FINAL REGULATORY EVALUATION, REGULATORY FLEXIBILITY ANALYSIS, INTERNATIONAL TRADE IMPACT ASSESSMENT, AND UNFUNDED MANDATES ACT ASSESSMENT

FOR

FINAL RULE:

FUEL TANK FLAMMABILITY REDUCTION AIRBUS AND BOEING AIRPLANE FLEETS
CFR PARTS 25, 121, 125, AND 129

OFFICE OF AVIATION POLICY AND PLANS
AIRCRAFT REGULATORY ANALYSIS BRANCH, APO-320

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EXECUTIVE SUMMARY

Introduction

On July 17, 1996, scheduled international passenger flight TWA 800 exploded in mid-air and crashed in the Atlantic Ocean off the coast of New York, killing all 230 people aboard. The cause of the accident was an explosion in the center wing tank (CWT). This accident was not an isolated incident because there have been two similar center wing tank explosion accidents (one in the Philippines and one in Thailand).

Cause of the Explosions

The explosions were caused by ignition of flammable fuel vapors in the center wing tank. Transport airplane fuel tanks have many potential ignition sources including sparks from wiring to electrical equipment (pumps, fuel quantity indicators, etc.), friction sparks from fuel pumps, heating of pump surfaces, lightning and electrostatics, and external heating of tank surfaces, which have the capability to fail and create an ignition source. In order to minimize the potential for an ignition source, the FAA established Special Federal Aviation Regulation (SFAR) 88 that required an engineering analysis and a physical examination of all fuel tank systems. This has resulted in approximately 60 Airworthiness Directives (ADs) to correct potential system failures.

Due to the design in most Boeing and nearly all Airbus airplanes that locates the air conditioning units adjacent to the CWT, these tanks may become heated on hot days when the air conditioning units are operating and exhausting heat. These tanks are "heated" CWTs (HCWT). Airplanes that do not have HCWT do not have such explosive potential. Reducing the oxygen level in the HCWT can prevent a HCWT from exploding and recent technological advances have developed a mechanical air separation module that filters nitrogen from the ambient air and directs it into the fuel tank to displace oxygen, thereby reducing the fuel tank oxygen level below the threshold necessary to support an explosion. This technology is called fuel tank inerting (FTI). This rule mandates the use of either FTI or some future technology or operational procedures that will make the fuel tank non-flammable.

Risk of an Explosion

As three fuel tank explosions have occurred, the probability of a future event is low, but predictable and even probable in the aggregate. Based on engineering analyses, the risk of an explosion would be one explosion every 100 million flight hours for the at-risk Boeing and Airbus fleet in the absence of SFAR 88 and this rule. There is an 80 percent probability that this explosion will occur in-flight and a 20 percent probability that it will occur on the ground. As we forecast that the fleet being analyzed will accumulate about 360 million flight hours between 2008 and 2042, we calculate that, in the absence of SFAR 88 and this final rule, there would be 3.6 accidents. Obviously, fractions of accidents do not occur. For analytic purposes we describe cumulative probabilities as fractions of accidents.

Number of Prevented Accidents

We cannot predict all of the potential sequences of events or sources that may cause an ignition. These events can be inherent in an airplane's operation and may develop between fuel tank inspections. Our statistical analysis indicates that SFAR 88 is 50 percent effective in preventing these accidents. Based on a 50 percent effectiveness rate, SFAR 88 would prevent 1.8 of these accidents.

As it will take time to install FTI on existing airplanes, some airplanes will be flown before it can be installed. Therefore, the final rule will not cannot eliminate all fuel tank explosion risks. Of the 1.8 accidents not prevented by SFAR 88, we estimate that the final rule would prevent 1.5 of them and airplanes flying without fuel tank inerting would account for 0.3 of the accidents.

Quantitative Benefits from Preventing an Explosion

Of great concern to the FAA is that a practical design solution now exists for this real threat of an aviation catastrophe. An in-flight explosion results in the total destruction of the airplane and all of its occupants. Using a $5.5 million value for a prevented fatality, the benefits from preventing an in-flight explosion range of $625 million to $750 million for a B-737 or an A-320 family airplane to $1.0 billion to $2.15 billion for all other affected airplanes. The mean of the estimated benefits from preventing an in-flight explosion (weighted by the number of flight hours for each type of affected airplane model) are $840 million.

In addition, the inevitable consequence of an in-flight explosion is a reduction in the public perception of airplane travel safety and a resultant decline in air travel. The estimated economic impact from this reduced demand is $290 million.

Thus, the undiscounted total weighted average benefit from preventing an in-flight explosion is $1.130 billion. Adjusting this value for the 20 percent of the accidents that will occur on the ground produces an undiscounted average benefit of about $1 billion.

There is also the possibility that an in-flight fuel tank explosion could be mistaken for a terrorist bomb (the explosions are initially indistinguishable from each other until an accident investigation is undertaken), which could result in costly governmental or industry responses to a perceived terrorist attempt. However, we did not quantify any benefits from these potential actions because this quantification would involve too many uncertainties.

We calculated that the present value of the weighted average benefits from preventing the 1.5 accidents would be $657 million.

Per Airplane Costs of Fuel Tank Inerting

The costs of installing fuel tank inerting systems are the initial costs of the equipment and its installation and the annual operating costs from the increased fuel burn due to its equipment weight as well as inspections, maintenance, and parts replacements.

To install the equipment during production, the inerting system costs from $100,000 to $210,000. The average annual operating costs are between $15,000 and $38,000.

To retrofit the equipment on an airplane in the fleet costs between $110,000 to $250,000. The average annual operating costs are between $13,000 and $34,000.

We calculated the present value of the compliance costs to be $1.014 billion.

Cost Benefit Analysis of the Final Rule

Although these are low probability accidents, they are high consequence events. For example, if a single in-flight catastrophic accident with 190 occupants (235 seats) is prevented by 2012, the present value of the benefits will be greater than the present value of the costs. There is a 25 percent probability that the present value of the benefits will be greater than $1 billion, making the rule cost-beneficial. The present value of the $657 million in weighted-average benefits are about two thirds of the $1.014 billion in costs.

<u>Costs and Benefits of Alternatives to the Final Rule</u>

As shown in Table 1, we evaluated the baseline costs and weighted average benefits for the following 8 alternatives to the final rule using a value of $5.5 million for a prevented fatality, a 7 percent discount rate, and a 50 percent SFAR 88 effectiveness rate:

ALTERNATIVE 1. cover only air carrier passenger airplanes
ALTERNATIVE 2. exclude auxiliary fuel tanks
ALTERNATIVE 3. cover only air carrier retrofitted passenger airplanes
ALTERNATIVE 4. cover only air carrier production passenger airplanes
ALTERNATIVE 5. cover only air carrier production passenger and cargo airplanes
ALTERNATIVE 6. final rule plus part 91 airplanes
ALTERNATIVE 7. final rule plus conversion cargo airplanes
ALTERNATIVE 8. final rule plus conversion and retrofitted cargo airplanes

TABLE 1

BENEFITS AND COST SUMMARIES FOR 8 ALTERNATIVES TO THE FINAL RULE USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY, A 7 PERCENT DISCOUNT RATE, AND A 50 PERCENT SFAR 88 EFFECTIVENESS RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE (7%)		NET BENEFITS
OPTION	BENEFITS	COSTS	
FINAL RULE	**$657**	**$1,012**	**($355)**

ALTERNATIVES			
1. Cover Only Part 121 Passenger Airplanes (excludes Part 121 cargo and Part 91)	$657	$ 975	($318)
2. Cover Only Part 121 Passenger Airplanes but No Auxiliary Tanks	$657	$ 975	($318)
3. Cover Only Part 121 Retrofitted Passenger Airplanes (excludes All Production Passenger, all Cargo, and Part 91 Airplanes)	$271	$ 438	($159)
4. Cover Only Part 121 Production Passenger Airplanes	$386	$ 537	($151)
5. Cover Only Part 121 Production Passenger and Cargo Airplanes	$386	$ 574	($188)
6. Final Rule Plus Part 91 Airplanes	$657	$1,026	($369)
7. Final Rule Plus Conversion Cargo Airplanes	$657	$1,109	($452)
8. Final Rule Plus Conversion and Retrofitted Cargo Airplanes	$657	$1,229	($572)

The FAA cautions decision makers from choosing an alternative based on minimizing losses. The total benefits estimate is based on the mean probability of a rare event. One high consequence accident that would occur during the time period can result in a cost beneficial rule.

Conclusion

Based on the weighted average estimated benefits, the present value of the $657 million in benefits are about two thirds of the $1.012 million in present value costs. When modeling discrete, rare events such as fuel tank explosions, it is important to understand and evaluate the distribution around the mean value rather than to rely only on a single point estimated value. This variability analysis indicates that there is a 26 percent probability that the quantified benefits will be greater than the costs.

The Federal Aviation Administration believes that the correct public policy choice is to eliminate the substantial probability of a high consequence fuel tank explosion accident by proceeding with the final rule.

I. INTRODUCTION

I.A. ACCIDENT HISTORY

There have been 17 worldwide airplane fuel tank explosions since 1960. Of these 17 explosions, the following 3 involved the center wing fuel tank for which no ignition source could be determined:

1. 5/11/90; Philippines Airlines; a B-737-300 that was almost new exploded on the ground in Manila; 8 fatalities, 30 injuries, and 82 escaped unharmed;
2. 7/16/96; TWA Flight 800, a B-747-100 that was 25 years old exploded in flight over the Atlantic Ocean; 230 fatalities with no survivors;
3. 3/3/01; Thai airlines; a B-737 that was 10 years old exploded on the ground in Bangkok; 1 fatality (a flight attendant) and no injuries because boarding had not begun.[1]

I.B. SOURCE OF PROBLEM

I.B.1. Introduction

The 3 factors (frequently referred to as the "Explosion Triangle") necessary to have a fuel tank explosion are: (1) an explosive substance; (2) sufficient oxygen; and (3) an ignition source.

I.B.2. Explosive Substance

Aviation fuel (Jet A) is kerosene, which is less volatile than gasoline but more volatile than diesel fuel.

I.B.3. Sufficient Oxygen

Aviation fuel vapor is explosive only when sufficient oxygen is present and under the appropriate combination of temperature and atmospheric pressure. For example, sea-level air is 19 percent oxygen and will support an explosion when the ambient

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[1] The National Transportation Safety Board (NTSB) has been cited as saying 346 people, not the 239 people reported in the preceding paragraph, have died from these explosions. These additional fatalities come from a May 11, 1990, in-flight Colombia Airlines airplane explosion. However, that explosion was the result of a bomb that ruptured the fuel tank, started a fire, and destroyed the airplane. Many believe that a fuel tank flammability protection system could not have prevented that fuel tank fire after the tank was ruptured by the initial explosion.

temperature is 100 degrees Fahrenheit. At 40,000 feet, aviation fuel is explosive at 45 degrees Fahrenheit if sufficient oxygen is present. In general, hotter fuel vaporizes more readily than colder fuel and produces a more explosive atmosphere. Finally, a completely full fuel tank cannot explode and an ignition source occurring beneath the fuel level cannot trigger an explosion.

I.B.4. Potential Ignition Sources

The 2 potential fuel tank ignition sources are electrical arcs and friction sparks. Most airplanes have insulated electric wire bundles running through their fuel tanks. However, this insulation can wear through after years of operation and maintenance resulting in an exposed wire that may not be visually discernable. Electrical arcing can then occur if the exposed wire contacts a metal surface. Submersible electrical fuel pumps can present the same problem. They are not an ignition source so long as they are fully submerged but, as fuel is consumed, their wiring can become exposed to air and be an ignition source. In addition, airplanes have electrical Fuel Quantity Indication Systems (FQIS) that may become ignition sources due to wire bundle insulation chafing.

Friction sparks can be caused by contact between rotating components (such as a steel fuel pump impeller) rubbing on the pump inlet check valve.

I.C. TYPES OF AIRPLANE FUEL TANKS

The two primary types of fuel tanks are center wing tanks (CWT) and wing tanks.

The CWT is the tank directly beneath the passenger compartment between the wings. In discussing the explosive potential of a CWT, the critical factor is whether the tank is a "heated" CWT (HCWT) or a "non-heated" CWT. A HCWT is one where the air conditioning units are located adjacent to the tank and the fuel tank system is not designed to offset the heat emitted by the air conditioning units and absorbed by the fuel tank. Most Boeing and Airbus airplanes have HCWTs. All other transport category airplanes have "non-heated" CWTs.

Wing tanks are the largest tanks and are located in both wings. Traditionally, these tanks have not posed a significant safety risk because they are exposed to the air and cool more rapidly than a center wing tank that is enclosed within the fuselage and is being heated by air conditioning exhaust.

I.D. POTENTIAL RISK OF A FUEL TANK EXPLOSION

Although there is some disagreement about the exact percentages, a HCWT is explosive an average of 12 to 30 percent of the time, a "non-heated" CWT is explosive 5 to 7 percent of the time, and a wing tank is explosive 3 to 5 percent of the time.

I.E. CHARACTERISTICS OF THE THREE FUEL TANK EXPLOSIONS

The common characteristics of the 3 explosions is that they occurred on Boeing HCWT airplanes that had been delayed on the ground on hot days with the air conditioning running for at least 40 minutes prior to the explosion. However, these airplanes were of substantially different ages, so that the explosion appears to be largely independent of the airplane's age.

I.F. FAA ACTIONS TO PREVENT FUEL TANK EXPLOSIONS

The two possible methods to prevent a fuel tank explosion are to prevent the ignition or to prevent an explosive atmosphere. The FAA developed Special Federal Aviation Rule 88 (SFAR 88) to prevent ignition from occurring. However, the SFAR 88 fuel tank safety inspections are continuing to find unexpected ignition sources. As a result, we have determined that the SFAR 88 engineering analysis by itself cannot predict every potential ignition source that may develop during the operational life of an airplane. This flammability reduction method (FRM) rule is designed to minimize the amount of time a fuel tank is in an explosive state so that if an ignition does occur, the fuel tank will not explode.

II. **INDUSTRY PROFILE**

II.A. BACKGROUND

As noted in the Introduction section, the only HCWTs[2] are found on Boeing and Airbus airplanes. All Boeing airplane models have HCWT with the exceptions of the B-717, B-727, a few B-767-200s, a few B-777s, and future B-787 models. All Airbus airplane models have HCWTs with the exception of a few A-319 and the A-330-300. In order to determine the impact of this rule on the aviation industry, we determined the current and future numbers of the affected Boeing and Airbus airplanes and their flight hours.

The following are the three aviation operations that use airplanes with HCWTs:

1. Air carrier passenger operations (Part 121 operators);
2. Air carrier cargo operations (Part 121 operators); and
3. General aviation operations (Part 91 operators).

II.B. FLEET FORECASTS

II.B.1. Time Frame of Analysis

We used a 10-year period of analysis (2008 through 2017) in order to allow the entire fleet sufficient time to comply with the final rule. We then extend the analysis period through 2042, which is the year that all of the fleet will be retired, to incorporate the lifetime costs and benefits.

We assume manufacturers will complete their FRM engineering assessments, obtain the amended Type Certificates (TCs), and begin production cut-in on January 1, 2009. This analysis, therefore, includes 9 years of production airplanes (2009-2017) that will have an installed FRM system. We also assume it will take two years for manufacturers to complete the assessments for their affected out-of-production airplane models. Finally, we assume that retrofitting kits will not be available until 2010, which is one year after the kits will be available for production airplanes.

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[2] The rule addresses "high flammability" tanks – not just HCWTs. Although there may be non-heated CWT airplanes that may be affected by the rule, for the purposes of this analysis, we focus solely on HCWT airplanes.

We realize that two years have passed since the Regulatory Evaluation was initially completed and that the projected dates may be a year later than used in this analysis. We did not update the entire analysis to reflect the likely one year delay when these dates will actually occur because the overall cost –benefit analysis would not be significantly changed.

