

Space and Missile Systems Center



GPS Spectrum Management

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Outline

SPACE AND MISSILE SYSTEMS CENTER

- Overview & GNSS
- International Spectrum (INTSPEC) Management
- Domestic Spectrum (DOMSPEC) Management



GPS Enterprise View

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Civil Cooperation

- 1+ Billion civil & commercial users
- Search and Rescue
- Civil Signals
 - L1 C/A (Original Signal)
 - L2C (2nd Civil Signal)
 - L5 (Safety of Life)
 - L1C (International)



39 Satellites / 31 Set Healthy
Baseline Constellation: 24 Satellites

Satellite Block	Quantity	Average Age	Oldest
GPS IIA	3	21.5	24.4
GPS IIR	12	13.3	17.7
GPS IIR-M	7	7.7	9.6
GPS IIF	9	1.8	4.9
Constellation	31	9.5	24.4

AS OF 20 APR 15

Department of Defense

- Services (Army, Navy, AF, USMC)
- Agencies (NGA & DISA)
- US Naval Observatory
- PNT EXCOMS
- GPS Partnership Council

Maintenance/Security

- All Level I and Level II
 - Worldwide Infrastructure
 - NATO Repair Facility
- Develop & Publish ICDs Semi-Annually
 - ICWG: Worldwide Involvement
- Update GPS.gov Webpage
- Load Operational Software on over 970,000 SAASM Receivers
- Distribute PRNs for the World
 - 120 for US and 90 for GNSS

International Cooperation

- 56 Authorized Allied Users
 - 25+ Years of Cooperation
- GNSS
 - Europe - Galileo
 - China - COMPASS
 - Russia - GLONASS
 - Japan - QZSS
 - India - IRNSS



Spectrum

- World Radio Conference
- International Telecommunication Union
- Bilateral Agreements
- Lightsquared

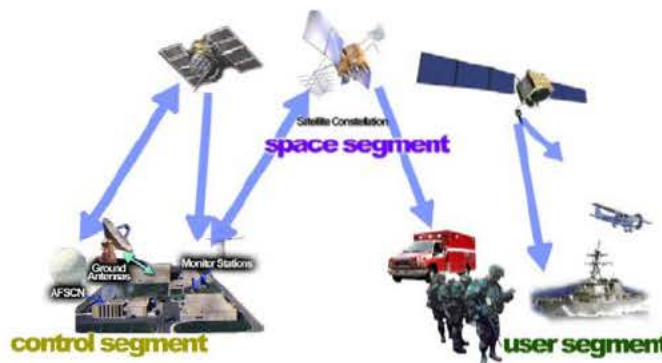


Department of Transportation

- Federal Aviation Administration

Department of Homeland Security

- U.S. Coast Guard



Foreign Military Sales (FMS)

Mexico 57th PPS Authorized Nation 11 Mar 14

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Sales to 57 authorized countries • 1 new country recently approved Mexico ~ Products: Receivers • Antenna Systems • Security Devices • Accessories





GNSS Deployed or Planned

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- Global Constellations (GNSS)
 - **GPS (24+, up to 36 filed) – US**
 - GLONASS (30+) - Russia
 - Galileo (27+3) - Europe
 - BeiDou (27 global and 5 GEO, 3 IGSO)
 - China
- Regional Constellations
 - QZSS (7) - Japan
 - IRNSS (4 GSO ,3 GEO) - India
- Satellite-Based Augmentations
 - **WAAS (3) - US**
 - MSAS (2) - Japan
 - EGNOS (3) - Europe
 - GAGAN (3) - India
 - SDCM (3)- Russia
 - ALSATCOM (1) - Algeria

