

Perspectives on Global Navigation Satellite Systems as an enabler for future ATM Environment

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- History of Aeronautical Navigation
- Current situation of GNSS technology
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Goals

- There is no question at all that in the future GNSS will play a more important role to support aviation industries.
- Without the technology, new advanced ATM could not be realized.

Origin of Position Determination

- Latitude
 - Basic instruments are almost identical to those of GNSS
 - Size of the instrument is the size of the instrument
 - Observation
 - ..Artificial stars with known positions
 - ..Precise clock
- Longitude
 - ..Global coordinates (WGS-84)
 - Requires very precise clock and global time/position reference .
 - Need to wait until A.D.16-17 century
 - Royal Greenwich Observatory established in 1675

Navigation technologies for remote and oceanic areas for aviation



- Celestial Navigation
 - DC-8 used to have small windows on the ceil of the cockpit for this purpose.
- Inertial Navigation – widely used
- Doppler radars – measuring ground speed and directions
 - Need to have initial positions -> KE007 case
 - Accumulation of errors
 - >For long haul flight – requirement of position update by other methods (GPS, VOR/DME)

The first global radio navigation system



- OMEGA system '80's – 1997
 - Receivers perform automatic position calculations
 - Accuracy is low
 - several kilo meters depending on propagation conditions and geometry of ground stations
 - Surface applications especially for vessels -> not widely recognized as aeronautical navigation aids
 - **Underwater applications (i.e. Submarine navigation)**

GPS has taken over the role.

GPS as a pioneer of the new era

- GPS (1990's – now) for civil use
 - No accumulation of errors
 - No need to have initial positions
 - Precise time base, timing synchronizations
 - Almost global coverage – polar regions may have poorer DOPs.
 - Sufficient accuracy over the globe for aviation with augmentations as necessary
 - Vertical guidance with proper augmentations
 - APV-I,II, LPV200, CAT-I,II,III by GBAS

GPS vs other techniques

- GPS – Celestial Navigation
 - No navigators necessary, accuracy, frequency of measurements
- GPS – OMEGA
 - 3D(4D) positioning, accuracy
- GPS-INS/IRS
 - no initial position, no cumulative errors
 - **Smoothness of tracking, polar regions**

Current situation of GNSS technologies and its services




- GPS is available now.
 - At least 27 satellites
 - Has exhibited good performances so far
 - Longer actual life time of satellites than designed.
 - Tendency of delaying a replacement with new satellites
 - As of today, virtually dominating sat-nav. market.
 - Besides aviation, various applications available in our daily lives
 - Cars, mobile-phones, securities, emergencies, science, sports, surveys, network synchronizations, etc.

Core satellite networks other than GPS

- GLONASS is available.
 - Still needs to launch additional satellites for full capacity
 - Need to develop receivers especially for commercial applications
 - Modernization program expected
- GALILEO as a future system
 - Two experimental satellites in orbit
 - For IOC, needs to wait until around 2012

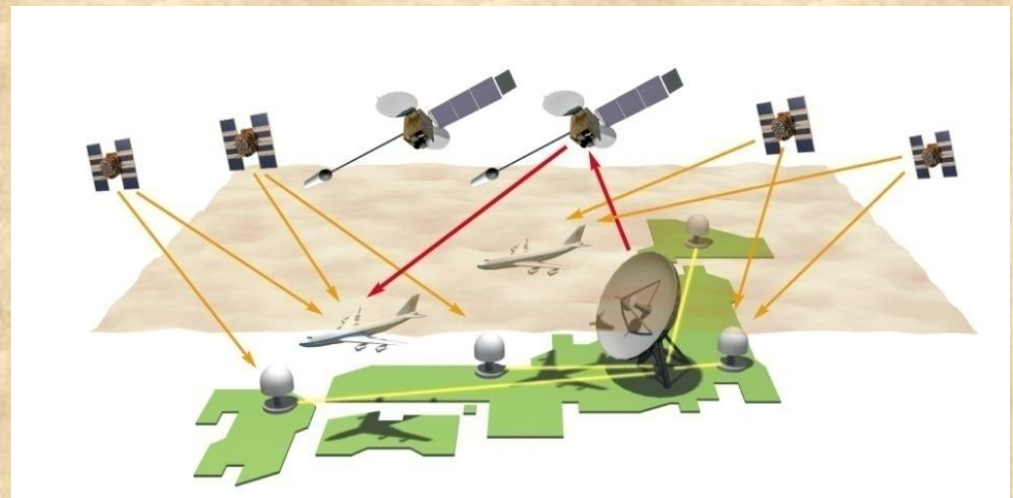
Core satellite networks other than GPS (cont'd)

The logo for ENRI (Environmental and Nuclear Research Institute) is located in the top right corner. It consists of the letters "ENRI" in a bold, green, sans-serif font, with a thin black line curving around the top and right sides of the letters.

