

Space and Missile Systems Center



GPS Spectrum Management

Capt Doug Pederson
29 Apr 15

Outline



SPACE AND MISSILE SYSTEMS CENTER

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

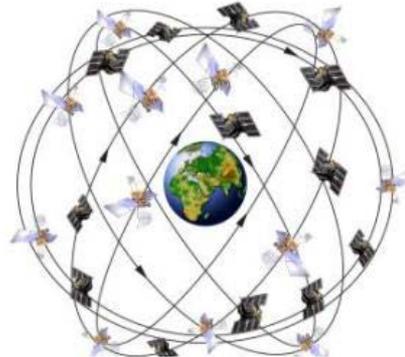


GPS Enterprise View

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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

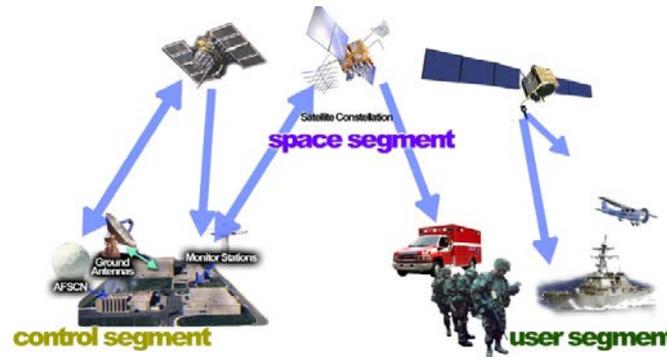


Department of Transportation

- 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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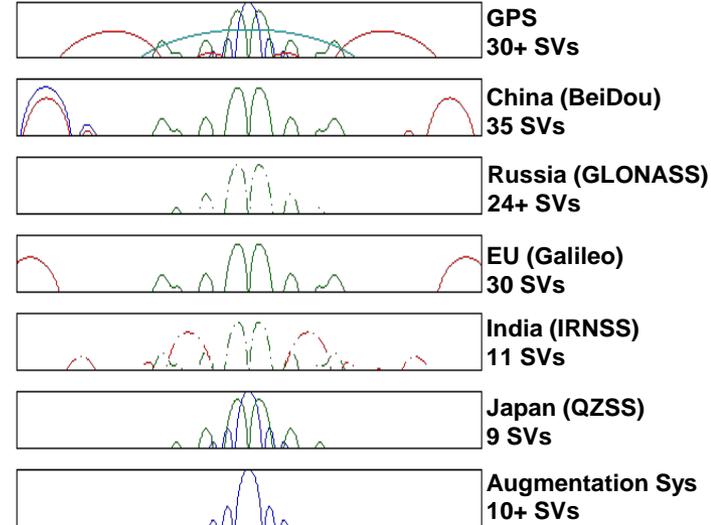
Radio Navigation Satellite System	Host Nation	Coverage	Constellation Size (planned/ healthy)	Operational Status	Orbit
GPS	USA	global	24 / 30	FOC 1995	6 MEO planes; 20,200 km; 55°
GLONASS	Russia	global	30 / 24	FOC 2011 (regional 2010)	3 MEO planes; 19,100 km; 64.8°
Galileo	Europe	global	27 / 4-6	planned 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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- 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)



International Committee on
Global Navigation Satellite Systems



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



DOMSPEC

PRN Assignments Documentation

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- Documentation
 - PRN Assignment Tables update
 - PRN Assignment Public Guidance Document update
 - PRN Assignment GP Operating Instruction initial release
- Terrestrial Transmitter (Pseudolite) Language
 - Was: []
 - Recommend: “SMC/GP opposes any terrestrial transmissions that degrade GPS reception.”

The image shows four screenshots of PRN assignment tables, labeled L1 C/A, L1C, L2C, and L5. Each table contains columns for PRN number, frequency, and other technical parameters. The L1 C/A and L5 tables have a yellow highlight on the first few rows.

GLOBAL POSITIONING SYSTEMS DIRECTORATE (SMC/GP) OPERATING INSTRUCTIONS
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 PRC-010

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OPIC: SMC/GP (1st Lt Frank R. Schmidt) Contacted by: SMC/GP (1st James R. Bernal) Page: 9
 Distribution: S

This Operating Instructions (OI) defines the process for handling requests for the assignment of all Global Positioning System (GPS) Pseudolite Noise (PNO) codes for use in GPS receiver operations. It applies to all GPS Receivers and is responsible for the research, development, and maintenance of PNO code assignments.

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SUMMARY OF CHANGES:
 None to report

GLOBAL POSITIONING SYSTEMS DIRECTORATE (SMC/GP)
 PSEUDORANDOM NOISE (PNO) NUMBER
 ASSIGNMENT PROCESS
 06 February 2014

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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

