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Agenda Item 6: Future direction
6.1: Implementation plans and methodologies

NEGATIVE CONSEQUENCES OF MANDATING EQUIPAGE OF SPECIFIC GNSS ELEMENTS

(Presented by the International Coordinating Council of Aerospace Industries Associations and the International Air Transport Association)

EXECUTIVE SUMMARY

This paper discusses negative consequences that arise from State mandates for equipage or use of specific global navigation satellite system (GNSS) elements. The paper also discusses the negative consequences of any State precluding the use of specific GNSS elements within its airspace.

Action: The Conference is invited to agree with the recommendation in paragraph 6.2.

1. INTRODUCTION

1.1 The global navigation satellite system (GNSS) has been in a continuous state of evolution since the advent of satellite navigation concepts in the 1960s. As the technology matures, the evolution is accelerating with additional States developing and offering for use new core constellations and augmentation systems. The expected evolution of GNSS is described in Appendix B of AN-Conf/12-WP/21. While this planned evolution of GNSS will provide benefits to the users in terms of improved robustness of GNSS and will potentially enable new capabilities, there are some negative consequences in addition to the benefits. Many of these are also discussed in the referenced papers in the section on “Challenges”. The evolution of GNSS towards multiple core constellations and multiple frequencies in conjunction with an associated evolution and proliferation of augmentation systems represents a fragmentation of navigation services that if not dealt with carefully could destroy much of the value of GNSS from the end-user perspective.

2. CHALLENGES ASSOCIATED WITH FRAGMENTATION OF SATELLITE NAVIGATION SERVICES

2.1 Use of multiple constellation and multiple frequencies in GNSS presents challenges for avionics and aircraft integration as well as aircraft operators. These challenges arise from the complexity of the combined services themselves and the consequential complexity of integrating these services into aircraft and aircraft operations. These challenges can be even greater when inappropriate regulatory or institutional policies are applied. The policies that can be most damaging are mandates for equipage or use of specific GNSS core constellations or augmentation systems. These challenges are discussed in greater detail in WP/21. However, for completeness, this paper reviews the challenges and further expands on the implications of mandates or prohibitions of GNSS elements or services.

2.2 As discussed in WP/21 a significant technical challenge will be in the cost and complexity of receivers. Although it is theoretically possible to design an integrated receiver that uses all the core constellation signals and augmentation signals that will be available, such a receiver will consequently have many modes of operation. Each mode of operation will need to be tested as well as the transitions between modes.

2.3 The near-continuous evolution of GNSS, as new core constellations are added and new signalling waveforms on new frequencies or the same frequencies are introduced, will challenge receiver designers to implement receiver architectures that can adapt and are also simple and certifiable. While industry will undoubtedly rise to this challenge, development and certification of new receiver designs is an expensive proposition and the number of design iterations will need to be limited in order for GNSS receivers to remain affordable. This is particularly true for air transport class avionics where the number of units over which development costs can be amortized is relatively small and development costs are relatively high due to the cost of certification, etc. Premature mandates (i.e. before development of requirements and standards for other GNSS elements are mature) for equipage or use of specific GNSS elements (e.g. a particular core constellation) could force early receiver development. This would likely lead to unnecessary iterations of the design cycle and a proliferation of receivers with more variation in capabilities. It could even discourage operators from later replacing the mandated GNSS receiver by a more capable modernized GNSS receiver, by raising the bar at which the business case becomes positive.

2.4 Another challenge is in the operational control of the more complex receivers. Although there are technical aspects to this challenge, it is largely driven by political and institutional policies. The Chicago Convention establishes that all States have sovereign control over their airspace. Consequently all States have both the right and responsibility to determine what navigation signals and services are authorized for use in their airspace. This means that a State might require or preclude the use of a particular element of GNSS (i.e. a specific constellation, signal or augmentation service). This poses some particularly difficult challenges for avionics integration from technical, financial and institutional standpoints. If States exercise this sovereign right and mandate equipage or use of a particular GNSS element or service, then equipage cycles will be impacted, and operational use of GNSS systems will become more difficult and expensive. Furthermore, such mandates would ensure a proliferation of receiver types that may only be capable of utilizing subsets of the available GNSS elements. Such mixed equipage is not in itself a problem unless there are operational restrictions or mandates associated with GNSS elements. For international operators, the management of which GNSS elements are approved, required, or prohibited as the aircraft flies from one State into another would prove to be very cumbersome and probably costly. In addition, such a mandate would likely be difficult to enforce, as the State would have no easy way of knowing which GNSS element an aircraft is using at any given time.