GNSS Comparison

Constellations

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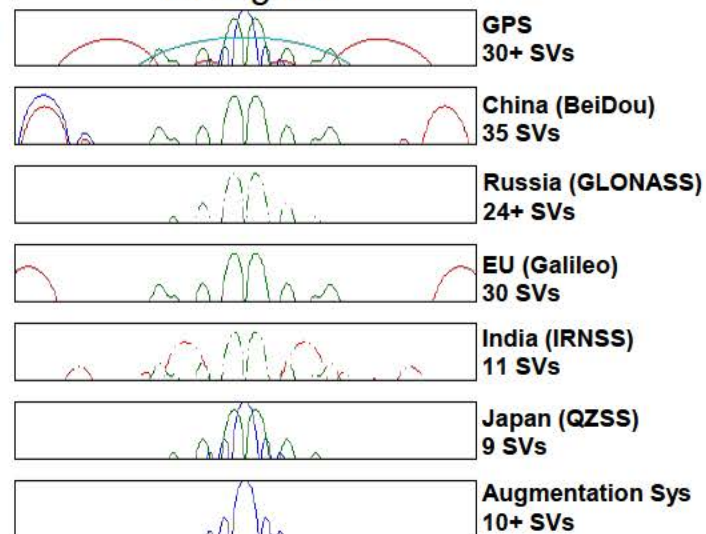
Radio Navigation Satellite System	Host Nation	Coverage	Constellation Size (planned/ healthy)	Operational Status	Orbit
GPS	USA	global	24 / 30	FOC 1995	6 MEO planes; 20,200 km; 55°
GLONASS	Russia	global	30 / 24	FOC 2011 (regional 2010)	3 MEO planes; 19,100 km; 64.8°
Galileo	Europe	global	27 / 4-6	planned FOC 2019	3 MEO planes; 23,222 km; 56°
BeiDou	China	global / regional	35 / 15	planned FOC 2020 (regional 2012)	GEO (5 SVs); 3 MEO planes (27 SVs), 21,500 km, 55.2; 3 inclined GEO planes (3 SVs)
QZSS	Japan	regional	7 / 1	planned FOC 2020	Quasi-Zenith, 32,000 - 40,000 km, 40°
IRNSS	India	regional	7 / 4	planned FOC 2016	GEO (3 SVs); GSO (4 SVs) 24,000 km apogee, 250 km perigee, inclined 29°



GPS International Cooperation

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L1 Signals



• International cooperation critical to SMC/GP mission success

- 10+ Global Navigation Satellite Systems (GNSSs) and regional augmentation systems now (eventually 160+ satellites) share the same spectrum for civil and military signals
- GPS must ensure radio frequency compatibility with other GNSSs
- Interoperability (cross-system functionality) is a key focus of GPS international relationships

• Recent successes

- Prevented UK patent claim from impacting L1C receiver implementation and common civil signal viability
- Convinced India to rethink signal plan that could overlay M-Code



GPS has unique spectrum challenges that require close international cooperation



International Telecommunications Union (ITU)

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- The ITU is a United Nations specialized agency
 - Headquartered in Geneva, Switzerland
 - Currently 193 Member States (sovereign nations)
 - Also many Sector Members (companies or international organizations)
- ITU Radiocommunication Sector (ITU-R)
 - International management of the radio-frequency spectrum & satellite use of spectrum
- Purpose of SMC/GP involvement is to directly influence international radio regulations to protect GPS frequency spectrum
 - Prevent regulatory restrictions on GPS operations
 - Ensure regulations do not allow harmful interference to GPS



ITU Recent Accomplishments

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- JTG 4-5-6-7 - successfully maintained pro-GPS language in the 2015 World Radiocommunications Conference (WRC-15) agenda item (AI) 1.1 draft conference preparatory meeting (CPM); proactively keeping possible mobile broadband allocations away from GPS in-band and adjacent bands at the WRC-15 and beyond
- WP 4C – completed an ITU report on the potential for interference from multiple space based sensors on L2 GPS receivers; the aggregate interference is an issue that the space sensor community must take into account during their coordinations; Space Frequency Coordination Group (SFCG) action item developed at the last June meeting
- WP 7C – working with NASA to ensure co-existence between space based sensors and GPS receivers in the L2 band without harmful interference; allow NASA to deploy their sensors while protecting GPS assets
- Resolution 609 – significant technical contributions to the 10th and 11th consultation meetings; US delegation looks to SMC/GP for lead; improved U.S. position as the technical lead; elected vice convener



