Dynamic Positioning Committee
Marine Technology Society

Sensors

Advantages of Using DNSS For Positioning in DP Applications

Ole Ørpen, Arne Norum, and Tor Egil Melgård

Fugro Seastar AS

October 17-18, 2006

Return to Session Directory

Advantages of using GNSS for positioning in DP applications

Ole Ørpen, Tor Egil Melgård, Arne Norum, Fugro Seastar AS, Norway

Presented at MTS DP Conference, Houston, 17-18 Oct 2006

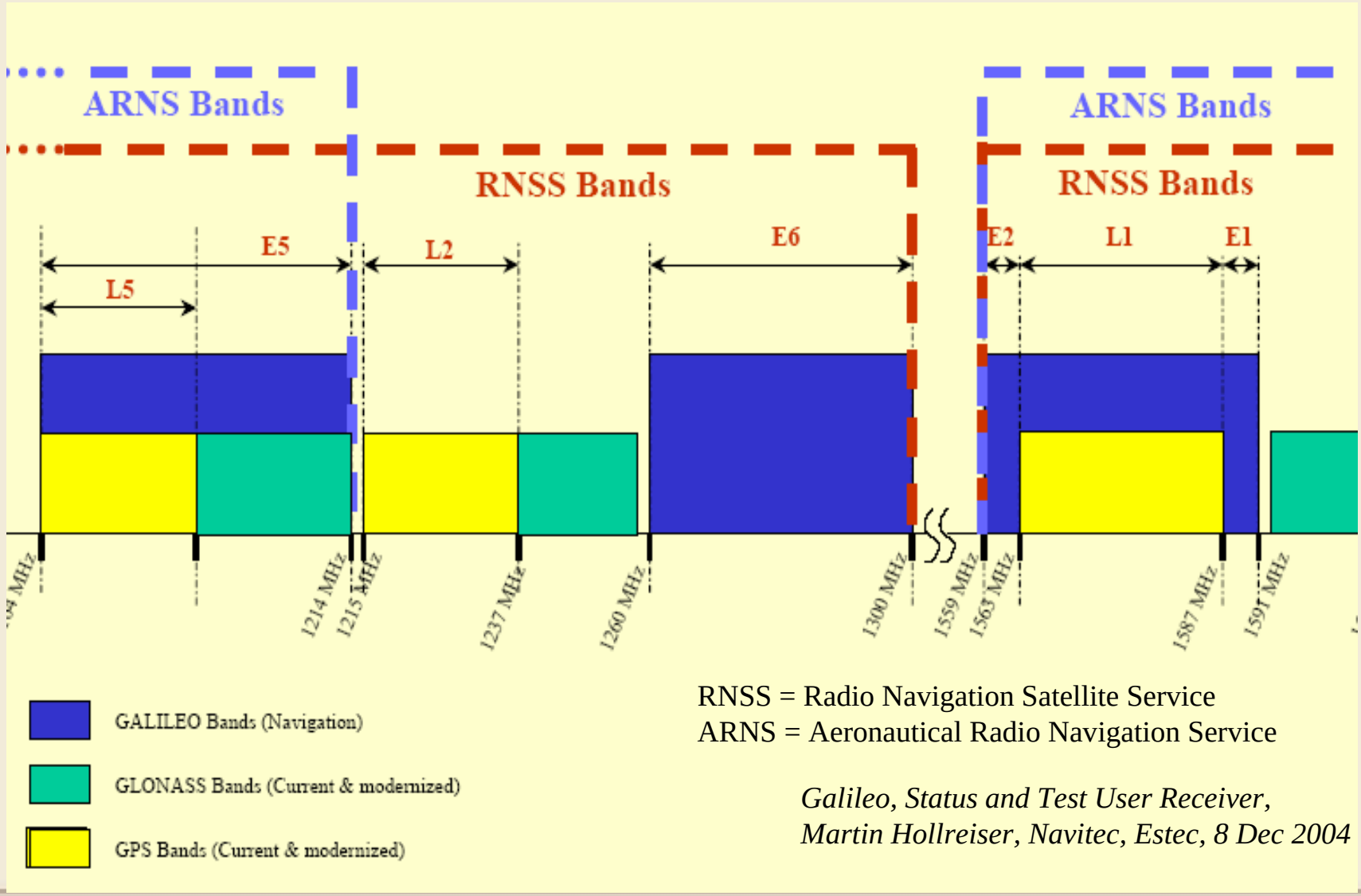
Global Navigation Satellite Systems, GNSS

- Overview:
- Background
- GPS
- GLONASS
- Galileo
- Space Based Augmentation and Regional Systems
- GNSS Receiver Availability
- Improvements in performance
- Implications for DP Operations
- Conclusions

Global Navigation Satellite Systems, GNSS

- Additional Satellite Navigation Services will add:
- Satellites
  - Today about 40 satellites are available (28 GPS and 12 GLONASS)
  - In 5 years about 80 satellites will be available
- Frequencies
  - Today two frequencies are available
    - One tracked codeless with reduced tracking margin
  - In 5-8 years three frequencies will be available with full code tracking
- Interoperability
  - There is coordination between GNSS operators to ensure compatibility/interoperability (frequencies, modulation codes, coordinate reference frames, timing reference)

GALILEO/GPS/GLONASS FREQUENCY BANDS



RNSS = Radio Navigation Satellite Service
ARNS = Aeronautical Radio Navigation Service

Galileo, Status and Test User Receiver,
Martin Hollreiser, Navitec, Estec, 8 Dec 2004

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GPS Status

- 29 Operational Satellites
- Global GPS availability was better than 99.99% in 2005
- GPS Accuracy 5-10 m 95%

- GPS IIR-14(M)
- New civilian signal on L2
- launched 25 Sep 2005

GPS Modernization Program

Increasing System Capabilities ◆ Increasing Defense / Civil Benefit

Block IIA/IIR

Basic GPS

- Standard Service
  - – Single frequency (L1)
  - – Coarse acquisition (C/A) code navigation
- Precise Service
  - – Y-Code (L1Y & L2Y)
  - – Y-Code navigation

Block IIR-M, IIF

IIR-M: IIA/IIR capabilities plus

- **2nd civil signal (L2C)**
- M-Code (L1M & L2M)

2005-2012

IIF: IIR-M capability plus

- **3rd civil signal (L5)**
- Anti-jam flex power

2008-2015

Block III

- Backward compatibility
- **4th civil signal (L1C)**
- Increased accuracy
- Increased anti-jam power
- Assured availability
- Navigation surety
- Controlled integrity
- Increased security
- System survivability