2.5 Today virtually all air transport class aircraft avionics are based on GPS alone. The determination of which system can be used in a given airspace is relatively simple. A given State has either authorized the use of GPS or it has not. In the future some State may authorize the use of one GNSS core constellation, but forbid the use of some other. This presents a problem for the integration of avionics in that the receiver must now be told which constellations can be used when. The same concept extends to multiple frequencies and to multiple regional augmentation systems like SBAS where significant coverage of augmentation signals may extend outside the service volume. Such a means to control when a receiver uses individual GNSS elements is not yet fully defined except when it is linked to the selection of an approach requiring the use of a particular GNSS, under an ANSP authority, such as APV SBAS or GLS. It is likely that relying on pilots in such tactical decisions is impractical and therefore some level of automation would be required. The GNSS satellite/signal selection algorithms would likely become complex functions of current authorizations, the current GNSS element status and the current position of the aircraft. Also, since the status of which element is permitted or precluded in which airspace would change over time, this implies that the information driving an automated function would need to be updated on a regular basis. The management of that information, the tracking who has authorized what, and the maintenance of that information would likely be a costly process. Such a situation might also introduce as yet undefined safety hazards that would need to be managed and possibly mitigated.

2.6 Another challenge that would be exacerbated by mandates is associated with aircraft airworthiness approval. An airworthiness certificate is issued to an aircraft by the State of Registry. The certificate denotes among other things that the aircraft was found to conform to its approved design which is typically detailed in the type certificate data sheet (TCDS) which is part of the type certificate (TC) that is awarded by the State of Design. The TC is awarded to designers after they have shown that the particular design conforms to the State design standard including the applicable regulations prescribed by the CAA of the particular State of Design. Consequently, type certification of an aircraft that includes use of GNSS elements not approved by the State of Design will be problematic. Such situations are likely to get even more complicated in the future as different GNSS core constellations will mature at different rates and different States of Design and States of Registry may approbate the different GNSS elements at different times. This situation would be complicated even further if a State were to mandate equipage of a type for which no MOPS exists as the basis of airworthiness certification. This would cause aircraft manufacturers and State certification authorities to pursue development of airworthiness certification requirements before the standards and requirements for some other GNSS elements are mature.

3. THE HIGH COST OF MANDATES

3.1 There are different levels of mandates that might be considered. Each type introduces costs for the aircraft manufacturers and the end users. Mandates by one State may also introduce costs to other States when those States are the State of Design for an affected aircraft manufacturer.

3.2 Equipage-only mandates: It is possible that a State may decide to mandate only that some or all operators must carry equipment capable of using a particular GNSS core constellation or augmentation system. Such mandates are expensive for the manufacturer and the end user as they can cause premature or unnecessary iterations of GNSS receiver design. Potential costs to the States include the requirement to develop a means of verifying compliance.

3.3 Equipment mandates with an associated requirement for operational use: It is possible that a State may decide to mandate that some or all operators must carry equipment capable of using a particular GNSS core constellation and that all operators must in fact use that GNSS core constellation when operating in that State's airspace. Such mandates are expensive for the manufacturer and the end-user for all the reasons listed in the previous paragraph. In addition, requirements around operational use will introduce additional costs associated with the control of the sensor. This could include impacts to displays for cockpit annunciation in order to ensure that the mandated system is actually being used where required. This could introduce costs associated with pilot training to ensure that the pilots understand when the required GNSS element is in use and how to react if the required element is not in use when it should be etc. In the end, such GNSS system specific requirements should be unnecessary if the more appropriate philosophy of performance-based navigation (PBN) is used.