Boeing and the ATA commented that the standard air carrier passenger airplane service life was 25 years. The FAA,[3] however, forecasts specific numbers of retired airplanes for each year through 2017, which we use for that time period. After 2017, we assign a 25-year life span for all passenger airplanes. No comments were made about the lifespan of air carrier cargo airplanes or Part 91 business jets and for the purposes of this analysis we determined that they have a lifespan of 25 years.

For production airplanes that will be manufactured between 2009 and 2017, we calculated the total flight hours for 2010 through 2042. For airplanes manufactured between 1992 and 2008, we calculated the total flight hours for 2009 through 2033, when all of these airplanes will be retired.

Finally, we determined that the average number of flight hours per airplane model will not change significantly over the time frame of this analysis. Thus, we use current average annual flight hours per airplane model for all future years.

II.C. AFFECTED AIRPLANE MODELS

The final rule affects the following U.S.-registered Airbus and Boeing airplane models operating under FAR parts 91, 121, 125, and 129:

1. B-737-100/200;
2. B-737-300/400/500 (referred to as the B-737 "Classic");
3. B-737-600/700/800/900 (referred to as the B-737 Next Generation ("NG"));
4. B-757;
5. B-747-100/200/300;
6. B-747-400;
7. B-747-800;

[3] U.S. Department of Transportation Federal Aviation Administration Aviation Policy and Plans, FAA Aerospace Forecast Fiscal Years 2007-2025.

8. B-767;[4]
9. B-777;[5]
10. B-787;[6]
11. A-300 (includes A-300 and A-300-600);
12. A-310;
13. A-318, A-319, A-320, and A-321 (referred to as A-320 "Family");
14. A-330-200;[7]
15. A-340;
16. A-350; and
17. A-380.

II.D. NUMBERS OF AIR CARRIER HCWT AIRPLANES[8]

II.D.1. Data Sources

We used two primary data sources. The first data source is the Jet Information Services (JTI) World Jet Inventory Year-End 2005 (WJI), which provides the basis for the total number of airplanes at the start of the time period. It supplies the total number of US airplanes on January 1, 2006, for all air carriers, non-air carrier operators, airplanes not currently flying but available for lease, and government-owned airplanes. We used their reported number of air carrier airplanes as the basis for our forecast.

The second data source is an ESG Aviation Services (ESG) forecast of the future numbers of airplanes. This source also reports an initial number of airplanes on January

[4] Boeing reported that 24 B-767s do not have center wing tanks and these 24 airplanes are not included in this analysis.
[5] Boeing reported that 12 B-777s do not have center wing tanks and these 12 airplanes are not included in this analysis.
[6] The B-787 is not included in the costs or benefits because it needs FRM to comply with its existing Part 25 certification requirements. Nevertheless, their data are included on the spreadsheets in the Appendix.
[7] Airbus stated in its comment that the A-330-300 does not have a HCWT, although the A-330-200 does.
[8] In order to minimize repetition, the terms "airplane" and "fleet" refer to only HCWT airplanes unless otherwise noted.

1, 2006, for all air carriers that file the Department of Transportation (DOT) Quarterly Form 41.[9] The ESG forecast is then based on this initial number of airplanes.[10]

II.D.2. Adjusted Numbers of Air Carrier Airplanes[11]

As shown in Table II-1, which summarizes Appendix II-1, ESG reported 3,448 air carrier airplanes at the start of 2006, which are 110 airplanes (3 percent) fewer than the 3,558 airplanes reported in the WJI data. For air carrier passenger airplanes, ESG reported 3,018 airplanes in 2007, which are 84 airplanes (3 percent) fewer than the 3,102 airplanes in the WJI data. For air carrier cargo airplanes, ESG reported 394 airplanes, which is 26 airplanes (7 percent) fewer than the 420 airplanes in the WJI data. In order to include all of the air carrier airplanes, we calculated the ratios between the ESG-reported airplanes and the WJI-reported airplanes for each model and applied those ratios to the ESG forecasts.

TABLE II-1

ESG AND WJI NUMBERS OF AIR CARRIER AIRPLANES
(JANUARY 1, 2006)

AIRPLANE OPERATION	ESG NUMBER	WJI NUMBER	WJI/ESG RATIO
ALL AIRPLANES	3,448	3,558	1.03
PASSENGER AIRPLANES	3,018	3,102	1.03
CARGO AIRPLANES	394	420	1.07

As shown in Table II-2, which summarizes Appendix II-2, we applied the adjusted ESG forecast for the years 2006, 2007, and 2008 to obtain the 2009 air carrier passenger fleet of 3,971 airplanes, of which 2,717 will be Boeing airplanes and 1,254 will be Airbus airplanes. Of these airplanes, 3,467 will be passenger airplanes, of which

9 Generally, all air carriers with about 5 airplanes are required to file a Form 41. Consequently, several very small air carriers do not file it because they are not required.

10 The ESG forecast is found in Appendix II-1. Note that the forecast for passenger airplanes must be calculated as a residual from the forecasts for all airplanes and for cargo airplanes.

11 In the Initial Regulatory Evaluation, we included airplanes that were available for lease but were not currently in active service in the total number of affected airplanes. Since then, we have determined that the airplane leasing industry has changed and that a large number of these airplanes available for lease are too old for economic use in the United States and, hence, not subject to the final rule. Therefore, these airplanes are not included in the number of airplanes affected by the final rule.

2,457 will be Boeing airplanes and 1,010 will be Airbus airplanes. Of the 504 cargo airplanes, 260 will be Boeing airplanes and 244 will be Airbus airplanes. Thus, even though we forecast the numbers of airplanes that will be manufactured in 2006, 2007, and 2008, for the purposes of this forecast they are considered to be 'existing' airplanes that will be built without FRM.

TABLE II-2

NUMBERS OF AIR CARRIER PASSENGER AND CARGO AIRPLANES
(JANUARY 1, 2009)

	TOTAL NUMBER OF AIR CARRIER AIRPLANES		
MODEL	**ALL AIRPLANES**	**PASSENGER AIRPLANES**	**CARGO AIRPLANES**
B-737-200	28	28	0
B-737-Classic	596	585	11
B-737-NG	847	847	0
B-747-100/200/300	92	13	79
B-747-400	73	51	22
B-747-800	0	0	0
B-757	615	539	76
B-767	336	225	71
B-777	130	130	0
B-787	0	0	0
A-300	174	0	174
A-310	70	0	70
A-320 Family	960	960	0
A-330	50	50	0
A-340	0	0	0
A-350	0	0	0
A-380	0	0	0
TOTAL	**3,971**	**3,467**	**504**
BOEING TOTAL	2,717	2,457	260
AIRBUS TOTAL	1,254	1,010	244

II.D.3. <u>Future Air Carrier Fleet</u>

As shown in Table II-3, which summarizes Appendix II-2, the total air carrier fleet will increase from 3,970 in 2009 to 5,555 (a gain of 1,585) airplanes by 2018. The air carrier passenger fleet will increase from 3,467 in 2009 to 4,851 airplanes (a gain of 1,384) and the air carrier cargo fleet will increase from 503 to 705 airplanes (a gain of

202). It needs to be emphasized that we forecast that Boeing will produce 398 passenger B-787s, but that these airplanes are not incorporated into the Tables because they will be required to have FRM even in the absence of this rule. After 2018, the fleet in this analysis begins to decline as airplanes are retired until there are no airplanes from the 2017 fleet remaining in air carrier service by 2043.

TABLE II-3

AIR CARRIER AIRPLANES BY TYPE OF ACTIVITY IN THIS ANALYSIS

	NUMBER OF AIR CARRIER AIRPLANES		
YEAR	TOTAL	PASSENGER	CARGO
2009	3,971	3,467	504
2010	4,180	3,654	525
2011	4,368	3,816	551
2012	4,526	3,949	577
2013	4,699	4,083	616
2014	4,857	4,202	655
2015	5,053	4,364	689
2016	5,322	4,600	721
2017	5,574	4,806	768
2018	5,555	4,851	705
2019	5,356	4,680	676
2020	5,156	4,509	647
2021	4,957	4,339	618
2022	4,757	4,168	589
2023	4,558	3,997	561
2024	4,358	3,826	532
2025	4,159	3,656	503
2026	3,959	3,485	474
2027	3,760	3,314	445
2028	3,560	3,144	416
2029	3,360	2,973	388
2030	3,161	2,802	359
2031	2,961	2,632	330
2032	2,762	2,461	301
2033	2,562	2,290	272
2034	2,559	2,290	268
2035	2,298	2,046	252
2036	2,066	1,847	219
2037	1,839	1,655	184
2038	1,605	1,450	155
2039	1,349	1,225	124
2040	1,026	934	92
2041	661	601	60
2042	342	312	30

II.D.4. Air Carrier Production Airplanes

II.D.4.a. Passenger Airplanes

As shown in Table II-4, which summarizes Appendix II-3, 2,290 air carrier production passenger airplanes will be built between 2009 and 2017[12], of which Boeing will produce 1,268 and Airbus will produce 1,022.

TABLE II-4

NUMBER OF AIR CARRIER PRODUCTION PASSENGER AIRPLANES BY MANUFACTURER

	NUMBER OF AIR CARRIER PRODUCTION PASSENGER AIRPLANES		
YEAR	TOTAL	BOEING	AIRBUS
2009	244	104	140
2010	199	90	109
2011	192	79	114
2012	205	107	98
2013	225	141	84
2014	291	175	116
2015	333	190	143
2016	289	194	95
2017	312	189	123
TOTAL	**2,290**	**1,268**	**1,022**

II.D.4.b. Cargo Airplanes

There are two distinct types of new air carrier cargo airplanes. The first type is new cargo airplanes manufactured by Airbus and Boeing specifically to be cargo airplanes ("production" cargo airplanes). The second type is former passenger airplanes converted into cargo airplanes ("conversion" cargo airplanes). Typically, conversion airplanes are relatively old (at least 15 to 20 years old) and are converted because the maintenance and operational costs make them uneconomical for passenger service.

The ESG forecast for new cargo airplanes does not distinguish between production and conversion cargo airplanes either by individual model or in the aggregate. Boeing forecasts that 25 percent of the new cargo fleet will be production cargo airplanes

[12] This excludes the B-787.

and 75 percent will be conversion cargo airplanes. We accordingly applied the Boeing forecast to forecast the numbers of future production and conversion cargo airplanes.

As shown in Table II-5, which summarizes Appendix II-3, there will be 352 new cargo airplanes of which 264 will be conversion airplanes (CON) and 88 will be production airplanes (PROD). Of the 88 production airplanes, we expect that 66 will be Boeing production airplanes and 22 will be Airbus production airplanes.

TABLE II-5

NUMBERS OF AIR CARRIER CONVERSION AND PRODUCTION CARGO AIPLANES BY MANUFACTURER AND BY YEAR

YEAR	ALL AIRPLANES			BOEING			AIRBUS		
	TOTAL	CON	PROD	TOTAL	CON	PROD	TOTAL	CON	PROD
2009	22	17	5	12	9	3	10	8	2
2010	41	30	11	30	22	8	11	8	3
2011	38	28	10	28	21	7	10	7	3
2012	40	30	10	28	21	7	12	9	3
2013	42	32	10	32	25	7	10	7	3
2014	37	28	9	32	24	8	5	4	1
2015	35	26	9	31	23	8	4	3	1
2016	47	35	12	34	25	9	13	10	3
2017	50	38	12	39	30	9	11	8	3
TOTAL	**352**	**264**	**88**	**266**	**200**	**66**	**86**	**64**	**22**

II.D.5. Potential Air Carrier Retrofitted Airplanes

II.D.5.1. Passenger Airplanes

Using a January 1, 2008, publication date, the rule does not require existing airplanes to be in compliance until January 1, 2018 (a 10-year compliance time period (2008-2017). We determined that no operator will retrofit an airplane if that airplane will be retired before January 1, 2018. Therefore, the fleet that will be retrofitted is the fleet manufactured before 2009 that is forecasted to be in service in 2018

The forecast does not include any potential impact of the final rule FRM requirement on accelerating airplane retirements. If some air carriers accelerate their airplane retirements rather than incur FRM retrofitting cost, then we have overestimated the number of retrofitted airplanes. However, we do not believe that the FRM retrofitting requirement will materially affect an airplane's retirement date.

As shown in Table II-6, which summarizes Appendix II-4, 2,732 air carrier passenger airplanes were manufactured before 2009 and will be retrofitted, of which 1,780 will be Boeing airplanes and 952 will be Airbus airplanes.

TABLE II-6

NUMBER OF AIR CARRIER RETROFITTED PASSENGER AIRPLANES

MODEL	NUMBER OF AIR CARRIER RETROFITTED PASSENGER AIRPLANES
B-737-200	0
B-737-Classic	112
B-737-NG	847
B-747-100/200/300	11
B-747-400	51
B-747-800	0
B-757	476
B-767	153
B-777	130
B-787	0
A-300	0
A-310	0
A-320 Family	902
A-330	50
A-340	0
A-350	0
A-380	0
TOTAL	**2,732**
BOEING TOTAL	1,780
AIRBUS TOTAL	952

II.D.5.2. Cargo Airplanes

Although the final rule does not require that cargo airplanes be retrofitted, in response to comments from the Airline Pilots Association (ALPA) and the Allied Pilots Association (APA), we evaluated the alternative of requiring FRM on existing cargo airplanes.

As shown in Table II-7, which summarizes Appendix II-4, if the final rule had included FRM on existing cargo airplanes, 401 air carrier cargo airplanes would have needed to be retrofitted, of which 231 would have been Boeing airplanes and 170 would have been Airbus airplanes.

TABLE II-7

NUMBER OF AIR CARRIER CARGO AIRPLANES THAT WOULD NEED TO BE RETROFITTED IF THE RULE APPLIED TO THEM

MODEL	NUMBER OF AIR CARRIER RETROFITTED CARGO AIRPLANES
B-737-200	0
B-737-Classic	6
B-737-NG	0
B-747-100/200/300	79
B-747-400	14
B-747-800	0
B-757	76
B-767	56
B-777	0
B-787	0
A-300	109
A-310	61
A-320 Family	0
A-330	0
A-340	0
A-350	0
A-380	0
TOTAL	**401**
BOEING TOTAL	231
AIRBUS TOTAL	170

II.E. NUMBERS OF PART 91 HCWT AIRPLANES

II.E1. Number of Current Airplanes

As shown in Table II-5, the WJI reports that in 2006, 53 U.S. private operator fleet contained 79 Boeing HCWT airplanes.[13] It does not report how many are passenger airplanes and how many are cargo airplanes, but the large majority are owned by corporations and used to ferry executives and other employees to various destinations. Consequently, we assume that they are all passenger airplanes.

[13] A list of the number of Part 91 airplanes by operator and by airplane model is provided in Appendix II-5.

TABLE II-8

NUMBERS OF PART 91 PASSENGER AIRPLANES[14]
(JANUARY 1, 2006)

MODEL	TOTAL NUMBER OF PART 91 AIRPLANES
B-737-200	18
B-737-Classic	7
B-737-NG	36
B-747-100/200/300	9
B-747-400	2
B-747-800	0
B-757	6
B-767	1
B-777	0
B-787	0
A-300	0
A-310	0
A-320 Family	0
A-330	0
A-340	0
A-350	0
A-380	0
GRAND TOTAL	**79**
BOEING TOTAL	79
AIRBUS TOTAL	0

II.E.2. Part 91 Airplane Production

The Transportation Research Board (TRB) Light Commercial and General Aviation Committee – Subcommittee on Business Aviation collects a general business aviation consensus forecast for large business jets[15] from the individual forecasts of 12 industry representatives. Their aggregated forecast projects that there will be 26 large production business jets per year for the next 10 years. This forecast does not disaggregate that number by individual production business jet model. Based on our

[14] Jet Information Services, Inc. World Jet Inventory Year-End 2005, Section 6 Table 2, pp. 138-143 and Section 2, Table 2, pp. 192-197, 2006.
[15] The specific models in Class X (the largest-sized business jet category and the only ones potentially affected by the final rule) are the Avcraft Corporate Shuttle (all), the Embraer Legacy Shuttle (all), Bombardier Challenger 800, Boeing 717 VIP, Airbus ACJ, Boeing BBJ, Boeing BBJ2 (B-737-800), and the Avcraft Envoy 3.

review of the TRB forecast,[16] we determined that 2 of these 26 airplanes will be new B-737-800s added to the Part 91 fleet from 2006 through 2017, for a total of 24 production Part 91 airplanes affected by the rule.

