canso TRANSFORMING GLOBAL ATM PERFORMANCE

Initial Phase of ADS-B Implementation Over the South China Sea

Cost Benefit Study

Prepared by CANSO
Supported by: FAA and CAAS
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COST BENEFIT STUDY FOR THE INITIAL PHASE OF ADS-B IMPLEMENTATION OVER THE SOUTH CHINA SEA

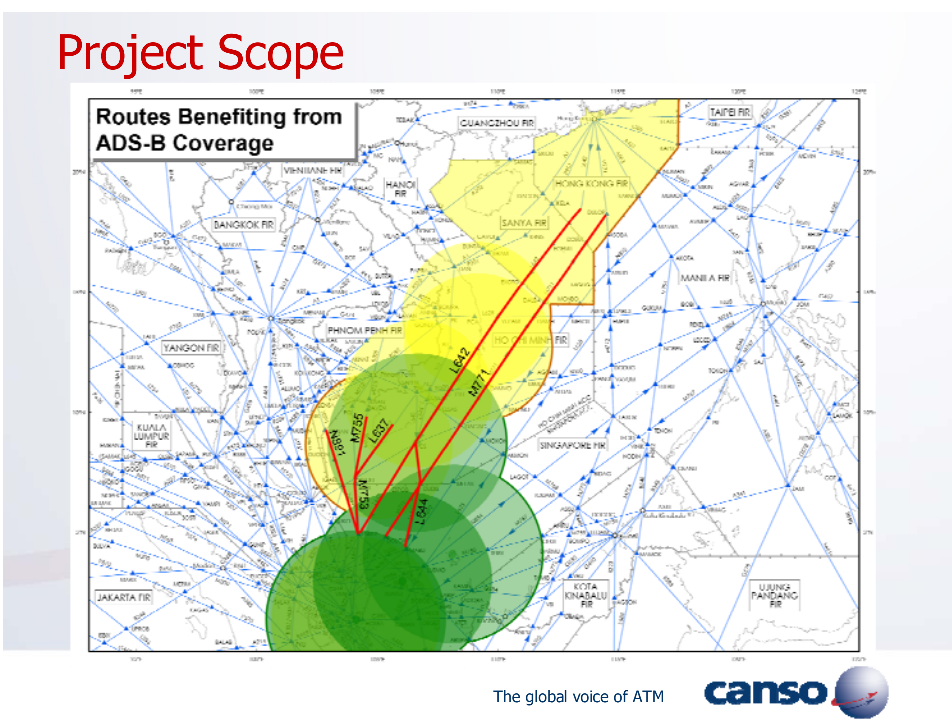
1 BACKGROUND

1.1 In July 2008 at the 3rd ADS-B South East Asia(SEA) Working Group Meeting in Kuala Lumpur, CANSO and IATA agreed to conduct a cost benefit study for the initial phase of the ADS-B project over the South China Sea.

1.2 The South China Sea area was identified for this purpose as it contains some of the highest traffic density routes which would benefit most from ADS-B implementation. The initial phase involves ADS-B stations in Indonesia, Vietnam and Singapore which would be ready by 2010. The aim is to enable radar-like separation for suitably equipped aircraft on selected routes in the area covered by the project scope.

2 PROJECT SCOPE

2.1 The ANSPs of Indonesia, Vietnam and Singapore have reported that they would install ADS-B stations in the following locations by 2010: Matak and Natunas (Indonesia), Con Son (Vietnam) and Singapore. The chart shows the coverage of the ADS-B stations in green, existing radar coverage in yellow and the air routes (in red) that will benefit from the project.



3 OBJECTIVE

3.1 The objective of this study is three fold.

(a) Firstly, to determine the benefits and costs of ADS-B implementation for this project.
(b) Secondly, to provide an example of good governance in developing a business case for the project, and
(c) Thirdly, to promote regional ADS-B collaboration among ANSPs and users.

3 METHODOLOGY OF COST BENEFIT STUDY

3.1 The study commenced with data collection and analysis in the second half of 2008 with the assistance of the FAA and CAAS as CANSO members. CAAS provided historical traffic data while FAA did the technical analysis. In February 2009, the status, assumptions and methodology of this work was presented and discussed at the 4th ADS-B SEA WG in Melbourne.

3.2 The study is based on the concept of operations summarized in **Attachment A.**

3.2 The study made the following assumptions:

(a) There is ADS-B data sharing across FIRs and the provision of VHF communications to adjacent States as required.
(b) Radar-like separation will be implemented in exclusive airspace for appropriately equipped aircraft
(c) 20year life-cycle cost FY 2013-32
(d) The analysis is based on extrapolation of traffic data and estimated infrastructure costs.

3.3 In terms of aircraft equipage, information from the first SEA ADS-B WG meeting showed that about 60% of aircraft operating in the area were transmitting ADS-B data. A review of aircraft types operating on the air routes within the area during Jul- Oct 2008 reinforced this, where 61.9% were assessed as ADS-B capable. 25% of the remaining was assessed as retrofit ready. IATA expects that with on-going fleet renewal and an effective mandate; more than 85% of aircraft would be ADS-B (Out) capable.

