

Interagency GPS Executive Board

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Galileo: Friend or Foe ?

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Presentation Contents

- A Brief History of GPS
- GPS and Civil Navigation
- Galileo: Rationale, Services, Features
- US and EU Concerns
- Solutions to the Impasse?
- A Glimpse beyond 2010

History of GPS (Part 1): 1980's

- GPS: Military Force Enhancer
- Early Civilian Applications
- Differential GPS Technique
- Breakthrough: Carrier Phase GPS
- Shapiro & Counselman (MIT, Radio Astro)

History of GPS (Part 2): 1990's

- Military Navigation (Land, Sea, Air)
- Hundreds of Civilian Applications, eg
- Geodesy, Geophysics, Oceanography
- Surveying & Mapping, Timing, Meteorology,
- Civil Engineering, Offshore Exploration,
- Fleet Management, Agriculture, Space, . . .
- **But NOT Safety Critical Navigation, eg**
- **Civil Aviation, Marine Navigation, . . .**

Why Not ?

GPS Designed for Military Use

HDOP < 1.7
90% of the Time



VDOP < 2.8
90% of the Time



YES



NO

Civil Navigation View

GPS Drawbacks

- Not sufficient Accuracy, Integrity, Coverage
- Can be Jammed locally (eg Airports)
- GPS Vulnerability (Volpe)
- Not enough Satellites for some Applications
- No backup for Critical System Failure

Critical Failure: How? When? Where?

- London Stock Exchange Computer (April 2000)
 - Incorrect Data Upload
- Analogy: Yesterday's Ephemeris ??
- Faulty Navigation Message Data (SVN 35, 1997)
- Satellite Clock Error (PRN 22, 2001)
- Other Instances

***Users Require Safeguards Against such Failures
And Improvements in Standard Performance***

GPS Performance & Vulnerability

1. Better Performance

- Increase Number of Satellites (DOP)
- Augment GPS (WAAS, LAAS)
- Combine Systems (eg GPS + INS)

2. Overcome GPS Vulnerability

- Through Integrity Monitoring (eg RAIM)
- GPS Modernization
- Some Applications Need a Backup Nav. System

Better Performance

- WAAS, EGNOS, MSAS
- Backup Navigation Systems
- Provide Sufficient Integrity
- And an Increase in Accuracy, but . . .
- Need more Satellites (cost a lot), and...
- An Alternative in Case of Critical Failure

Hence Galileo

- 30 MEO Satellites (similar to GPS)
- ***Compatible & Interoperable with GPS***
- System Back-up for GPS; and with GPS . . .
- ***Meets most Accuracy & Integrity Requirements***
- Plenty of Satellites for New Applications
- ***Galileo Costs Shared by EU Industry***
- *At No Cost to US Taxpayer, but of course*
- ***Economic and Commercial Benefits to Europe***

Galileo Navigation Services

1. Open Access Service (OAS)

- *Free Service* for Mass Market Applications

2. Commercial Access Service (CAS)

- Encrypted Value Added Data
- Local Augmentation Services
- Integration with Communication Networks

3. Safety of Life Service (SAS)

- Addition of Integrity, for applications such as
- Civil Aviation (CAT 1), Ship Docking, Trains,...

Galileo Navigation Services

4. Public Regulated Service (PRS)

- Encrypted Signals under EU Government Control
- Providing Greater Continuity of Service for
- Public Applications (Police, Fire, Customs, . . .)
- Better Resistance to Interference and Jamming
- Restricted to EU and Participating States

Galileo Operational Features

- Galileo can provide Autonomous Services
- **But designed for Interoperability with GPS**
- To provide an Enhanced Service Performance
- **Compatible with EU Foreign and Security Policy**
- **But Who Pays ?**

Galileo Costs (PwC Report)

- **Financial Study by PricewaterhouseCoopers**
Winning Consortium*
- **Recommendations for a PPP based on**
 - Public Support for Development Phase (- 2005)
 - Then Concession to *Galileo Operating Company*
 - For System Deployment, Operation & Maintenance
 - Against Payment for Service Performance Delivery
- **Thick Report - Only Exec. Summary is Public**
(Ask VA for Report Summary)

Perceived NATO & US* Concerns

- **Signal Security Issues**

- Why have a PRS ?
- Why should PRS be Resistant to Jamming ?
- Who decides when and how to Jam PRS ?

- **Economic and Commercial Issues**

- Will the US have Access to Encryption Keys ?
- Will Galileo be Treated Differently from GPS ?

* US DoD Letter to EU Ministers

EU Security Approach to PRS

- Secure Signal for Public Safety & Security
- **Robust to Interference & Jamming**
- Accessible when Other Signals are denied in “Times of Crisis”
- **Security Maintained through Encryption**
- Two Possible Technical Options Exist
 - PRS Code Identical to the GPS M-Code
 - PRS Code Different from the GPS M-Code
- **Both Options require EU-US Coordination**

Current Status of Galileo

- ESA already Approved funding to 2005
- EU Heads to take Decision in March
- Project could go ahead with Qualified Majority
- Making life very Difficult for Close Allies...
- US not keen on PRS (on Security Grounds)
- European Perception: Security is *Not* Main Issue
- But . . . US Economic & Commercial Interests

Any Solution to the Impasse* ?

- EU Offer to develop “Reconfigurable Frequency”
- **Flexible PRS: Jammed in “Times of Crisis” ?**
- Need to develop Joint EU-US Security Policy
- **GPS could eventually have its Own PRS**
- EU Credibility to Manage Galileo at Stake
- ***Why not Split Areas of Agreement from Others?***

* Impasse: Position from which progress is impossible (Oxford Dictionary)

A Glimpse Beyond 2010

- GPS and Galileo Operating Jointly
- Hundreds more *New* Civilian Applications
- Global Economic & Commercial Benefits
- And then . . . *New* Navigation Satellite Systems
- eg Small Sats (Mini, Micro, Nano, Pico,...)
 - Cheaper to manufacture, launch, use and maintain
- But . . . What shall we call them ?!

* Mini: > 100kg, Micro: 10 - 100kg, Nano: 1 - 10kg, Pico: < 1kg

How About... ?

- Galileo: NASA & ESA
- Columbus ? 15 US Cities
- Amerigo Vespucci ?
- Marconi ?
- Marco Polo ?

We Have A Problem !