II.F. FLIGHT HOURS FOR AIR CARRIER AIRPLANES

II.F.1. Passenger Airplanes

II.F.1.a. Annual Passenger Airplane Model Flight Hours

In the IRE, we used average air carrier passenger airplane model annual flight hours data from Back Aviation Solutions, Inc. In its comments, Boeing reported the following air carrier passenger airplane annual flight hours, which we accepted and applied to their Airbus model counterparts. As shown in Table II-9, annual flight hours range from 3,000 hours for the older, smaller airplanes to 4,250 for the largest (but, not necessarily the newest (see the B-747-100/200/300) airplanes).

TABLE II-9

ANNUAL NUMBER OF FLIGHT HOURS BY AIR CARRIER PASSENGER AIRPLANE MODEL

MODEL	ANNUAL AIR CARRIER PASSENGER AIRPLANE FLIGHT HOURS
B-737-200	3,000
B-737-Classic	3,000
B-737-NG	3,250
B-747-100/200/300	3,000
B-747-400	4,000
B-747-800	4,250
B-757	4,250
B-767	4,250
B-777	4,000
B-787	4,000
A-300	4,000
A-310	4,000
A-320 Family	3,250
A-330	4,000
A-340	4,250
A-350	4,000
A-380	4,250

[16] The specific forecast is provided in Appendix II-6.

II.F.1.b. Total Passenger Airplane Flight Hours

In Table II-10, which summarizes the tables in Appendix II-7, we provide the projected numbers of flight hours for air carrier passenger airplanes by manufacturer and by whether the hours are flown by production airplanes (PRODUCT), retrofitted airplanes (RETRO), or by airplanes without FRM (NO FRM). The airplanes that fly without FRM are either airplanes that will be retired by 2017 or airplanes that will accumulate flight hours until they are retrofitted with FRM. In summary, the 2008-2017 air carrier passenger fleet will fly about 364 million hours between 2008 and 2042[17]. Of these 364 million flight hours, 199 million will be flown by production passenger airplanes, 104 million will be flown by retrofitted passenger airplanes, and 61 million will be flown by passenger airplanes without FRM.

TABLE II-10

ANNUAL FLIGHT HOURS FOR AIR CARRIER PASSENGER AIRPLANES
(2008-2017 for All Airplanes and 2018-2043 for the 2017 Fleet)
(in Millions of Hours)

		BOEING				AIRBUS			
YEAR	TOTAL	TOTAL	PRODUCT	RETROFIT	NO FRM	TOTAL	PRODUCT	RETROFIT	NO FRM
2008	10.9	7.8	0.0	0.0	7.8	3.1	0.0	0.0	3.1
2009	11.3	8.0	0.3	0.0	7.7	3.3	0.5	0.0	2.8
2010	11.9	8.1	0.6	0.6	6.9	3.8	0.8	0.3	2.7
2011	12.4	8.3	0.9	1.3	6.1	4.1	1.2	0.7	2.2
2012	12.9	8.4	1.3	1.9	5.2	4.5	1.5	1.0	2.0
2013	13.2	8.5	1.7	2.5	4.3	4.7	1.8	1.3	1.6
2014	13.7	8.6	2.3	3.1	3.2	5.1	2.2	1.7	1.2
2015	14.1	8.7	2.9	3.8	2.0	5.4	2.6	2.0	0.8
2016	14.9	9.1	3.5	4.8	0.8	5.8	3.0	2.6	0.2
2017	16.2	9.8	4.2	5.6	0.0	6.4	3.2	3.2	0.0
2018	16.2	9.7	4.2	5.5	0.0	6.5	3.4	2.9	0.0
2019	15.5	9.4	4.2	5.2	0.0	6.1	3.4	2.7	0.0
2020	14.8	9.0	4.2	4.8	0.0	5.8	3.4	2.5	0.0
2021	14.3	8.6	4.2	4.4	0.0	5.7	3.4	2.3	0.0
2022	13.8	8.3	4.2	4.1	0.0	5.5	3.4	2.2	0.0
2023	13.2	7.9	4.2	3.7	0.0	5.3	3.4	2.0	0.0
2024	12.6	7.5	4.2	3.3	0.0	5.1	3.4	1.8	0.0
2025	12.1	7.2	4.2	3.0	0.0	4.9	3.4	1.6	0.0
2026	11.6	6.8	4.2	2.6	0.0	4.8	3.4	1.4	0.0
2027	10.9	6.4	4.2	2.2	0.0	4.5	3.4	1.2	0.0
2028	10.3	6.0	4.2	1.8	0.0	4.3	3.4	1.0	0.0

[17] These flight hours exclude those 41.4 million that will be flown by the B-787.

2029	9.9	5.7	4.2	1.5	0.0	4.2	3.4	0.8	0.0
2030	9.2	5.3	4.2	1.1	0.0	3.9	3.4	0.6	0.0
2031	8.7	4.9	4.2	0.7	0.0	3.8	3.4	0.4	0.0
2032	8.2	4.6	4.2	0.4	0.0	3.6	3.4	0.2	0.0
2033	7.5	4.2	4.2	0.0	0.0	3.3	3.3	0.0	0.0
2034	7.5	4.2	4.2	0.0	0.0	3.3	3.3	0.0	0.0
2035	7.1	3.8	3.8	0.0	0.0	3.3	3.3	0.0	0.0
2036	6.4	3.5	3.5	0.0	0.0	2.9	2.9	0.0	0.0
2037	5.8	3.3	3.3	0.0	0.0	2.5	2.5	0.0	0.0
2038	5.1	2.9	2.9	0.0	0.0	2.2	2.2	0.0	0.0
2039	4.4	2.5	2.5	0.0	0.0	1.9	1.9	0.0	0.0
2040	3.5	1.9	1.9	0.0	0.0	1.6	1.6	0.0	0.0
2041	2.4	1.3	1.3	0.0	0.0	1.1	1.1	0.0	0.0
2042	1.3	0.6	0.6	0.0	0.0	0.7	0.7	0.0	0.0
TOTAL	**363.8**	**220.8**	**108.3**	**67.9**	**44.0**	**144.0**	**91.0**	**36.4**	**16.6**

II.F.2. Cargo Airplane Flight Hours

II.F.2.a. Annual Cargo Airplane Model Flight Hours

In the IRE, we used average air carrier cargo airplane model annual flight hours data from Back Aviation Solutions, Inc. In its comments, Boeing reported the following air carrier cargo airplane flight hours, which we accepted and applied to their Airbus model counterparts. As shown in Table II-11, annual flight hours range from 1,000 and 1,500 hours for the older, smaller airplanes to 4,250 for the largest airplanes.

TABLE II-11

ANNUAL NUMBER OF FLIGHT HOURS BY AIR CARRIER CARGO AIRPLANE MODEL

MODEL	**ANNUAL AIR CARRIER CARGO AIRPLANE FLIGHT HOURS**
B-737-200	1,500
B-737-Classic	1,500
B-737-NG	1,000
B-747-100/200/300	1,500
B-747-400	2,600
B-747-800	4,250
B-757	4,250
B-767	4,250
B-777	4,000
B-787	2,600
A-300	2,600
A-310	2,600
A-320 Family	1,000

A-330	4,000
A-340	4,250
A-350	2,600
A-380	1,500

II.F.2.b. Total Cargo HCWT Airplane Flight Hours

In Table II-12 we provide the projected numbers of flight hours for air carrier cargo airplanes by manufacturer and by whether the hours are flown by production cargo airplanes (PRODUCT), by conversion cargo airplanes (CONVER), and by existing airplanes (EXIST). The air carrier cargo fleet through 2017 will fly about 46 million hours between 2008 and 2042. Of these 49 million flight hours, 20.1 million will be flown by existing cargo airplanes, 21.2 million will be flown by conversion cargo airplanes, and 7.7 million will be flown by production cargo airplanes. Of the 7.7 million flight hours for production cargo airplanes, Boeing airplanes will fly 5.7 million and Airbus airplanes will fly 2 million.

TABLE II-12

ANNUAL NUMBER OF FLIGHT HOURS FOR AIR CARRIER CARGO AIRPLANES
(in Millions of Hours)

		BOEING				AIRBUS			
				NEW				NEW	
YEAR	TOTAL	TOTAL	EXIST	CONVERT	PRODUCT	TOTAL	EXIST	CONVERT	PRODUCT
2008	1.2	0.7	0.7	0.0	0.0	0.5	0.5	0.0	0.0
2009	1.4	0.7	0.7	0.1	0.0	0.7	0.7	0.0	0.0
2010	1.5	1.0	0.7	0.2	0.1	0.7	0.6	0.0	0.0
2011	1.5	1.0	0.7	0.3	0.1	0.7	0.6	0.1	0.0
2012	1.6	1.1	0.6	0.3	0.1	0.7	0.6	0.1	0.0
2013	1.7	1.2	0.6	0.4	0.1	0.7	0.6	0.1	0.0
2014	1.8	1.3	0.6	0.5	0.2	0.7	0.5	0.1	0.0
2015	1.9	1.4	0.6	0.6	0.2	0.7	0.5	0.1	0.0
2016	2.0	1.5	0.6	0.7	0.2	0.7	0.5	0.1	0.0
2017	2.1	1.7	0.6	0.8	0.3	0.7	0.4	0.2	0.1
2018	2.3	1.7	0.6	0.8	0.3	0.6	0.4	0.2	0.1
2019	2.0	1.4	0.6	0.6	0.2	0.6	0.4	0.2	0.1
2020	1.9	1.3	0.5	0.6	0.2	0.6	0.4	0.2	0.1
2021	1.8	1.3	0.5	0.6	0.2	0.6	0.3	0.2	0.1
2022	1.7	1.2	0.5	0.6	0.2	0.5	0.3	0.2	0.1
2023	1.7	1.2	0.4	0.6	0.2	0.5	0.3	0.2	0.1
2024	1.6	1.1	0.4	0.6	0.2	0.5	0.2	0.2	0.1
2025	1.5	1.1	0.3	0.6	0.2	0.4	0.2	0.2	0.1

2026	1.4	1.0	0.3	0.6	0.2	0.4	0.2	0.2	0.1
2027	1.4	1.0	0.2	0.5	0.2	0.4	0.2	0.2	0.1
2028	1.3	0.9	0.2	0.5	0.2	0.4	0.1	0.2	0.1
2029	1.2	0.9	0.2	0.5	0.2	0.3	0.1	0.2	0.1
2030	1.1	0.8	0.1	0.5	0.2	0.3	0.1	0.2	0.1
2031	1.1	0.8	0.1	0.5	0.2	0.3	0.1	0.2	0.1
2032	1.0	0.7	0.0	0.5	0.2	0.3	0.0	0.2	0.1
2033	0.9	0.7	0.0	0.5	0.2	0.2	0.0	0.2	0.1
2034	0.9	0.7	0.0	0.5	0.2	0.2	0.0	0.2	0.1
2035	0.9	0.7	0.0	0.5	0.2	0.2	0.0	0.2	0.1
2036	0.9	0.7	0.0	0.5	0.2	0.2	0.0	0.2	0.1
2037	0.7	0.6	0.0	0.4	0.1	0.2	0.0	0.1	0.0
2038	0.6	0.5	0.0	0.4	0.1	0.2	0.0	0.1	0.0
2039	0.5	0.4	0.0	0.3	0.1	0.1	0.0	0.1	0.0
2040	0.4	0.3	0.0	0.2	0.1	0.1	0.0	0.1	0.0
2041	0.3	0.2	0.0	0.2	0.1	0.1	0.0	0.1	0.0
2042	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
TOTAL	**49.0**	**33.0**	**11.3**	**16.1**	**5.7**	**15.0**	**8.8**	**5.1**	**2.0**

II.G. FLIGHT HOURS FOR PART 91 AIRPLANES

A GRA, Inc. study reports that the average general aviation turbofan airplane weighing more than 60,000 pounds flies about 350 hours a year,[18] which we use in this Regulatory Evaluation. As shown in Table II-13 Part 91 airplanes will fly 763,000 flight hours, of which 163,800 will be flown by production airplanes and 599,900 will be flown by existing airplanes. There will be 451,950 hours flown by part 91 airplanes with FRM and 211,750 hours flown by Part 91 airplanes without FRM.

TABLE II-13

ANNUAL NUMBER OF FLIGHT HOURS FOR PART 91 AIRPLANES
(2008-2017 for All Airplanes and 2018-2042 for the 2017 Fleet)

	NUMBER OF FLIGHT HOURS				
		EXISTING			PRODUCTION
YEAR	TOTAL	TOTAL	NO FTI	RETROFIT	
2008	33,250	33,250	33,250	0	0
2009	33,250	32,550	32,550	0	700
2010	33,250	31,850	30,100	1,750	1,400

[18] GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report, Table 3-10, p. 3-14, December 31, 2004.

2011	33,250	31,150	27,300	3,850	2,100
2012	33,250	30,450	23,800	6,650	2,800
2013	33,250	29,750	20,300	9,450	3,500
2014	33,250	29,050	16,800	12,250	4,200
2015	33,250	28,350	12,950	15,400	4,900
2016	33,250	27,650	9,100	18,550	5,600
2017	33,250	26,950	4,900	22,050	6,300
2018	33,250	26,950	700	26,250	6,300
2019	31,850	25,550	0	25,550	6,300
2020	31,150	24,850	0	24,850	6,300
2021	30,450	24,150	0	24,150	6,300
2022	29,750	23,450	0	23,450	6,300
2023	28,350	22,050	0	22,050	6,300
2024	26,250	19,950	0	19,950	6,300
2025	24,150	17,850	0	17,850	6,300
2026	22,050	15,750	0	15,750	6,300
2027	20,300	14,000	0	14,000	6,300
2028	19,250	12,950	0	12,950	6,300
2029	18,200	11,900	0	11,900	6,300
2030	16,800	10,500	0	10,500	6,300
2031	15,750	9,450	0	9,450	6,300
2032	14,700	8,400	0	8,400	6,300
2033	13,650	7,350	0	7,350	6,300
2034	12,600	6,300	0	6,300	6,300
2035	10,850	5,250	0	5,250	5,600
2036	9,100	4,200	0	4,200	4,900
2037	7,000	2,800	0	2,800	4,200
2038	5,250	1,750	0	1,750	3,500
2039	4,200	1,400	0	1,400	2,800
2040	3,150	1,050	0	1,050	2,100
2041	2,100	700	0	700	1,400
2042	1,050	350	0	350	700
TOTAL	**763,700**	**599,900**	**211,750**	**388,150**	**163,800**

III. COSTS AND BENEFITS OVERVIEW

III.A. INTRODUCTION

This section provides an overview of the costs and benefits that will be developed in Sections IV, V, and VI. The purpose of this rule is to prevent fuel tank ignitions like the two that have happened outside the United States and the 1996 TWA 800 explosion. The industry has not made the investment to eliminate this threat because these accidents infrequently occur. In this Regulatory Evaluation, unlike in the IRE, we provide aviation demand losses subsequent to a TWA 800-like explosion. Further we use $5.5 million for the value of an averted fatality, instead of $3 million. In the IRE we had assumed that Boeing would voluntarily install FRM systems and that the air carriers purchasing Boeing airplanes would use them. Thus, we excluded Boeing production airplanes from the NPRM cost and benefit analyses. We have since learned that Boeing does not intend to voluntarily install FRM in its production airplanes with the exception of the B-787. Consequently, with the exception of the B-787, we now include Boeing production airplanes in the final rule cost and benefits estimates. In addition, the projected fuel tank inerting (FTI) equipment costs and aviation fuel costs have increased. The net effect of these changes is higher benefits and costs estimates.

