**THE FORTIETH MEETING OF THE**

**INFORMAL PACIFIC ATC CO-ORDINATING GROUP**

**(IPACG/40)**

(Washington, DC 8 – 12 September 2014)

Agenda Item 5: Air Traffic Management (ATM) Issues

**AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B)**

**IN-TRAIL PROCEDURES (ITP) OPERATIONAL**

**FLIGHT TRIAL PROJECT STATUS**

(Presented by the Federal Aviation Administration)

**SUMMARY**

The purpose of this information paper is to present the U.S. Federal Aviation Administration (FAA) activities associated with the ADS-B In-Trail Procedures (ITP) operational trial being conducted in the Pacific.

1. Introduction
   1. FAA Surveillance and Broadcast Services (SBS) Program is developing a number of airborne Automatic Dependent Surveillance - Broadcast (ADS-B) applications to provide benefits to operators that choose to equip their aircraft with appropriate avionics, including "ADS-B In" (i.e. the ability to receive, process, and display ADS-B data from surrounding aircraft). One such airborne ADS-B application being developed is ADS-B In-Trail Procedures (ITP).
   2. Aircraft operating in oceanic airspace are, at times, held at non-optimal flight levels due to conflicting traffic either at the desired flight level or at flight levels between the existing flight level and the optimal flight level. The use of flight level changes enabled by ADS-B ITP can supplement existing oceanic procedures, creating greater operational efficiency.
   3. The purpose of this paper is to provide an update on results from the ADS-B ITP operational trial that began in August 2011.
2. Concept Overview
   1. ADS-B ITP is comprised of a set of six flight level change geometries with each geometry dictated by whether the ITP aircraft desires to climb or descend and its proximate relationship with the other aircraft:

• Leading climb • Leading descent

• Following climb • Following descent

• Combined climb • Combined descent

While there is no limit on the total climb authorized in the ADS-B ITP flight level change, the other aircraft cannot be more than 2,000 feet above or below the ADS-B ITP aircraft’s altitude. ADS-B ITP maneuvers may be conducted with up to two other aircraft.

* 1. For ADS-B ITP, the maneuvering (trailing or leading) aircraft obtains the flight identification (ID), altitude, position and ground speed transmitted by proximate ADS-B equipped non-maneuvering aircraft. Based on the ADS-B data from the non-maneuvering, or reference aircraft, a pilot can request clearance for an ITP altitude change to air traffic control (ATC). The controller verifies that the ITP and reference aircraft are same direction traffic and that the maximum closing Mach differential is less than or equal to a Mach Number of 0.06. If the controller determines that the requesting aircraft will maintain standard separation minima with all aircraft other than the ITP reference aircraft, a clearance for the climb or descent may be issued. After re-validating that the ITP initiation criteria are still valid, the maneuvering aircraft may then vertically transition through the altitude of the non-maneuvering aircraft.