3.4 The benefits that were monetized comprised the following:

(a) Savings in aircraft fuel burn arising from availability of optimum flight levels and reduction in airborne and ground delays
(b) Reduction in carbon emissions
(c) Reduction in flight delays leading to savings in Aircraft Direct Operating Cost (ADOC) and Passenger Value of Time (PVT)

3.5 The cost estimates were based on data provided by CAAS in consultation with the other ANSPs while traffic estimates were based on extrapolation of historical data provided by CAAS over 3 months in 2008 (Traffic Data Collection summary in **Attachment B**). ADOC and PVT were based on FAA figures with the latter discounted by about 40% based on the weighted GDP average for the region.

3.6 Given the economic downturn and the volatility of traffic projections a sensitivity analysis was conducted based on the three traffic growth scenarios: low growth at 3% pa, medium growth of 5% pa and high growth of 7% pa.

4 RESULTS OF STUDY

4.1 Based on data provided by CAAS for the period Jan 08 to March 08 for flights operating on the airways that would benefit from the ADS-B deployment, the potential savings from improved airborne efficiency and reduction in ground delays are summarized below in Table A and Table B respectively:

Airborne Efficiency - Potential Savings 2008	3 months	12 months
Fuel Burn Savings (lbs)	608,488	2,433,953
Fuel Burn Savings (FY09 US $)	$177,097	$708,389
Flight time savings (hours)	117	468
Airborne ADOC w/o fuel savings (FY09 US $)	$346,283	$1,385,134
PVT savings (FY09 US $)	$292,493	$1,169,974
CO2 Emissions Savings (lbs)	1,920,389	7,681,554
CO2 Savings (FY09 US $)	$21,777	$87,108
Total Economic Savings (FY09 US $)	$837,651	$3,350,605

TABLE A

Ground Delay - Potential Savings 2008	
Fuel Burn Savings (lbs)	469,769
Fuel Burn Savings (FY09 US $)	$136,724
Time savings (hours)	188
Ground ADOC w/o fuel savings (FY09 US $)	$206,132
PVT savings (FY09 US $)	$469,509
CO2 Emissions Savings (lbs)	1,482,591
CO2 Savings (FY09 US $)	$16,812
Total Economic Savings (FY09 US $)	$829,177

TABLE B

4.2 If we assume that ADS-B is 100% effective in overcoming the airborne inefficiencies and ground delays, we are looking at annual savings of nearly 3 million lbs of fuel burn and 10 million lbs of CO_2 emissions just for these few airways.

4.3 Based on the estimated infrastructure costs, an equipment life cycle of 20 years and an estimated ADS-B effectiveness of 90% and 75% in overcoming the airborne inefficiencies and the ground delays respectively, the cost benefits were calculated under the three traffic scenarios. The results are shown in Table C:

	Most Likely Estimate		
Demand Growth	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66
Benefits FY09 $M	$127.96	$200.47	$328.11
IRR	17%	22%	27%
Costs PV	$27.17	$27.17	$27.17
Benefits PV	$50.29	$73.60	$112.43
NPV	$23.12	$46.43	$85.26
B/C Ratio	1.9	2.7	4.1
Payback Year	2020	2018	2017

TABLE C

4.4 Table D below shows the Cumulative Present Value for the 3 growth scenarios based on the most likely estimate of ADS-B effectiveness and the discount rate of 7% used by the FAA.

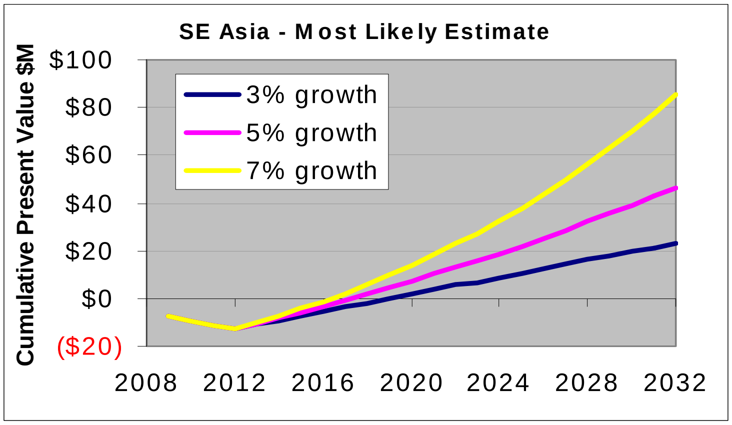


TABLE D

5 CONCLUSION

5.1 The Cost Benefit Study for the initial phase of ADS-B implementation over the South China Sea showed clearly that there is a strong business case for the project. Details of the Cost Benefit Study are in **Attachment C.**

ATTACHMENT A

CONCEPT OF OPERATIONS

The following briefly describes the concept of operations of the initial phase of the ADS-B project over the South China Sea and sets the context for the cost benefit study undertaken by CANSO and IATA.

OBJECTIVE

To increase airspace capacity and enhance flight safety and efficiency through the application of radar-like separation in the area of interest.

SCOPE

The area of interest covers the en-route phase of flights on 2 main trunk routes (L642 and M771) and 4 other routes (L637, N891, M753 and L644) in South China Sea Area.