3.4 Operational Prohibitions: It is possible that a State may decide to authorize the use of some GNSS elements but forbid the use of other GNSS elements. This kind of mandate would introduce the same kinds of costs that are discussed in the previous paragraph. And again, such restrictions on the use of GNSS elements are unnecessary and counterproductive when compared to systems that integrated in a manner that supports the PBN concept.

3.5 The PBN concept represents a shift from sensor-based to PBN. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors and equipment that may be used to meet the performance requirements. Operators have the ability to choose the most cost-effective technology and navigation services to meet the required performance rather than an artificially mandated solution.

4. THE RUSSIAN MANDATE FOR GLONASS EQUIPPAGE

4.1 An information paper[1] was presented by Russia at a Navigation Systems Panel Working Group of the Whole (NSP WGW) held in May of 2012 concerning a recent order of the Ministry of Transport of Russia regarding the "implementation of GLONASS or GLONASS/GPS satellite navigation equipment on civil aircraft". The order was published on February 13, 2012 and provides compliance dates for different types of aircraft and operations, including the following deadlines for foreign-manufactured aircraft included in an Operator's Certificate (Operator's License) issued in the Russian Federation:

a) airplanes and helicopters used for commercial transportation with a maximum takeoff weight of more than 495 kg – before 1 January 2017; and

b) general aviation airplanes and helicopters (…) – before 1 January 2018.

4.2 During the discussion it was emphasized that the order stipulates requirements for domestically manufactured and foreign-manufactured aircraft certified for operation by Russian aircraft operators; it does not impose new requirements on non-Russian aircraft operators. The following points were also made: 1) the mandate does not specify the requirements to be met by such equipment and there are currently no international standards for such equipment. This poses a major problem for airframe manufacturers; 2) it will be extremely difficult to produce standards, develop certified receivers, and install them on foreign-manufactured aircraft by 2017; and 3) the mandate imposes the development and installation on aircraft of a first generation of dual-constellation receiver (GPS/GLONASS) only a few years before a new generation of multi-frequency, multi-constellation receivers will be developed to take advantage of the new core constellations under development.

4.3 During the NSP WGW discussion it was further noted that the Russian Federation does not have the intention of prohibiting the use of other constellations in Russian airspace. It was further suggested by the Panel that the topic of GNSS mandates should be addressed at the AN-Conf/12. It was also noted that the mandate is ambiguous on whether the GPS/GLONASS equipment needs to be used for navigation or simply installed on the aircraft. The NSP WGW expressed concerns that this mandate is contrary to the concept of PBN and sets a precedent that could potentially seriously complicate future GNSS implementation if other such mandates were to require, or restrict, specific GNSS implementations.

5. SUMMARY AND CONCLUSIONS

5.1 The evolution of GNSS offers many benefits. However, mandates by States for airlines to equip and/or use specific GNSS elements are counter-productive and threaten to raise manufacturer and end user costs to an unbearable level. GNSS Mandates delay the break-even point in time when benefits could be brought to ATM systems, operators and passengers by applying PBN using any GNSS available rather than fragmenting the satellite navigation services.

[1] NSP May 12 WGW/IP2, On the Order of Ministry of Transport of the Russian Federation.

6. RECOMMENDATIONS

6.1 ICCAIA and IATA endorse all the recommendations made in WP/21. However, more should be done.

6.2 The Conference is invited to agree to the following recommendation:

Recommendation 6/x – Implementation of the global navigation satellite system in accordance to the performance-based navigation concept

That States, when defining their air navigation plans and introducing new operations based on global navigation satellite system:

a) abstain from issuing mandates for equipage or use of any particular global navigation satellite system core constellation or augmentation system;

b) implement new operations based on global navigation satellite system in accordance with the performance-based navigation concept, provided that such operations offer benefits to airspace users; and

c) refrain from precluding operators and aircraft manufacturers from using any global navigation satellite system means available to operate, under the condition that the required navigation performance is met, thus realizing the full benefits of performance-based navigation.

— END —