



GPS Modernization and Program Update

**GPS Update to ION
Southern California Chapter**

22 Feb 2011

**Colonel Bernie Gruber
Director
Global Positioning Systems Directorate**



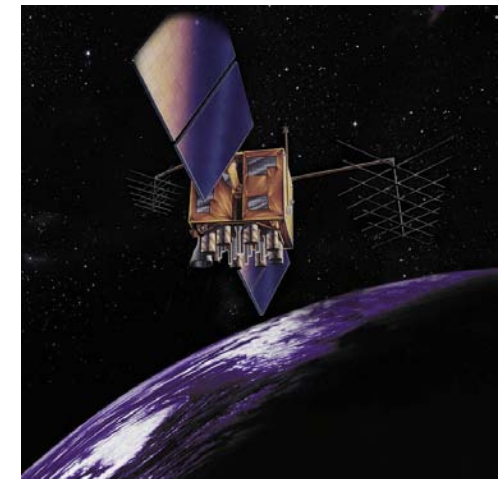
Contents

- ➔ • **Current Constellation**
- **Modernization**
- **Other Improvements**



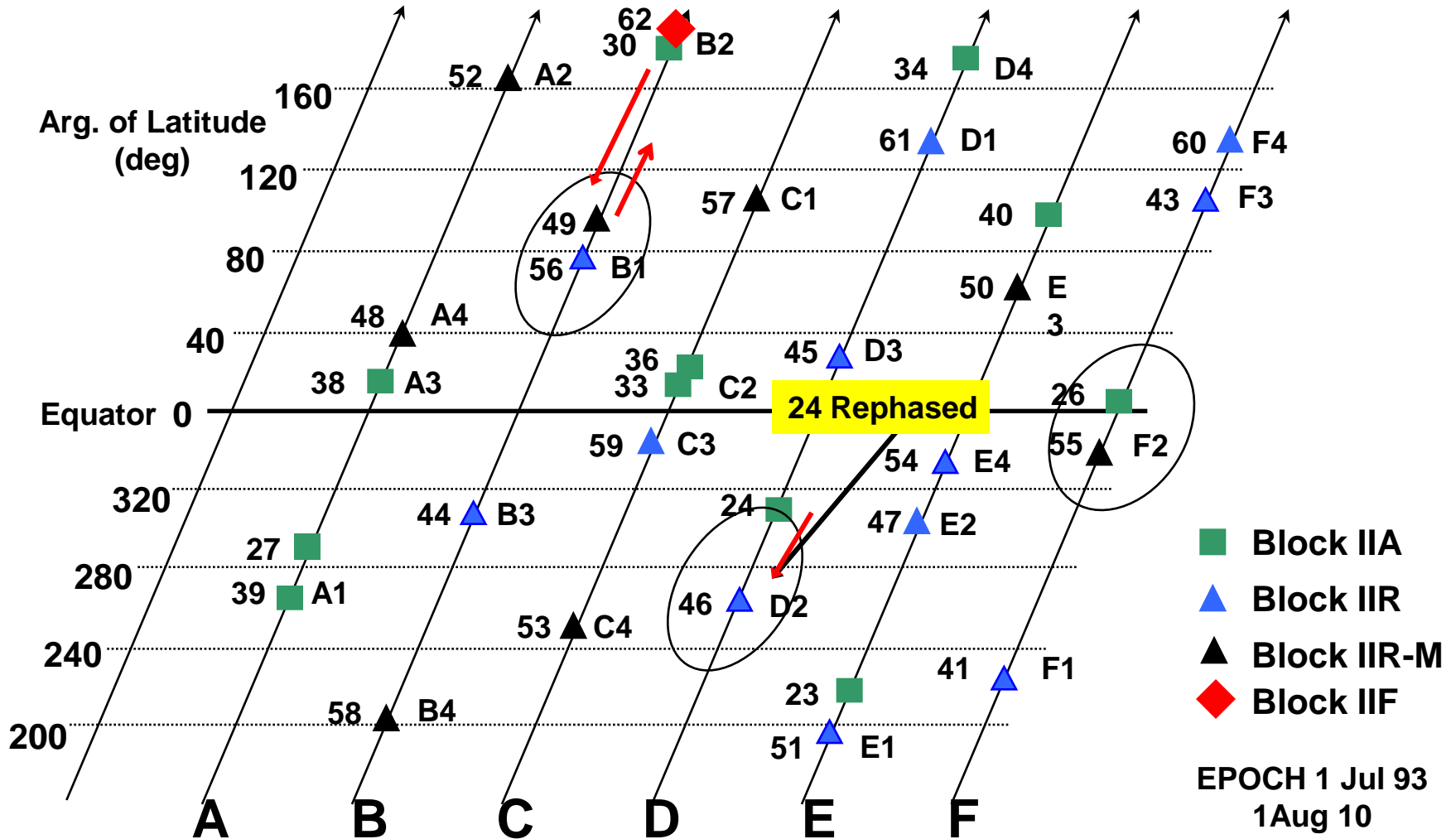
GPS Constellation

- **Very robust constellation**
 - 31 space vehicles currently in operation
 - 11 GPS IIA
 - 12 GPS IIR
 - 7 GPS IIR-M
 - 1 GPS IIF
 - 3 additional satellites in residual status
 - 1 satellite in “test” mode – SVN 49
- **Global GPS civil service performance commitment met continuously since Dec 1993**





Current Satellite Positions



Expanded Constellation will be fully achieved by Jun 2011



Coming Up: SPS PS Update

- **Planning a draft update of the SPS PS by 1QFY11**
 - Name change to "Open Service Performance Standard" (OS PS)
 - Addition of L2C signal to current L1 C/A signal
 - Same performance values
 - Draft update will be circulated for review & comment within U.S. Government
 - SPS PS update approval before Initial Operational Capability (IOC) declaration for L2C
- **Planning subsequent draft updates for L5 signal & for L1C signal**
 - Prior to each subsequent IOC declaration