CONSTRAINTS

There is a lack of surveillance coverage and direct controller pilot communications over parts of the service area.

ELEMENTS OF CHANGE

- Installation of ADS-B stations and VHF repeaters at Con Son, Matak, Natuna Islands and Singapore
- Collaboration among the ANSPs of Indonesia, Singapore and Vietnam with agreement to share data and communications
- Agreement by ANSPs to apply radar-like separation for whole of the en-route phase in the area of operations.

OPERATIONAL PHASES

ADS-B operations will be implemented and operationalised in three phases – phase 1 is for stakeholders to familiarize themselves with the new surveillance system, phase 2 allows for mixed mode of operations and enables reduced separation to be applied on an opportunity basis. Phase 3 is the operational implementation phase where exclusive ADS-B airspace is defined for suitably equipped aircraft and radar like separation applied to aircraft operating in exclusive airspace.

AWARENESS PHASE, (Year X)

- commence when the necessary ground infrastructures are in place
- monitor and validate performance of ADS-B surveillance capability and integrity
- monitor and validate performance of VHF communications
- review and resolve operational issues

- no reduction in separation
- improve situational awareness of ATC and pilots
- learning opportunity for all stakeholders

TRIAL PHASE (Year Y)

- enhanced surveillance augmenting various surveillance and communication sources
- bilateral/multilateral agreements with adjacent ATS units to enhance capacity on selected routes / flight bands
- mixed mode of operations
- applying ADS-B radar like separation on opportunity basis

IMPLEMENTATION PHASE (Year Z)

- defining ADS-B exclusive airspace
- applying ADS-B radar like separation in exclusive airspace

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ATTACHMENT B

SUPPORTING AIR TRAFFIC DATA FROM CAAS

To support the cost benefit study for the initial phase of ADS-B implementation over the South China Sea, CAAS provided 3 months (January – March 2008) of flight data in the Singapore FIR for flights using the ATS routes that would receive reduced separation with the implementation of ADS-B. The routes included N891, M753, M755, L637, L642, M771, and L644.

Source

Archived flight plan data were extracted from the Singapore air traffic control system, LORADS II.

Dataset

The supporting data contain the following fields to facilitate analysis;

- Date of Flight
- Flight Callsign
- Aircraft Type
- Departure & Arrival Airport
- ATD and ATA
- Route information
- Actual Time Over waypoints on route
- Cruising Speed
- Planned Flight Level
- Cleared Cruising Flight Level prior to leaving Singapore FIR

Additionally, for flights departing from Changi Airport, Singapore, ATC departure clearance restrictions field was included in the dataset to facilitate analysis of ground delay due to route capacity.

Other Inputs

CAAS provided route structure information, i.e. Distance between waypoints on routes. This helped to determine the flight time norms so that abnormal situations, like weather deviations can be excluded.

In addition, CAAS also provided operational inputs from air traffic controllers to determine the qualitative estimates in the study where data alone was insufficient to support, eg. Departure delay taken at gate

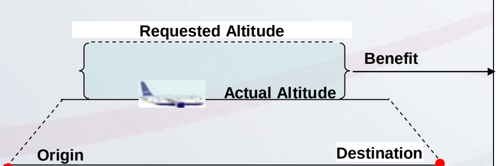
ECONOMIC ANALYSIS

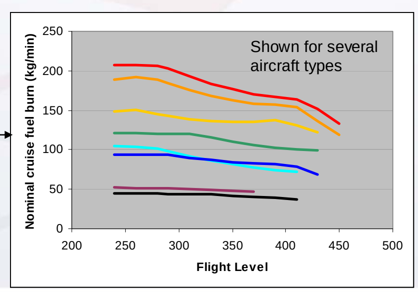
OVERALL ASSUMPTIONS

- ADS-B data sharing across FIRs
- Provision of VHF communications to adjacent States as required
- Provision of radar-like separation in exclusive airspace starting in FY2013
- Analysis based on extrapolation of CAAS traffic data and IATA's demand projections
- Estimated infrastructure costs
- 20-year lifecycle starting in first year of benefits: FY2013-FY2032
- No costs for avionics or aircraft equipage will be considered as aircraft operate beyond the region and the study
  - The study assumes that all states in the region will require ADS-B equipage based on APANPIRG Conclusion 19/37- Revised Mandate Regional ADS-B Out implementation

Benefits – Benefit Mechanisms

- **Problem:** In the current system the procedural separation (50 nmi - 80 nmi) necessary in the non-radar region prohibits many aircraft from receiving their requested (optimal) cruise altitude. These aircraft either receive a non-optimal cruise altitude (increasing fuel burn; see below) or receive a ground delay to wait for an opening in the requested altitude.
- **Benefit Mechanism:** ADS-B surveillance, improved communications, and data sharing between ANSPs should allow radar-like separation (5 nmi) in the current non-radar area. The reduction in separation should increase the availability of optimal altitudes; thereby decreasing the need to either fly at a non-optimal altitude or accept a ground delay to wait for an optimal altitude.