1. ADS-B ITP Operation Evaluation
   1. In 2008, the FAA SBS program established a project for the purpose of enabling an operational evaluation of ADS-B ITP by aircraft operating in revenue service. The objectives of the project were to a) validate the operational performance and economic benefits of ITP; and b) develop and validate ADS-B ITP Minimum Operational Performance Specifications (MOPS).
   2. The entire ITP system was certified for use on a United Boeing 747 in June 2011. United Airlines subsequently received Operational Approval from FAA Flight Standards to commence ITP operations on 15 August 2011.
   3. FAA En Route and Oceanic Safety and Operations Support authorized Oakland Air Route Traffic Control Center (KZAK) to initiate the operational evaluation in the South Pacific (SOPAC) airspace on 15 August 2011. This authorization was expanded to include the entire Oakland Oceanic Flight Information Region (FIR) in December 2011. The original authorization was scheduled to expire in August 2012. The authorization was amended to permit ADS-B ITP operations in the Oakland Oceanic FIR until August 2013. On 30 September 2013, ADS-B ITP operations in the Oakland Oceanic FIR were authorized until 29 September 2014.
   4. United Airlines replaced Boeing 747 service to Australia with Boeing 777 service on March 30, 2014. As a result, even though ITP operations are still permitted in the SOPAC region of the Oakland Oceanic FIR, the SOPAC portion of the operational flight evaluation is essentially discontinued at this time (due to lack of equipped aircraft with qualified flight crews operating in this region).
   5. This operational evaluation is an initiative within the Asia and South Pacific Initiative to Reduce Emissions (ASPIRE) program. The ASPIRE program allows partner organizations to share data and provides a mechanism for providing mutual support of the operational evaluation.
   6. The FAA worked with the air navigation service providers (ANSPs) for New Zealand and Fiji to expand the ITP operational evaluation into the Nadi FIR and the Auckland Oceanic FIR in 2014. Airports Fiji Ltd and Airways Corporation New Zealand conducted operational evaluations of ADS-B ITP and offered ADS-B ITP services in their flight information regions until March 30, 2014. The FAA has also held discussions with the Civil Aviation Bureau, Japan (JCAB) about the potential for offering ITP in the Fukuoka FIR at some point in the future.
   7. Additional background information can be obtained in sections 2 and 3 of IPACG/37 IP-04.
2. Operation Evaluation Results
   1. The operational evaluation is being conducted using 12 ITP-equipped United Airlines Boeing 747-400’s operating in the Oakland Oceanic FIR. There is a designated data collection activity for both United Airlines and Oakland ARTCC (ZOA). The data collected is being used to enhance the understanding of the economic, safety and operational impact of ADS-B ITP. Specifically, this data is used to validate operational performance and economic benefits of ITP, validate safety requirements and assumptions and monitor operational hazards. Any significant adverse operational issues that may be discovered (such as communication or workload), which cannot be safely mitigated, will result in an immediate suspension of the operational evaluation. The data is collected, analyzed and used to address key higher-level metrics and hazard tracking.
   2. The operational evaluation began on 15 August 2011. On the first day of the operational evaluation there were 9 ITPs performed by the two United Airlines flights that were flying from the United States to Sydney, Australia. Data collected from those flights were reported in IPACG/36 IP-05.
   3. Between September 2011 and July 2012, the first year of the ITP operational flight evaluation, there were seven ITP requests resulting in three standard climb clearances granted and no ITP climb clearances. Four requests were denied due to operational issues such as opposite direction traffic and ITP requests being received close to an airspace boundary where the other airspace region was not authorized to grant an ITP clearance.
   4. Between August 15, 2012 and July 31, 2013, the second year of the ITP operational flight evaluation, there were 87 ITP requests made by flight crews. 13 of those requests resulted in ITP clearances being granted and 35 resulted in standard altitude change clearances being granted. 39 requests were denied for operational reasons.
   5. The ITP operational flight evaluation is currently in the third year of data collection. Attachment A is an example of the monthly reports that are generated as a result of the data collection process. The attachment is a summary of the resulting “application validation metrics” and “safety measurements” for June 2014. The tables are divided into three different time periods. The middle of the table includes data from the current month (in this case June 2014). The columns on the right side of the table are for the current portion of the third year of the operational evaluation (August 2013 – June 2014) and the entire operational evaluation completed to date (August 2011 – June 2014).
   6. The application validation metrics demonstrate how often ITP requests are being made and the results of the requests. This was done for flights in the South Pacific region as well as the Northern Pacific region of the Oakland Oceanic FIR. As mentioned above, United Airlines has discontinued Boeing 747 service in the SOPAC as of March 30, 2014 so there were no results in the SOPAC during June of 2014.
   7. For the month of June 2014, there were 12 ITP requests in the Northern Pacific region. The 12 ITP requests resulted in three ITP climbs, five standard climbs, three denials of the ITP request, and one “standard climb after a period of time”.
   8. The last three categories mentioned on the chart were not included in previous reports of ADS-B ITP operational data (for example, attachment A of IPACG/37 IP-04). Previously these situations would have been included in the number of denials. A detailed analysis of the data revealed that, while flight crews did not receive an ITP or standard climb to their requested altitude, in many cases they did receive a partial climb or received a delayed climb to their desired altitude or intermediate altitude. In order to more accurately reflect the data, the following additional categories were added to the list of potential outcomes from an ITP request:

