International Civil Aviation Organization

WORKING PAPER

NAVIGATION SYSTEMS PANEL (NSP)

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Agenda Item 7: Guidance on operational implementation issues

The Need for an Alternative PNT

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Summary

This paper suggests that there is a need to revisit research on the transition to a satellite-based sole navigation service and the potential need for Alternative PNT, and if deemed necessary develop corresponding international standards. In also proposes that any potential work be broadly framed within the general direction established by ICAO Doc 9883 --Manual on Global Performance of the Air Navigation System. Finally, for information purposes, its Appendix 1 summarizes the capabilities of the Locata System –one more option beyond those summarized in NSP May17-28/WGW/IP_13.

1. BACKGROUND AND BRIEF DISCUSSION

1.1 In 2003 the Eleventh Air Navigation Conference (ANC/11) recommended that:

> "ICAO continues to develop as necessary provisions which would support seamless GNSS guidance for all phases of flight and facilitate transition to satellite-based sole navigation service with due consideration of safety of flight, technical, operational and economics factors." (Recommendation 6/1.a)

1.2 Using this recommendation as a basis, since that time ICAO and its participating States have worked to transition CNS functions to satellite based systems. This transition has resulted in such initiatives as Performance Based Navigation (PBN), Approaches with Vertical Guidance (APV), Automatic Dependent Surveillance Broadcast (ADS-B) and, of late, satellited-based back-up for ATS voice communications in some operational environments. Clearly the ICAO preference is for a satellite based CNS infrastructure that is being supported by the development of the appropriate rules and procedures.

1.3 The apparent need for Alternative Positioning, Navigation and Timing (APNT) systems is beginning to emerge around the world and is driven by a number of reasons. For example, the efforts being currently undertaken in the USA have been summarized under NSP May17-28/WGW/IP_13. However, these types of efforts are generally based on State assessments of safety and security issues of CNS systems and not on ICAO based research.

1.4 The above suggests that there is a need to revisit research on the transition to a satellite-based sole navigation service and the potential need for Alternative PNT, and if deemed necessary develop corresponding international standards.

1.5 Moreover, since international transition to GNSS was predicated on the high cost of infrastructure that was technologically older, alternatives should take into account similar, if not broader, considerations. The need to broaden our consideration of the problem and its potential solutions is well recognized by ICAO in its *Manual on Global Performance of the Air Navigation System* (Doc. 9883) which proposes a structured method to do so as the aviation community moves toward the Global ATM Operational Concept.

1.6 As recognized by Doc. 9883, the expectations, conditions and resources of the ATM Community do vary around the world, and hence different potential techno/operational solutions will also have different appeal. For example, there exist other options beyond those summarized in NSP May17-28/WGW/IP_13. Some are based on enhancements to well established or new systems, as is the case with GPS III, Glonass and e-LORAN, and in the near future, Galileo. Others could be based on emerging technologies–such hybrid GNSS receivers, MEMs, or as the Locata System described in Appendix 1.

2. ACTION BY THE MEETING

2.1 Given the arguments and information presented above, the meeting is invited to:

a) Consider updating the NSP work programme to revisit research on the transition to a satellite-based sole navigation service and the potential need for Alternative PNT, and if deemed necessary develop corresponding international standards.

b) Consider broadly framing the above work within the general direction established by ICAO Doc 9883 – *Manual on Global Performance of the Air Navigation System*.

c) Note the existence of options beyond those summarized in NSP May17-28/WGW/IP_13 such as e-LORAN, hybrid receivers, MEMs and the Locata System.

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APPENDIX 1

1. LOCATA SYSTEM TECHNOLOGY AND MATURITY SUMMARY

(http://www.locatacorp.com/index3.html)

1.1 Alternative technologies do not always offer the simplicity or accuracy of GPS while still remaining fully independent, nor can they provide position information reliably in all environments. Locata was designed from the ground up as a positioning system with four major design objectives: available in all environments; high reliability; high accuracy; cost effective; and full independence or practically seamless augmentation mode.

