A COST-BENEFIT ANALYSIS FOR THE INSTALLATION OF FIRE SUPPRESSION SYSTEMS IN CARGO COMPARTMENTS OF CARGO AIRPLANES
Freighter Cost Benefit Analysis

We would like to thank

The U.S. Federal Aviation Administration and the U.K. CAA

for giving us the opportunity to work on this interesting project.
Freighter Cost Benefit Analysis

✓ The NTSB recommended that fire suppression systems be installed in the cargo compartments of all cargo airplanes operating under 14 CFR Part 121.

✓ Currently, Class E cargo compartments, which are the primary cargo compartment type used in US cargo airplanes, do not require fire suppression systems.
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✓ In response to this recommendation, FAA has requested that a cost/benefit analysis be carried out relating to the installation of on-board fire detection and extinguishment systems in cargo airplanes.
The analysis assessed whether fire suppression systems, fitted to the upper deck cargo bays of cargo airplanes, type certificated to FAR Part 25 and operating under FAR Part 121, are likely to be cost beneficial.
Freighter Cost Benefit Analysis

Analysis carried out for aircraft types grouped into weight categories

<table>
<thead>
<tr>
<th>WEIGHT CATEGORY</th>
<th>AIRCRAFT MAXIMUM TAKE-OFF WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>12,500 lb to 100,000 lb</td>
</tr>
<tr>
<td>C</td>
<td>100,000 lb to 250,000 lb</td>
</tr>
<tr>
<td>D</td>
<td>250,000 lb to 400,000 lb</td>
</tr>
<tr>
<td>E</td>
<td>Greater than 400,000 lb</td>
</tr>
</tbody>
</table>
Freighter Cost Benefit Analysis

Potential benefits will result from a reduction in:

✓ Injuries (Fatal and Serious)

✓ Damage incurred to the aircraft and its cargo, and

✓ Damage that might be incurred to property on the ground.
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Potential costs are those incurred from:

✓ System Installation

✓ Operation (Fuel Burn, Maintenance, etc.)
Freighter Cost Benefit Analysis

Benefit Analysis based on:

✓ Monte Carlo model
✓ Statistical distributions derived from data on in-service airplanes and accident information.
Freighter Cost Benefit Analysis

The Monte Carlo model was based on the following Benefit equation:

\[
\frac{\text{Benefit}}{\text{Year}} = \frac{\text{Accidents}}{\text{RTM}} \times \frac{\text{RTM}}{\text{Year}} \times \frac{\text{Cost}}{\text{Accident}}
\]

RTM = Revenue Ton Miles
Freighter Cost Benefit Analysis

Accident Rate (Accidents per RTM) based on US cargo fleet experience over the period 1967 to 2007:

✓ Four accidents caused by cargo compartment fires
✓ Approximately 545,200,000,000 Revenue Ton Miles
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Cost of Collateral Damage

Based on an analysis of accident data it was assessed that approximately one in eighteen freighter aircraft fire accidents are likely to result in some degree of Collateral Damage.
Freighter Cost Benefit Analysis

Probability Distribution of the Monetary Value of Collateral Damage
Freighter Cost Benefit Analysis

Cost Assessments based on:

- The new Type F Cargo Compartment (considered for combi aircraft) using a Halon type fire suppression system together with suitable cargo compartment liners. The data used in the cost assessment was based on that contained in the ARAC document relating to main deck class B cargo compartments.
A COST-BENEFIT ANALYSIS
FOR THE INSTALLATION OF
FIRE SUPPRESSION SYSTEMS
IN CARGO COMPARTMENTS OF CARGO AIRPLANES

Conclusions:
Conclusions - Costs
Freighter Cost Benefit Analysis

Conclusions: Cost

- Fuel, 30%
- Liner Installation, 45%
- System Installation, 24%
- System Development, 0.1%
- Liner Development, 0.2%
- Maintenance, 2%
Freighter Cost Benefit Analysis

Conclusions: Cost

<table>
<thead>
<tr>
<th>Weight Category</th>
<th>Total Cost per Aircraft per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>$50,791</td>
</tr>
<tr>
<td>C</td>
<td>$156,053</td>
</tr>
<tr>
<td>D</td>
<td>$290,182</td>
</tr>
<tr>
<td>E</td>
<td>$446,008</td>
</tr>
</tbody>
</table>
Conclusions - Benefits
Freighter Cost Benefit Analysis

Conclusions: Benefit

✓ Collateral damage costs do not appear to contribute significantly to the prediction of benefit.

✓ Crew injuries (fatal and serious combined) are a significant factor in the prediction of benefit.