* Immediate limited climb using standard separation techniques: ITP request results in an immediate standard climb, but not to the ITP requested altitude. An example would be a clearance for a 1000 foot climb that resulted from request for a 3000 foot ITP climb with traffic 2000 feet above the ITP aircraft and the first 1000 is free of traffic conflicts.
* Climb after moving the reference aircraft: controller moves the reference aircraft and then clears the ITP aircraft to the altitude that the reference aircraft vacated
* Standard climb after period of time: a climb (either to the desired altitude or an intermediate altitude) that was issued after the initial request was made and the ITP aircraft was initially told “stand by” -- after which the conflicting aircraft moved to eliminate the conflict (or at least part of the conflict). An example of this would be a situation where an ITP flight crew was told “stand by” and then the conflicting aircraft requests and is granted a climb, enabling the ITP aircraft an opportunity to climb.
  1. From the last column of attachment A, the data demonstrate that for the entire operational evaluation (August 2011 to June 2014), there have been 202 ITP requests resulting in 39 ITP clearances, 74 standard climb clearances, 13 immediate limited standard climbs, 11 standard climbs after moving reference aircraft, and nine standard climbs after a period of time. There were 56 flight level change denials for operational reasons (e.g., opposite direction traffic, close to other airspace boundaries, etc.).
  2. The safety measurements (the lower half of attachment A), show the safety related data resulting from ITPs that have been performed. The three ITP climbs performed during June 2014 were performed at an average initiation distance of 24.0 nautical miles and took an average of 4 minutes to accomplish. The data for the third year of the operational evaluation (August 2013 – June 2014) and the entire operational evaluation (August 2011 – June 2014) demonstrate that the measured results are more conservative than the expected values. For the entire ITP operational evaluation, ITP flight level changes were initiated at an average value of 28.6 nautical miles and the ITP distance at co-altitude was an average of 29.2 nautical miles; an increase of 0.6 nautical miles during the flight level change.
  3. The ITP system developed by Honeywell, and installed on 12 United Airlines Boeing 747-400s, includes a Honeywell traffic computer that has the potential for capturing detailed, electronic surveillance information. The data that is recorded includes ITP related parameters, signal-in-space data and ITP system health and status data. The data that is processed by the traffic computer is recorded on to a removable PCMCIA card. United Airlines and United Airline Pilots Association (ALPA) developed an acceptable process for collecting, de-identifying and analyzing the electronic data. This electronic data is used to validate how the ITP system and procedure is working, and also to advance the understanding of ADS-B for future ADS-B In applications. Beginning in mid-July 2013, United Airlines initiated a regular install/remove process for these data cards on the ITP-equipped aircraft. Selected results from these data cards will be included in a future IPACG information paper.
  4. The merger of United Airlines and Continental Airlines affected labor-management relations at the merged airline, which impacted overall 747 training and, along with it, ITP training for these same pilots. At the beginning of January 2013, United Airlines and United ALPA signed an agreement regarding ITP training. As a result of the agreement, a significant amount of ITP training occurred between January 2013 and April 2013. As of 17 April 2013, all United Boeing 747 pilots were trained and authorized to perform ITP operations. This resulted in a noticeable increase in ITP requests in the Oakland Oceanic FIR. The average requests in early 2013 were about 2-5 per month, rising to 11 in April 2013, and then a new range of about 14 per month from May through July 2013. As noted in section 3.3, the second year of the operational evaluation was completed in August of 2013 and the third year began at the end of September 2013 (operations actually did not resume until November due to the U.S. Government “shutdown” in October 2013). Due to the delay in the start of the third year of the operational evaluation, there was a resulting drop off in the number of ITP requests. The data indicates that the number of ITP requests have increased again and are now in the range of 12 per month. The slight drop from 14 to 12 is expected since there are no more flights being performed in the SOPAC region.
  5. Although ITP operations in the Fiji and New Zealand FIRs were only conducted between January and March of 2014, there were a total of four ITP requests made in those regions; two in Fiji’s airspace and two in New Zealand’s airspace. Of the four requests, two resulted in ITP climbs and two were denied for operational reasons.
  6. Additional anecdotal data indicate that pilots of ITP equipped aircraft are making good use of the increased situation awareness they receive from the ITP system. Pilots can now see traffic within approximately 200 nm of their current position. This allows them to manage their flight and make more informed climb requests, which results in more efficient and safe operations.