BENEFITS – GENERAL METHODOLOGY

Data

- CAAS provided 3 months (January – March 2008) of flight data in the Singapore FIR for flights using the routes that should receive reduced separation (N891, M753, M755, L637, L642, M771, and L644)

Benefits Estimation Methodology

- Examine current airborne inefficiency (fuel and flight time) for flights that currently do not receive requested altitude
- Examine current ground delays for flights along these routes
- Estimate potential for benefits in current system with reduced separation
- Extrapolate benefits to future years considering impact of increased demand on system
- Aggregate savings in terms of reduced Fuel Burn, Aircraft Direct Operating Costs (ADOC), Passenger Value of Time (PVT), and Carbon Emissions.

Benefits – Airborne Efficiency Savings

Steps in airborne efficiency calculations

1. Examined percent of flights that received < than their requested cruise altitude

	Number	Percentage
Total flights	16239	100.00%
Received >= requested altitude	12464	76.75%
Received < requested altitude	3775	23.25%

2. Examined difference in median flight time between flights that received ≥ requested altitude and those that received < requested altitude

Median flight time >= requested altitude (min)	54.00
Median flight time < requested altitude (min)	55.86
Excess median flight time (min) when received < requested altitude	1.86

3. Found that 15 aircraft types described over 96% of the traffic along the routes
4. For each aircraft type found the average difference in received and requested altitude when received was < requested
5. Used BADA* nominal fuel burn profiles to calculate the excess fuel burn from flying non-optimal altitudes

*BADA refers to Eurocontrol Experimental Centre's Base of Aircraft Data

BENEFITS - AIRBORNE EFFICIENCY SAVINGS

Monetizing the potential savings

1. Monetized potential fuel burn savings using US standard fuel values
2. Monetized potential carbon emissions savings using carbon markets
3. Monetized additional potential flight time savings using ADOC (w/o fuel) and PVT calculated specifically for the region

Airborne Efficiency - Potential Savings 2008	3 months	12 months
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Total Economic Savings (FY09 US $)	$837,651	$3,350,605

The potential savings assume 100% effectiveness of ADS-B in solving the airborne efficiency problem; the final effectiveness values applied were based on operational input.

Benefits - Ground Delay Savings

Steps in ground delay calculations

1. Examined average daily ground delay for flights on these routes
2. Made sure daily delay average was **not** skewed due to off-nominal events (weather, airport closure)
3. Estimated percent of ground delay taken at the gate
4. Monetized potential savings

The potential savings assume 100% effectiveness of ADS-B in solving the ground delay problem; the final effectiveness values applied were based on operational input.

Analysis of Jan-Mar 2008	
Number of aircraft delayed on ground	280
Total Ground Delay (min)	2810
Average Delay per day 2008 (min)	31

Percent of ground delay taken at gate	30%

Based on the operational input of the controllers

Ground Delay - Potential Savings 2008	
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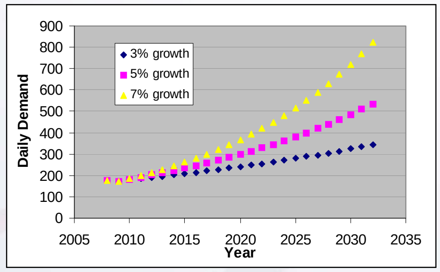
Benefits – Extrapolating to the Future

Daily Demand

- The most important factor in extrapolating the 2008 results to the future is demand
- Given the economic downturn and the volatility of projections, we conducted sensitivity analysis based on the following scenarios:

Low: 3% growth
Medium: 5% growth
High: 7% growth



Note: The medium and most probable growth rate for air traffic is set at 5% based on IATA's Forecast AAGR (2007-2011) for APAC which is 5.9% for pax and 5.4% for freight. With the sudden downturn however traffic is expected to **contract by 2.5% in 2009** and resume growth in 2010.

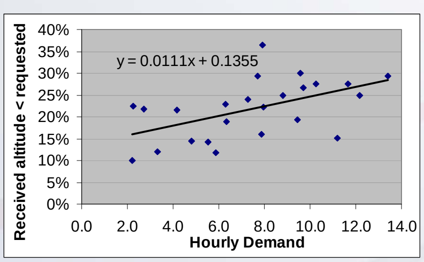
Benefits – Extrapolating to the Future

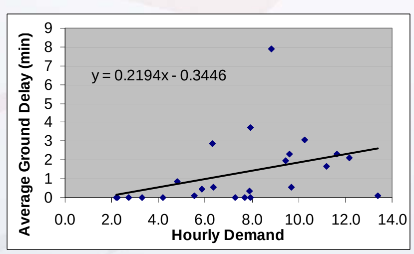
How do the benefits depend on demand

To examine this issue we decided to explore 2 important trends using regression analysis:

1. Does the percent of flights that received < than their requested cruise altitude change with demand?

2. Does the observed ground delay change with demand?

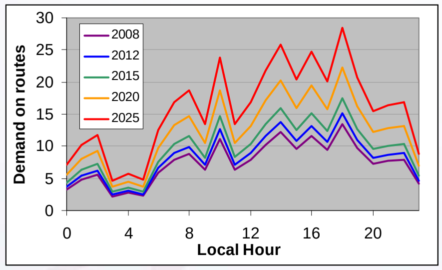




Benefits – Extrapolating to the Future

Extrapolation

1. Calculated the average hourly demand using the 2008 data
2. Assumed each hour would contain the same percent of the daily demand as in 2008
3. Applied the regressions to estimate the baseline percent of flights that received < than their requested cruise altitude and the baseline ground delay for each hour