2013-2021

National Space-Based PNT Coordination Office, USA

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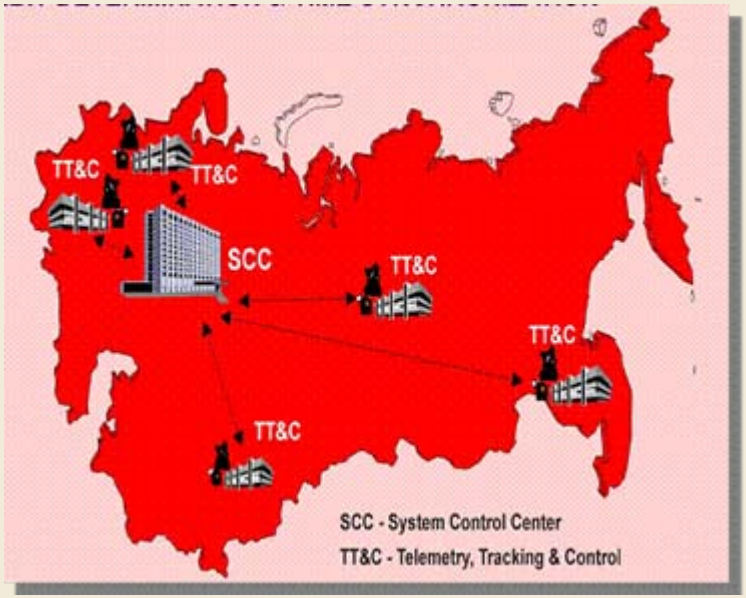
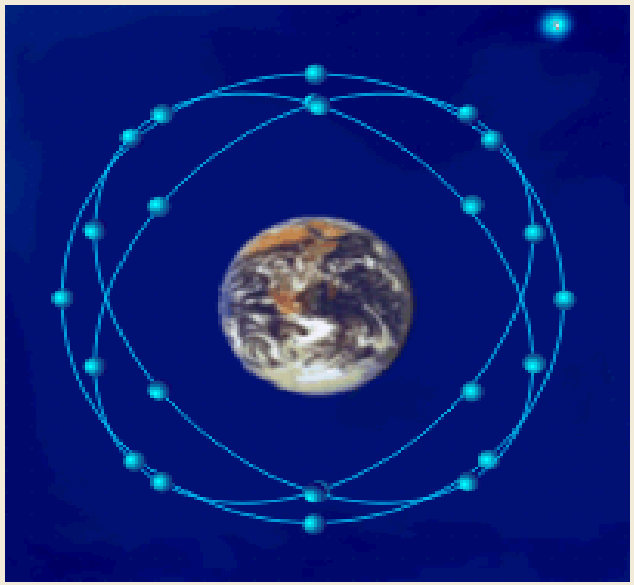
GLONASS, Russian Satellite Navigation System

- Constellation: 24 satellites, 3 orbital planes
- Orbital altitude: 19100 km, Inclination: 64.8°
- Period of revolution: 11h 15m (repeat ground track in 17 days)
- Frequency Division Multiple Access (FDMA):
  - L1i=1602+i×0.5625 [MHz]; L2i=1246+i×0.4375 [MHz]
  - i = frequency number



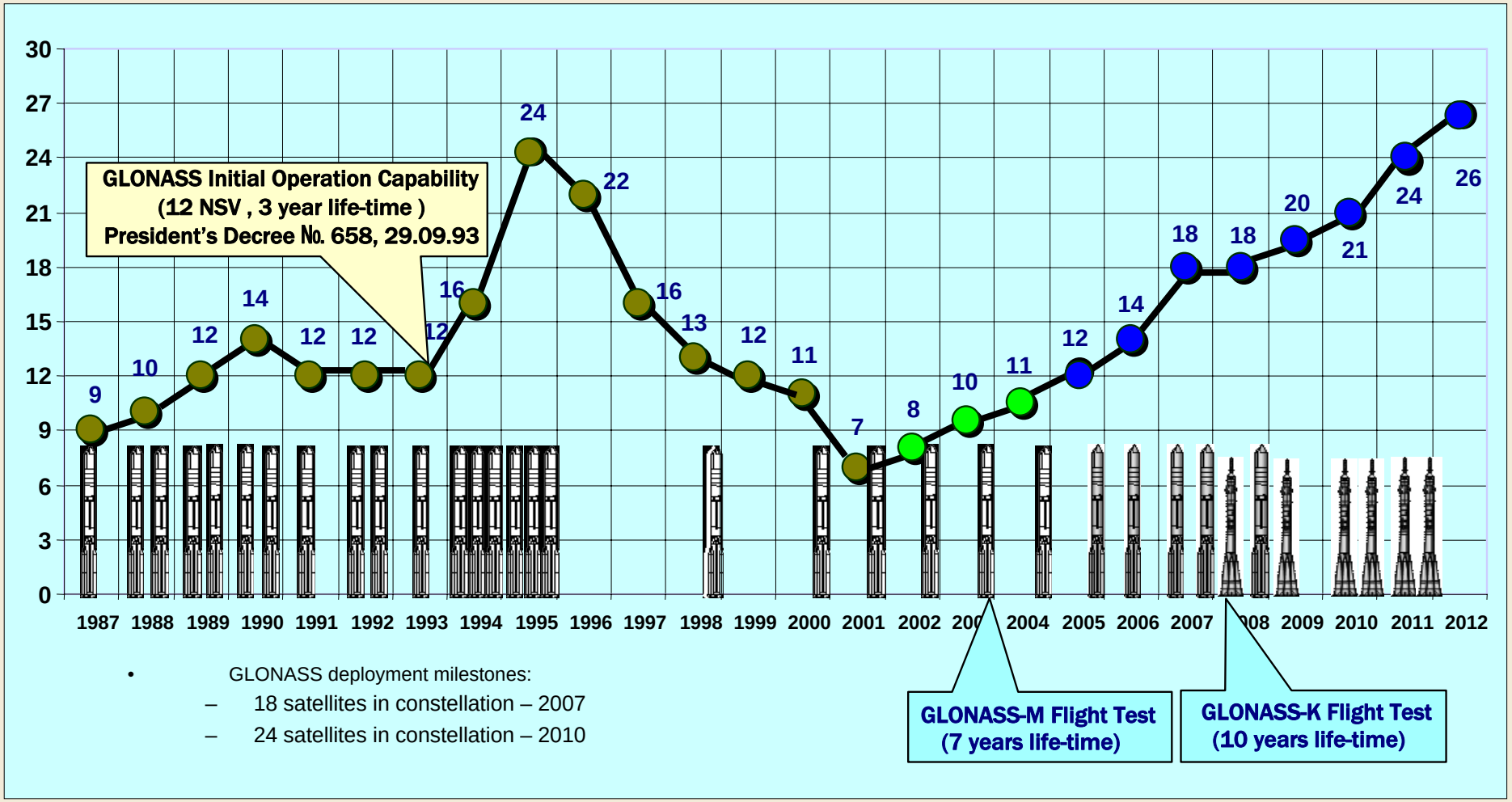


GLONASS STATUS AND PLANS, Veniamin Malyshev, Moscow Aviation Institute
Presented at Nordic Satnav User Conference, 29-30 Nov 2005, www.nornav.org

GLONASS Status

- 3 Satellites Launched 26 December 2005
- 12-14 Operational
- Russian Aerospace Agency has approval for long term plan for GLONASS:
  - 18 Sat end 2007
  - 24 Sat end 2009
- GLONASS will also get more frequencies:
  - GLONASS M, second civilian frequency (from 2004)
  - GLONASS K, third civilian frequency (from 2008)

GLONASS Constellation Deployment, original plan



- GLONASS deployment milestones:
  - 18 satellites in constellation – 2007
  - 24 satellites in constellation – 2010

Russia

Putin orders completing GLONASS satellite system before 2008

14:35 | 26/12/2005

MOSCOW, December 26 (RIA Novosti) - Russian President Vladimir Putin said Monday that he wanted the GLONASS global navigation satellite system ready before 2008.

"The GLONASS system should be created before 2008, as it was originally planned," Putin told government members. "We have the possibility. Let us see what can be done in 2006-2007."

Defense Minister Sergei Ivanov said three new satellites had been successfully put into orbit Sunday to expand the navigation system.

He said 19 out of 24 GLONASS satellites were currently in orbit.

"I am convinced that by 2008, all the 24 satellites will be in orbit as part of the GLONASS federal target program," Ivanov said.

The president noted however that the satellites should be put into orbit earlier.

