**THE FORTY-FIRST MEETING OF THE**

**INFORMAL PACIFIC ATC CO-ORDINATING GROUP**

**(IPACG/41)**

(Kyoto, Japan 16 – 17 September 2015)

Agenda Item 6: Air Traffic Management (ATM) Issues

Benefits of ATSA-ITP and ADS-C CDP over the North Pacific

(Presented by ENRI, Japan)

**SUMMARY**

This paper presents evaluation results of the implementation of ATSA-ITP and ADS-C CDP. Benefits were estimated by an ATC simulation operating ASAS-ITP and ADS-C CDP based on the possibility of traffic density equivalent to that of future 2018. The benefit of PACOTS is larger than that of NOPAC.

1. Introduction
   1. ASAS(Airborne Surveillance Application Systems) have many applications and these applications are categorized into 4 types by PO-ASAS(Principals of Operation for ASAS). ITP(In-Trail Procedure) is one of the applications of ATSA(Airborne Traffic Situational Awareness) which reduces separation minima during altitude change. ITP realizes a safe altitude change of at least 15NM, but normally more than 30NM for RNP4 is necessary, during altitude change. FAA reported the results of the ITP trial over the Pacific Ocean at IPACG meetings. The ITP trial was also conducted over the Atlantic Ocean.
   2. CDP(Climb Descend Procedure) is an operational function which reduces separation minima during altitude change. The controller issues altitude change by using the CDP. The concept of ITP resembles CDP, however, the condition and essential equipment are different. Essential equipment of ITP additionally needs ASAS. The condition of CDP is looser than that of ITP, however, the width of altitude change by CDP is narrower than that of the ITP. FAA reported the results of the CDP trial over the Pacific Ocean at IPACG meetings.
   3. Recently, the ratio of RNP4 equipped aircraft has been over 90% for the flights between Asia and North America. At present, ASAS equipped aircraft have not flown yet, however, they are expected to increase as newly created aircraft increase. JCAB is planning to implement ATSA-ITP and ADS-C CDP from FY2017 according to CARATS. ENRI(Electronic Navigation Research Institute) estimated the benefits of using ITP and CDP based on Oceanic ATC simulations. Traffic volume was assumed for 2018 by the ICAO, and the ratio of RNP4 and ASAS was assumed to be ideal.
2. Simulation
   1. The Oceanic Air Traffic Simulator at ENRI lets targets fly based on flight plans reflected with GSM (Global Scale Model) wind. All flights are defined as being applied RNP value and being equipped or not equipped with ASAS. A controller participant maintains ATC separation between all aircraft. When the separation is less than the separation minima, the controller changes the altitude. When a flight requests a change in altitude according to the flight plan, the controller assigns optimum altitude due to traffic. Flight times and fuel consumptions are analyzed.
   2. JCAB is planning to introduce ASAS-ITP and ADS-C CDP from FY2017 according to CARATS. ENRI made 8 scenarios based on 1.2 times the traffic in 2013 according to “Report of the Asia/Pacific area Traffic Forecasting Group 16th meeting”. Table 1 shows the details of the scenarios.

Table 1 Scenarios

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | Route or First Oceanic Fix  (flight direction) | No. of flights | Simulation Areas \*  (Oceanic sector) |
| A | R580(West) | 34 | FUK＋ANC |
| B | R220(West) | 89 | FUK＋ANC |
| C | A590(East) | 100 | FUK＋ANC |
| D | R220(West) | 75 | FUK＋ANC |
| E | EMRON、LEPKI(East) | 54 | FUK＋OAK |
| F | KALNA(East) | 72 | FUK＋OAK |
| G | A590(East) | 55 | FUK＋ANC |
| H | KALNA、LEPKI(East) | 39 | FUK＋OAK |

\* FUK: Fukuoka FIR, ANC: Anchorage FIR, OAK: Oakland FIR

* 1. ENRI conducted Oceanic ATC simulations. One series of simulations is composed of 3 types of trial names: STD (climb applied by the current standard separation minimum), CDP and ITP. At the STD, a controller participant operates in the same way as current Oceanic operation. The condition of altitude change depends on distance and the value of RNP with neighbouring flights (Normal Climb). In the CDP, a controller participant operates normal altitude change. He/she also operates CDP to satisfy the condition. In the ITP, a controller participant operates normal altitude change. He/she also operates ITP to satisfy the condition. 95% of targets are assumed to be equipped with RNP4 and ASAS.
  2. Maximum climbing altitude depends on flight plans. In the simulation of CDP and ITP, it is possible to climb 1,000ft higher than in the plan in the case of ITP or CDP operation. When a following flight approaches, it is also possible to climb 1,000ft higher than in the plan.
  3. When a controller considers the operation of ITP or CDP, the Oceanic ATC simulator shows a support monitor. It shows separation, speed and its difference with neighbouring flights. It helps to judge whether ITP or CDP have been fully carried out.
  4. Climb altitude