III.B. NUMBER OF POTENTIAL FUEL TANK EXPLOSIONS

We estimate the risk of a fuel tank explosion as one explosion every 100 million HCWT airplane flight hours. Of this risk, we expect 80 percent of the explosions will occur in flight and 20 percent of the explosions will occur on the ground. If there were no SFAR 88 or FRM final rule, 3.64 air carrier passenger airplane and 0.035 air carrier cargo airplane fuel tank explosions would occur to the 2008-2017 fleet affected by this final rule. With an SFAR 88 effectiveness rate of 50 percent, 1.82 accidents could be prevented by the final rule. However, airplanes flying without FRM before the airplanes are retired or before the airplanes are retrofitted with FRM will accumulate 61 million flight hours. Thus, the final rule is expected to prevent 1.52 air carrier passenger airplane explosions with 0.30 of these explosions are expected to occur to air carrier passenger airplanes flying without FRM. For air carrier production cargo airplanes, the final rule is expected to prevent 0.0075 accidents.

III.C. MARKET FAILURE

United States scheduled airplane operators have very low accident rates and understandably have not indicated a willingness to incur substantial retrofit and operating costs to avoid a rare accident. The cost-benefit decision criterion for an individual firm differs from that for society. An individual firm bears a full share of the equipage and operational costs and will never know if its investment avoided a catastrophic accident. The American public expects air travel to be safe and fully expects that the necessary investment has been made to keep travel safe. Under these circumstances, firms see substantial costs with certainty and accurately realize little probability of benefits. For the society the accident risk is small, but with potentially catastrophic outcomes.

III.D. FINAL RULE BENEFITS AND COSTS

The baseline analysis of the final rule quantified benefits and costs uses the values of $5.5 million for a prevented fatality, a 7 percent discount rate, and an SFAR 88 effectiveness rate of 50 percent.

As shown in Table III-1, the rule’s total quantified benefits have a present value of $657 million, $271 million is attributable to air carrier retrofitted passenger airplanes and $386 million is attributable to air carrier production passenger airplanes. The rule’s present value of the total cost is $1.012 billion, of which $975 million will be incurred by air carrier passenger airplane operators and $37 million will be incurred by air carrier cargo operators. Of the $975 million incurred by air carrier passenger airplane operators, $438 million will be incurred by operators of air carrier retrofitted passenger airplanes and $537 million will be incurred by operators of air carrier production passenger airplanes.

The overall benefit-cost ratio for the final rule is 65 percent. For air carrier passenger airplanes it is 0.67. It is 0.62 for air carrier retrofitted passenger airplanes and 0.72 for air carrier production airplanes. The cost-benefit ratio is lower for retrofitted airplanes because it is more expensive to retrofit FTI on an airplane than it is to install it on a production airplane. Further, all production airplanes will fly 25 years whereas retrofitted airplanes will fly less than 25 years after being retrofitted.

TABLE III-1

TOTAL PRESENT VALUE BENEFITS AND COSTS
(in Millions of 2007 Dollars)

		PRESENT VALUE (7%)		
TYPE OF OPERATION	NUMBER OF PREVENTED ACCIDENTS	BENEFITS	COSTS	BENEFIT/COST RATIO
AIR CARRIER PASSENGER				
RETROFITTED	0.52	$271	$ 438	0.62
PRODUCTION	1.00	$386	$ 537	0.72
TOTAL	**1.52**	**$657**	**$ 975**	**0.67**
AIR CARRIER CARGO	**0.03**	**<$0.1**	**$ 37**	**<0.01**
GRAND TOTAL	**1.55**	**$657**	**$1,012**	**0.65**

As shown in Table III-2, the prevented loss of aviation demand is $251 million and the direct benefits from the prevented deaths and property losses are $406 million. Thus, 38.2 percent from the resulting loss in overall demand for air travel, and 61.8 percent due to the direct loss of life and property from the prevented accidents.

TABLE III-2

PRESENT VALUE OF TOTAL BENEFITS BY SOURCE OF BENEFITS
(in Millions of 2007 Dollars)

	BENEFITS		
	TOTAL	DEMAND	DIRECT
AIR CARRIER			
RETROFITTED	$271	$100	$171
PRODUCTION	$386	$151	$235
TOTAL	**$657**	**$251**	**$406**
PERCENT OF TOTAL		**38.2%**	**61.8%**

IV. BENEFITS

IV.A. INTRODUCTION

In this section we estimate the risk of an air carrier passenger airplane explosion and the statistically expected numbers of accidents. We establish the proportion of these accidents that occur in flight and on the ground. We project the statistically expected years of these accidents. We calculate the potential economic losses from such an accident and then quantify the total benefits of the final rule. We then estimate the final rule's potential benefits for air carrier cargo airplanes and Part 91 airplanes.

IV.B. SUMMARY OF THE ASSUMPTIONS TO QUANTIFY THE BENEFITS

IV.B.1. Number of Accidents

- Accident Rate: 1 in 100 million flight hours
- Total Number of Flight Hours: 364 Million

Includes all Boeing and Airbus production and existing airplanes except the B-787, B-717, B-727, certain B-767s, certain B-777, B-878, and the A-321-300.

- Number of Flight Hours By Airplanes with FRM: 303 Million
- Number of Flight Hours By Airplanes without FRM: 61 Million

  (Flown by airplanes before they are retired or before they are retrofitted)

- Number of Retrofitted Airplanes: 2,732

BOEING	1,780
AIRBUS	952

- Number of Production Airplanes: 2,290

BOEING	1,268
AIRBUS	1,022

- Number of Affected Airplanes: 5,022

BOEING	3,048
AIRBUS	1,974

- SFAR 88 Effectiveness Rate: 50%
- Percentage of In-Flight Accidents: 80%
- Percentage of On-the-Ground Accidents: 20%

Thus, as shown in the following table, we project that there will be 3.64 fuel tank explosions, of which SFAR 88 will prevent 1.82, the final rule will prevent 1.52, and 0.32 will not be prevented because SFAR 88 would not have protected the airplane and it will fly without FTI.

TABLE IV-1

NUMBER OF ACCIDENTS AFFECTED BY THE FINAL RULE

	NUMBER OF ACCIDENTS AFFECTED BY THE FINAL RULE				
CATEGORY	TOTAL	IN-FLIGHT	ON-THE-GROUND	AIRPLANES WITH FRM	AIRPLANES WITHOUT FRM
RETROFITTED	0.82	0.66	0.16	0.52	0.30
PRODUCTION	1.00	0.80	0.20	1.00	0.00
TOTAL	**1.82**	**1.46**	**0.36**	**1.52**	**0.30**

IV.B.2. Summary of Quantified Benefits

Overall Aviation Demand Decline Per Accident: $292 Million

Value of a Prevented Fatality: $5.5 Million

Direct Accident Benefits: $696 Million
(80 Percent of the Explosions Occur In-Flight; 20 Percent of the Explosions Occur On-the-Ground)

As shown in the Table IV-2, we calculate that there is a possible $845 million in potential present value benefits from the final rule of which $657 million (77.8 percent) will be realized from the final rule while $188 million (22.2 percent) will not be realized due to the number of hours flown by airplanes that will not have FRM. Of the realized benefits of $657 million, $250 million will be due to avoiding the losses due to the reduced demand for aviation demand (37.9 percent of the total realized benefits) and $407 million will be the direct benefits (62.1 percent of the total realized benefits).

TABLE IV-2

PRESENT VALUE USING A 7 PERCENT DISCOUNT RATE OF THE POTENTIAL BENEFITS BY SOURCE OF BENEFITS
(in Millions of 2007 Dollars)

	PRESENT VALUES OF POTENTIAL BENEFITS USING A 7 PERCENT DISCOUNT RATE ($ Millions)		
SOURCE OF BENEFITS	TOTAL	WITH FRM	NO FRM
DEMAND	$311	$250	$ 61
DIRECT	$536	$407	$127
TOTAL	**$845**	**$657**	**$188**
PERCENT OF TOTAL		**77.8%**	**22.2%**

As shown in Table IV-3, the following table, the present value of the benefits to retrofitted airplanes will be $271 million (41.2 percent of the total benefits) while the present value of the benefits to production airplanes will be $386 million (58.8 percent of the total benefits).

TABLE IV-3

PRESENT VALUE USING A 7 PERCENT DISCOUNT RATE OF THE TOTAL BENEFITS BY TYPE OF FTI INSTALLATION AND BY MANUFACTURER
(in Millions of 2007 Dollars)

MANUFACTURER	RETROFITTED	PRODUCTION	TOTAL
BOEING	$177	$208	$385
AIRBUS	$ 94	$178	$272
TOTAL	**$271**	**$386**	**$657**
PERCENT OF TOTAL	**41.2%**	**58.8%**	

IV.C. RISK ANALYSIS

IV.C.1. Model of the HCWT Accident Rate and SFAR 88 Effectiveness

This benefit analysis depends on the expected HCWT accident rate. The estimation problem begins with the fact that these accidents are rare events. In its evaluation of the risk of an HCWT explosion, the first Aviation Rulemaking Advisory Committee (ARAC 1) determined that the risk of an explosion was linearly related to the number of flight hours and that this rate was one fuel tank explosion every 60 million HCWT airplane flight hours. This rate was the rate we used in the NPRM.

However, complicating the problem of determining the risk rate, we have been issuing airworthiness directives (ADs) since 1994 addressing HCWT safety problems. In 2001, SFAR 88 became effective and more ADs were subsequently issued. To the extent these ADs and SFAR 88 have been effective, they have reduced the observed accident rate.

After publishing the NPRM the FAA asked Sandia National Laboratories to assess the evidence.[19] Their independent assessment validates that ADs have improved center wing tank safety and that SFAR 88 while effective does not guarantee there will be no future accidents. However, they did not provide a specific accident rate or SFAR 88 effectiveness rate, except to note that SFAR 88 was less than 90 percent effective.

In their comments on the NPRM, industry provided two different accident rates. Boeing commented that the accident rate is 1 in a 100 million flight hours. ATA and Airbus commented that the accident rate is 1 in a 150 million flight hours.

They also commented on the SFAR 88 effectiveness rate. The ATA suggested a 90 percent SFAR 88 effectiveness rate and Airbus suggested an 80 percent SFAR 88 effectiveness rate. They noted that SFAR 88 AD 2001-08-24 improved center wing tank safety for B-737s by a factor of 10. In their comments ATA and Airbus erroneously attributed this reported improvement to the entire fleet when the AD applied only to B-737s

Still the question remains: What is the HCWT accident rate given SFAR 88? We developed an interactive model of the accident rate and SFAR 88 effectiveness. The model provides reasoned range estimates of the future accident rate incorporating a sensitivity analysis around the accident rate and SFAR 88 effectiveness.

To create a model of HCWT accident rate and SFAR 88 effectiveness, the inputs must relate measures of risk and mitigation. The commonly accepted measure of HCWT risk is the number of accidents per cumulative flight hours. We have mitigated the risk of HCWT accidents by issuing ADs which have provided an accumulated safety improvement. Even though SFAR 88 was codified in 2001, we include ADs issued prior

[19] Sandia National Laboratories. Sandia Report: Assessment of Preventing Ignition Sources with SFAR 88 Airworthiness Directives. November, 2005.

to 2001 that were designed to reduce HCWT accidents. AD 99-11-05 was the first such AD issued in 1994 for the B-767. As the model results depend on the number and the effectiveness of the ADs, we begin by discussing the ADs as an input.

Very simply, we accumulate ADs on at-risk airplanes from 1994 through 2006. Under the assumption operators do not want to incur the liability of not addressing a safety risk, we assume all (worldwide) affected airplanes will comply with the AD requirement. An AD in effect on an airplane for one year is referred to as an AD "application". Total AD applications increase with the number of ADs and with the number of airplanes. From 1994 through 2006, 58 ADs have been issued, 10 of which are excluded because their compliance dates have not been reached.

Table IV-4 displays the method to calculate SFAR 88 AD applications. Lines 1 and 2 show the number of ADs issued and those effective by compliance year. Lines 3, 4, and 5 contain a count of ADs multiplied by the number of applicable airplanes. As a reference, the total Airbus and Boeing HCWT at-risk airplanes are listed on lines 6 and 7. By 2006 there are 2.71 ADs per Airbus HCWT airplane, and 5.32 ADs per Boeing HCWT airplane. Just the count of AD applications by Airbus and Boeing airplanes indicates a risk of HCWT accidents exists. Furthermore the cumulative number of ADs has increased every year since SFAR 88 was codified providing evidence new safety risks are being addressed every year. In this vein, SFAR 88 effectiveness must be measured at a point in time. The measure used here is based on the percentage of total 2006 AD applications. Line 12 shows the proportion of applications per airplane relative to the total number in 2006.

Table IV-4.

Cumulative Effect of HCWT ADs: 1994-2006

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
1. No. of ADs (Effective Year)	1			3	8	6	5	8	4	1	6	8	8	58
2. No. of ADs (Compliance Yr)	1			2	7	3	9	2	7	4	3	6	4	48
3. No. of Airbus HCWT AD Applications							203	262	1184	1927	3706	5276	11653	

4. No. of Boeing HCWT AD Applications	279	591	633	1980	5789	11734	16476	24008	28085	34920	37394	38114	42725
5. Total HCWT AD Applications	279	591	633	1980	5789	11734	16679	24270	29269	36847	41100	43389	54378
6. World Total Airbus HCWT APs	1168	1293	1407	1570	1755	2048	2365	2555	2871	3125	3518	3882	4300
7. World Total Boeing HCWT APs	4688	4897	5102	5381	5763	6211	6627	6717	7018	7215	7494	7663	8031
8. World Total HCWT Fleet APs	5856	6190	6509	6951	7518	8259	8992	9272	9889	10340	11012	11545	12331
9. Airbus AD Applications/Airplane (Line 3/ line 6)							0.09	0.10	0.41	0.62	1.05	1.36	2.71
10. Boeing AD APPS/Airplane (Line 4/Line 7)	0.06	0.12	0.12	0.37	1.00	1.89	2.49	3.57	4.00	4.84	4.99	4.97	5.32
11. HCWT Fleet AD Applications/Airplane (Line5/Line8)	0.05	0.10	0.10	0.28	0.77	1.42	1.85	2.62	2.96	3.56	3.73	3.76	4.41
12. HCWT Fleet AD Apps/AP as proportion of 2006 Apps/AP	**0.011**	**0.022**	**0.022**	**0.065**	**0.175**	**0.322**	**0.421**	**0.594**	**0.671**	**0.808**	**0.846**	**0.852**	**1.00**

Source: Numbers of airplanes are from Back Aviation, Inc., Fleet i-NET database, March 5, 2007.

With the historical accident rate, the proportion of 2006 SFAR 88 AD applications completed, and a 2006 SFAR 88 effectiveness rate, the future HCWT accident rate can be predicted. We need to either constrain the expected number of accidents to the historical number of 3, which generates an estimate of the pre-SFAR 88 accident rate, or use an unconstrained estimate of the pre-SFAR 88 accident rate. The future accident rate then incorporates the assigned SFAR 88 effectiveness and the past accident rate experience. Table IV-5 presents the results for an SFAR 88 effectiveness rate of 50 percent and 3 accidents by the end of 2006. Under these conditions the pre-SFAR 88 accident rate is 0.0081 or 1 in approximately 125 million flight hours and the post-SFAR

88 rate is .00405 or 1 in approximately 250 million flight hours. As the model constrains the outcome to 3 accidents at the end of the analysis period, this outcome is our lower bound estimate of the accident rate. We should note, however, that this lower bound (and our other accident rate estimates) are overestimated to some extent because we have not taken into account the effect of the 10 ADs whose compliance dates have not yet been reached.