- Beidou (China)
 - Need to have further information about the new constellations.

Augmentation systems

- Satellite based Augmentation Systems
 - Operational systems – WAAS, MSAS
 - Close to be operational – EGNOS, GAGAN
 - Compass/Beidou ?
 - QZSS – R&D phase



Augmentation systems (cont'd)

- Ground based Augmentation Systems
 - Expected certification of CAT-I GBAS ground system by FAA in 2009
 - CAT-II,III GBAS will be developed under the international effort.
 - Marketing strategy and attractive applications provided by GBAS are surely needed to compete existing Instrument Landing System.
 - Requirement must be different due to regional unique characteristics. Necessary user involvement will resolve the specific issues.

Why GPS is so successful ?

- Stable operations since 1990's after declaring for civil use
- Political commitments to international

Many of users are satisfied with GPS as a whole.

- Disclosure of technical information
 - Specifications of Signal In Space
 - Other related documents
 - Status of operations – through USCG web site

Expectations of future GNSS environment



- Can we expect in the future that GNSS is still available for users ?
- Who will provide GNSS services?
- What kind of services will be available ?

Can we expect in the future that GNSS is still available for users ?

- GNSS will keep its momentum for certain states to build, launch, operate and maintain the system.
 - There is a reality that space technology still has been keeping national interests for countries since the successful launch of the Suptnik-1 satellite 50 years ago.
 - It seems the situation would not be drastically changed during the coming 10-15 years.

- The history may not go backward after knowing GNSS benefit.
- As a result, there is enough reason to believe GNSS will be available in the future.

Who will provide GNSS services and why?



- Core constellations will be even provided by few countries while technologies themselves may be disseminated in the world.
- Competitions among core satellite networks may occur.
 - Users expect new services through the competitions.

What kind of services will be available ?



- Considering the current dominant situation by GPS, new constellations should have marketing strategies to compete GPS.
- Excellent new services by other satellite networks should be required for wider user acceptance.
- Through competitions, more attractive services may be realized.
- In this sense, involvement of users is necessary.

Discussion and conclusion

Message from users to future constellations



- Additional capabilities will be absolutely necessary, when compared with existing systems.
- Disclosure and dissemination of technical information will drive development of user applications.
- Stable political commitment will brew users' confidence to the core satellites.

For users

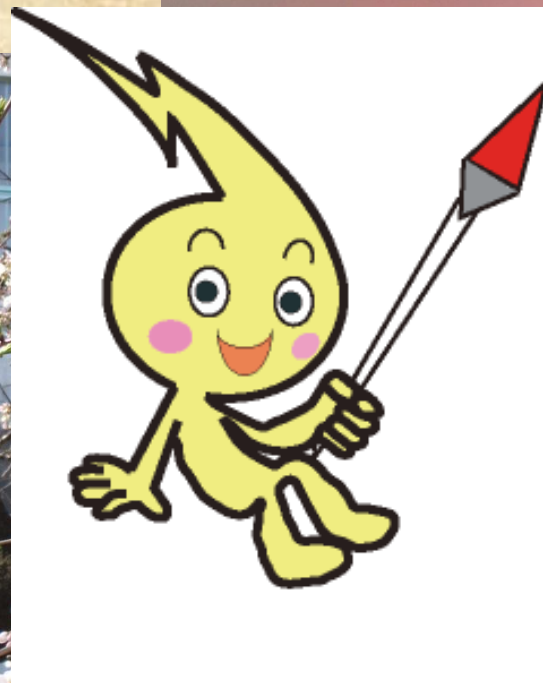
(countries other than core satellite providers)

- Need to know themselves that they are a ‘follower’ by nature, e.g. more or less, dependent on GNSS policies of core satellite providing countries.
- Understanding the context above, however, to maximize influence to the GNSS services, users should conduct R&D to catch up with or even surpass them at least technical competence concerned and,

For users (cont'd)

- let the core satellites know the reality of the GNSS user market, resulting in more preferable and excellent new services under competitive GNSS environment.

Thank you



Questions?