1.2 To achieve these goals, the Locata System uses a network of ground transceivers or *LocataLites*, instead of orbiting satellites. The LocataLites create a network that can be called "a local replica of GPS". The three characteristics of the LocataLites that are most relevant to any discussion on Alternative PNT are:

a) that they self-synchronize autonomously at the picosecond level without using atomic clocks or external aiding – a central and critical technological advance referred to as *TimeLoc*, signifying that the terrestrial Locata transmitters are chronologically "locked" together. This autonomous synchronization gives Locata the ability to supply autonomous position solutions, which require only a single, simple receiver utilizing only one-way ranging signals, in the same manner as GPS;

b) that they blanket a chosen area with signals that are much stronger than GPS. The signals can be transmitted at any power level required to perform satisfactorily for a given application. Locata devices today are in use operationally for industrial applications where their weakest signal is more than 1,000 times stronger than the most sensitive autonomous GPS solution; and

c) that they transmit GPS-like signals to allow relatively straightforward integration into GPS-style position solutions.

1.3 A standalone receiver or *Locata*, almost identical to a standard GPS receiver, can acquire and track both Locata and GPS signals. It treats the Locata signal as "a Local Constellation" whose pseudorange and carrier-phase measurements are used in a combined position solution in exactly the same way as, say, GLONASS or Galileo measurements. This design provides an optimum location solution by providing a seamless transition between environments where a user can utilize standalone Locata signals, GPS signals, or both. A Locata receiver therefore exploits the strong heritage and history of GPS, yet evolves the technology to a higher level. Locata provides precise range measurements and accurate position solutions, while maintaining the simplicity and low cost which have made GPS so successful.

Locata's terrestrial base gives local control and regional coverage. The *LocataLites* incorporate both the transmitters and receivers and this allows the system to be configured to meet specific, localized demands for availability, accuracy, and reliability. This capability ensures the Locata network and its' signal integrity can be assured in even the most demanding environments. This ability to modify the availability and reliability of signals is beyond the reach of GPS, or any other technology that lacks native local control of the transmitters generating the location signal.

1.4 The following table summarize the systems strengths and weakness, and also gives a comparison of Locata and GPS signal structure:

Locata	
Strengths	*Weaknesses*
• Proven and tested technology which locally replicates GPS functionality. • GPS reference frames for both position *and* time. • "Surveyor" accuracy without reference networks, external corrections, data links or atomic clocks. • Extremely flexible; any number of signals can be deployed to ensure reliable performance. • High-powered signals can be transmitted; much harder to jam than weak GPS signals. • Currently operates in "free" 2.4GHz ISM band; easily modified to transmit at other frequencies. • Extends and expands GPS capability. Reaches into areas where GPS (or any satellite-based system) can't reach, such as indoors. • Can be used by appropriate GPS receiver as "just another available constellation signal". • Can be tailored for specific applications. • Networks can self-survey to ease installation. • Networks self-propagate for ubiquitous coverage with no restrictions on common visibility.	• Not yet commercially available as an integrated "GPS-Locata" receiver. • Not yet available in ASIC (chip set) form factor. • Not yet available in large commercial quantities. • Vertical geometry (VDOP) can be worse than GPS as ground-based network may be "planar". • Requires further development to meet ICAO standards. • Currently small base of engineers with Locata experience. • ICD will not be publicly released until September 2011??

Locata Signal	*GPS C/A Signal*
CDMA + TDMA	CMDA - only
100 bps navigation data on signal	50 bps navigation data on signal
20 MHz spreading	2 MHz spreading
4 signals, 2 frequencies, 2 separate antenna	2 frequencies, 1 common antenna
Maximum sensitivity -105 dBm	Maximum sensitivity -165 dBm
Typical clear view strong signal (-60 dBm)	Typical clear view strong signal (-125 dBm)
Fixed positioning geometry	Continuously variable positioning geometry

1.5 In June 2010 the USA DOD's Central Inertial and GPS Test Facility (CIGTF) awarded a contract to redesign and upgrade its current Locata network to cover 6,500 square kilometres with an Ultra High Accuracy Reference System (UHARS) that will provide sub-meter accuracies in a GPS denied environment to evaluate the performance accuracies of next generation weapon and aircraft systems.

1.6 The mining fleet management specialist, Leica Geosystems recently announced the launch of its Terrestrial GPS Augmentation Network, which is based on Locata technology. Leica considers that "this innovative terrestrial network ensures 24/7 positioning coverage in adverse GPS situations"; that it "enables a level of control and flexibility which is not possible from the standard satellite network"; that it "makes a significant advance in the availability of consistent positioning signals, independent from the satellite constellation"; and that it is "a significant step in meeting the positioning requirements critical to GPS based collision avoidance and automated mining developments."

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