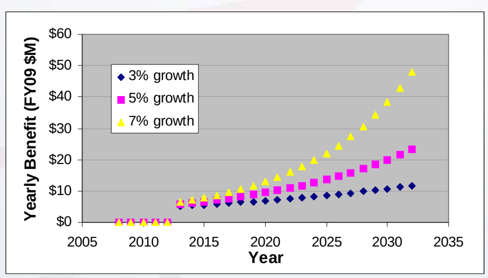
4. Used the results to grow the potential 2008 benefit for future years

Benefits – Quantitative Results

Estimated the effectiveness of ADS-B separation (5 nmi vs. 50-80 nmi)

	Most Likely Estimate
Effectiveness of ADS-B separation in addressing Airborne Efficiency	90%
Effectiveness of ADS-B separation in addressing Ground Delay	75%

Assumed start year for benefits of 2013 continuing through a 20-year lifecycle



Sensitivity analyses were performed on effectiveness and demand

OTHER BENEFITS

- **Improved safety**
  - enhanced tracking of aircraft
  - safer and more efficient weather deviations
- **Improved surveillance**
  - increased situational awareness for ATC
  - facilitates Search and Rescue efforts
- **Improved flight data collection**
  - enhanced flight data for better analysis and planning

COSTS – GROUND RULES & ASSUMPTIONS

- **Costs provided by CAAS in consultation with the other ANSPs:**
  - 4 ADS-B dual link radio sites/ 7 ADS-B VSAT data links
  - 3 dual redundant VHF radio sites/ 3 VHF VSAT data links
  - Upgrade of automation platform (Ho Chi Minh)
  - Generator set (Matak)

- **Capital Cost for VHF and ADS-B sites include:**
  - Equipment
  - Tech Refresh
  - Testing, Installation, and Program Management
  - Spare parts
  - Training
  - Software Development

- **Recurrent Cost for VHF and ADS-B sites include:**
  - Labor (Including remote monitoring)
  - Spare parts and material management
  - Sub-contractors
  - Power

- **Sunk Costs excluded from cost estimate:**
  - Natuna ADS-B Ground Station - $300K
  - Matak ADS-B Ground Station - $350K
  - Natuna-Jakarta VSAT link - $100K
  - Matak-Jakarta VSAT link - $100K

- **No additional Air Traffic Controller costs were included**
- **Singapore automation platform costs are accounted for outside this effort**
- **Jakarta automation platform upgrade in place**

COSTS – HARDWARE / TELCO MATRIX

Hardware/Telco Matrix				
Location	ADS-B Dual Link Ground Station	VHF Radio	Telco - ADS-B	Telco - VHF
Singapore	1			
Con Son	1	4		
Natuna	1	4		
Matak	1	4		
Natuna-Singapore			1	1
Matak-Singapore			1	1
Jakarta-Singapore			1	
Natuna-Jakarta			1	
Matak-Jakarta			1	
Con Son-Ho Chi Minh			1	
Ho Chi Minh-Singapore			1	
Con Son-Singapore				1

COSTS – SUMMARY THEN YEAR ($ K)

Southeast Asia - ADS-B	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17-32	Totals-Then Year $K
SEASIA - Total Costs	$7,355.3	$2,631.7	$1,939.5	$1,978.4	$2,018.0	$2,058.3	$2,099.5	$2,141.5	$34,622.5	$56,844.7
HW/SW Design, Development and Production	$6,393.7	$1,357.6	$532.8	$543.5	$554.4	$565.5	$576.8	$588.3	$5,093.8	$16,206.4
Software Build	$5,114.9	$522.2	$532.8	$543.5	$554.4	$565.5	$576.8	$588.3	$1,836.5	$10,834.9
Procurement/Production	$1,278.7	$835.5	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$3,257.3	$5,371.5
System Hardware	$1,278.7	$835.5	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$2,114.2
Dual ADS-B Ground Station	$306.9	$365.5	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$672.4
Generator Set	$102.3	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$102.3
Dual Redundant VHF Radios	$869.5	$470.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$1,339.5
Technology Refresh	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$3,257.3	$3,257.3
Logistics	$245.5	$334.2	$341.0	$347.8	$354.8	$361.9	$369.1	$376.5	$7,158.5	$9,889.4
Recurrent Costs	$245.5	$334.2	$341.0	$347.8	$354.8	$361.9	$369.1	$376.5	$7,158.5	$9,889.4
Infrastructure Support	$716.1	$939.9	$1,065.7	$1,087.0	$1,108.8	$1,130.9	$1,153.6	$1,176.6	$22,370.2	$30,748.9
Telecommunications	$716.1	$939.9	$1,065.7	$1,087.0	$1,108.8	$1,130.9	$1,153.6	$1,176.6	$22,370.2	$30,748.9

Economic Analysis

Most economic metrics depend highly on the time value of money assumed (discount rate)

For a specified discount rate one can determine the:
•Net Present Value (NPV)
•Benefit to Cost Ratio (B/C Ratio)
•Payback Year