Table 2 shows the number of altitude changes which are normal changes, by CDP or ITP. For the ITP in Scenario A and D (yellow), Normal Climb increases from STD. CDP and ITP made an open altitude and it realized additional climb. And for Scenario A and G, the number of CDPs (in the top CDP column) is equal to the number of ITPs(in the top of ITP column). For Scenario C, G and H(orange), the number of Normal Climbs decreased from STD to CDP to ITP. The all-at-once climb, not by several step-up climbs. It also reduces the controller’s workload and CPDLC frequency.

Figure 1 shows Average of climbed altitude in the oceanic airspace and Figure 2 shows Rate of allocated requested altitude at the end of the oceanic airspace.

Table 2 Number of altitude changes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Operation | | | | |
|  | STD | CDP | | ITP | |
| Scenario | Normal Climb | Normal Climb | CDP | Normal Climb | ITP |
| A | 9 | 12 | 3 | 12 | 3 |
| B | 39 | 38 | 4 | 38 | 4 |
| C | 79 | 78 | 7 | 76 | 7 |
| D | 34 | 36 | 4 | 36 | 5 |
| E | 94 | 94 | 1 | 91 | 3 |
| F | 115 | 111 | 5 | 111 | 7 |
| G | 37 | 35 | 5 | 34 | 5 |
| H | 58 | 57 | 3 | 49 | 7 |



**Figure 1 Average of climb altitude in the oceanic airspace**



**Figure 2 Rate of allocated requested altitude**

* 1. Altitude at each FIX

Distributions of flight altitude at each longitude are shown in Figure 3 and 4. Figure3-a shows STD simulation by STD and Figure 3-b shows ITP by ITP of Scenario F. Figure 4-a and Figure 4-b show STD and ITP of Scenario H.

|  |  |
| --- | --- |
|  |  |
| **Figure 3-a Distributions of flight altitude**  **(Scenario F, STD)** | **Figure 3-b Distributions of flight altitude**  **(Scenario F, ITP)** |
|  |  |
| **Figure 4-a Distributions of flight altitude**  **(Scenario H, STD)** | **Figure 4-b Distributions of flight altitude**  **(Scenario H, ITP)** |

In Figure 3, there are few defferences in low altitude between STD and ITP. Focused on high altitude, ITP realizes earlier rises (see FL390;violet and FL400; blue green).

In Figure 4, the total of flights decreases after 150W because Scenario H includes 2 flights bound for Anchorage. Focused on low altitude, low altitude flights in ITP are less than that in STD (see FL320; yellow green and FL330; violet at 150W).

* 1. Fuel consumption

Table 3 shows the Total and Maximum of fuel benefits depending on the method of altitude change. CDPs and ITPs help save fuel, which are for westbound flights at about 300 to 600lbs, and for eastbound flights at up to about 1,000lbs, and additionally in some cases up to 3,000lbs. ITP is available to make altitude changes over 2,000ft, so ITP has more potential benefits (it depends on the climb timing and the density of traffic on each route). Especially, for eastbound PACOTS flights which fly long distance in Oceanic Airspace, benefits are larger than that of other short flight distances in Oceanic Airspace (Scenario E, F, H as yellow).

Table 3 Total fuel benefits depending on the method of altitude change compared with “Only Standard”

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sce-nario | No. of aircraft | Route or First Oceanic Fix  (flight direction) | Oceanic Area \* | Standard and CDP | | Standard and ITP | |
| Total Benefits | Max. benefit /flight | Total Benefits | Max. benefit /flight |
| A | 34 | R580(West) | FUK＋ANC | -1,662lbs | -649 lbs | -2,509lbs | -1,281 lbs |
| B | 89 | R220(West) | FUK＋ANC | -1,485lbs | -590 lbs | -1,485lbs | -590 lbs |
| C | 100 | A590(East) | FUK＋ANC | -2,632lbs | -627 lbs | -3,019lbs | -790 lbs |
| D | 75 | R220(West) | FUK＋ANC | -1,875lbs | -668 lbs | -1,875lbs | -668 lbs |
| E | 72 | KALNA(East) | FUK＋OAK | -1,395lbs | -1,214 lbs | -2,461lbs | -1,214 lbs |
| F | 54 | EMRON,LEPKI(East) | FUK＋OAK | -4,940lbs | -2,577 lbs | -7,515lbs | -2,577 lbs |
| G | 55 | A590(East) | FUK＋ANC | -3,876lbs | -1,804 lbs | -3,945lbs | -1,804 lbs |
| H | 39 | KALNA,LEPKI(East) | FUK＋OAK | -6,970lbs | -3,282 lbs | -8,378lbs | -2,689 lbs |