The first GLONASS satellite was put into orbit in 1982, but the system was officially launched in 1993.

send by e-mail >>

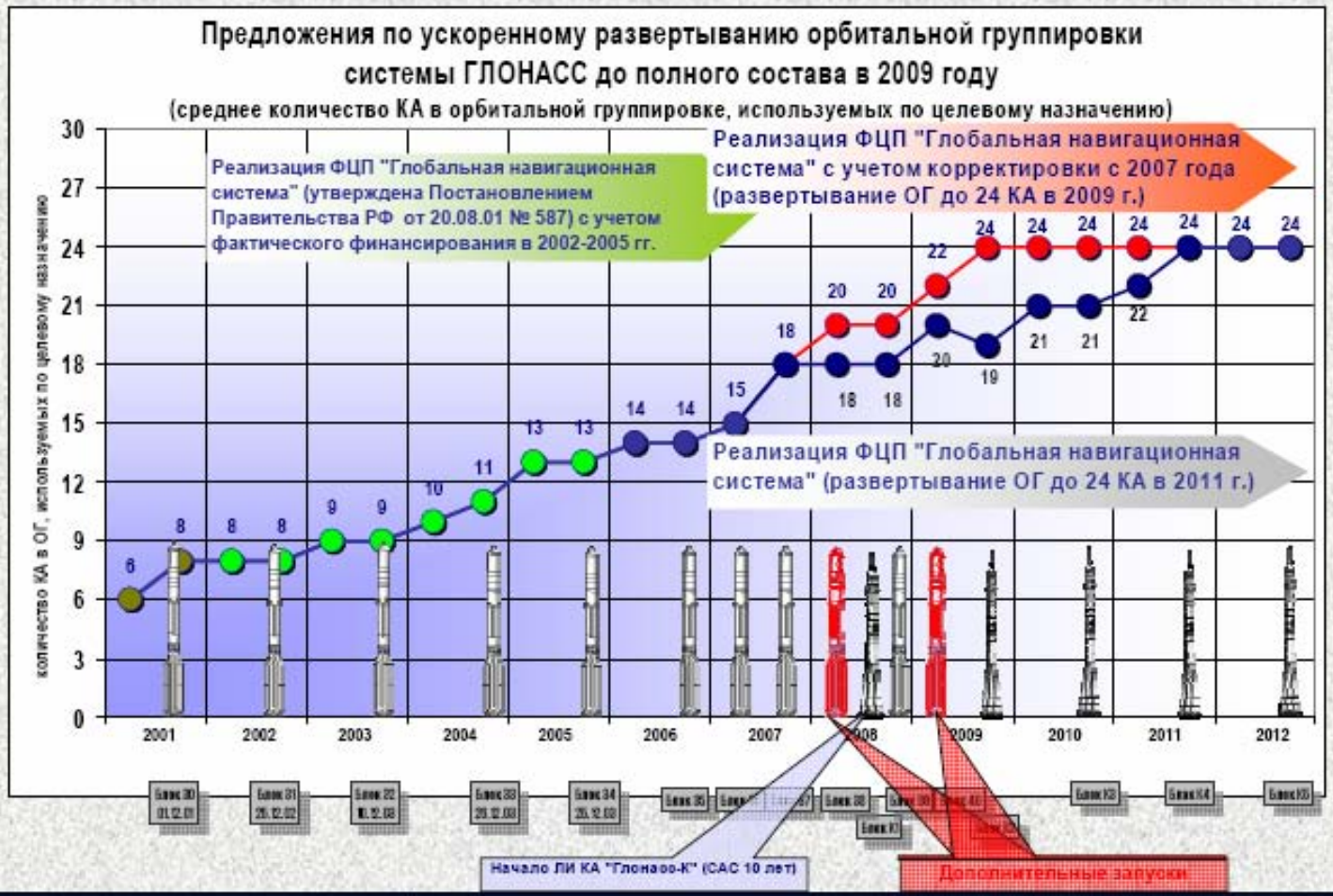
back to main page >>

RUSSIAN NEWS & INFORMATION AGENCY NOVOSTI

http://en.rian.ru/russia/20051226/42709745.html

GLONASS Constellation Deployment, Updated

GLONASS Deployment Program



http://www.munich-satellite-navigation-summit.org/Program.htm

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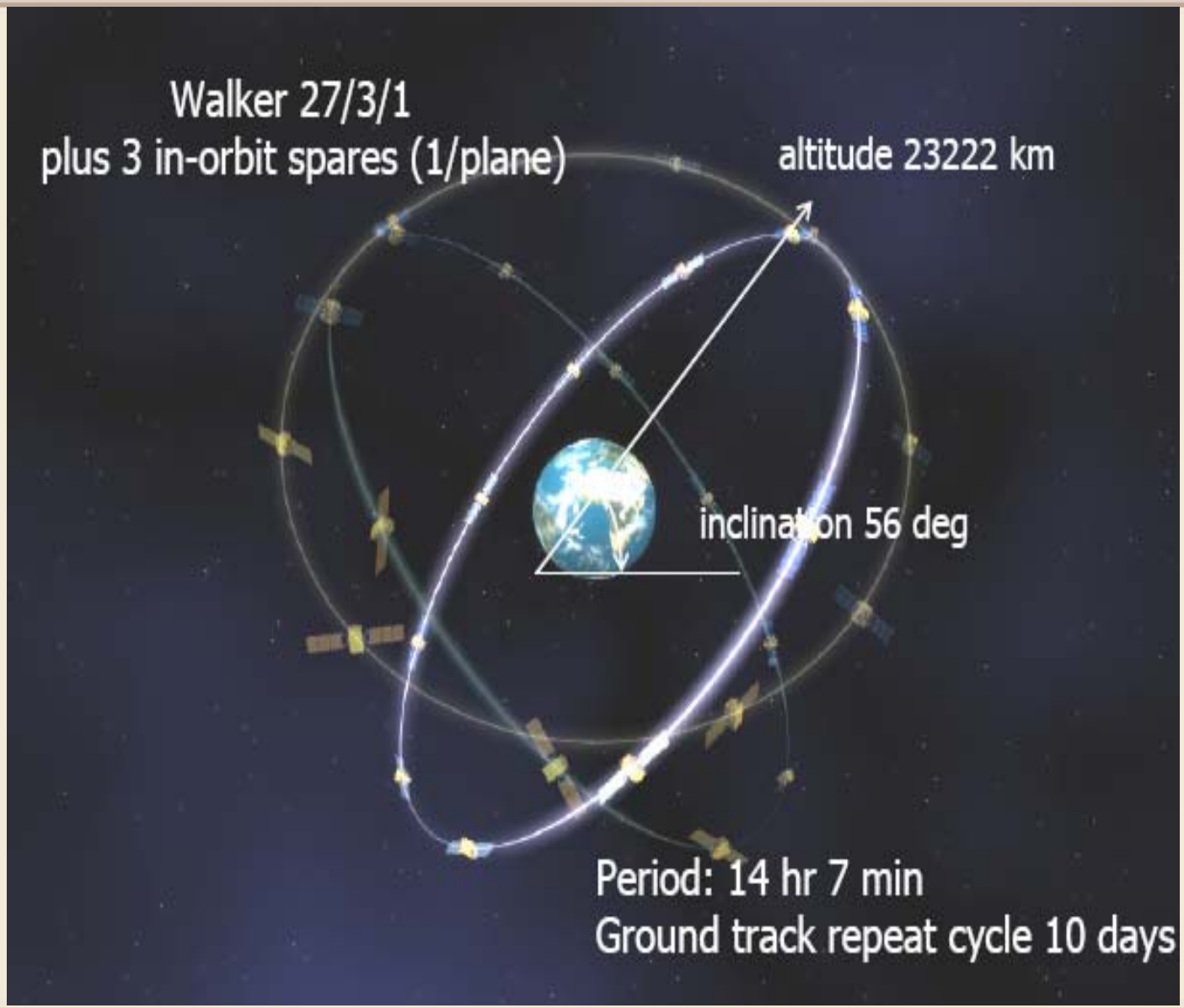
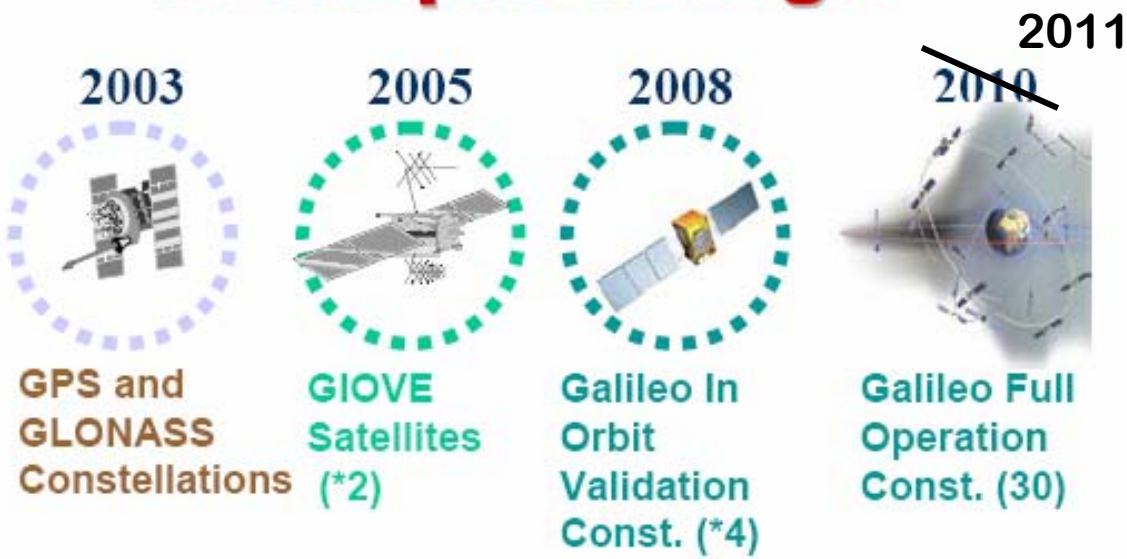
GALILEO, European Satellite Navigation System