Table IV-5

SFAR 88 Accident Rates and 2006 SFAR 88 Effectiveness

	Accident rate per million flight hours	0.0081	1 accident in 125 million flight hours		2006 SFAR 88 effectiveness →	0.50	
Year	World HCWT Flt Hours (1)	Cumulative World HCWT Flt Hours (2)	Proportion of 2006 SFAR88 Completed (3)	SFAR 88 Effectiveness (3)*0.50 (4)	Post-SFAR 88 Acc. Rate [(C1)*(1 - SFAR88 Eff.)] (5)	□ = Expected no. of Accident s (6)	Cumulative Expected no. of Accidents (7)
1968	0.2	0.2	0.0	0.000	.0081	0.001	0.001
1969	0.8	1.0	0.0	0.000	.0081	0.007	0.008
1970	1.0	2.0	0.0	0.000	.0081	0.008	0.016
1971	1.3	3.3	0.0	0.000	.0081	0.011	0.027
1972	1.5	4.8	0.0	0.000	.0081	0.013	0.039
1973	1.8	6.6	0.0	0.000	.0081	0.014	0.054
1974	1.9	8.5	0.0	0.000	.0081	0.015	0.069
1975	2.1	10.6	0.0	0.000	.0081	0.017	0.086
1976	2.3	12.9	0.0	0.000	.0081	0.019	0.105
1977	2.5	15.4	0.0	0.000	.0081	0.020	0.125
1978	2.8	18.2	0.0	0.000	.0081	0.022	0.147
1979	3.1	21.2	0.0	0.000	.0081	0.025	0.172
1980	3.6	24.8	0.0	0.000	.0081	0.029	0.201
1981	3.8	28.6	0.0	0.000	.0081	0.031	0.232
1982	4.2	32.9	0.0	0.000	.0081	0.034	0.266
1983	4.6	37.5	0.0	0.000	.0081	0.037	0.304
1984	5.2	42.7	0.0	0.000	.0081	0.043	0.346
1985	5.8	48.5	0.0	0.000	.0081	0.047	0.393
1986	6.6	55.1	0.0	0.000	.0081	0.054	0.446
1987	7.4	62.5	0.0	0.000	.0081	0.060	0.506
1988	8.0	70.5	0.0	0.000	.0081	0.065	0.571
1989	8.5	79.0	0.0	0.000	.0081	0.069	0.640
1990	10.2	89.2	0.0	0.000	.0081	0.083	0.723
1991	11.3	100.5	0.0	0.000	.0081	0.092	0.814
1992	13.2	113.7	0.0	0.000	.0081	0.107	0.921

1993	14.4	128.2	0.0	0.000	.0081	0.117	1.038
1994	15.8	144.0	0.011	0.005	0.00806	0.127	1.165
1995	17.2	161.2	0.022	0.011	0.00801	0.138	1.303
1996	18.7	179.9	0.022	0.011	0.00801	0.150	1.454
1997	21.3	201.3	0.065	0.032	0.00784	0.167	1.621
1998	22.9	224.1	0.175	0.087	0.00739	0.169	1.790
1999	24.9	249.1	0.322	0.161	0.00680	0.169	1.959
2000	27.1	276.2	0.421	0.210	0.00640	0.174	2.133
2001	27.2	303.4	0.594	0.297	0.00570	0.155	2.288
2002	26.6	330.0	0.671	0.336	0.00538	0.143	2.431
2003	29.0	359.0	0.808	0.404	0.00483	0.140	2.571
2004	32.8	391.7	0.846	0.423	0.00467	0.153	2.724
2005	31.5	423.2	0.852	0.426	0.00465	0.146	2.870
2006	31.5	454.7	1.000	0.500	0.00405	0.128	2.998
					Total	2.998	

Sources: 1. Flight hours for 1968-2004 from a dataset created by Ivor Thomas for the FAA, Transport AP Directorate, Transport Standards Staff, Safety Management Branch.
2. Cumulative Flight hours for 2006 from Back Aviation, Inc., Fleet i-NET database, March 5, 2007.
3. Flight hours for 2005 estimated by average of flight hours for 2004 and 2006.
4. "Proportion of 2006 SFAR 88 completed" from IV-A, row 12.

Setting a lower bound is an easier task than setting an upper bound. Even though we decided to use the actual historical rate as of 1996 given the rare-event nature of these accidents, the rate could be set higher. For the upper bound we use the pre-SFAR 88 accident rate of 1 accident per 90 million flight hours, the same rate as existed in 1996 when the TWA accident occurred. With this accident rate and 50 percent SFAR 88 effectiveness the modeled 3 accidents occur in the same years as the historical experience. The disturbing result is these model parameters predict another accident by 2006 (see Table IV-6). Because of the nature of rare events, these results are also consistent with statistical theory. In fact when we ran 1,000 Monte Carlo simulation trials, 3 accidents occurred 233 times in the historical period. For those 3-accident cases, two accidents happened in the same year 25 times. With flight hours accumulating quickly, the risk of such rare-event accidents now increases faster annually than in the past.

Table IV-6.

SFAR 88 Accident Rates and SFAR 88 Effectiveness

	Accident rate per million flight hours →	0.0111	1 Accident in 90 million flight hours		2006 SFAR 88 Effectiveness →	0.50	

Year	World HCWT Flt Hours (1)	Cumulative World HCWT Flt Hours (2)	Proportion of 2006 SFAR88 Completed (3)	SFAR 88 Effectiveness (3)*0.50 (4)	Post-SFAR 88 Acc. Rate [(C1)*(1 - SFAR88 Eff.)] (5)	□ = Expected no. of Accidents (6)	Cumulative Expected no. of Accidents (7)
1968	0.2	0.2	0.0	0.000	.0111	0.002	0.002
1969	0.8	1.0	0.0	0.000	.0111	0.009	0.011
1970	1.0	2.0	0.0	0.000	.0111	0.011	0.022
1971	1.3	3.3	0.0	0.000	.0111	0.014	0.037
1972	1.5	4.8	0.0	0.000	.0111	0.017	0.054
1973	1.8	6.6	0.0	0.000	.0111	0.020	0.073
1974	1.9	8.5	0.0	0.000	.0111	0.021	0.095
1975	2.1	10.6	0.0	0.000	.0111	0.023	0.118
1976	2.3	12.9	0.0	0.000	.0111	0.026	0.144
1977	2.5	15.4	0.0	0.000	.0111	0.027	0.171
1978	2.8	18.2	0.0	0.000	.0111	0.031	0.202
1979	3.1	21.2	0.0	0.000	.0111	0.034	0.236
1980	3.6	24.8	0.0	0.000	.0111	0.040	0.276
1981	3.8	28.6	0.0	0.000	.0111	0.043	0.318
1982	4.2	32.9	0.0	0.000	.0111	0.047	0.365
1983	4.6	37.5	0.0	0.000	.0111	0.051	0.416
1984	5.2	42.7	0.0	0.000	.0111	0.058	0.475
1985	5.8	48.5	0.0	0.000	.0111	0.064	0.539
1986	6.6	55.1	0.0	0.000	.0111	0.074	0.612
1987	7.4	62.5	0.0	0.000	.0111	0.082	0.694
1988	8.0	70.5	0.0	0.000	.0111	0.089	0.783
1989	8.5	79.0	0.0	0.000	.0111	0.095	0.878
1990	10.2	89.2	0.0	0.000	.0111	0.113	0.991
1991	11.3	100.5	0.0	0.000	.0111	0.126	1.117
1992	13.2	113.7	0.0	0.000	.0111	0.147	1.264
1993	14.4	128.2	0.0	0.000	.0111	0.160	1.424
1994	15.8	144.0	0.011	0.005	0.01105	0.175	1.599
1995	17.2	161.2	0.022	0.011	0.01099	0.189	1.788
1996	18.7	179.9	0.022	0.011	0.01099	0.206	1.994
1997	21.3	201.3	0.065	0.032	0.01075	0.229	2.223
1998	22.9	224.1	0.175	0.087	0.01014	0.232	2.455
1999	24.9	249.1	0.322	0.161	0.00932	0.232	2.688
2000	27.1	276.2	0.421	0.210	0.00877	0.238	2.926
2001	27.2	303.4	0.594	0.297	0.00781	0.212	3.138
2002	26.6	330.0	0.671	0.336	0.00738	0.197	3.335
2003	29.0	359.0	0.808	0.404	0.00662	0.192	3.526
2004	32.8	391.7	0.846	0.423	0.00641	0.210	3.737
2005	31.5	423.2	0.852	0.426	0.00638	0.201	3.937
2006	31.5	454.7	1.000	0.500	0.00556	0.175	4.112
					Total	4.112	

Finally, we ran the model under the null hypothesis of one accident in 100 million flight hours with a 50 percent SFAR 88 effectiveness rate. Table IV-7 presents these results. Again, under these conditions the model indicates an increased probability of another accident by the end of 2006. We find one accident per 100 million flight hours and a 50 percent SFAR 88 effectiveness rate to be reasonable, as it is consistent with statistical theory of rare events and falls between the modeled risk ranges. Thus we cannot reject this combination as the null hypothesis. As a result of accepting the 1 accident in a 100 million flight hours and with SFAR 88 being 50 percent effective, we expect this rule to prevent 1 accident in 200 million flight hours.

The alternative of 1 accident per 150 million flight hours is not consistent with SFAR 88 being effective. At this rate to obtain 3 accidents in the historical period we had to lower the SFAR 88 effectiveness rate from 50 percent to 1 percent. The reduction in accidents after 1996 and the Sandia report all point to an effectiveness rate substantially greater than 1 percent. Some may argue SFAR 88 is 100 percent effective. This extreme value is not consistent with the increasing number of ADs being written, nor consistent with the Sandia assessment.

Table IV-7.

One Accident in 100 Million Flight Hour Accident Rates and 50% SFAR 88 Effectiveness

	One Accident in 100 Million Flight Hours→	0.01		SFAR 88 Effectiveness at 50% →	0.50	
Year	World HCWT Flt hours (1)	Cumulative World HCWT Flt hours (2)	Proportion of 2006 SFAR88 completed (3)	Pre-SFAR 88 Acc. Rate (C3)*[1 - (3* SFAR88 Eff.)] (4)	λ = Expected no. of accidents (5)	Cumulative Expected no. of accidents (6)
1968	0.2	0.2	0.0	.0100	0.002	0.002
1969	0.8	1.0	0.0	.0100	0.008	0.010
1970	1.0	2.0	0.0	.0100	0.010	0.020
1971	1.3	3.3	0.0	.0100	0.013	0.033
1972	1.5	4.8	0.0	.0100	0.015	0.048
1973	1.8	6.6	0.0	.0100	0.018	0.066
1974	1.9	8.5	0.0	.0100	0.019	0.085
1975	2.1	10.6	0.0	.0100	0.021	0.106
1976	2.3	12.9	0.0	.0100	0.023	0.129
1977	2.5	15.4	0.0	.0100	0.025	0.154

1978	2.8	18.2	0.0	.0100	0.028	0.182
1979	3.1	21.2	0.0	.0100	0.031	0.212
1980	3.6	24.8	0.0	.0100	0.036	0.248
1981	3.8	28.6	0.0	.0100	0.038	0.286
1982	4.2	32.9	0.0	.0100	0.042	0.329
1983	4.6	37.5	0.0	.0100	0.046	0.375
1984	5.2	42.7	0.0	.0100	0.052	0.427
1985	5.8	48.5	0.0	.0100	0.058	0.485
1986	6.6	55.1	0.0	.0100	0.066	0.551
1987	7.4	62.5	0.0	.0100	0.074	0.625
1988	8.0	70.5	0.0	.0100	0.080	0.705
1989	8.5	79.0	0.0	.0100	0.085	0.790
1990	10.2	89.2	0.0	.0100	0.102	0.892
1991	11.3	100.5	0.0	.0100	0.113	1.005
1992	13.2	113.7	0.0	.0100	0.132	1.137
1993	14.4	128.2	0.0	.0100	0.144	1.282
1994	15.8	144.0	0.011	.0099	0.157	1.439
1995	17.2	161.2	0.022	.0099	0.170	1.609
1996	18.7	179.9	0.022	.0099	0.185	1.795
1997	21.3	201.3	0.065	.00968	0.206	2.001
1998	22.9	224.1	0.175	.00913	0.209	2.210
1999	24.9	249.1	0.322	.00839	0.209	2.419
2000	27.1	276.2	0.421	.00790	0.214	2.633
2001	27.2	303.4	0.594	.00703	0.191	2.824
2002	26.6	330.0	0.671	.00664	0.177	3.001
2003	29.0	359.0	0.808	.00596	0.173	3.174
2004	32.8	391.7	0.846	.00577	0.189	3.363
2005	31.5	423.2	0.852	.00574	0.181	3.544
2006	31.5	454.7	1.000	.00500	0.157	3.701
				Total	3.701	

These model results provide a reasonable expectation of the future HCWT accident rate. For the lower bound we set the model to a 50 percent SFAR 88 effectiveness rate and constrained the outcome to 3 accidents to occur by the end of the historical period, the resulting pre-SFAR 88 accident rate was 1 accident in 125 million flight hours. For the upper bound estimate we constrained the model by the historical accident rate of 1 accident per 90 million flight hours again with a 50 percent SFAR 88 effectiveness rate. Both of these results are consistent with the facts and consistent with statistical analysis. We accepted the accident rate of 1 accident per 100 million flight hours with a 50 percent effectiveness rate as it falls within the range of outcomes. Our modeling results indicate the future accident rate (including SFAR88 effectiveness) of 1 accident in 200 million flight hours provides a good measure of the expected risk.

Lastly we ran the null hypothesis of one accident in a 100 million flight hours with a 50 percent SFAR 88 effectiveness rate. Boeing recommended one accident in a 100 million flight hours. Table IV-7 presents these results. Again under these conditions the model predicts another accident could well have occurred. We find the Boeing recommendation of one accident per 100 million flight hours and a 50 percent SFAR 88 effectiveness rate to be reasonable and we cannot reject this combination as the null hypothesis. One accident in 100 million flight hours does not factor in SFAR 88 effectiveness. With SFAR 88 being 50 percent effective, we expect this rule to prevent 1 accident in 200 million flight hours.

These model results provide a reasonable expectation of the future HCWT accident rate. When we first constrained the model to a 50 percent SFAR 88 effectiveness rate and 3 accidents to occur in the historical period, the pre-SFAR 88 accident rate was 1 accident in 125 million flight hours. Next we constrained the model by the historical accident rate of 1 accident per 90 million flight hours and a 50 percent SFAR 88 effectiveness rate. Here the accidents occur in the same year as the historical period, but the model predicts an additional accident by 2006 even with an effectiveness rate of 80 percent. Lastly we applied the Boeing recommended accident rate of 1 accident per 100 million flight hours and with a 50 percent effectiveness rate, the model estimates 3.7 total accidents by 2006. All of these results are internally consistent and consistent with statistical analysis. Further, the evidence from the Sandia Report and the continuing increase in SFAR 88-related ADs strongly suggests SFAR 88 is nowhere near 100 percent effective. Most disturbing was that using the rate of 1 accident in 90 million flight hours, results in a predicted accident by 2006 across a high range of SFAR 88 effectiveness. Our modeling results indicate the future (post-SFAR 88) accident rate of 1 accident in 200 million flight hours reasonably models the expected risk.

IV.C.2. Airplane Operational Cycle When an Explosion Will Occur

Two of the three fuel tank explosions occurred when the airplane was on the ground, resulting in relatively few fatalities (8 in one accident and 1 in the other) while one occurred in-flight. In the IRE, our engineering analysis indicated that (regardless of the actual events up to that point) there was a 92 percent probability that an explosion would occur in-flight and an 8 percent probability that it would occur on the ground.

Since then, manufacturers have completed additional engineering assessments of fuel tank flammability and we have re-analyzed their data. The ATA and Airbus commented that the probability of an in-flight explosion and an on-the-ground explosion is the simple extrapolation of the three events; that is, there is a 33.33 percent probability of an in-flight explosion and a 66.67 percent probability of an on-the-ground explosion. Boeing commented that its engineering analysis indicated an 80 percent probability of an in-flight explosion and a 20 percent probability of an on-the-ground explosion.