ITU Watch Items

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- WRC-15 AI 1.1 – mobile broadband; finalization of CPM in Mar 2015; WRC-15 in Nov 2015; must keep mobile broadband allocation far way from GPS bands
- WRC-15 AI 7 – regulatory changes affecting satellite filings
- WP 4C - ITU-R Recommendation M.1831 under revision; maintain flexibility for bilateral coordination team to fully protect C/A code; re-evaluate protection of GPS receivers from pulsed radio frequency interference (RFI) sources; possible update to RNSS recommendations to include additional receivers
- WP 7C/SFCG – additional space sensors in the L2 band; working with NASA to influence SFCG to ensure protection of GPS receivers in this band; work towards SFCG resolution on aggregate RFI issues
- Resolution 609 – the maximum aggregate equivalent power flux density nearing acceptable limit; develop COAs



ITU Filings

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- ITU filings required for international recognition and protection from interference from other systems operating in-band or in adjacent-bands to GPS signals
- “USRSR” is the latest GPS “Satellite Network” filing; filed in Jun 2009 and coordination is ongoing
 - USRSR filing must be brought into use (BIU) by Summer 2016 to maintain coordination agreements on interference and compatibility
- Watch Item: new ITU filing will need to be put in place for SAR/GPS (~3-5 years before 1st launch of an SV w/ SAR/GPS)

International Committee on GNSS (ICG)

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International Committee on
Global Navigation Satellite Systems

- ICG is a UN organization established in 2005
- Purpose of the ICG
 - Encourage cooperation between civil satellite-based positioning, navigation, and timing services
 - Promote compatibility and interoperability among the GNSS systems
- ICG is different than other satellite navigations forums
 - No commercial involvement
 - Multi-lateral (UN-style) discussions between GNSS providers
 - Outputs are consensus-based recommendations (nonobligatory)



SMC/GP supports the ICG to ensure compatibility & interoperability of GNSSs



Recent ICG Activities

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Recent Accomplishments:

- ICG WG-A – initiated examination of how to increase protection of RNSS bands (safety of life); began efforts to gain international support for US ABC study with potential to increase result pool; GNSS OS Positioning Standard initiated
- IDM Workshop - working to limit “personal privacy devices” or GPS jammers and other interferers to civil GNSS signals
- Interoperability Workshop – efforts to learn from international manufactures of receiver chips and equipment to better meet future needs
- ICG-9 (2014) – updates from system providers on latest launch schedules and constellation plans



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Summary Chart Needed PRN Assignments

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- Indian Space Research Organization: GAGAN
 - Requests 3rd PRN assignment for L1 C/A and L5 I5 codes
 - ISRO agrees to tentative PRN 139 assignment; need to confirm received power level
 - Currently assigned
 - PRN 127, L1 C/A and L5: GSAT-8
 - PRN 128, L1 C/A and L5: GSAT-10
- FAA: WAAS
 - Planning to request PRN assignment for hosted payload on Satmex 9
 - Target PRN 134, currently listed as 'WAAS (Reserved)'
 - Currently assigned
 - PRN 133: INMARSAT 4F3
 - PRN 135: Intelsat Galaxy 15
 - PRN 138: ANIK-F1R



Summarize Process - DD1494

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- GPS III DD1494 Stage 4
 - Status: NTIA review underway



Activity	Estimated Completion Date	Need Date
SMC/EN submission to AFSMO	06 Dec 13	---
AFSMO submission to NTIA	22 May 14	---
NTIA Review	(22 Nov 14)	---
NTIA Signature	(22 Feb 15)	---
MCEB Review	(22 May 15)	Sep 2016 (GPS III SV01 AFL)



Signal Monitoring

Applied Research Laboratories at the University of Texas

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- ARL:UT SPS/PPS Performance Standard Evaluations
 - Provides thorough analysis of performance standard adherence throughout the year
- ARL:UT Signal Monitoring
 - Provides critical insight into anomaly root cause analysis and mitigation development