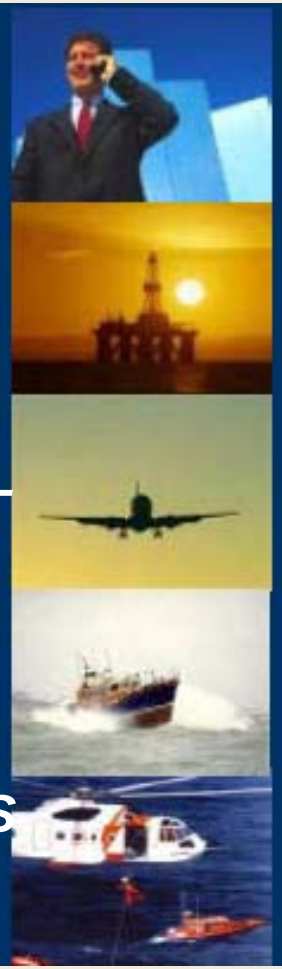
GALILEO Global Component Development Logic



http://www.munich-satellite-navigation-summit.org/Program.htm

GALILEO Services Definition

- ***Open Access***
  - Free to air; Mass market; Simple positioning
    (L1 single frequency: 15m H, 35m V, dual frequency: 4m H, 8 m V)
- ***Commercial***
  - Encrypted; High accuracy; Guaranteed service
- ***Safety of Life***
  - Unencrypted; Integrity; Authentication of signal
    (12 m HAL, 20 m VAL, others service level available)
- ***Search and Rescue***
  - Near real-time; Precise; Return link feasible
- ***Public Regulated***
  - Encrypted; Integrity; Continuous availability



Galileo, Status and Test User Receiver,
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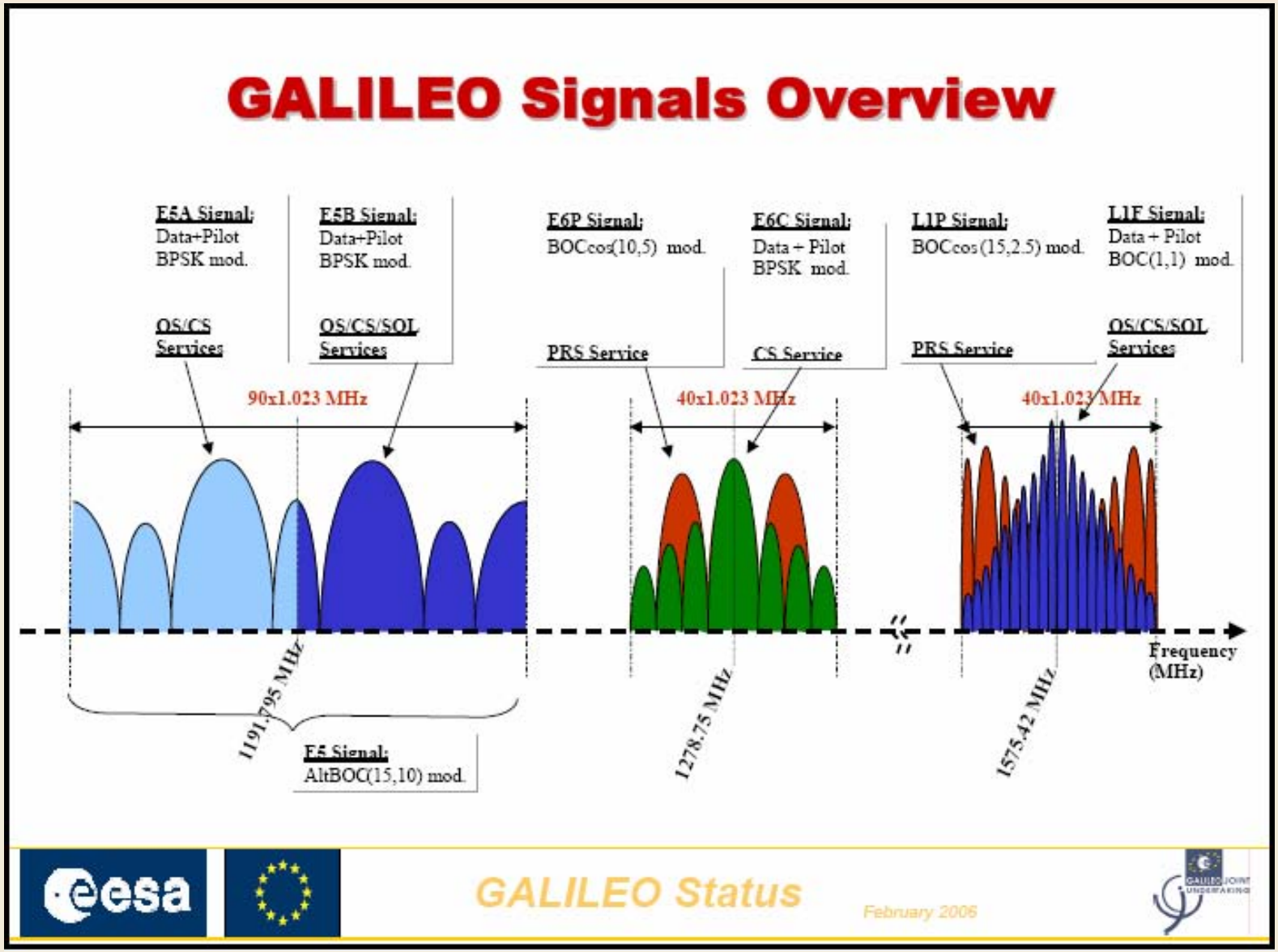

http://www.munich-satellite-navigation-summit.org/Program.htm

COMPASS, Chinese Satellite Navigation System

- China has filed for frequencies at ITU (International Telecommunications Union)
- 27 Satellites MEO, 21500 km, 55 deg
- 5 Satellites in Geostationary Orbit, 35786 km
- 3 Satellites Inclined Geostationary Orbit, 35786 km, 55 deg
- Similar frequencies as Galileo
- No information on plans to implement

http://www.itu.int/home/index.html

http://www.itu.int/jive/servlet/JiveServlet/download/432-1165-287168-650/COMPASS-up.doc

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EGNOS the European SBAS: added value

GPS-like signals

Differential corrections

Integrity (Use / Don't Use)