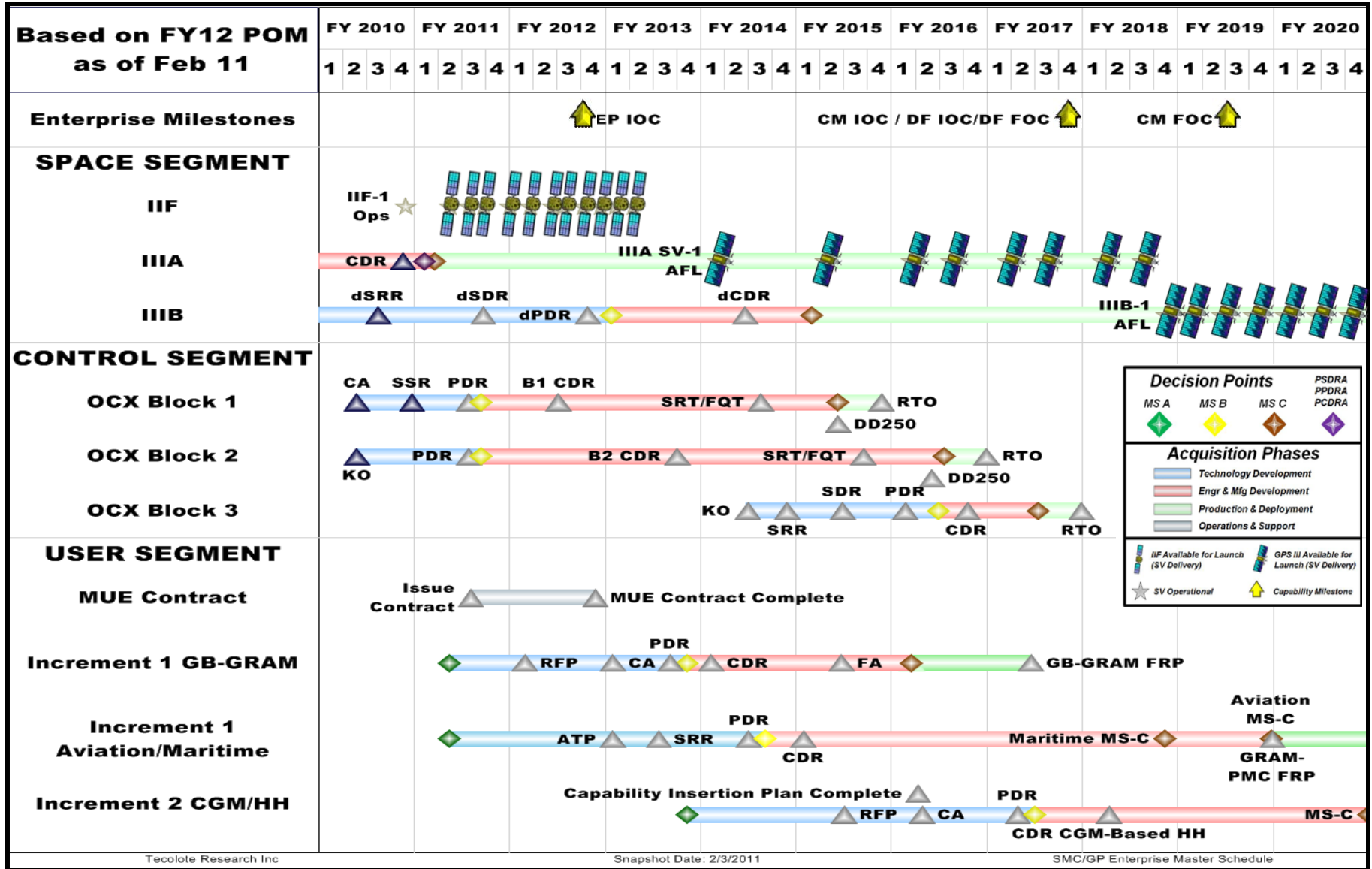


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GPS Enterprise Schedule





GPS Modernization – New Civil Signals

- **Second civil signal “L2C”**

- Designed to meet commercial needs
- Available since 2005 without data message
- Phased roll-out of CNAV message
- Full capability: 24 satellites and full CNAV ~2016 *



- **Third civil signal “L5”**

- Designed to meet transportation safety-of-life requirements
- Uses Aeronautical Radio Navigation Service band
- Available since 2010; 24 satellites and full CNAV ~2020*

- **Fourth civil signal “L1C”**

- Designed for GNSS interoperability
- Specification developed in cooperation with industry
- Launches with GPS III in 2014
- Available on 24 SVs by ~ 2026*



Urban Canyons

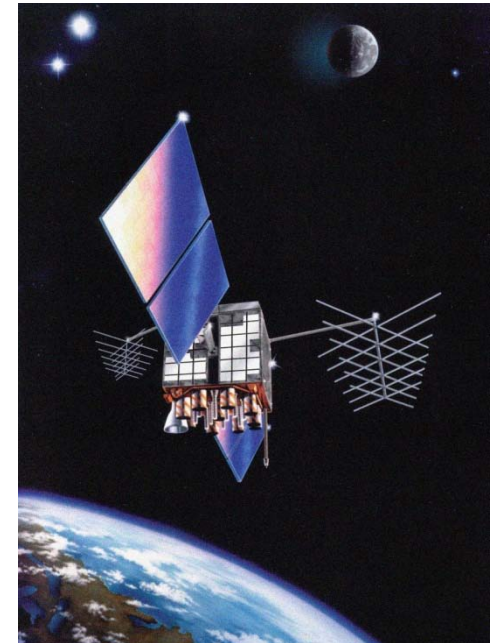
Improved performance in challenged environments

