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TSG Proposal to resolve the Long P4 Issue

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SUMMARY

This Working Paper discusses the options for reducing unwanted 1090 MHz interference due to transponder DF 11 IIS 0 replies. This is a result of the presentation of ASP08-07 to the ASP Working Group at the April 2010 Montreal Meeting. The TSG was tasked to make recommendations to reduce the impact of undesirable DF 11 IIS 0 transmissions. Analysis presented at the January 2010 TSG of flight test data collected on 1030 MHz and 1090 MHz in the United States Northeast corridor in 2007 showed high transmission rates of DF 11 with IIS 0, more than the expected once per second per aircraft. This WP offers options that the TSG may consider for incorporating requirements as a result of these findings.

1. Introduction

Data was presented to the TSG in WP TSGWP08-23, "Analysis of Measured Squitter Rates", and WP TSGWP08-21, "Aircraft DF 11 Transmissions", recommending that the TSG consider modifying provisions for wide P4 reply. This was further discussed at the April 2010 ASP Working Group Meeting in WP ASP08-07, "Proposal to Eliminate Mode S Transponder Reply to ATCRBS/Mode S All-Call Interrogations". Reply of Mode S transponders to a wide P4 to support acquisition has been a fundamental capability of Mode S, so removal of this function needs to be carefully considered. However, its use is discouraged and eliminating it would help insure the safe and efficient use of Mode S. This WP provides information on the issue to support the TSG discussion.

2. Discussion

A summary of 1090 MHz DF code replies was done on collected data from the Northeast corridor flight test in 2007. The following conclusions can be made from this analysis of squitter replies. An analysis of DF 11 replies was done on the data collected from the 1090 MHz receiver equipped on the flight test aircraft. The original goal of this analysis was to identify the Mode S Ground interrogators soliciting All-Call replies. The remainder of the address/parity decoding of DF 11 results in the IIS code of the interrogator. Since there were no interrogators using IIS of 0, it was expected that DF 11 IIS of 0 from individual aircraft would be once per second to correspond to the acquisition squitter transmit rate. The conclusion reached from the analysis is that most aircraft are transmitting more than one DF 11 IIS of 0 per second. Analyzing individual aircraft transmitting more than one per second, it was seen that the extra squitters usually stop when the aircraft landed and were on the ground. This leads to the conclusion that the extra squitters result from the interpretation of an ATCRBS/Mode S All-Call, since replying to these interrogations is normally inhibited when on the ground. Exceptions were seen but there are aircraft that have a known problem with automatic inhibition of All-Call and ATCRBS replies when on the ground. These aircraft continue to have the extra squitters while on the ground. The data and analysis suggests that the extra squitters are replies to a misinterpreted ATCRBS Only All-Call that the transponder sees as a P1, P3 and wide P4 interrogation. The rate of extra squitters sometimes increases dramatically just before landing or just after taking off (when the aircraft is very near the ground). The timing of many extra squitters resembles that of the whisper/shout interrogation sequence of TCAS and ASDE-X. They may be responses to misinterpreted ATCRBS Only All-Calls. A corrupted P4 pulse (1.6 microseconds instead of 0.8 microseconds) will result in the ATCRBS/Mode S All-Call interrogation.

Since ADS-B rulemaking will prompt Mode S transponder platform updates in the US, Europe and other countries, and RTCA and Eurocae are working on a change to the Mode S transponder MOPS, it may be an opportune time to consider a change to the requirements regarding the wide P4. The following are some options that can be considered to address the problem.

Option to Eliminate Transponder Reply to Wide P4

One option that has been suggested and discussed is the elimination of the requirement to reply to a wide P4 interrogation. This is the most effective method of reducing the interference. From the ASP Working Group meeting in April, there were several States that indicated use of this interrogation. The UK indicated its known use on mobile military interrogators. Due to size constraints, many military maritime platforms have a single RF rotating joint in the antenna pedestal and a single RF power amplifier. Consequently, it is not possible to do the simultaneous P6 and (ISLS) P5 pulse required for a UF 11 interrogation. Instead, the interrogator uses ATCRBS interrogations along with a long P4, which can be implemented with a single rotary joint channel. As there are no simultaneous pulse transmissions, ISLS can still be achieved using the P2 pulse and switching the RF feed above the rotating joint. Although the UK supported removal of the wide P4 interrogation, the UK requested that a final decision be deferred until December 2010 to enable a full investigation on the effect of removal of this function on these military mobile interrogators.