+ ACCURACY
+ AVAILABILITY
+ CONTINUITY

+ SAFETY

6 sec time to alarm

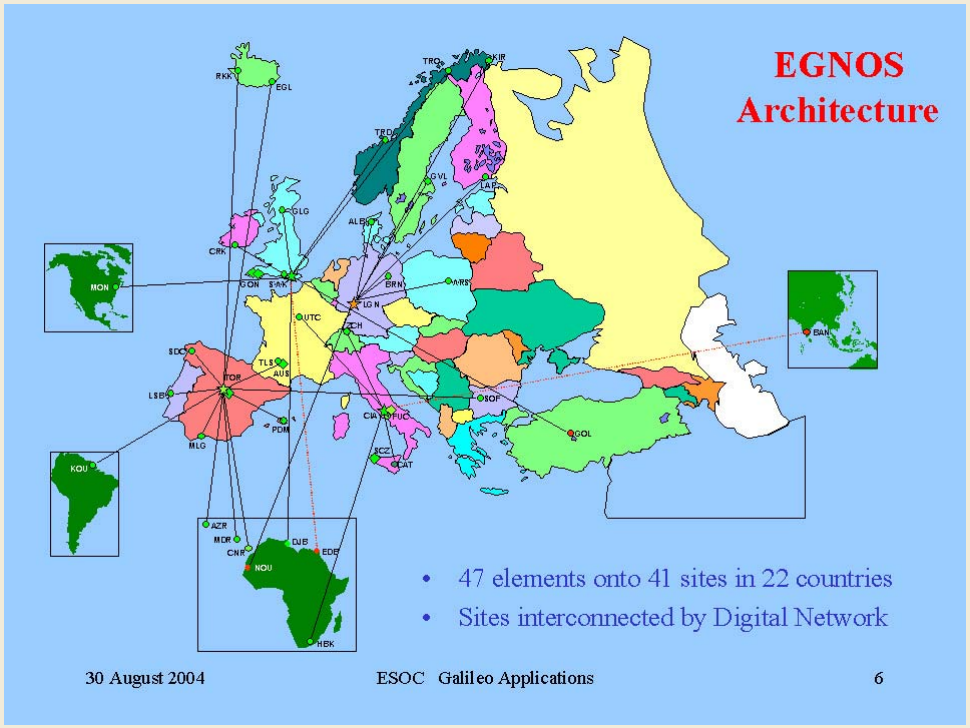
European Geostationary Navigation Overlay Service

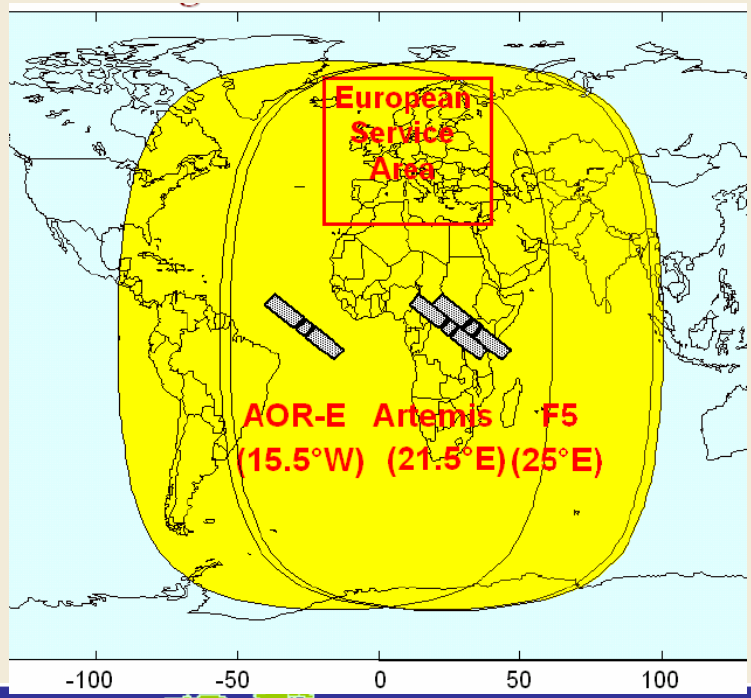
SBAS

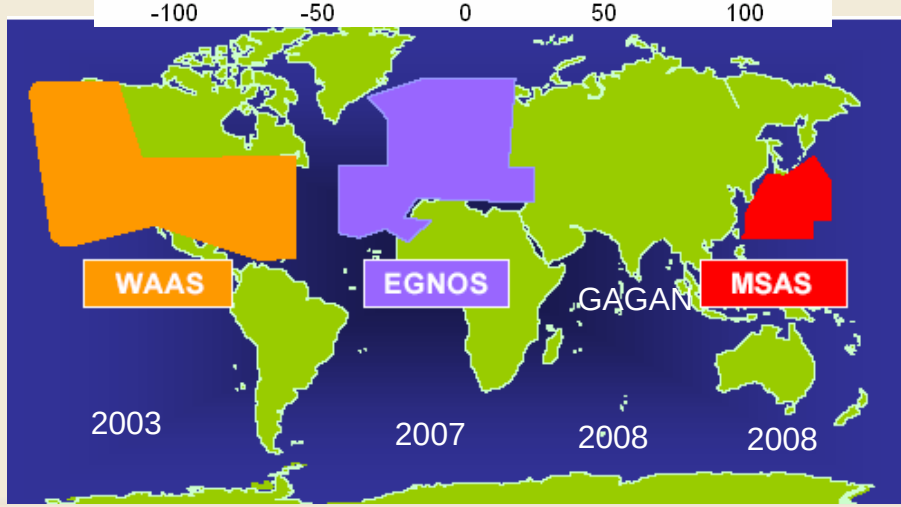
- WAAS
  - Wide Area Augmentation Service, USA. Operational 2003
- EGNOS
  - European Geostationary Navigation Overlay Service, 2006-2007
- MSAS
  - MTSAT (Multi functional Transport Satellites) Satellite based Augmentation Systems (MSAS), Japanese SBAS, operational 2008
- GAGAN
  - GPS-Aided Geo Augmented Navigation, Indian SBAS, operational 2008

- Commercial Space Based Augmentation Systems (no ranging)
  - Higher Accuracy
  - World Wide Coverage

- Fugro plans to extend Augmentation (Differential GNSS) to GLONASS and Galileo, when available


EGNOS
Architecture
• 47 elements onto 41 sites in 22 countries
• Sites interconnected by Digital Network
30 August 2004
ESOC Galileo Applications
6

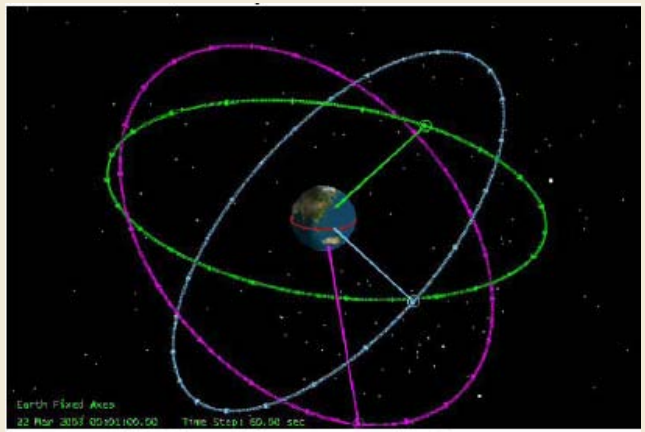

European
Service
Area
AOR-E Artemis F5
(15.5°W) (21.5°E) (25°E)
-100
-50
0
50
100


WAAS
EGNOS
GAGAN
MSAS
2003
2007
2008
2008

2003

Regional Systems

- QZSS
  - Quasi Zenith Satellite System in Japan
  - Three additional satellites supplementing GPS/GLONASS/Galileo
  - At least one over Japan at any time
  - Same L1 signal as Galileo/GPSIII
  - 2009 ->
- IRNSS
  - Indian Regional Navigation Satellite System
  - Three geostationary satellites and four inclined orbit (29 deg inclination) (2013)
  - S-Band frequency
  - ”Authorized Users”
- Beidou (”Big Dipper”)
  - Chinese military, geostationary satellites (2000-2010)
  - 2.49175 GHz
  - ”Authorized Users”



QZSS orbit constellation

QZSS Ground Track

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GNSS Receiver Availability

- Some Commercial GPS/GLONASS receivers have been available for more than 10 years.
- In 2006 all major receiver manufacturers have launched a new generation of receivers:
  - Combined receivers for two or more GNSS systems
    - Some prepared for Galileo
  - Support new civilian signals (L2C, L5)
- Multiple satellite system implementations in the new generation receivers prompted by the revitalization of GLONASS
- This added availability of receivers very important for acceptance of use of combined systems.