* FOC dates are based on our best guess for launch schedule



IIR/IIR-M Satellites

- **All GPS IIR and IIR-M satellites have now been launched**
 - Current backbone of the GPS constellation
- **Excellent on-orbit performance**
 - SIS URE of .50 meters - 1 Year Performance Jul 2010
- **Excellent life expectancy**
 - Solar array capacity far exceeds specified Mean Mission Duration
 - No clock failures to date
- **Completed deployment of IIR-M**
 - L2C CNAV message type 0 capability deployed this year on IIR-M to support testing of civil UE
 - Full CNAV message with OCX





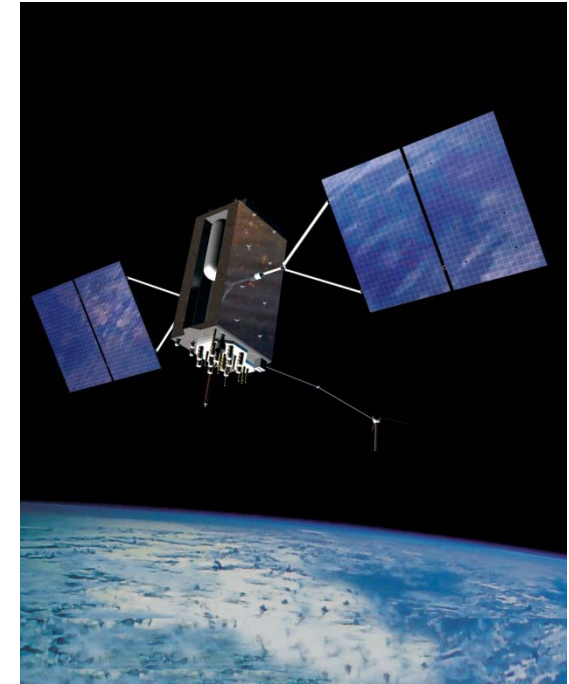
IIF Satellites

- **Launched GPS IIF SV-1 in May 2010**
 - SVN62, PRN 25
 - Was set healthy 26 Aug 10
 - First operational L5
- **11 more IIFs in the pipeline**
 - SVs 2-5 are in production
- **IIF SV-2 launch by Summer 2011**