Another WP at the ASP Working Group meeting, ASP08-12, confirmed that unexpected DF 11 IIS 0 transmissions also occur in Europe. The WP pointed out that a high number of military platforms use the wide P4 and therefore the proposed removal of the wide P4 requirements would impact these platforms.

Germany reported in ASP08-19 that neither civil nor military surveillance systems use wide P4 interrogations and have no plans to use these interrogations in the future. Germany supported the elimination of the requirement to reply to wide P4 interrogations if it is applied only to new transponders. If this was not possible, Germany recommended exemption rules for state aircraft.

One approach to implementing the requirement is to require a provision to inhibit the reply to wide P4. The transponders must support a configuration control to inhibit reply to wide P4. This would get the capability to inhibit reply to wide P4 to be designed into the transponder and give time for the transponder population to incorporate the capability. Also, this would give a time period for ground interrogator to modify their equipment to eliminate the reliance on wide P4 acquisition. A reasonable amount of time would need to be provided to allow the change. Initially, the configuration control would be set to not inhibit the reply to wide P4. A future Mode S transponder MOPS revision would require setting the configuration to inhibit the reply to wide P4. Appropriate provisions in the SARPS would be necessary to mandate the change at the specified point in time.

Option to Tighten Interrogation Acceptance of Wide P4

This approach was a recommended option to consider in ASP WP08-12. The advantage of this approach, if feasible, is that it will not impact those systems relying on this transponder function for Mode S acquisition. However, the impact to transponder design could be significant, especially in older platforms. If the current P4 transponder acceptance criteria are examined, the pulse width must accept tolerance is 1.5 microseconds to 1.7 microseconds. It must be rejected if the width of P4 is less than 1.2 microseconds or greater than 2.5 microseconds. To be effective in mitigating the impact of a short P4 stretching and being detected as a wide P4, the lower end of the pulse width rejection would need to be tightened. There is only 300 nanoseconds between the must accept and must reject criteria, 1.2 microseconds to 1.5 microseconds. There is not much room for improvement.

Option to Make No Changes

Another option to consider is to do leave the requirements as they currently exist. Analysis of the data suggests that, although not all of the extra squitters will be eliminated by the addition of the low level Mode S requirement incorporated into the RTCA and Eurocae Mode S transponder MOPS, it will improve things. For example, in the data presented in TSG08-23, there were many examples of aircraft with high squittter rates. These higher rates may be able to be attributed to transponders more prone to replies due to low level Mode S interrogations. The analysis of the 10 minute data sample form the 2007 flight test included rates from the flight test aircraft. In bench tests of several Mode S transponder models for the low level Mode S interrogation characteristic, the transponder used on the flight test aircraft exhibited the least susceptibility to low level Mode S interrogations. The ownship transponder replied 1.32 squitters per second for the 10 minute interval examined. To put that into perspective, if there are 1000 aircraft in a 100 nautical mile radius around a victim 1090 MHz receiver, 320 extra squitters per second would be contributed to the RF environment if they all performed this well. To demonstrate the importance of containing this characteristic, in this scenario, every 1 squitter per second increase contributes 1000 squitters as interference to the receiver. The low level Mode S requirement will not eliminate the problem and as aircraft densities increase, TCAS equipped aircraft will be contributing more 1030 MHz interrogation activity, increasing the likelihood of additional squitters, even with the additional protection of the low level Mode S restrictions. The highest rates of additional squitters were observed with aircraft landing and departing from the airport. These high rates are most likely due to multipath. These transmissions will not be eliminated without considering requirement changes.

3. Conclusion

The meeting is invited to discuss the subject of this paper and determine TSG actions.