The Internal Rate of Return (IRR) is the discount rate at which the NPV = 0 and the B/C Ratio = 1.0

A fixed discount rate of 7% is used in most FAA investment analyses

	Most Likely Estimate		
Demand Growth	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66
Benefits FY09 $M	$127.96	$200.47	$328.11
IRR	17%	22%	27%
Costs PV	$27.17	$27.17	$27.17
Benefits PV	$50.29	$73.60	$112.43
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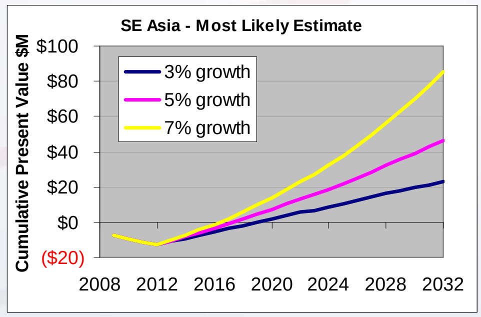
B/C Ratio	1.9	2.7	4.1
Payback Year	2020	2018	2017



SUMMARY & FUTURE WORK

- **Summary**
  - Examined costs and benefits of an initial implementation of ADS-B leading to reduced separation along 7 routes in the South China Sea starting in 2013
  - Considered costs to the ANSP and benefits to the airlines (fuel, ADOC, carbon emissions) and to the passengers (PVT)
  - Performed economic analyses checking for sensitivity in demand and effectiveness factors
  - Positive results were found for each level of demand and effectiveness examined
  - For the most likely demand (5% growth) and effectiveness values the model estimated an IRR of 22%
  - Using a 7% discount rate the most likely results suggested a B/C ratio of 2.7, an NPV of $46.43M (US$), and a payback year of 2018
- **Future Work**
  - The positive results found in the region of study suggest that expanded coverage of ADS-B in South China Sea may also be cost-beneficial

SUPPORTING INFORMATION

Benefits – Monetizing

There are three types of benefits we plan to monetize: fuel burn, carbon emissions, and delay

Fuel Burn – used FY08 price per gallon suggested by US FAA Office of Policy and Planning

Carbon Emissions – directly related to fuel burn; used Reuters survey of EU Carbon Emissions price forecast, February 2009 to monetize

Delay – used Aircraft Direct Operating Costs (ADOC) and Passenger Value of Time (PVT) per hour from US FAA Office of Policy and Plans. Modified PVT using regional GDP per capita.

ADOC and PVT per hour for a flight depend on aggregate aircraft types, phase of flight (ground, airborne), and flight purpose (passenger, freight)

Economic Value Assumptions FY09 US$		Airborne Efficiency Estimate	Ground Delay Estimate
Fuel price per gallon	$1.95	X	
CO_2 costs per tonne	$25.00	X	X
Airborne ADOC w/o fuel cost*	$2,959	X	
Ground ADOC*	$2,607		X
Passenger Value of Time (PVT)	$17.60	X	X
Average PVT per aircraft*	$2,499	X	X

*ADOC and PVT weighted for fleet mix along relevant routes

•FAA Office of Policy and Plans, "Economic Values for FAA Investment and Regulatory Decisions, A Guide," October 2007
•FAA Office of Financial Analysis & Process Reengineering "Supporting Documentation for the Economic Factors Used in Investment Analysis" April 2009

Benefits – ADOC

Aircraft Direct Operating Costs (ADOC)

1. Determined fleet mix on routes from CAAS data
2. Used aircraft type to categorize fleet by body style and number of engines
3. Used call signs to determine percent of each category that were freight carriers

SE Asia project fleet categorized for ADOC and PVT calculations			
% Fleet	Engines	Body	% Freight
43.61%	2	Narrow	4.6%
44.11%	2	Wide	1.8%
1.60%	3	Wide	72.2%
10.67%	4	Wide	23.9%

4. FAA references provided airborne, ground, and block ADOC values by aircraft category and flight purpose (carrier or freight)
5. ADOC considers fuel, crew costs, and maintenance
6. Developed weighted values of airborne and ground ADOC with and without fuel costs for SE Asia fleet

	SE Asia Fleet	US Domestic Fleet
Variable ADOC Airborne	$5,198	$4,045
Variable ADOC Airborne w/o fuel	$2,959	$2,303
Variable ADOC Ground	$2,607	$2,037
Variable ADOC Ground w/o fuel	$1,568	$1,225

Note: US Domestic weighted ADOC is lower than SE Asia because it is dominated by smaller (2-engine Narrow body) aircraft

•FAA Office of Policy and Plans, "Economic Values for FAA Investment and Regulatory Decisions, A Guide," October 2007
•FAA Office of Financial Analysis & Process Reengineering "Supporting Documentation for the Economic Factors Used in Investment Analysis" April 2009