- **Newest block of GPS satellites**
 - First satellite to broadcast common L1C signal
 - Multiple civil and military signals; L1 C/A, L1 P(Y), L1M, L1C, L2C, L2 P(Y), L2M, L5
 - +10 dB earth coverage power increase on M-Code
 - Three Rubidium clocks
- **Completed Critical Design Review for Block IIIA**
 - Two months in advance
- **Completed Delta System Requirements Review for Block IIIB**
- **Conducting Analysis of Alternatives for Blocks IIIB and IIIC**
 - Revalidate requirements and associated cost/benefits





Ground Segment



Monitor Station



Ground Antenna

- **Deployed several AEP upgrades including SAASM upgrade**
- **Conducted flex power demo with live IIR-M SVs**
- **Awarded OCX Phase B to Raytheon Feb 2010**
 - Completed Technical Baseline Review Mar 2010
 - Completed Independent Baseline Review Aug 2010
 - Completed Software Specification Review Sep 2010
 - Preliminary Design Review planned for Apr 2011
 - OCX Block I deployment planned for 2015



User Segment

- **Delivers new set of GPS receivers to support service nominated lead platforms**
 - Support operations in a Navigation Warfare (NAVWAR) environment and countering current and emerging PNT threats
 - Upgrade GPS receivers to exploit new technologies: M-Code, Blue Force Electronic Attack (BFEA), Anti-Jam, Anti-Spoof & Anti-Tamper
 - Prevent PNT service disruptions due to non-compliance
- **Common GPS Module (CGM) proposed to meet long-term needs of DoD GPS users & authorized foreign allies**
- **Modernized User Equipment (MUE)**
 - Prototype GB-GRAM-M receiver deliveries completed 1QFY11
 - Undergoing independent Govt testing. Est. Completion ~4QFY11
- **Military GPS User Equipment (MGUE)**
 - Entering Technology Development Phase leveraging the success and achievements of MUE
 - Technical Requirement Document (TRD) anticipated CCB ~ 2QFY11
 - Targeting MGUE RFP release 1QFY12





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- **Modernized GPS SVs have Flex Power capabilities**
 - Can shift power between M-Code, P(Y) code and C/A code
- **Previous on-orbit testing conducted in 2005 and 2007**
- **Conducted extensive on-orbit Flex Power test Sep 7-11, 2010**
 - Turned on Flex Power for 8 IIR-M satellites
- **Identified two issues**
 - Canadian Differential GPS Service - planned for decommissioning NLT Mar 2011
 - FAA integrity monitors gave false positives – mitigations being developed
- **Developing Flex Power Concept of Operations (CONOPS)**



Capability Deployment

- **GPS receiver anomalies were reported several times this year coinciding with testing activities**
 - Almanac problem in Nov 2009, SAASM problem in Jan 2010, etc.
- **Problems were traced to non-compliant UE**
 - Unauthorized use of reserved bits, incorrect assumption on almanac time, incorrect implementation/interpretation of a security function
- **Problems mitigated by working extensively with UE vendors to fix non-compliance issues**
- **Undertaking improvements in deployment method and certification paradigm**

Smooth Deployment of New Capabilities Key to Modernization



New Transition and Certification Paradigms

- **Instituting methodical capability transition process**
 - Carefully planned transition event testing
 - Extensive participation by representative users and applications
 - Identification of potential issues prior to capability deployment
- **Improvements in compliance verification are being put in place**
 - Exploring Underwriters Laboratories construct for independent certification of ICD compliance and associated testing
- **Seeking feedback from user community on transition approaches and compliance verification**



ICD Compliance is Critical for GNSS Success



PRN Expansion

- **Control segment is currently limited to 32 PRNs, limitation removed with OCX**
- **Legacy UE are limited to 32 satellites**
- **Current constellation has 31 operational satellites and 3 residual non-operational satellites**
- **63 sets of L1 C/A, L2C, L5, and L1C codes have been defined**
- **Developing CONOPS and ICD changes to exploit additional PRN capability while remaining backward compatible with legacy UE**
 - Proposing to assign higher PRNs to the worse performing satellites
 - Soliciting feedback from user community