We believe that the appropriate method to evaluate the future risk is through an engineering analysis rather than on observations of an infrequently occurring event. As a result, we agree with the Boeing analysis and disagree with the ATA and Airbus analyses, we have revised our risk analysis so that there is an 80 percent probability that an explosion will occur in flight and a 20 percent probability that it will occur on the ground.

IV.C.3. Airplane Models At Risk

As all 3 explosions have occurred on Boeing airplanes, Airbus commented that the final rule should not include their airplanes because their fuel tanks differ from Boeing fuel tanks and different risk evaluations need to be made for each manufacturer. However, both ARAC working groups concluded that the fuel tank architectures for HCWT Boeing and Airbus airplanes are sufficiently similar that the risks for these airplanes are comparable. Further, Boeing HCWT airplanes have logged 7 to 8 times more cumulative flight hours than have Airbus airplanes, which indicates that if both models had the same probability of an explosion, there is a 7 to 8 times greater likelihood that it would have happened to a Boeing airplane.[20] In addition, we continue to issue ADs to Airbus airplanes as a result of SFAR 88 and fuel tank inspections.

IV.D. NUMBER OF AIR CARRIER PASSENGER AIRPLANE EXPLOSIONS

IV.D.1. Air Carrier Passenger Airplane Flight Hours

The previous section described how the forecasted number of airplane explosions depends on the number of flight hours. As shown in Tables IV-8 and IV-9, the affected

[20] For example, at the time of the first explosion in 1990, Boeing HCWT airplanes had logged about 25 times the cumulative number of flight hours than Airbus airplanes had logged.

air carrier passenger fleet will fly 364 million hours during the time period (2008 – 2042) of this analysis. Of these 364 million flight hours, 104 million will be flown by retrofitted passenger airplanes (68 million by Boeing airplanes and 36 million by Airbus airplanes), 199 million will be flown by production passenger airplanes, (108 million by Boeing airplanes and 91 million by Airbus airplanes), and 61 million will be flown by passenger airplanes that will not have FRM (44 million by Boeing airplanes and 17 by Airbus airplanes). Thus, 83.2 percent of the 364 million flight hours (303 million) will be flown by airplanes with FRM and 16.8 percent (61 million) will be flown by airplanes without FRM.[21] Further, of the 303 million flight hours by airplanes with FRM, 34.1 percent (104 million) will be flown by retrofitted airplanes and 65.9 percent (199 million) will be flown by production airplanes.

TABLE IV-8

ANNUAL NUMBER OF FLIGHT HOURS FOR AIR CARRIER PRODUCTION AND RETROFITTED PASSENGER AIRPLANES
(in Millions of Hours)

		BOEING				AIRBUS			
YEAR	TOTAL	TOTAL	PRODUCT	RETROFIT	NO FRM	TOTAL	PRODUCT	RETROFIT	NO FRM
2008	10.9	7.8	0.0	0.0	7.8	3.1	0.0	0.0	3.1
2009	11.3	8.0	0.3	0.0	7.7	3.3	0.5	0.0	2.8
2010	11.9	8.1	0.6	0.6	6.9	3.8	0.8	0.3	2.7
2011	12.4	8.3	0.9	1.3	6.1	4.1	1.2	0.7	2.2
2012	12.9	8.4	1.3	1.9	5.2	4.5	1.5	1.0	2.0
2013	13.2	8.5	1.7	2.5	4.3	4.7	1.8	1.3	1.6
2014	13.7	8.6	2.3	3.1	3.2	5.1	2.2	1.7	1.2
2015	14.1	8.7	2.9	3.8	2.0	5.4	2.6	2.0	0.8
2016	14.9	9.1	3.5	4.8	0.8	5.8	3.0	2.6	0.2
2017	16.2	9.8	4.2	5.6	0.0	6.4	3.2	3.2	0.0
2018	16.2	9.7	4.2	5.5	0.0	6.5	3.4	2.9	0.0
2019	15.5	9.4	4.2	5.2	0.0	6.1	3.4	2.7	0.0
2020	14.8	9.0	4.2	4.8	0.0	5.8	3.4	2.5	0.0
2021	14.3	8.6	4.2	4.4	0.0	5.7	3.4	2.3	0.0
2022	13.8	8.3	4.2	4.1	0.0	5.5	3.4	2.2	0.0
2023	13.2	7.9	4.2	3.7	0.0	5.3	3.4	2.0	0.0
2024	12.6	7.5	4.2	3.3	0.0	5.1	3.4	1.8	0.0
2025	12.1	7.2	4.2	3.0	0.0	4.9	3.4	1.6	0.0
2026	11.6	6.8	4.2	2.6	0.0	4.8	3.4	1.4	0.0
2027	10.9	6.4	4.2	2.2	0.0	4.5	3.4	1.2	0.0
2028	10.3	6.0	4.2	1.8	0.0	4.3	3.4	1.0	0.0
2029	9.9	5.7	4.2	1.5	0.0	4.2	3.4	0.8	0.0
2030	9.2	5.3	4.2	1.1	0.0	3.9	3.4	0.6	0.0
2031	8.7	4.9	4.2	0.7	0.0	3.8	3.4	0.4	0.0

[21] If the 41 million B-787 flight hours are included, the percentage of flight hours flown by airplanes with FRM increases to 84.9 percent (344 million hours out of 405 million hours).

2032	8.2	4.6	4.2	0.4	0.0	3.6	3.4	0.2	0.0
2033	7.5	4.2	4.2	0.0	0.0	3.3	3.3	0.0	0.0
2034	7.5	4.2	4.2	0.0	0.0	3.3	3.3	0.0	0.0
2035	7.1	3.8	3.8	0.0	0.0	3.3	3.3	0.0	0.0
2036	6.4	3.5	3.5	0.0	0.0	2.9	2.9	0.0	0.0
2037	5.8	3.3	3.3	0.0	0.0	2.5	2.5	0.0	0.0
2038	5.1	2.9	2.9	0.0	0.0	2.2	2.2	0.0	0.0
2039	4.4	2.5	2.5	0.0	0.0	1.9	1.9	0.0	0.0
2040	3.5	1.9	1.9	0.0	0.0	1.6	1.6	0.0	0.0
2041	2.4	1.3	1.3	0.0	0.0	1.1	1.1	0.0	0.0
2042	1.3	0.6	0.6	0.0	0.0	0.7	0.7	0.0	0.0
TOTAL	**363.8**	**220.8**	**108.3**	**67.9**	**44.0**	**144.0**	**91.0**	**36.4**	**16.6**

Table IV-9 provides a summary of the flight hours by the various airplane categories.

TABLE IV-9

SUMMARY OF AIR CARRIER PASSENGER AIRPLANE FLIGHT HOURS
(in Millions of Flight Hours)

AIRPLANE CATEGORY	FLIGHT HOURS
TOTAL	**364**
PRODUCTION AIRPLANES	**199**
BOEING	108
AIRBUS	91
EXISTING AIRPLANES	**165**
RETROFITTED WITH FRM	104
NO FRM	61

IV.D.2. Projected Numbers of Air Carrier Passenger Airplane Explosions

We project that there will be 3.64 air carrier passenger airplane fuel tank explosions based on the one accident every 100 million flight hours rate and 364 million flight hours. If the final rule were effective on January 1, 2008, of these 3.64 potential explosions, 83.2 percent of them (3.03 accidents) would occur to airplanes with FRM, 16.8 percent (0.60 accidents) would occur to airplanes without FRM,[22] while 2.91 accidents will occur in-flight and 0.73 will occur on the ground. However, there is an SFAR 88 that will reduce the number of future air carrier explosions. In the IRE, we

[22] If the B-747 production passenger airplane flight hours were included, it would add 41 million flight hours that would generate 0.41 accidents.

estimated that SFAR 88 would prevent 50 percent (the SFAR 88 "effectiveness rate") of the fuel tank explosions, but also analyzed the potential impact if this effectiveness rate were 75 percent or 25 percent.

As previously discussed, we cannot reject the hypothesis that SFAR 88 and its associated and future Airworthiness Directives (ADs) have an effectiveness rate of 50 percent. Using a 50 percent SFAR 88 effectiveness rate, we calculated that SFAR 88 will prevent 1.82 air carrier passenger airplane explosions in the 2018 fleet while the remaining 1.82 accidents will be addressed by FRM. Of the 1.82 accidents addressed by the final rule, we expect it to prevent 1.51 but 0.31 may occur to airplanes flying without FRM and not be prevented by SFAR 88.[23] Based on the number of flight hours, of these 1.51 prevented air carrier passenger airplane explosions, 34.1 percent (0.51 accidents) will occur to retrofitted passenger airplanes and 65.9 percent (1 accident) will occur to production passenger airplanes.

However, as we did in the IRE, we performed a sensitivity analysis using SFAR 88 effectiveness rates of 75 percent and 25 percent.[24]

IV.D.3. Expected Years of an Air Carrier Passenger Airplane Explosion

In the IRE, we estimated the individual years when a potential accident is statistically expected to occur by assuming that each accident will occur when its cumulative probability of occurring equals 50 percent of the mean, which would be at 50 million flight hours. Although we received comments about the accident rate, we received no comments about our methodology of estimating the accident dates and we use the same methodology in this Regulatory Evaluation. Thus, the first statistical accident will occur at the 50 million flight hour point, the second accident will occur at the 150 million flight hour point, and the third accident will occur at the 250 million flight hour point. Finally, 0.64 of an accident will occur at the 332 million flight hour

[23] Although it flies in the face of common sense to talk of fractions of accidents (either an accident occurs or it doesn't), the difficulty in discussing statistical accidents of infrequent events is that using whole numbers can lead to significantly misleading results. Thus, it is appropriate to use fractions of statistical accidents for greater accuracy.

[24] This sensitivity analysis is provided in Appendix B.

point.[25] As shown in Table IV-10, a statistical accident is expected to occur in 2012, 2019, 2026, and 0.64 of an accident in 2035.[26] [27]

TABLE IV-10

ANNUAL NUMBER OF FLIGHT HOURS FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of Hours)

	TOTAL		WITH FRM		NO FRM	
YEAR	CUMULATIVE	ANNUAL	CUMULATIVE	ANNUAL	CUMULATIVE	ANNUAL
2008	10.9	10.9	0.0	0.0	10.9	10.9
2009	22.5	11.6	1.1	1.1	21.4	10.5
2010	34.8	12.3	3.8	2.7	31.0	9.6
2011	47.5	12.7	8.2	4.4	39.3	8.3
2012	60.7	13.2	14.2	6.0	46.5	7.2
2013	74.3	13.6	21.9	7.7	52.4	5.9
2014	88.3	14.0	31.5	9.6	56.8	4.4
2015	103.0	14.7	43.4	11.9	59.6	2.8
2016	118.5	15.5	57.9	14.5	60.6	1.0
2017	134.4	15.9	73.8	15.9	60.6	0.0
2018	150.2	15.8	89.6	15.8	60.6	0.0
2019	165.5	15.3	104.9	15.3	60.6	0.0
2020	180.2	14.7	119.6	14.7	60.6	0.0
2021	194.4	14.2	133.8	14.2	60.6	0.0
2022	208.1	13.7	147.5	13.7	60.6	0.0
2023	221.2	13.1	160.6	13.1	60.6	0.0
2024	233.7	12.5	173.1	12.5	60.6	0.0
2025	245.7	12.0	185.1	12.0	60.6	0.0
2026	257.1	11.4	196.5	11.4	60.6	0.0
2027	267.9	10.8	207.3	10.8	60.6	0.0
2028	278.1	10.2	217.5	10.2	60.6	0.0
2029	287.8	9.7	227.2	9.7	60.6	0.0
2030	296.9	9.1	236.3	9.1	60.6	0.0
2031	305.4	8.5	244.8	8.5	60.6	0.0
2032	313.4	8.0	252.8	8.0	60.6	0.0
2033	320.9	7.5	260.3	7.5	60.6	0.0
2034	328.4	7.5	267.8	7.5	60.6	0.0
2035	335.5	7.1	274.9	7.1	60.6	0.0
2036	341.9	6.4	281.3	6.4	60.6	0.0
2037	347.7	5.8	287.1	5.8	60.6	0.0

[25] As noted earlier, there is no such thing as 0.64 of an accident. However, there is some accident risk associated with the 64 million flight hours and this fraction is a means of mathematically representing that risk.
[26] The 32nd millionth flight hour (halfway point of the 63.8 million flight hours occurs in 2035.
[27] It needs to be remembered that this is not the total number of potential accidents to the U.S. air carrier HCWT passenger fleet because the flight hours from airplanes built after 2017 are not included in this benefits analysis.

2038	352.8	5.1	292.2	5.1	60.6	0.0
2039	357.2	4.4	296.6	4.4	60.6	0.0
2040	360.7	3.5	300.1	3.5	60.6	0.0
2041	363.1	2.4	302.5	2.4	60.6	0.0
2042	364.4	1.3	303.8	1.3	60.6	0.0
TOTAL	**364.4**			**303.8**		**60.6**

IV.E. ANCILLARY BENEFITS FROM PREVENTING AN IN-FLIGHT EXPLOSION

IV.E.1. Introduction

There are two possible adverse ancillary economic effects that could result from an in-flight explosion. The first possible ancillary effect would arise if a HCWT explosion, which is initially indistinguishable from a terrorist bomb explosion, is mistaken for a terrorist bomb explosion. As it will take investigatory time to determine whether the explosion was caused by a HCWT ignition or by a terrorist bomb, (particularly if a terrorist organization were to claim credit for the disaster) there could be economic losses if the aviation authorities or the airlines were to impose security or other measures in mistaken response to this threat.

A second ancillary effect is that a mid-air explosion, regardless of its cause, will have a negative effect on overall demand for air travel because it will frighten some people who will believe that airplane travel is too risky or unsafe.

IV.E.2. Economic Losses from Precautionary Response to a Potential Terrorist Attack

It is very speculative to predict whether the authorities and the airlines would interpret an in-flight explosion as a potential terrorist act that may be a harbinger of other terrorist acts. Thus, we did not include a quantitative estimate of the potential economic effect in the main text of this analysis.[28]

IV.E.3. Economic Losses from Perception that Air Travel is Unsafe (Demand Effect)

The fact that a passenger airplane exploded in mid-air will negatively affect the public perception of air travel safety. Measuring the economic impact of reduced air travel demand following previous catastrophic airplane accidents has proven to be

[28] We provide a example of a quantitative estimate of this effect in Appendix A.

difficult due to the other impacts of seasonal, political, weather, state of the economy, etc. on air travel demand.

Historically, not all airplane accidents have had the same impact on overall public perception. For example, the 2003 catastrophic crash of a 19-seat Beech 1900-D in North Carolina in which all on board died appeared to have little effect on overall air travel demand. However, international air travel declined by about 30 percent in the three months in the wake of the Pan American Lockerbie Scotland explosion.[29] In summary, there is no "average" public reaction to an "average" airplane accident because there is no "average" <u>catastrophic</u> airplane accident. Each such accident has a unique effect on the overall public perception of air travel safety.

Where would a HCWT in-flight catastrophic explosion fit into the public consciousness and what would its potential impact be on the public perception of air travel safety? Clearly, a mid-air explosion of an air carrier passenger airplane carrying hundreds of people is as severe as it can be. The televised and photographed images of hundreds of bereaved family members have a powerful impression in the minds of the traveling public. The image of an airplane exploding in mid-air, like TWA 800, is one of the most graphic, easily comprehended, and horrific visions possible to a potential air traveler.

History shows that people largely associate such an accident not only with an individual air carrier but with the entire air travel industry.[30] The air carrier suffering such an accident would incur the largest decline in passenger demand because some of its potential passengers would switch to other air carriers. Wong and Yeh[31] studied the decline in passenger demand on Taiwanese air carrier after each of 26 Taiwanese air carrier accidents (from 1981 through 1999, 2 of the accidents involved more than 200

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[29] Although this estimate cannot be applied directly to the result from a fuel tank explosion, it demonstrates the principle that there can be a significantly negative effect on air travel if the public believes that it is unsafe (regardless of the accident's cause).