\* FUK: Fukuoka FIR, ANC: Anchorage FIR, OAK: Oakland FIR

1. Discussion
   1. The meeting is invited to note the information provided.

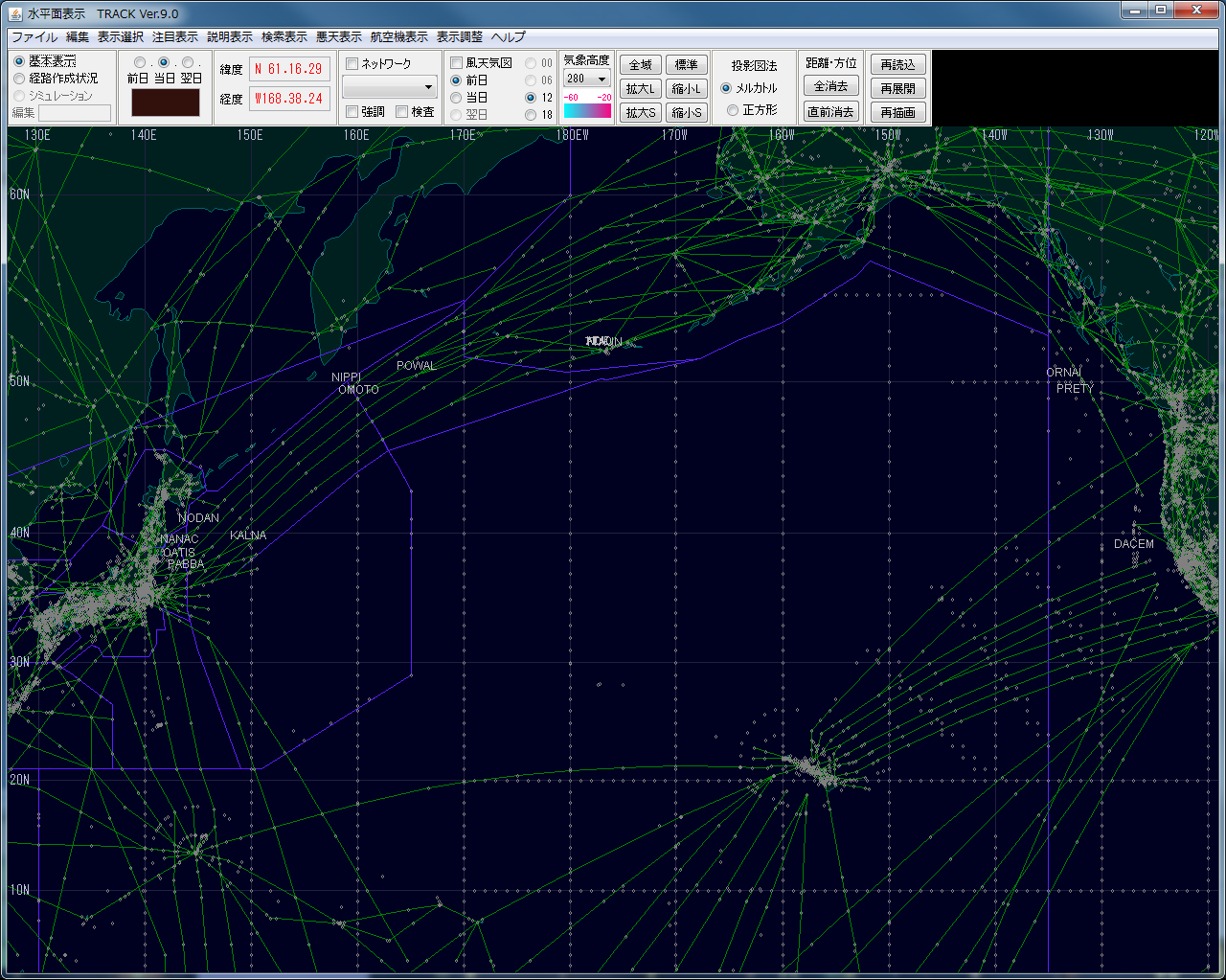
Attachment 1

1. Present Situation Analysis
   1. ENRI analysed CPDLC log data for several days. The situation of “UNABLE” altitude change was extracted from CPDLC log files and the reasons were analysed. When the separation of two RNP4 equipped aircraft was less than 30NM while increasing their altitude, the ITP conditions were satisfied in some cases.
   2. In one day’s example, 40 flights were denied their requests for altitude change. Five of those flights, including two deviated flights, satisfied the ITP conditions. Additionally, in three cases, if a manoeuvre flight or a reference flights was equipped with RNP4, the ITP conditions would have been satisfied. It shows that ITP makes chances for the current traffic volume.

Attachment 2

1. Scenario information and list of all flights with benefits

Figure A2-1 shows the image of entry fix and exit fix in each scenario. Computed intervals are between entry fix and exit fix for westbound scenarios. The interval is from Japanese airports or entry fix to exit fix in eastbound scenarios(C, E, F, G, H). In this simulation, take-off weight is set as heavier than standard take-off weight of BADA.



ORNAI

PRETY

DACEM

NIPPI OMOTO PLADO

NANACOATIS

PABBA

KALNALEPKI

R220：Scenario B，D

R580：Scenario A

A590：Scenario C，G

KALNA~ORNAI&PRETY：Scenario F，H

KALNA~DACEM：Scenario H

LEPKI~DACEM：Scenario E

Figure A2-1: Routes and Computed Intervals for fuel consumption in each scenario

Table A2-2: ALL benefits of CDP or ITP

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario Name | Date(yyyymmdd), Route name, Computed interval:Entry FIX - Exit FIX | | | |
| C/S | CityPair | STD | CDP | ITP |
| X01（C/S）# | DEP-ARR | not climb(-) | Operation of CDP, Standard climb(STD) or not climb(-) ## | Operation of ITP , Standard climb(STD) or not climb(-) ## |