Benefits – PVT

Passenger Value of Time

1. Based PVT on average US estimate for Air Carrier Passengers of $28.60 per hour
2. Determined count of flights servicing airports along relevant routes in SE Asia study from city pair data, and aggregated data by country
3. Found GDP per capita* for each country
4. Developed a weighted average GDP per capita for region based on flight count per country
5. Compared weighted average GDP per capita for region to US GDP per capita (result = 62%)
6. Scaled US PVT by GDP ratio to estimate SE Asia PVT ($17.82)
7. FAA references provided passengers per aircraft by aircraft category and flight purpose (carrier or freight)
8. Developed weighted value of PVT per aircraft for SE Asia fleet

Country	Count	% of Total	GDP PPP
Singapore	11078	34.11%	52000
China	6929	21.33%	6100
HongKong	4617	14.22%	45300
Malaysia	3763	11.59%	15700
Vietnam	1958	6.03%	2900
Macau	1046	3.22%	30000
Australia	718	2.21%	39300
Thailand	690	2.12%	8700
Indonesia	665	2.05%	3900
Cambodia	650	2.00%	2100
Taiwan	141	0.43%	31900
South Kor	92	0.28%	26000
Japan	61	0.19%	35300
Philippines	56	0.17%	3400
New Zeala	10	0.03%	28500
USA	4	0.01%	48000

Weighted Average	29913
Compared to US	62%

US Airline PVT per hour $28.60
SE Asia Regional PVT per Hour* $17.82

*We believe this is a conservative result because we suspect that the average income of airline passengers in SE Asia and US is more comparable than the average GDP over all citizens

*CIA World Fact Book

BENEFITS – AIRBORNE EFFICIENCY SAVINGS

Fuel burn calculations for flights that received < requested altitude

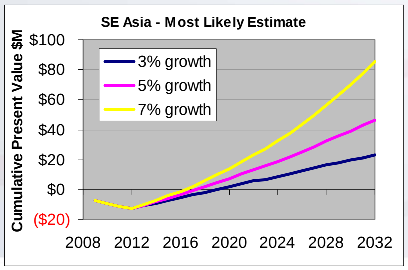
Aircraft Type	Average Planned Alt (100s feet)	Average Actual Alt (100s feet)	Calculated Difference (100s feet)	Nominal values from BADA: Fuel burn desired kg/min	Nominal values from BADA: Fuel burn received kg/min	Fuel Savings in lbs	% aircraft in fleet
A306	340	316	24	83.85	86.31	133.35	1.53%
A319	369	340	29	35.71	38.85	110.04	4.36%
A320	368	339	29	40.36	42.85	97.22	23.58%
A321	347	319	28	46.50	49.52	115.99	2.97%
A333	392	368	24	74.43	78.40	163.73	12.31%
B733	349	329	20	37.76	38.87	60.23	1.05%
B737	374	342	32	37.08	39.28	87.21	2.02%
B738	364	333	31	40.72	43.23	98.16	5.73%
B742	365	342	23	172.15	179.46	331.15	1.24%
B744	369	341	28	159.00	165.36	295.91	8.98%
B752	355	334	21	59.75	61.78	102.06	2.06%
B763	369	346	23	83.18	85.06	118.18	2.17%
B772	385	358	27	103.33	108.38	215.71	17.08%
B773	368	341	27	119.67	123.81	206.29	9.14%
MD11	364	340	24	135.61	136.00	124.55	1.53%

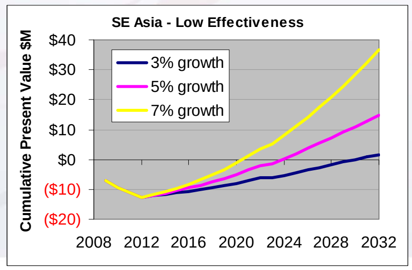
Weighted Average	161.19

Fb_A - Fuel Burn Actual, Fb_D - Fuel Burn Desired
T_A -Median Flight Time for < requested altitude
T_D -Median Flight time for ≥ requested altitude
Potential Fuel Burn Savings = $Fb_A*T_A – Fb_D*T_D$
Additional non-fuel related flight time savings were calculated using difference in median times (T_A-T_D)

Economic Analysis – Effectiveness Sensitivity

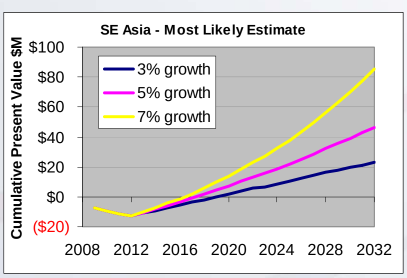
	Most Likely Estimate			Using Low Effectiveness Values		
Demand Growth	3%	5%	7%	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66	$45.66	$45.66	$45.66
Benefits FY09 $M	$127.96	$200.47	$328.11	$73.30	$114.42	$186.48
IRR	17%	22%	27%	8%	13%	18%
Costs PV (7%)	$27.17	$27.17	$27.17	$27.17	$27.17	$27.17
Benefits PV (7%)	$50.29	$73.60	$112.43	$28.82	$42.06	$64.00
NPV (7%)	$23.12	$46.43	$85.26	$1.65	$14.89	$36.83
B/C Ratio	1.9	2.7	4.1	1.1	1.5	2.4
Payback Year	2020	2018	2017	2031	2024	2021