1. SUMMARY

5.1 The FAA began an operational evaluation of ADS-B ITP along SOPAC routes in August 2011 which has been expanded to all oceanic airspace controlled by KZAK in December 2011. Airports Fiji, Ltd and Airways Corporation New Zealand joined the operational evaluation in 2014, which expanded the availability of ADS-B ITP to the Nadi and Auckland FIRs. There is a comprehensive designated data collection activity for the operational evaluation. The data collected is being used to enhance the understanding of the economic, safety and operational impact of ADS-B ITP.

5.2 For additional information on the operational evaluation, please contact Mr. Ken Jones at Kenneth.M.Jones@nasa.gov or +1 (757) 864-5013.

**6. ACTION BY THE MEETING**

6.1The meeting is invited to note the information provided in this paper and attachment.

ATTACHMENT A

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Application Validation Metric** | **Southern Pacific**  **June 2014** | | **Northern Pacific**  **June 2014** | | **Totals** | |
| **Expected** | **Actual** | **Expected** | **Actual** | **8/2013 - 6/2014** | **8/2011 - 6/2014** |
| **Number of ITP capable flights per month** | **0** | **0** | **180** | **190** | **2474** | **3840** |
| **Number of ITP requests** | **0** | **0** | **12** | **12** | **99** | **202** |
| **Number of ITP maneuvers performed** | **0** | **0** | **2** | **3** | **17** | **39** |
| **Number of "standard" flight level changes** | **0** | **0** | **7** | **5** | **36** | **74** |
| **Number of denied flight level changes** | **0** | **0** | **3** | **3** | **27** | **56** |
| **Number of immediate limited standard climbs** | **0** | **0** | **0** | **0** | **9** | **13** |
| **Number of climbs after moving reference aircraft** | **0** | **0** | **0** | **0** | **6** | **11** |
| **Number of standard climbs after period of time** | **0** | **0** | **0** | **1** | **4** | **9** |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Safety Related Parameter** | **Expected Avg.** | **Measurements (June 2014)** | | | **Measurements (8/2013 - 6/2014)** | | | **Measurements (8/2011 - 6/2014)** | | |
| **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max** | **Min** | **Mean** | **Max** |
| **ITP Initiation Distance** | **20 nm** | **21.6** | **24.0** | **27.1** | **19.8** | **28.9** | **67.7** | **19.1** | **28.6** | **88.4** |
| **ITP Distance at Co-altitude** | **18 nm** | **23.1** | **24.5** | **27.3** | **21.5** | **29.2** | **67.9** | **20.2** | **29.2** | **88.5** |
| **Time From ITP Initiation to Level Off at New Altitude** | **7 min** | **2.0** | **4.0** | **7.0** | **2.0** | **4.7** | **8.0** | **2.0** | **4.8** | **8.0** |
| **Percentage of ITPs where a wake encounter occurred and a wake incident was reported** | **2%** |  | **0.0** |  |  | **0.0** |  |  | **0.0** |  |
| **Wake Turbulence Incident Severity (5-1) (5 is minimal, 1 is catastrophic)** | **5** |  | **N/A** |  |  | **N/A** |  |  | **N/A** |  |