| Aircraft Type | Exit FIX(from Oceanic Airspace) | Flight altitude at the exit FIX(in STD simulation) | Flight altitude at the exit FIX(in CDP simulation) | Flight altitude at the exit FIX(in ITP simulation) |
|  | Fuel Consumption  (lbs) | STD’s Fuel Consumption in the computed interval | CDP’s Fuel consumption(benefit with STD)  in the interval | ITP’s Fuel consumption(benefit with STD) in the interval |

One surrounded bold line shows information of one flight which has benefits of ITP and/or CDP.

#: The background colors of C/S mean as follows;

* Yellow shows that the benefits of ITP operation are larger than CDPs.
* Cyan shows that the benefits of CDP operation are equal to the ITPs.
* Umber shows lucky flights which climbed to an empty altitude due to CDPs or ITPs of other flight.

##: And CDP operation is colored in yellow and ITP operation is colored in cyan.

The altitude in the table is at exit way-point from the oceanic airspace.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario A | 20140626, R580, Interval: OMOTO-OATIS | | | |
| C/S | CityPair | STD | CDP | ITP |
| A01 | KSFO-RCTP | - | CDP operated | ITP operated |
| B744 | OATIS | FL330 | FL370 | FL370 |
|  | Fuel | 41206 | 40557(-649) | 39925(-1281) |
| A02 | KSFO-RCTP | - | CDP operated | ITP operated |
| B744 | OATIS | FL350 | FL360 | FL360 |
|  | Fuel | 40731 | 40562(-169) | 40562(-169) |
| A03 | KSFO-RJAA | - | CDP operated | ITP operated |
| B744 | OATIS | FL360 | FL380 | FL380 |
|  | Fuel | 39450 | 38900(-550) | 38900(-550) |
| A04 | KLAX-RCTP | - | STD \* | STD \* |
| B773 | OATIS | FL340 | FL350 | FL350 |
|  | Fuel | 27323 | 27248(-75) | 27033(-290) |
| A05 | KSFO-RCTP | - | STD \* | STD \* |
| B744 | OATIS | FL350 | FL360 | FL360 |
|  | Fuel | 39886 | 39667(-219) | 39667(-219) |
| Total | | | -1662lbs | -2509lbs |

\*: This STD means that the flight climbs applied by standard separation minimum to an altitude opened by the CDP or ITP aircraft climbing.

