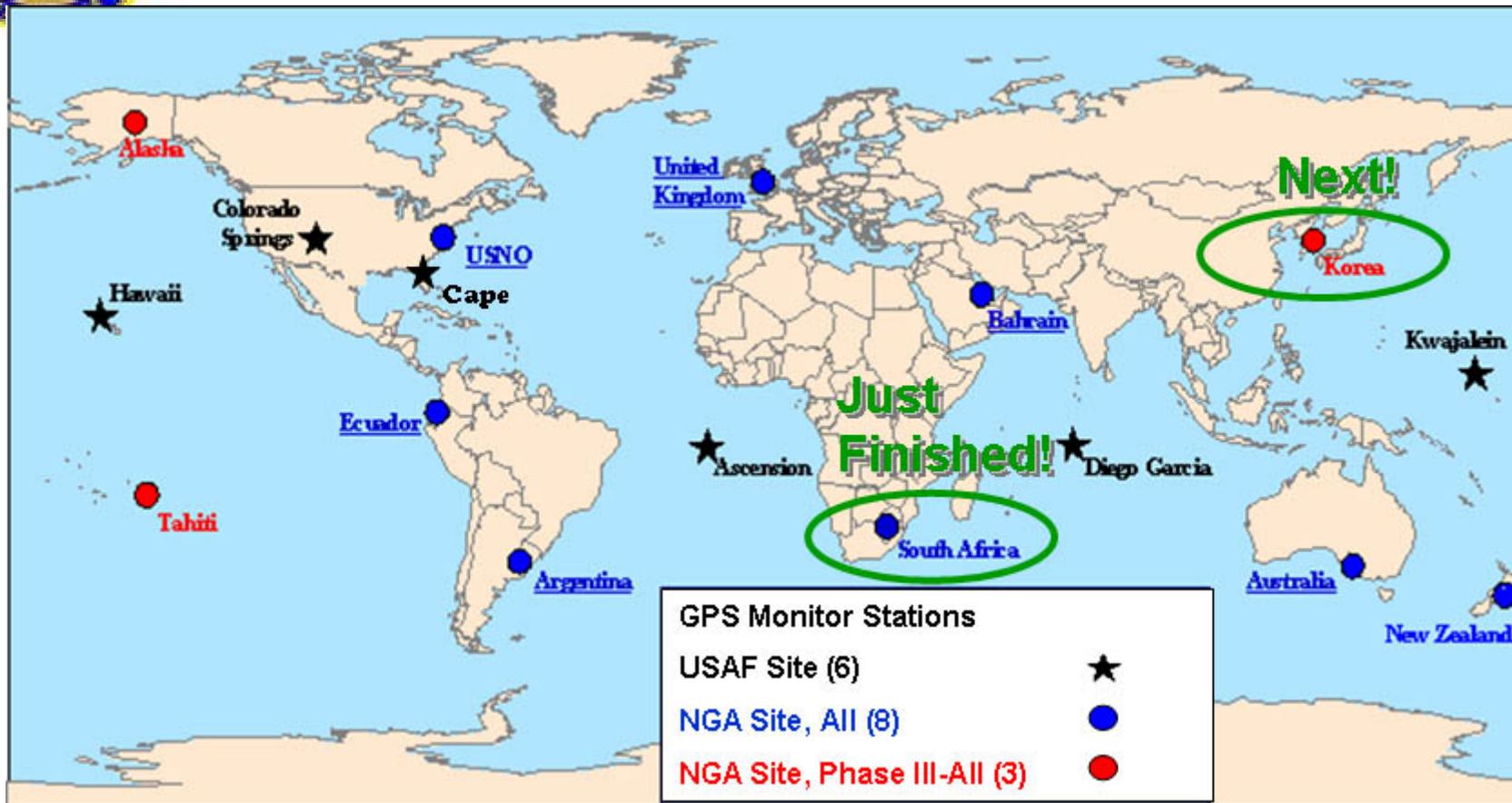
GPS III (OCX V2)

- GPS III TT&C
- Real-Time C2





Modernizing the operational control segment (OCS): Legacy Accuracy Improvement Initiative (L-AII)



- Each SV tracked by three or more monitor stations over 99% of time
- Zero age-of-data URE improved from ~46 cm to ~27 cm
- L-AII SIS URE improved from ~1.25 m to ~1.05 m



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- • **Interoperability & International Collaboration**
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International Cooperation



- **Past decade of intensive diplomacy on GNSS issues**
 - 1996 - First State Department-led GPS team visits Tokyo
 - 1997 – Bid at WRC to share GNSS frequency band with other services narrowly averted
 - 1997 – First US-EU discussions on satellite navigation
 - 1998 to present – GNSS consultations with more than two dozen countries
- **Positive results of these efforts beginning to be seen**
 - New satellite constellations and regional augmentations systems, while independently owned and operated, are being designed to be compatible and interoperable
 - Coordination mechanisms are being created to promote interoperability, promote GNSS use, and ensure a level playing field in the global marketplace





GPS-Galileo Cooperation



- **In 2004, United States and European Community signed landmark agreement on GPS-Galileo cooperation**
 - Recognizes importance of compatibility/interoperability for all parties
 - Agreed to spectrally separate signals for military and civilian services
 - Agreed to implement a common, open, civil signal on both Galileo and GPS III
- **Working Groups established to continue dialogue:**
 - Compatibility & Interoperability
 - Trade & Civil Applications
 - Next-Generation GNSS
 - Security Issues
- **Joint Handout on “GPS and Galileo... Progress Through Partnership” distributed at Munich Summit**



June 26, 2004, press conference at U.S.-EU Summit in Ireland (U.S. Sec. of State Colin Powell, Irish Foreign Minister Brian Cowen, EU Vice-President Loyola De Palacio)



US-Japan Cooperation



- **Japan's status as a world leader in GPS applications and user equipment makes it an important partner**
- **Policy consultations and technical meetings on GPS cooperation have been held since 1996 between the United States and Japan**
- **Discussion topics include Japan's regional augmentation system (MSAS) and interoperability between GPS and Japan's planned Quasi-Zenith Satellite System (QZSS)**



GPS-GLONASS Cooperation



- **Discussions on US-Russia agreement on satellite navigation cooperation have been underway since late 2005**
 - Next meeting is planned for spring 2007
- **Working groups are pursuing GPS-GLONASS interoperability**
 - Enhanced PNT availability through common open service civil signals
 - Cooperative search and rescue capabilities



US-India Cooperation



- **Policy and technical consultations on GPS cooperation have been held since 2005 between the US and India**
- **One aim is to ensure interoperability between GPS augmentation system WAAS and India's planned GAGAN augmentation system based on GPS**
- **Another important topic is ionospheric distortion and solutions**
- **US-India Joint Statement on GNSS Cooperation issued in February 2007 in Washington**



Summary



- **Continuing success in GPS sustainment & modernization**
 - New capabilities delivering enhanced performance
 - Developments on track to enhance space and control segments
- **International Collaboration**
 - Excellent cooperation with civil service providers
 - Improving RNSS interoperability/compatibility for best GNSS