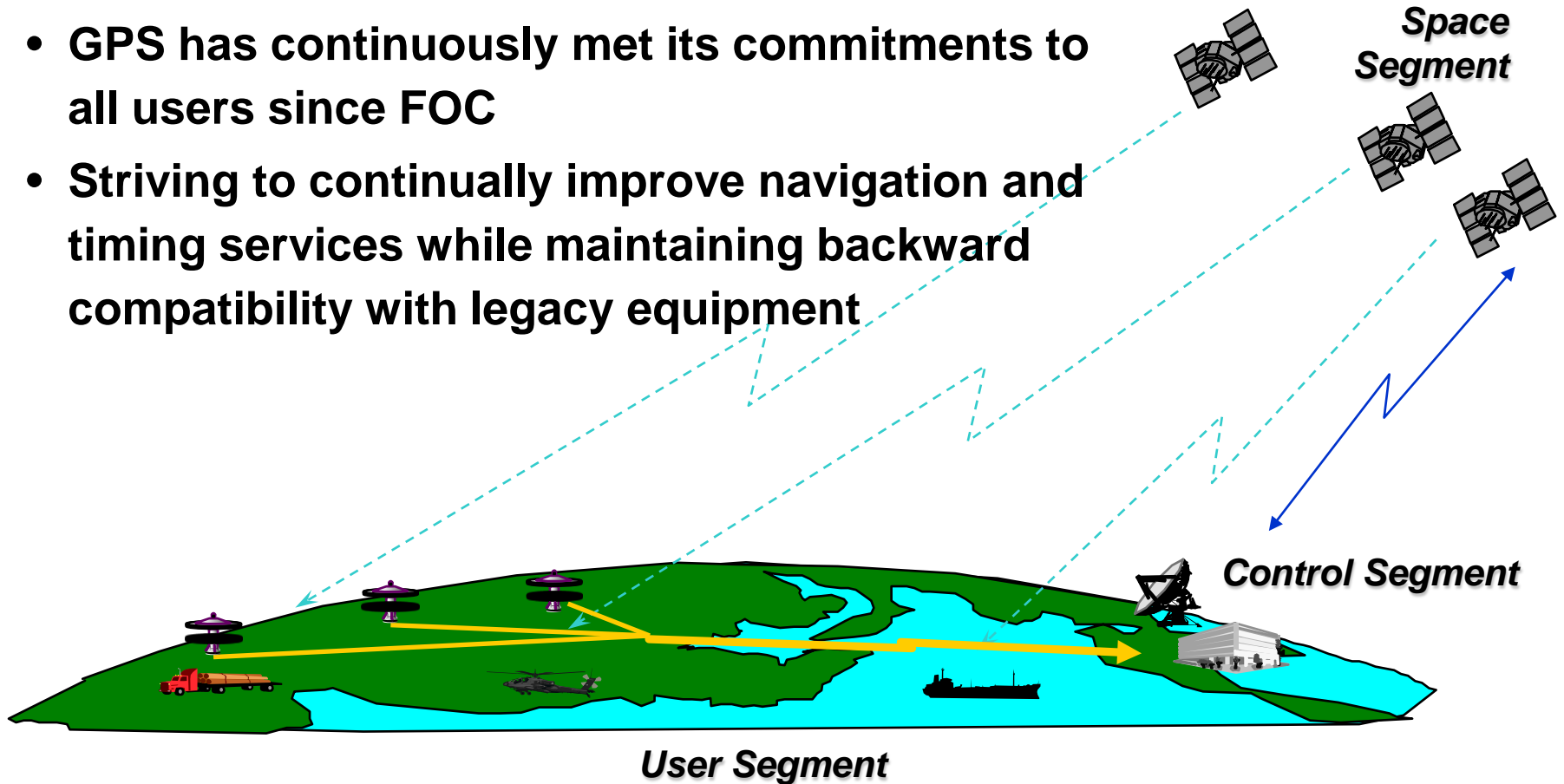


- **Developing an updated set of performance metrics**
 - Include different user applications and terrain environments
- **Need to shift away from just counting satellites in the sky**
 - 95% probability of 24 satellites anywhere in the constellation
- **Goal is to identify a short list of most meaningful metrics and report on them regularly**
 - Cover the big five, i.e. Availability, Accuracy, Bounded inaccuracy, Integrity, Interference (inadvertent or malicious)
 - Cover key user applications
- **Challenge is representing the metrics in terms of effect on users/application**



Summary

- Modernization of all GPS Segments is on track
- GPS has continuously met its commitments to all users since FOC
- Striving to continually improve navigation and timing services while maintaining backward compatibility with legacy equipment



Maintaining And Improving GPS Services For All Users Is Job #1