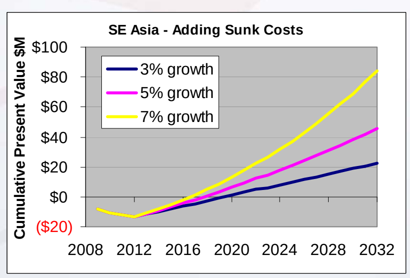




Economic Analysis – Sunk Cost Sensitivity

	Most Likely Estimate			Adding Sunk Costs		
Demand Growth	3%	5%	7%	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66	$46.64	$46.64	$46.64
Benefits FY09 $M	$127.96	$200.47	$328.11	$127.96	$200.47	$328.11
IRR	17%	22%	27%	17%	21%	26%
Costs PV (7%)	$27.17	$27.17	$27.17	$28.07	$28.07	$28.07
Benefits PV (7%)	$50.29	$73.60	$112.43	$50.29	$73.60	$112.43
NPV (7%)	$23.12	$46.43	$85.26	$22.22	$45.53	$84.36
B/C Ratio	1.9	2.7	4.1	1.8	2.6	4.0
Payback Year	2020	2018	2017	2020	2018	2017





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CANSO members are responsible for supporting over 85% of world air traffic, and through our Workgroups, members share information and develop new policies, with the ultimate aim of improving air navigation services on the ground and in the air. CANSO also represents its members' views in major regulatory and industry forums, including at ICAO, where we have official Observer status.

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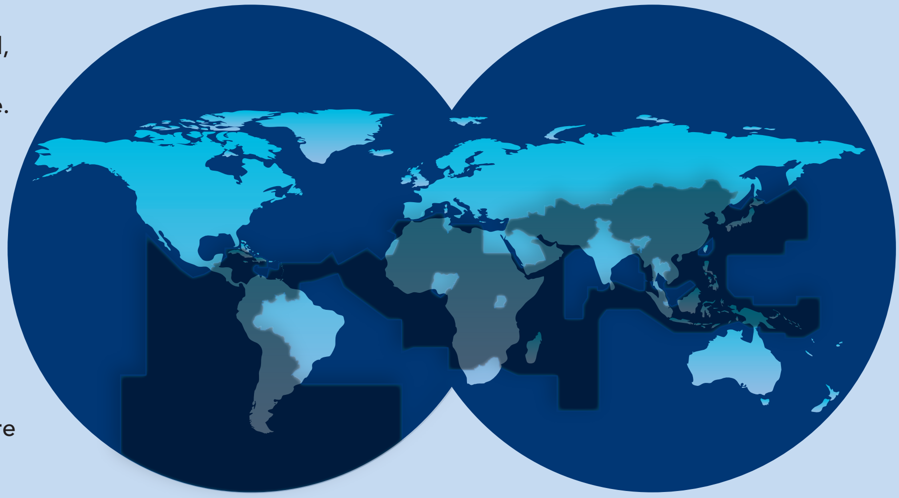

Lighter areas represent airspace covered by CANSO Members

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- Austro Control
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- Department of Civil Aviation, Republic of Cyprus
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- Entidad Pública Aeropuertos Españoles y Navegación Aérea (Aena)
- Estonian Air Navigation Services (EANS)
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- Finavia Corporation
- GCAA United Arab Emirates
- General Authority of Civil Aviation (GACA)
- Hellenic Civil Aviation Authority (HCAA)
- HungaroControl Pte. Ltd. Co.
- Irish Aviation Authority (IAA)
- ISAVIA Ltd
- Kazaeronavigatsia
- Latvijas Gaisa Satiksme (LGS)
- Letové prevádzkové Služby Slovenskej Republiky, Štátny Podnik
- Luchtverkeersleiding Nederland (LVNL)
- Luxembourg ANA
- Maldives Airports Company Limited (MACL)
- Malta Air Traffic Services (MATS)
- NATA Albania
- National Air Navigation Services Company (NANSC)
- NATS UK
- NAV CANADA
- NAV Portugal
- Naviair
- Netherlands Antilles - Curaçao ATC (NAATC)
- Nigerian Airspace Management Agency (NAMA)
- Office de l'Aviation Civile et des Aeroports (OACA)
- ORO NAVIGACIJA, Lithuania
- PNG Air Services Limited (PNGASL)
- Polish Air Navigation Services Agency (PANSA)
- Prishtina International Airport JSC
- ROMATSA
- Sakaeronavigatsia Ltd
- SENEAM
- Serbia and Montenegro Air Traffic Services Agency (SMATSA)
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- skyguide
- Slovenia Control
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- State ATM Corporation
- The LFV Group
- Ukrainian Air Traffic Service Enterprise (UkSATSE)

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- ATC Network
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- Avitech AG
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- Entry Point North
- Etihad Airways
- Fokker Services B.V.
- GE Aviation's PBN Services
- Harris Corporation
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- HITT Traffic
- Honeywell International Inc. / Aerospace
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- Quintiq
- Rohde & Schwarz GmbH & Co. KG
- Saab AB
- SELEX Systems Integration Inc.
- SITA
- Ubitech Systems, Inc.
- U.S. DoD Policy Board on Federal Aviation
- WIDE

Correct as of 12 May 2011. For the most up-to-date list and organisation profiles go to www.canso.org/cansomembers