[30] However, people do make some distinction between an airplane and the airline industry. When the Pan Am explosion occurred over Lockerbie, the largest negative impact on trans-Atlantic travel occurred to Pan Am, although all airlines flying trans-Atlantic routes suffered extensive reductions in demand on those routes.

[31] Wong, Jinn-Tsai and Yeh, Wen-Chien, "Impact of Flight Accident on Passenger Traffic Volume of the Airlines in Taiwan," Journal of the Eastern Asia Society for Transportation Studies, vol. 5, October, 2003.

fatalities) estimated that, on average,[32] every Taiwanese air carrier suffered a decline in the number of passengers after an accident with a significant loss of life. The number of people who did not fly on these air carriers due to the accident was greater than the number of passengers these air carriers gained from the airline that had the accident. Wong and Yeh estimated that the overall effect on Taiwanese air carriers was a 4.56 percent loss in demand during the first month, a 1.94 percent loss in demand during the second month, and a 0.34 percent loss in demand in the following few months. Although their overall study includes the effects of several less catastrophic accidents than TWA 800, we use their percentage demand reductions to quantify the air travel demand losses.

Over time, the effect of the accident largely fades from the traveling public's mind and no longer affects air travel demand. Wong and Yeh estimated that the average effect on air travel demand lasted about two and a half months.

It is difficult to translate that air carrier passenger loss into a cost to the economy. Some of these potential passengers will travel by an alternative means of transportation, although at either greater inconvenience or at a greater cost to them. Some will use teleconferencing or e-Mail. Some will not travel, will stay home, and will spend on items other than on what they would have spent had they traveled. All of these alternatives involve some loss of consumer surplus in comparison to the pre-explosion decision to fly. However, we are aware of no studies that directly address this issue. As a result, we estimated only the effect on air travel.

We did not use air carrier net operating revenue to monetize the demand loss because several line items subsumed in operating revenues and in operating costs will not be measurably affected by a decline in passengers. Airlines must report revenue and expenses to the Department of Transportation using Form 41. There are about 40 categories of revenues and costs reported under this form – most of which are not directly tied to operations. We summed the revenue categories of "passenger revenues", "excess passenger baggage" revenues, and "charter revenues" as a measure of passenger revenue. From this revenue measure we subtract the operating costs savings of "flying

[32] The authors specifically noted that externality effects and the duration of these effects for different accidents differed by accident severity.

operations"[33] as the category most directly affected by whether or not a passenger boards an airplane.

The calendar year 2005 revenue directly affected by passenger demand totaled $107.6 billion and the calendar year 2005 cost directly affected by passenger demand totaled $48.2 billion. We divided this by 12 to obtain monthly averages of $8.968 billion for revenue and $4.013 billion for operating costs. We then applied the monthly percentage losses from Wong and Yeh to this net value.[34] As shown in Table IV-11, the total loss in passenger revenue will be $613 million and the total cost reduction will be $339 million. Thus, the ancillary air travel demand loss from a HCWT explosion is $274 million.

TABLE IV-11

LOSSES FROM DECLINE IN AIR TRAVEL DEMAND FROM AN IN-FLIGHT AIR CARRIER PASSENGER AIRPLANE EXPLOSION
(in Millions of 2007 Dollars)

		PASSENGER REVENUE LOSSES			
CATEGORY	MONTHLY REVENUE	TOTAL	IST MONTH (4.56%)	2ND MONTH (1.94%)	3RD MONTH (0.34%)
REVENUE					
PASSENGER	$8,440	$577	$385	$164	$ 29
BAGGAGE	$ 37	$ 3	$ 2	$ 1	$ 0
CHARTER	$ 491	$ 34	$ 22	$ 10	$ 2
TOTAL	**$8,968**	**$613**	**$409**	**$174**	**$30**
		PASSENGER COST REDUCTIONS			
	MONTHLY COSTS	TOTAL	IST MONTH (4.56%)	2ND MONTH (1.94%)	3RD MONTH (0.34%)
COSTS					
FLYING OPERATIONS	$4,955	$339	$226	$96	$17.
TOTAL	**$4,955**	**$339**	**$226**	**$96**	**$17**
REVENUE – COST	**$4,013**	**$274**	**$183**	**$78**	**$13**

[33] Back Aviation Solutions, US Department of Transportation Form 41 Database, Quarterly Data, Calendar Year 2005. The complete table is presented in Appendix IV-1.
[34] We assumed that the percentage decline for scheduled air travel is the same as the percentage decline for chartered air travel.

This demand impact is a percentage impact and, as the economy and the aviation industry grow, the absolute demand loss in real terms will similarly grow. As shown in Table IV-12, based on the economy and the aviation industry having annual real growth rates of 3 percent, we increased the 2006 value of $274 million by 3 percent (to $293 million) for 2007 and then modified that $293 million by the annual 3 percent growth rate and discount rates of 7 percent and 3 percent[35] to obtain the present values of the aviation industry loss from the demand reduction.

TABLE IV-12

PRESENT VALUE OF THE BENEFITS FROM PREVENTING THE AIR TRAVEL DEMAND REDUCTION FOLLOWING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION
(in Millions of 2007 Dollars)

YEAR	UNDISCOUNTED	PRESENT VALUE 7 % DISCOUNT RATE
2007	$292	$293
2008	$300	$282
2009	$310	$271
2010	$319	$260
2011	$328	$250
2012	$338	$241
2013	$348	$232
2014	$359	$223
2015	$370	$214
2016	$381	$206
2017	$392	$198
2018	$404	$190
2019	$416	$183
2020	$428	$176
2021	$441	$169
2022	$455	$163
2023	$468	$156
2024	$482	$150
2025	$497	$145
2026	$512	$139
2027	$527	$134
2028	$543	$129
2029	$559	$124
2030	$576	$119
2031	$593	$114

[35] Obviously, a 3 percent growth rate and a 3 percent discount rate cancel each other so that the present value in every year is $292 million, while a 7 percent discount rate in combination with a 3 percent growth rate is, effectively, a 4 percent discount rate.

2032	$611	$110
2033	$629	$106
2034	$648	$102
2035	$667	$ 98
2036	$688	$ 94
2037	$708	$ 90
2038	$729	$ 87
2039	$751	$ 84
2040	$774	$ 80
2041	$797	$ 77
2042	$821	$ 74

IV.F. DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER IN-FLIGHT EXPLOSION

IV.F.1. Assumptions and Parameters

The direct benefits from preventing an air carrier in-flight explosion are the fatalities prevented and the property saved. We made the following assumptions and calculations to quantify these direct benefits:

1. An in-flight explosion is a catastrophic accident in which all die and the airplane is completely destroyed.
2. An explosion that occurs on the ground results in the death of 10 percent of the average number of passengers and crew on that airplane and the airplane is completely destroyed.
3. The value for preventing a fatality is $5.5 million in year 2007 dollars.
4. As shown in Table IV-13, the 2006 average airplane seating capacities multiplied by the load factors[36] plus the number of flight crew members for an in-flight air carrier passenger explosion produces 110 to 372 potential fatalities.[37]
5. The average airplane replacement values are based on a FAA economic values.[38] As shown in Table IV-13, these "average" airplane values range from $15 million to $115 million[39] in 2007 dollars.

[36] Federal Aviation Administration, FAA Aerospace Forecast Fiscal Years 2006-2017, Table 13, p. 68, 2006.
[37] Does not include the B-737-200 and the A-380 models.
[38] GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, October 2004.
[39] Excludes the B-737-200 and the A-380 models.

6. Real passenger airplane replacement values will remain constant.
7. The average value of the luggage and cargo and the ground damage are not included in these calculations because they will be less than $1 million per accident.
8. Based on the FAA report,[40] the average cost to the U.S. government, the airline, and the manufacturer to investigate an in-flight passenger airplane accident will be $8 million.
9. The average cost to investigate an on-the-ground passenger airplane explosion will be $1 million.
10. We used a 7 percent discount rate to calculate the present values of these quantified benefits.

IV.F.2. Benefits from Preventing an In-Flight Air Carrier Passenger Airplane Explosion

As shown in Table IV-13, which summarizes Appendix IV-2, the "average" direct benefits from preventing an air carrier passenger airplane in-flight explosion range from $628 million to $2.169 billion.[41]

TABLE IV-13

DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE IN-FLIGHT EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Prevented Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	99	$ 545	$ 1	$8	$ 554
B-737-Classic	110	$ 605	$ 15	$8	$ 628
B-737-NG	123	$ 677	$ 30	$8	$ 715
B-757	176	$ 968	$ 34	$8	$1,010
B-767	224	$1,232	$ 50	$8	$1,290
B-747-100/200/300	332	$1,826	$ 15	$8	$1,849
B-747-400	372	$2,046	$ 85	$8	$2,139
B-747-800	372	$2,046	$115	$8	$2,169
B-777	290	$1,595	$100	$8	$1,703
B-787	224	$1,232	$ 75	$8	$1,315
A-300	224	$1,232	$ 34	$8	$1,274
A-310	204	$1,122	$ 25	$8	$1,155

[40] Ibid.
[41] This excludes the B-737-200 and the A-380 models.

A-320 Family	123	$ 677	$ 30	$8	$ 715
A-330	290	$1,595	$ 85	$8	$1,688
A-340	332	$1,826	$100	$8	$1,934
A-350	224	$1,232	$ 75	$8	$1,315
A-380	502	$2,761	$150	$8	$2,919

We multiplied each passenger airplane model expected accident loss by its projected total flight hours for 2008-2043 divided by the total flight hours for all airplanes in order to calculate a weighted average of the quantified benefits per model. We used flight hours rather than numbers of airplanes or operations because the accident risk is proportional to flight hours. An airplane flying twice as many hours as another airplane has approximately twice the probability of an explosion.

As shown in Table IV-14, air carrier passenger airplanes affected by the rule[42] will fly 364 million hours.[43] The percentage of all flight hours operated by a model is obtained by dividing its individual flight hours by the total number of flight hours. We then multiplied those percentages by the accident costs for each model (from Table IV-13), which were summed to obtain the weighted average of direct benefits from preventing an in-flight air carrier passenger airplane explosion of $841 million.[44] [45]

TABLE IV-14

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT AIR CARRIER PASSENGER AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Airplane Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 554	0.643	0.18%	$ 0.979
B-737-Classic	$ 628	14.782	4.08%	$ 25.712
B-737-NG	$ 715	146.563	40.49%	$289.293
B-757	$1,010	26.430	7.30%	$ 73.654
B-767	$1,290	14.350	3.96%	$ 51.110
B-747-100/200/300	$1,849	0.798	0.22%	$ 4.078
B-747-400	$2,139	4.940	1.36%	$ 29.191

42 The B-787 flight hours are not included in this weighted average.
43 Table II-10 provides more detailed information.
44 As detailed in Appendix B, there is a 6.20 percent probability (sum of the percentage of flight hours for all the B-747s, the B-777, the A-330, A-340, and the A-380) that the accident could occur to a large airplane with a resultant loss of at least $900 million.
45 If the B-787 were included, the weighted average would be $875 million.

B-747-800	$2,169	0.000	0.00%	$ 0.000
B-777	$1,703	13.317	3.68%	$ 62.649
B-787	$1,315	0.000	0.00%	$ 0.000
A-300	$1,274	0.149	0.04%	$ 0.525
A-310	$1,155	0.000	0.00%	$ 0.000
A-320 Family	$ 715	131.611	36.36%	$259.780
A-330	$1,688	4.377	1.21%	$ 20.408
A-340	$1,934	0.000	0.00%	$ 0.000
A-350	$1,315	1.900	0.52%	$ 6.899
A-380	$2,919	2.125	0.59%	$ 17.136
TOTAL		**361.984**[46]		**$841.414**

IV.E.3. Benefits from Preventing an On-The-Ground Air Carrier Passenger Airplane Explosion

The average number of fatalities for an on-the-ground explosion will be 10 percent of the number of fatalities for an in-flight explosion.[47] As shown in Table IV-15, which summarizes Appendix IV-3, the direct benefits from preventing an on-the-ground air carrier passenger airplane explosion range from $77 million to $320 million.[48] In addition to fewer fatalities, we expect the investigation costs of an on-the-ground accident to be less ($1 million versus $8 million) than the investigation costs of an in-flight accident.

TABLE IV-15

DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	10	$ 55	$ 1	$1	$ 57
B-737-Classic	11	$ 61	$ 15	$1	$ 77
B-737-NG	12	$ 66	$ 30	$1	$ 97
B-757	18	$ 99	$ 34	$1	$134

[46] The total number of flight hours differs slightly from the 364.4 million in Table IV-3 due to rounding.
[47] Ten percent is approximately the percentage of passengers on board the Philippines Airliner who died in that explosion. We believe the Thailand accident is an aberration in that only the flight crew was on board at the time. The typical US airline tends to exhibit quicker turnaround during which passengers are on board a higher percentage of time than they are on foreign flights.
[48] This excludes the B-737-200 and the A-380,

B-767	22	$121	$ 50	$1	$172
B-747-100/200/300	33	$182	$ 15	$1	$198
B-747-400	37	$204	$ 85	$1	$290
B-747-800	37	$204	$115	$1	$320
B-777	29	$160	$100	$1	$261
B-787	22	$121	$ 75	$1	$197
A-300	22	$121	$ 34	$1	$156
A-310	20	$110	$ 25	$1	$136
A-320 Family	12	$ 66	$ 30	$1	$ 97
A-330	29	$160	$ 85	$1	$246
A-340	33	$182	$100	$1	$283
A-350	22	$121	$ 75	$1	$197
A-380	50	$275	$150	$1	$426

Although time spent on the ground prior to flight is the appropriate measure to proxy the relative weights for individual models to have an on-the-ground explosion, we do not have those data. Rather, we assumed that total flight hours are proportional to on-the-ground hours. Following the same methodology used in Section IV.F.2., as shown in Table IV-16, which summarizes Appendix IV-3, the weighted average of the direct benefits from preventing an on-the-ground air carrier passenger airplane explosion will be $115 million.

TABLE IV-16

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 57	0.643	0.18%	$ 0.101
B-737-Classic	$ 77	14.782	4.08%	$ 3.144
B-737-NG	$ 97	146.563	40.49%	$ 39.274
B-757	$134	26.430	7.30%	$ 9.784
B-767	$172	14.350	3.96%	$ 6.818
B-747-100/200/300	$198	0.798	0.22%	$ 0.437
B-747-400	$290	4.940	1.36%	$ 3.958
B-747-800	$320	0.000	0.00%	$ 0.000
B-777	$261	13.317	3.68%	$ 9.602
B-787	$197	0.000	0.00%	$ 0.000
A-300	$156	0.149	0.04%	$ 0.064
A-310	$136	0.000	0.00%	$ 0.000
A-320 Family	$ 97	131.611	36.36%	$ 35.267

A-330	$246	4.377	1.21%	$ 2.974
A-340	$283	0.000	0.00%	$ 0.000
A-350	$197	1.900	0.52%	$ 1.034
A-380	$426	2.125	0.59%	$ 2.501
TOTAL		**361.984[49]**		**$114.959**

IV.F.4. <u>Present Value of the Average Benefits from Preventing an Air Carrier Passenger Airplane Explosion Weighted by the Probabilities of In-Flight and On-the-Ground Explosions</u>

We previously determined that there is an 80 percent probability that an air carrier passenger airplane explosion will occur in the air and a 20 percent probability that it will occur on the ground. As shown in Table IV-17, the weighted average value of the expected benefits from preventing an air carrier passenger explosion is $696 million in 2007 (80 percent times $841.414 plus 20 percent times $114.959 million). Table IV-17 also contains the present values of these benefits for each year through 2042 using a discount rate of 7 percent.