✓ Aircraft value is the largest contributor to the prediction of benefit.
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Conclusions Cost Breakdown:

- Aircraft: 58%
- Crew Fatal: 24%
- Cargo: 11%
- Crew Serious: 2%
- Collateral: 5%

1715\Model\Issue 2 - Summary of Results.xlsx
Freighter Cost Benefit Analysis

Conclusions: Benefit

Average, 7.4

90 Percentile range, 2.0 to 16.9

Benefit per year for the US fleet ($m)

Confidence Level

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

0 5 10 15 20 25 30
## Freighter Cost Benefit Analysis

### Conclusions: Benefit

<table>
<thead>
<tr>
<th>WEIGHT CATEGORY</th>
<th>BENEFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>NEGLIGIBLE</td>
</tr>
<tr>
<td>C</td>
<td>$640</td>
</tr>
<tr>
<td>D</td>
<td>$4,100</td>
</tr>
<tr>
<td>E</td>
<td>$19,900</td>
</tr>
</tbody>
</table>
## Freighter Cost Benefit Analysis

### Conclusions: Cost v Benefit

<table>
<thead>
<tr>
<th>Weight Category</th>
<th>Average Benefit per Aircraft per Year</th>
<th>Total Cost per Aircraft per Year</th>
<th>Cost Benefit Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>NEGLIGIBLE</td>
<td>$50,791</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>$640</td>
<td>$156,053</td>
<td>244</td>
</tr>
<tr>
<td>D</td>
<td>$4,100</td>
<td>$290,182</td>
<td>71</td>
</tr>
<tr>
<td>E</td>
<td>$19,900</td>
<td>$446,008</td>
<td>22</td>
</tr>
</tbody>
</table>
Conclusions:

✓ Halon fire suppression systems, or alternatives that are likely to be developed for below floor cargo compartments, are unlikely to be cost beneficial for the main deck cargo compartments of cargo aircraft of any weight category.
Freighter Cost Benefit Analysis

Conclusions:

✓ However, other fire suppression systems may prove to be cost beneficial.
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Conclusions: Weight Category C:

Threshold Benefit Line
(Benefit = $640 per a/c per year)

Cost Beneficial

Not Cost Beneficial
Freighter Cost Benefit Analysis

Conclusions: Weight Category D:

Threshold Benefit Line
(Benefit = $4,100 per a/c per year)

Cost Beneficial

Not Cost Beneficial

Total System Weight (lb)

Installation Cost per Aircraft (US$2007)
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Conclusions: Weight Category E:

- **Threshold Benefit Line**: Benefit = $19,900 per a/c per year
- **Not Cost Beneficial**
- **Cost Beneficial**

Graph showing total system weight (lb) vs. installation cost per aircraft (US$2007). The graph indicates the threshold benefit line and the regions for cost beneficial and not cost beneficial.
Freighter Cost Benefit Analysis

The Report:

DOT/FAA/AR-09/17 “A Cost-benefit Analysis For The Installation Of Fire Suppression Systems In Cargo Compartments Of Cargo Airplanes”

may be obtained from the FAA website

Thank you
Any Questions?
Freighter Cost Benefit Analysis

Assessed Number of Revenue Ton Miles for 1967 to 2007:

- 10,000,000
- 20,000,000
- 30,000,000
- 40,000,000
- 50,000,000
- 60,000,000
- 70,000,000
- 80,000,000

Year:
- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
- 2020
- 2030

RTM (Thousands):
- Approximately 31,354,000,000 Revenue Ton Miles in 2007
## Freightier Cost Benefit Analysis

Assessed Number of Revenue Ton Miles for 2007:

<table>
<thead>
<tr>
<th>WEIGHT CATEGORY</th>
<th>REVENUE TON MILES (2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>13,500,000</td>
</tr>
<tr>
<td>C</td>
<td>1,764,400,000</td>
</tr>
<tr>
<td>D</td>
<td>6,107,900,000</td>
</tr>
<tr>
<td>E</td>
<td>23,468,600,000</td>
</tr>
</tbody>
</table>
Freighter Cost Benefit Analysis

Cumulative Probability

Number of Crew

WEIGHT CATEGORY B

WEIGHT CATEGORY C

WEIGHT CATEGORY D

WEIGHT CATEGORY E

Freighter Fire Protection Cost Benefit Analysis

Assessed Distribution of Crew Numbers

0.2
0.4
0.6
0.8
1

0 2 4 6 8 10 12 14

0

October 2010 Fire & Cabin Safety Conference – Atlantic City NJ
Freighter Cost Benefit Analysis

Assessed Average Cargo Value per flight for US Cargo Fleet 2007:

<table>
<thead>
<tr>
<th>WEIGHT CATEGORY</th>
<th>CARGO VALUE ($ MILLIONS 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.14</td>
</tr>
<tr>
<td>C</td>
<td>1.1</td>
</tr>
<tr>
<td>D</td>
<td>2.6</td>
</tr>
<tr>
<td>E</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Freighter Cost Benefit Analysis

Cost per Accident based on:

Primary Damage

- Crew Injuries (Fatal and Serious)
- Damage incurred to the aircraft and its cargo, and

- Damage that might be incurred to property
- Personnel Injuries (Fatal and Serious)