Receiver Manufacturers and GLONASS Capability

PRESS RELEASE

Topcon Positioning Systems, Inc.
7400 National Drive
Livermore, CA 94551
800-443-4567

Topcon opens G3 door to the future

Livermore, California, January 17, 2006–

G3.
Simple name.
Revolutionary technology.

Topcon Positioning Systems (TPS) announces the Paradigm G3 chip, a new technology that sets the standard for the future of satellite positioning. Satellite positioning systems are widely used for land surveying and machine control tasks. To operate, these systems need to receive a minimum of five satellites at all times. When the minimum number of satellites is not available due to obstructions - trees, buildings, or steep slopes -- reception is interrupted, creating costly downtime on the job site.

Topcon's GPS+ GLONASS technology virtually eliminated satellite access problems. The new Topcon G3 technology takes it a step further by adding the soon-to-be-available European Union Galileo satellite constellation, which will eventually have a total of more than 30 satellites. The G3 chip with its patented Universal Signal Tracking capabilities has 72 universal channels that can receive signals from up to 36 satellites simultaneously.

The advantages of Topcon's Paradigm G3 are numerous and include:

- Tracks all signals from all available satellite positioning systems now and in the future to provide seamless positioning information.
- Patented new generation firmware is designed to dynamically adjust to satellites with best signal strength.
- High rate signal sampling delivers industry leading performance and accuracy.
- Streamlined chip profile - 75 percent smaller than current chips, enabling small, lighter receiver design.
- Unmatched tracking capabilities in difficult environments reduce signal degradation.

http://www.topconpositioning.com/news/PPR/pr_NetG3.html

Topcon and Thales have had GLONASS Capability many years.
Topcon announces new receiver, also Galileo compatible.

Receiver Manufacturers and GLONASS Capability

NovAtel Inc. Announces GPS+GLONASS Capability on its New OEMV Family of Receivers

FOR IMMEDIATE RELEASE

Contact: Farlin Halsey (403) 295-4970

Investor Contact: Sonia Ross (403) 295-4532

(Calgary, Alberta, Canada, February 6, 2006) - NovAtel Inc. (NASDAQ: NGPS), a precise positioning technology company, today announced that its new line of OEMV Global Positioning System (GPS) receivers will also be capable of tracking satellites from the growing Global Navigation Satellite System (GLONASS) constellation. Initial releases of the OEMV-2 and OEMV-3 models are expected to be available to customers by the end of March, as previously announced in September 2005, and will include dual-frequency GLONASS measurements as an option. Future releases will include full position and Real-time Kinematic (RTK) options as well as a GLONASS enabled, single-frequency OEMV-1 model.

http://www.novatel.com/about_us/news/20060206.htm

Novatel and Trimble add GLONASS capability for the first time (Announced within one day of each other)

Trimble Introduces Survey System and New Infrastructure Network Receiver with Added GNSS Support

Trimble R8 GNSS System and
Trimble NetR5 Reference Station Receiver Offer Greater Flexibility and
More Robust Signal Tracking

SUNNYVALE, Calif., Feb. 7, 2006 -- Trimble (NASDAQ:TRMB) today introduced two new products as part of its Connected Survey Site model-the Trimble® R8 GNSS system and Trimble NetR5™ reference station receiver with added Global Navigation Satellite System (GNSS) capabilities. The positioning products, with Trimble R-Track™ technology, support GPS L2C and L5 signals as well as GLONASS adding greater flexibility and more robust signal tracking to provide a seamless and streamlined workflow for all of the critical phases of surveying.

http://www.trimble.com/news/020706a.shtm

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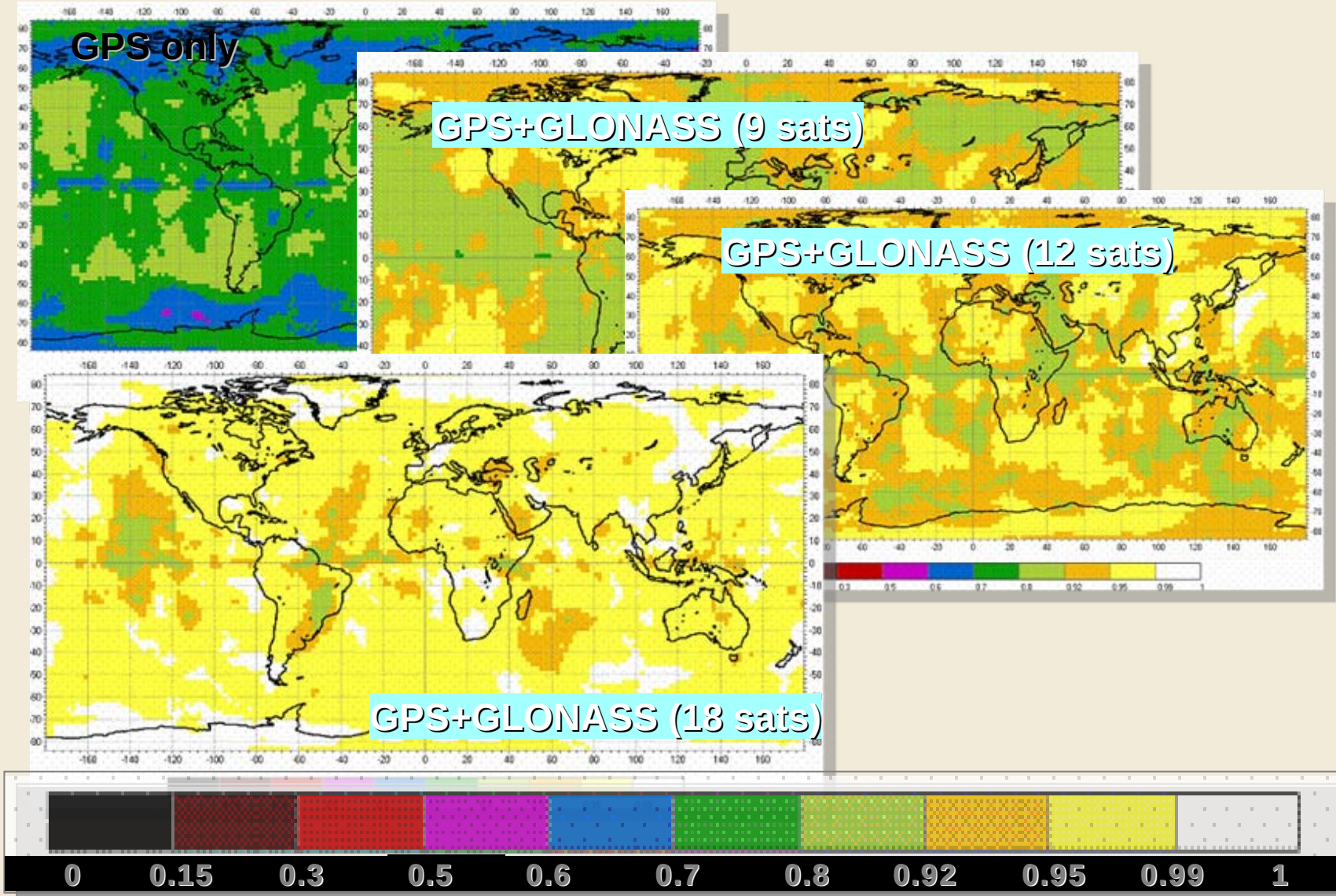
Improved Performance