These benefits are also considered as benefits of CDP or ITP in this analysis.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario B | 20140626, R220, Interval:NIPPI-NANAC | | | |
| C/S | CityPair | STD | CDP | ITP |
| B01 | KDFW-RJAA | - | CDP operated | ITP operated |
| B772 | NANAC | FL360 | FL380 | FL380 |
|  | Fuel | 24047 | 23457(-590) | 23457(-590) |
| B02 | KDFW-RJAA | - | CDP operated | ITP operated |
| B744 | NANAC | FL370 | FL390 | FL390 |
|  | Fuel | 35295 | 35151(-144) | 35151(-144) |
| B03 | KSEA-RJAA | - | CDP operated | ITP operated |
| B763 | NANAC | FL380 | FL380 | FL380 |
|  | Fuel | 18013 | 17808(-205) | 17808(-205) |
| B04 | KDFW-RJAA | - | CDP operated | ITP operated |
| B772 | NANAC | FL370 | FL390 | FL390 |
|  | Fuel | 23308 | 22829(-479) | 22829(-479) |
| B05 | KDFW-RJAA | - | STD | STD |
| B773 | NANAC | FL360 | FL380 | FL380 |
|  | Fuel | 25183 | 25116(-67) | 25116(-67) |
| Total | | | -1485lbs | -1485lbs |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario C | 20140725, A590, Interval: Japanese Airport or PABBA-PLADO | | | |
| C/S | CityPair | STD | CDP | ITP |
| C01 | RKSI-KDFW | - | CDP operated | ITP operated |
| B744 | PLADO | FL320 | FL320 | FL340 |
|  | Fuel | 64118 | 64069(-49) | 64081(-37) |
| C02 | ZSPD-KSEA | - | CDP operated | ITP operated |
| A332 | PLADO | FL370 | FL380 | FL380 |
|  | Fuel | 27397 | 26887(-510) | 26854(-543) |
| C03 | RJAA-KDFW | - | CDP operated | ITP operated |
| B772 | PLADO | FL320 | FL350 | FL350 |
|  | Fuel | 46350 | 45926(-424) | 45560(-790) |
| C04 | RJAA-KSEA | - | CDP operated | ITP operated |
| B773 | PLADO | FL310 | FL320 | FL320 |
|  | Fuel | 50361 | 49801(-560) | 49801(-560) |
| C05 | RJTT-PANC | - | CDP operated | ITP operated |
| B763 | PLADO | FL350 | FL370 | FL370 |
|  | Fuel | 35034 | 35014(-20) | 35014(-20) |
| C06 | RCTP-KLAX | - | CDP operated | ITP operated |
| A332 | PLADO | FL350 | FL360 | FL360 |
|  | Fuel | 28169 | 27542(-627) | 27542(-627) |
| C07 | RJAA-KDFW |  | STD | STD |
| B773 | POWAL | FL290 | FL300 | FL300 |
|  | Fuel | 51017 | 50575(-442) | 50575(-442) |
| Total | | | -2632lbs | -3019lbs |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario D | 20140706, R220, Interval: NIPPI-NANAC or NODAN | | | |
| C/S | CityPair | STD | CDP | ITP |
| D01 | KSEA-ZSPD | - | CDP operated | ITP operated |
| A332 | NODAN | FL380 | FL380 | FL380 |
|  | Fuel | 18624 | 18167(-457) | 18167(-457) |
| D02 | KSEA-RJAA | - | CDP operated | ITP operated |
| B763 | NANAC | FL360 | FL380 | FL380 |
|  | Fuel | 17889 | 17782(-107) | 17782(-107) |
| D03 | KSEA-RCTP | - | CDP operated | ITP operated |
| B744 | NANAC | FL350 | FL360 | FL360 |
|  | Fuel | 38751 | 38068(-683) | 38068(-683) |
| D04 | KDFW-RJAA | - | CDP operated | ITP operated |
| B772 | NANAC | FL390 | FL410 | FL410 |
|  | Fuel | 22688 | 22020(-668) | 22020(-668) |
| D05 | KDFW-RKSI | - | STD | STD |
| B773 | NODAN | FL360 | FL360 | FL360 |
|  | Fuel | 21610 | 21464(-146) | 21464(-146) |
| D06 | KLAX-RCTP | STD | - \*\* | - \*\* |
| B773 | NANAC | FL360 | FL350 | FL350 |
|  | Fuel | 25845 | 26031（▲186） | 26031（▲186） |
| Total | | | -1875lbs | -1875lbs |

\*\*: It is an unlucky flight. CDP/ITP was able to climb other flight and then this flight could not climb.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario E | 20140707，TRK3 and UPR(LEPKI),  Interval: Japanese Airport or LEPKI - DACEM | | | |
| C/S | CityPair | STD | CDP | ITP |
| E01 | RJAA-KLAX | - | - | ITP operated |
| B77W | DACEM | FL350 | FL350 | FL360 |
|  | Fuel | 130285 | 130285 | 129219(-1066) |
| E02 | RJAA-KLAX | - | - | ITP operated |
| B77W | DACEM | FL370 | FL370 | FL370 |
|  | Fuel | 127722 | 127722 | 127722 |
| E03 | RJAA-KSFO |  | CDP operated | ITP operated |
| B788 | DACEM | FL400 | FL410 | FL410 |
|  | Fuel | 78611 | 77397(-1214) | 77397(-1214) |
| E04 | RJAA-KSFO |  | STD | STD |
| B788 | DACEM | FL410 | FL400 | FL400 |
|  | Fuel | 75248 | 75067(-181) | 75067(-181) |
| Total | | | -1395lbs | -2461lbs |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario F | 20140707，TRK1 and UPR(over KALNA)，  Interval: Japanese Airport or PABAB - PRETY or ORNAI | | | |
| C/S | CityPair | STD | CDP | ITP |
| F01 | RKSI-KDFW | - | - | ITP operated |
| B772 | PRETY | FL390 | FL390 | FL410 |
|  | Fuel | 78064 | 78064 | 77206(-858) |
| F02 | RJAA-KSEA | - | - | ITP operated |
| B788 | ORNAI | FL380 | FL380 | FL400 |
|  | Fuel | 62446 | 62446 | 60728(-1717) |
| F03 | ZSPD-KSEA |  | CDP operated | ITP operated |
| B788 | ORNAI | FL370 | FL400 | FL400 |
|  | Fuel | 66127 | 63550(-2577) | 63550(-2577) |
| F04 | RCTP-KDFW |  | CDP operated | ITP operated |
| B77W | PRETY | FL350 | FL360 | FL360 |
|  | Fuel | 100758 | 99774(-984) | 99774(-984) |
| F05 | RCTP-KSEA |  | CDP operated | ITP operated |
| B77W | PRETY | FL350 | FL350 | FL350 |
|  | Fuel | 103021 | 101642(-1379) | 101642(-1379) |
| Total | | | -4940lbs | -7515lbs |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario G | 20141127, A590, Interval: Japanese Airport or PABBA - PLADO | | | |
| C/S | CityPair | STD | CDP | ITP |
| G01 | RKSI-PANC |  | CDP operated | ITP operated |
| B744 | PLADO | FL320 | FL340 | FL340 |
|  | Fuel | 62393 | 60883(-1510) | 60817(-1579) |
| G02 | RCTP-KDFW |  | CDP operated | ITP operated |
| B744 | PLADO | FL320 | FL340 | FL340 |
|  | Fuel | 61661 | 59857(-1804) | 59857(-1804) |
| G03 | RKSI-KDFW |  | CDP operated | ITP operated |
| B772 | PLADO | FL330 | FL350 | FL350 |
|  | Fuel | 43040 | 42478(-562) | 42478(-562) |
| Total | | | -3876lbs | -3945lbs |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario H | 20141127，TRK1 and UPR(KALNA) ,  Interval: Japanese Airport or PABBA –DACEM, ORNAI or SYA | | | |
| C/S | CityPair | STD | CDP | ITP |
| H01\*\*\* | RJAA-KLAX | - | CDP operated | ITP operated |
| B77W | DACEM | FL340 | FL370 | FL370 |
|  | Fuel | 137041 | 133759(-3282) | 134352(-2689)\*\*\* |
| H02 | RCTP-KSEA |  | CDP operated | ITP operated |
| B77W | ORNAI | FL340 | FL350 | FL350 |
|  | Fuel | 116862 | 114962(-1900) | 114928(-1934) |
| H03 | RJAA-KDFW | - | - | ITP operated |
| B77W | DACEM | FL350 | FL350 | FL360 |
|  | Fuel | 134952 | 134952 | 132985(-1967)\*\*\* |
| H04 | PCTP-PANC | - | CDP operated | ITP operated |
| B744 | ADK | FL330 | FL340 | FL340 |
|  | Fuel | 78982 | 77194(-1788) | 77194(-1788) |
| Total | | | -6970lbs | -8378lbs |

\*\*\* H03 could not climb by CDP. ITP was able to climb H03 and then H01 could not climb.