- Independence
  - When more systems become fully operational, they can be used as independent systems in safety critical applications
- Availability
  - Combined systems will improve availability of satellite navigation in situations where parts of the sky are obscured.
  - GPS today have periods with reduced availability at certain times in certain regions (DOP holes)
- Reliability
  - Increased redundancy of data (additional lines of position) will help to identify bad measurements
  - More resistant towards interference with more frequencies.
- Accuracy
  - Improved accuracy with more frequencies (ionospheric delay compensation) and satellites (improved geometry)
  - Improved convergence time in regional phase based decimeter level systems

Improved Availability, GPS plus GLONASS

Probability that GDOP<5 for mask angle of 25° (a case for urban canyon)



GLONASS System: Present Day and Prospective Status and Performance, Sergey V. Averin, ENC-2006, Manchester

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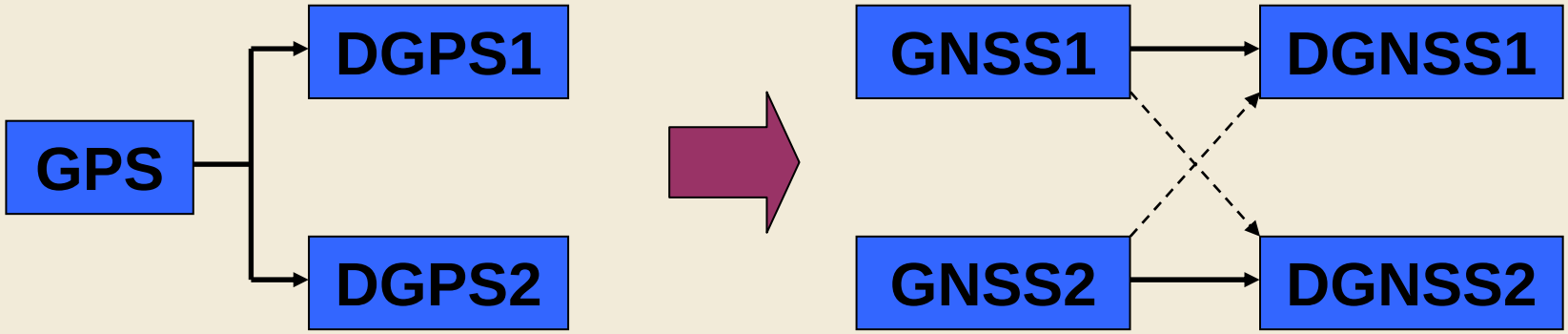
Implications for DP Operations

In the following slides comments of implications for DP will be given:

- Added Redundancy in Reference Systems
  - Independent satellite systems, GPS is no longer common source in multiple DGPS systems
- Added availability
  - Combined systems with additional satellites allows DP operations (eg Supply Vessels) close to structures
- Added Accuracy/Reliability/Availability
  - During ionospheric disturbances in upcoming Solar Cycle 24

Redundancy in Reference System



- Today GPS is used in all satellite navigation reference systems
- With multiple GNSS Systems, it will be possible to configure several totally independent reference system for DP applications
- During buildup of new GNSS systems, combined solutions will be used to take advantage of added satellites
- GNSS systems are preferred options for reference systems for a rapidly increasing DP fleet operating world-wide.

Grane Incident 6 May 2005

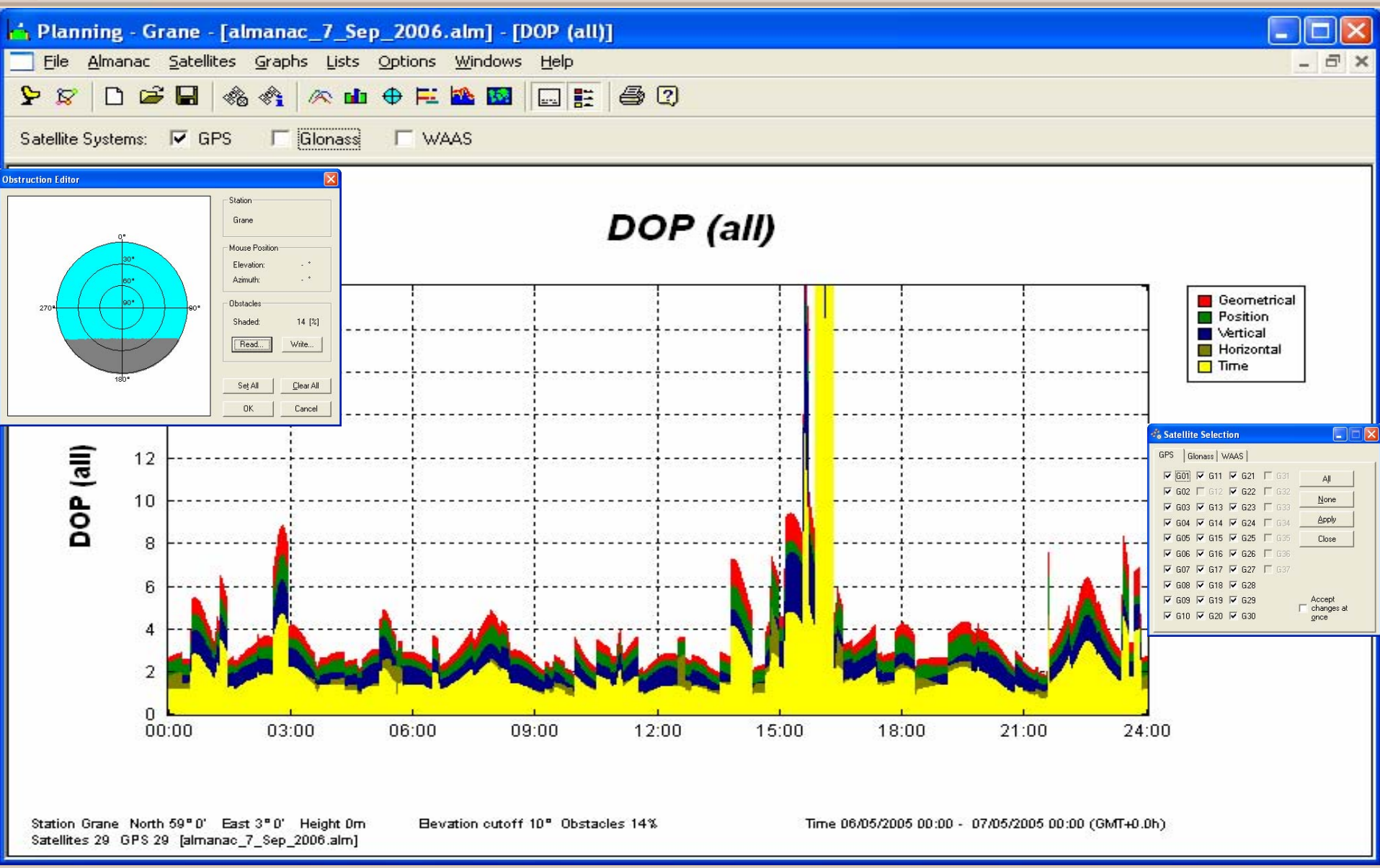
- Supply Vessel “Island Ranger” collided with Grane Platform during loading
  - Minor damage to Supply Vessel
- From the investigation:
  - The problems with the DGPS’s were caused by the position of the vessel close to the platform causing shielding of GPS satellites.
  - The vessel should not have operated on DP due to lack of positioning system redundancy

- Problems would have been mitigated with additional satellites providing safer operations.

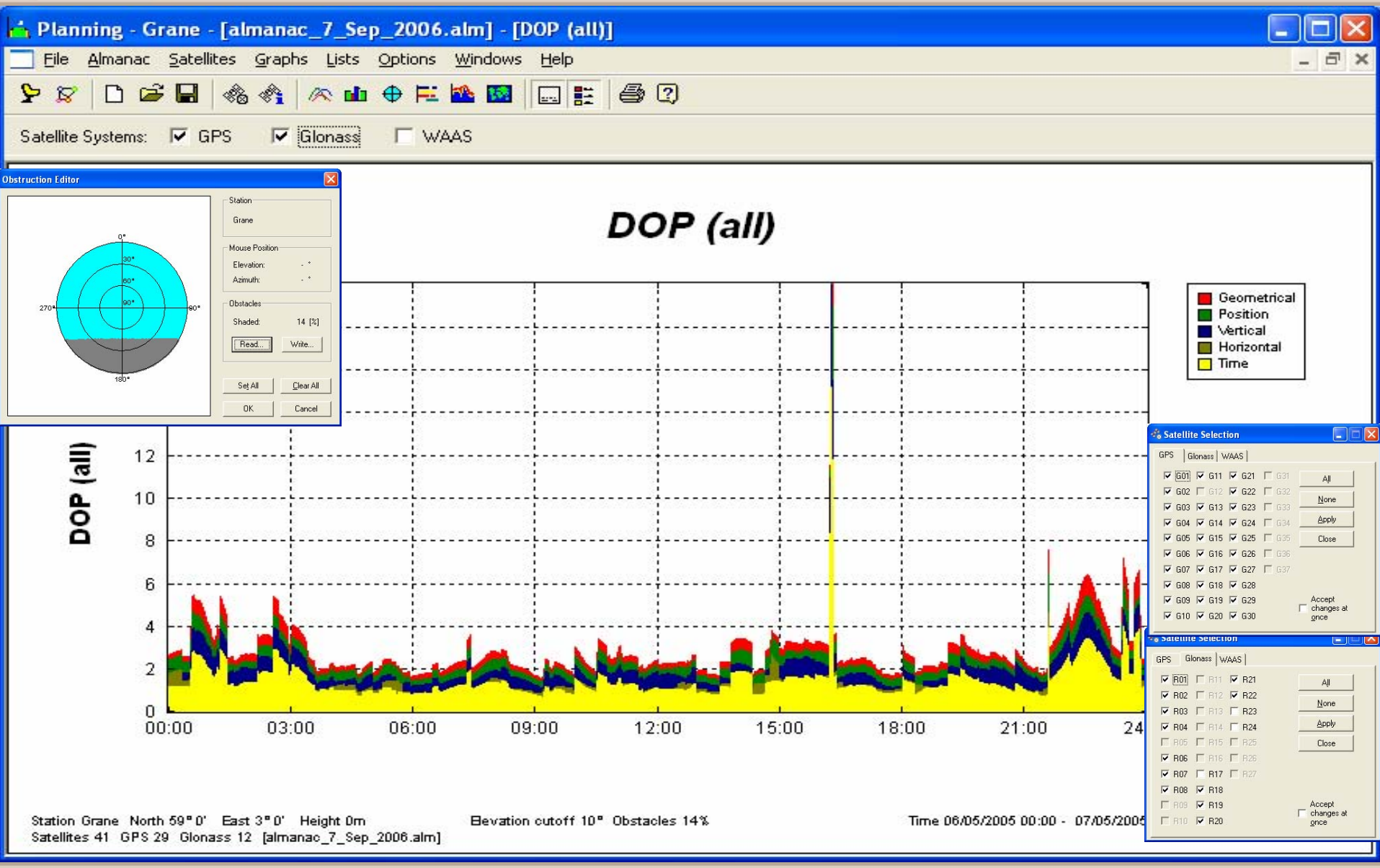
- This is just one example one of many similar incidents.

http://www.hydro.com/en/press_room/news/archive/2005_05/grane_en.html

GPS coverage example with shadowing



GPS + GLONASS coverage example with shadowing

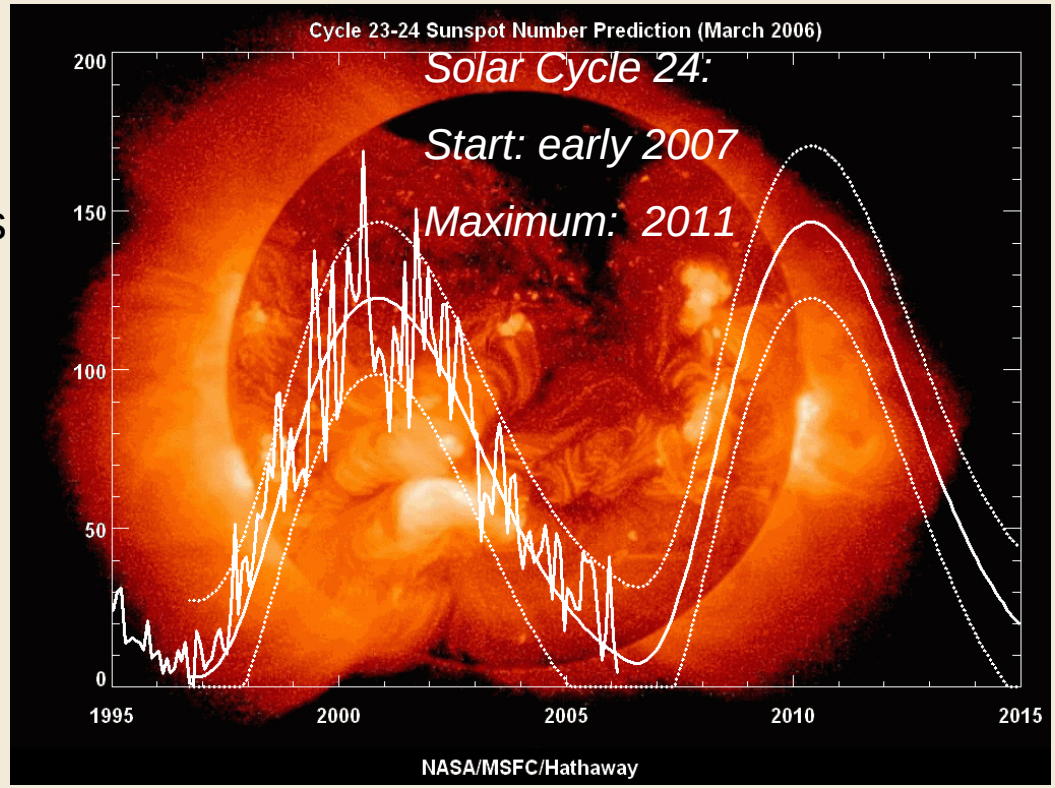


Ionospheric scintillations (tend to affect a part of the sky):

- Receiver looses lock
- Mitigated by additional satellites

Unpredictable ionospheric electron content:

- Delay in ranging measurement
- Mitigated by additional frequencies



- DP operations in equatorial regions where heavily affected during the previous solar cycle
- Petrobras specified use of GPS+GLONASS for certain operations in Brazil

http://www.nasa.gov/vision/universe/solarsystem/solar_cycle_graphics.html

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Conclusions

- GPS
  - 28 Operational satellites
  - Block IIR with L2C, M-Code: 2005-2012
  - Block IIF with L5: 2008-2015
- GLONASS
  - 14-17 Operational satellites
  - 24 planned by 2009
- Galileo
  - Initial Orbit Validation (IOV) 2008-2009
  - Fully operational end 2011
- Improvements in Performance
  - Independence, Availability, Reliability, Accuracy
- Implications for DP
  - Independent Reference Systems, Availability in shaded areas, Improved performance during next solar cycle

- Fugro will provide augmentation services (DGNSS) to all the Global satellite Navigation Systems