TABLE IV-17

PRESENT VALUE OF THE DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
2007	$696
2008	$651
2009	$608
2010	$568
2011	$531
2012	$496
2013	$464
2014	$434
2015	$405
2016	$379
2017	$354
2018	$331
2019	$309
2020	$289
2021	$270

[49] The total number of flight hours differs slightly from the 364.4 million in Table IV-3 due to rounding.

2022	$252
2023	$236
2024	$220
2025	$206
2026	$192
2027	$180
2028	$168
2029	$157
2030	$147
2031	$137
2032	$128
2033	$120
2034	$112
2035	$105
2036	$ 98
2037	$ 91
2038	$ 85
2039	$ 80
2040	$ 75
2041	$ 70
2042	$ 65

IV.G. TOTAL POTENTIAL AND REALIZED BENEFITS

IV.G.1. Potential Benefits from Preventing the Statistical 3.64 Air Carrier Passenger Airplane Explosions

As previously discussed, in the absence of SFAR 88, we expect that 3.64 accidents will occur.

We categorize the 3.64 accidents into:

1. Accidents that will be prevented by SFAR 88;
2. Accidents that will be prevented by the final rule; and
3. Accidents that will not be prevented because they can happen to airplanes without FRM.

In Section IV.D.3., we established that the 3.64 accident years are expected in 2012, 2019, 2026, and (0.64 of an accident) in 2035. In Table IV-18, we sum the undiscounted and present values of preventing an air carrier passenger airplane explosion in each of those three years from Tables IV-5 (the reduction in air travel) and IV-12 (the direct losses from the accident). Thus, if all of these accidents could be prevented, the undiscounted potential benefits from would be $4.228 billion, of which $1.695 billion would be prevented aviation demand losses, and $2.533 billion would be direct benefits. The present value of these potential benefits would be $1.590 billion, of which $626 million would be prevented aviation demand losses and $964 billion would be direct benefits. However, as more fully discussed in the next section, the final rule will not prevent all of these 3.64 accidents.

TABLE IV-18

UNDISCOUNTED AND PRESENT VALUE OF THE POTENTIAL BENEFITS FROM PREVENTING 3.64 AIR CARRIER PASSENGER AIRPLANE EXPLOSIONS USING A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	TOTAL		DEMAND		DIRECT	
YEAR	UNDISCOUNTED	PRESENT VALUE	UNDISCOUNTED	PRESENT VALUE	UNDISCOUNTED	PRESENT VALUE
2012	$1,034	$ 737	$ 338	$241	$ 696	$496
2019	$1,112	$ 492	$ 416	$183	$ 696	$309
2026	$1,208	$ 331	$ 512	$139	$ 696	$192
2035	$ 874	$ 130	$ 429	$ 63	$ 445	$ 67
TOTAL	**$4,228**	**$1,590**	**$1,695**	**$626**	**$2,533**	**$964**

IV.G.2. Number of Accidents Affected by the Final Rule

In order to determine the number of accidents that will be prevented by the final rule after the SFAR 88 impact is included, we need to determine the number of flight hours by airplanes with FRM and the number of flight hours by airplanes without FRM. Further, when these flight hours are accumulated is important because more recent flight hours have a greater present value effect on benefits than later flight hours do.

Table IV-19 contains the flight hours for passenger airplanes. The majority of the earliest flight hours are accumulated by airplanes without FRM (they accumulate no more flight hours after 2016). Retrofitted airplane annual flight hours increase until 2017 after which they gradually decline to zero by 2033 due to retirements. Production airplanes accumulated all of the flight hours after 2032 until the last production airplane is retired in 2043

TABLE IV-19

NUMBER OF FLIGHT HOURS FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of Hours)

	CUMULATIVE FLIGHT HOURS				
		WITH FRM			
YEAR	ALL	TOTAL WITH FRM	RETROFIT	PRODUCTION	NO FRM
2008	10.9	0	0	0	10.9
2009	22.5	1.1	0	1.1	21.4
2010	34.8	3.8	1.6	2.2	31.0
2011	47.5	8.2	3.9	4.3	39.3
2012	60.7	14.2	7.1	7.1	46.5
2013	74.3	21.9	11.3	10.6	52.4
2014	88.3	31.5	16.4	15.1	56.8
2015	103.0	43.4	22.8	20.6	59.6
2016	118.5	57.9	30.8	27.1	60.6
2017	134.4	73.8	39.3	34.5	60.6
2018	150.2	89.6	47.5	42.1	60.6
2019	165.5	104.9	55.2	49.7	60.6
2020	180.2	119.6	62.3	57.3	60.6
2021	194.4	133.8	68.9	64.9	60.6
2022	208.1	147.5	75.0	72.5	60.6
2023	221.2	160.6	80.5	80.1	60.6
2024	233.5	172.9	85.2	87.7	60.6
2025	245.7	185.1	89.8	95.3	60.6
2026	257.1	196.5	93.6	102.9	60.6
2027	267.9	207.3	96.8	110.5	60.6
2028	278.1	217.5	99.4	118.1	60.6
2029	287.8	227.2	101.5	125.7	60.6
2030	296.9	236.3	103.0	133.3	60.6
2031	305.4	244.8	103.9	140.9	60.6
2032	313.4	252.8	104.3	148.5	60.6
2033	320.9	260.3	104.3	156.0	60.6
2034	328.4	267.8	104.3	163.5	60.6
2035	335.5	274.9	104.3	170.6	60.6
2036	341.9	281.3	104.3	177.0	60.6
2037	347.7	287.1	104.3	182.8	60.6
2038	352.8	292.2	104.3	187.9	60.6
2039	357.2	296.6	104.3	192.3	60.6
2040	360.7	300.1	104.3	195.8	60.6
2041	363.1	302.5	104.3	198.2	60.6
2042	364.4	303.8	104.3	199.5	60.6
TOTAL	**364**	**304**	**104**	**200**	**60**

As previously discussed, we determined that the statistical accident will occur at the 50 millionth flight hour for each 100 million flight hour period. The number of flight hours appropriate to calculate the percentages that retrofitted, production, and no FRM airplanes fly during that time depends on the entire time 100 million hour flight period – not the 50 million flight hour period. As shown in Table IV-20, of the total 364 million flight hours, retrofitted airplanes will fly 28.6 percent, production airplanes will fly 54.8 percent, and airplanes without FRM will fly 16.6 percent.

TABLE IV-20

PERCENTAGE OF FLIGHT HOURS FLOWN BY AIR CARRIER PASSENGER AIRPLANES DURING THE TIME PERIOD FOR EACH STATISTICAL ACCIDENT
(in Millions of 2007 Dollars)

		WITH FRM			
MID-POINT YEAR	PERIOD	TOTAL	RETROFITTED	PRODUCTION	NO FRM
2012	2008-2016	48.86%	25.99%	22.87%	51.14%
2019	2017-2022	100.00%	53.76%	46.24%	0.00%
2026	2023-2031	100.00%	25.81%	74.19%	0.00%
2035	2031-2042	100.00%	0.00%	100.00%	0.00%
PERCENT OF TOTAL	**2008-2042**	**83.37%**	**28.62%**	**54.75%**	**16.63%**

IV.G.3. <u>Discounted Potential and Realized Quantified Total Benefits</u>

As shown in Table IV-21, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each category to the values in Table IV-18 results in a present value of the potential benefits (if all HCWT explosions were prevented) of $845 million for SFAR 88 and $845 million for the final rule. Of this $845 million potential benefits for the final rule, airplanes with FRM will account for (hence, prevent) $657 million while airplanes without FRM will account for (and not prevent) $188 million.

TABLE IV-21

PRESENT VALUE OF THE POTENTIAL **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM

2012	$ 737	$368	$369	$181	$188
2019	$ 492	$246	$246	$246	$ 0
2026	$ 331	$166	$165	$165	$ 0
2035	$ 130	$ 65	$ 65	$ 65	$ 0
TOTAL	**$1,690**	**$845**	**$845**	**$657**	**$188**

As shown in Table IV-22, of the rule's total realized benefits of $657 million, $273 million (41.6 percent of the total realized benefits) will be attributable to retrofitted airplanes and $384 million (58.4 percent of the total realized benefits) will be attributable to production airplanes.

TABLE IV-22

PRESENT VALUE OF THE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$181	$ 97	$ 84
2019	$246	$133	$113
2026	$165	$ 43	$122
2035	$ 65	$ 0	$ 65
TOTAL	**$657**	**$273**	**$384**
PERCENT OF TOTAL		**41.6%**	**58.4%**

IV.G.4. <u>Discounted Potential and Realized Quantified Demand Benefits</u>

Finally, as shown in Table IV-23, multiplying the demand losses in Table IV-18 by the percentages in Table IV-20 produces potential demand benefits of $313 million, of which $251 million (80.2 percent) will be realized by airplanes with FRM and $62 million (19.8 percent) will occur to airplanes without FRM. Of the $251 million in realized demand benefits, $100 million (39.8 percent) will be realized by retrofitted airplanes and $151 million (60.2 percent) will be realized by production airplanes.

TABLE IV-23

PRESENT VALUE OF THE POTENTIAL AND REALIZED **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE
(in Millions of 2007 Dollars)

	PRESENT VALUE (7 %)				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$121	$ 59	$ 32	$ 27	$62
2019	$ 91	$ 91	$ 49	$ 42	$ 0
2026	$ 70	$ 70	$ 19.	$ 51	$ 0
2035	$ 31	$ 31	$ 0	$ 31	$ 0
TOTAL	**$313**	**$251**	**$100**	**$151**	**$62**
PERCENT OF POTENTIAL		**80.2%**	**31.9%**	**48.2%**	**19.8%**
PERCENT OF REALIZED			**39.8%**	**60.2%**	

IV.G.5. Discounted Potential and Realized Quantified Direct Benefits

Finally, as shown in Table IV-24, multiplying the direct losses in Table IV-18 by the percentages in Table IV-20 produces potential direct benefits of $532 million, of which $406 million (76.3 percent) will be realized by airplanes with FRM and $126 million (23.7 percent) will occur to airplanes without FRM. Of the $409 million in realized direct benefits, $173 million (42.6 percent) will be realized by retrofitted airplanes and $233 million (57.4 percent) will be realized by production airplanes.

TABLE IV-24

PRESENT VALUE OF THE POTENTIAL AND REALIZED **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE
(in Millions of 2007 Dollars)

	PRESENT VALUE (7 %)				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$248	$122	$ 65	$ 57	$126
2019	$155	$155	$ 83	$ 72	$ 0
2026	$ 96	$ 96	$ 25	$ 71	$ 0
2035	$ 33	$ 33	$ 0	$ 33	$ 0
TOTAL	**$532**	**$406**	**$173**	**$233**	**$126**
PERCENT OF POTENTIAL		**76.3%**	**32.5%**	**43.8%**	**23.7%**
PERCENT OF REALIZED			**42.6%**	**57.4%**	

IV.G..5. Total Benefits by Airplane Manufacturer

In calculating the quantified total benefits by manufacturer, we used the same average benefits from the demand impact and the direct impact for both Boeing and Airbus airplanes. Thus, the distribution of the undiscounted and the present value of the benefits by manufacturer is a function of only the flight hours for each manufacturer's airplanes. Table IV-25 contains a summary of those flight hours based on Table IV-8 and the percentage of hours flown by each category of airplane. The total benefits are found in Table IV-22. As shown in Table IV-25, Boeing airplanes will accumulate present value benefits of $387 million, of which $179 million will be attributable to retrofitted airplanes and $208 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $271 million, of which $94 million will be attributable to retrofitted airplanes and $175 million will be attributable to production airplanes.

TABLE IV-25

TOTAL BENEFITS FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE AND BY MANUFACTURER
(Numbers in Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS
RETROFITTED	**114.3**		**$271**
BOEING	67.9	65.44%	$177
AIRBUS	36.4	34.56%	$ 94
PRODUCTION	**199.3**		**$384**
BOEING	108.3	54.19%	$207
AIRBUS	91	45.81%	$176
TOTAL	**303.6**		**$656**
BOEING	176.2	58.88%	$386
AIRBUS	127.4	41.42%	$270

IV.H. QUANTIFIED BENEFITS FROM PREVENTING AN AIR CARRIER CARGO

AIRPLANE EXPLOSION

IV.H.1. Risk of an Explosion

In the NPRM we had requested information concerning the accident risk for cargo airplanes. The only comment we received was from Boeing that stated they did not know of any difference in risk between passenger airplanes and cargo airplanes. As a result, we use the passenger airplane risk of one accident every 100 million flight hours for cargo airplanes.

IV.H.2. Demand Benefits

The impact on passenger air travel demand after an air cargo airplane explosion will be minimal because it will not generate the high number of fatalities that would significantly attract the public's attention.

IV.H.3. Direct Benefits

IV.H.3.a. Assumptions

We made the following assumptions and calculations to quantify the direct benefits from preventing an air carrier cargo airplane explosion.

1. An in-flight explosion is a catastrophic accident occurs in which the crew dies and the airplane and its cargo is completely destroyed.
2. An on-the-ground explosion results in no deaths, but the airplane and its cargo are completely destroyed.
3. The value for preventing a fatality is $5.5 million in year 2007 dollars.
4. There are 2 to 3 flight crew members.
5. The average cargo airplane replacement values are based on a GRA Incorporated report.
6. The real cargo airplane replacement values will remain constant.
7. The 1999 Montreal Convention established an international insurance payment for destroyed of 17 Special Drawing Rights (SDRs)[50] per kilogram of cargo, unless a special declaration of value is made and an extra sum is paid. We assume that relatively few special declarations of value are made and their impact

[50] A SDR is a unit of account established by the World Bank. It is based on a combination of 4 currencies (the dollar, the Euro, the British pound, and the Yen). It is used as a bookkeeping device to settle transactions at the World Bank.

is minimal. Currently, one SDR is worth $1.49, which results in an average cargo value of $25.33 per kilogram (about $11.51 a pound).

8. We determined that the average value of the ground damage will be less than $1 million per accident. As a result, it is not included in the calculations.
9. The average cost to the U.S. government, the airline, and the manufacturer to investigate an in-flight cargo airplane accident will be $8 million.
10. The average cost to investigate an on-the-ground cargo airplane accident will be $1 million.
11. We used a 7 percent discount rate to calculate the present values of these quantified benefits.

IV.H.3.b. Benefits from Preventing an In-Flight Air Carrier Cargo Airplane Explosion

As shown in Table IV-26, which summarizes Appendix IV-4, the "average" direct benefits from preventing an in-flight air carrier cargo airplane explosion ranges from $29 million to $126 million.

TABLE IV-26

DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT AIR CARRIER CARGO AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Value of Cargo	Cost of Investigation	Total Cost of Accident
B-737-Classic	2	$11	$ 10	$0.345	$8	$ 29
B-757	2	$11	$ 25	$0.485	$8	$ 44
B-767	2	$11	$ 45	$0.740	$8	$ 65
B-747-100/200/300	3	$16.5	$ 35	$1.679	$8	$ 61
B-747-400	3	$16.5	$100	$1.824	$8	$126
B-747-800	2	$11	$100	$1.976	$8	$121
B-777	2	$11	$ 80	$1.748	$8	$ 101
A-300	2	$11	$ 45	$0.740	$8	$ 65
A-310	2	$11	$ 40	$0.740	$8	$ 60

We multiplied each cargo airplane model potential direct benefits by its total flight hours to calculate a weighted average of direct benefits. As shown in Table IV-27, the weighted average of the direct benefits from preventing an in-flight air carrier cargo airplane explosion will be $81 million.

TABLE IV-27

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT AIR CARRIER CARGO AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Airplane Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-Classic	$ 29	2.100	4.64%	$ 1.3
B-757	$ 44	2.277	5.04%	$ 2.2
B-767	$ 65	3.795	8.39%	$ 4.9
B-747-100/200/300	$ 61	4.797	10.61%	$ 6.4
B-747-400	$126	2.286	5.06%	$ 4.6
B-747-800	$121	11.161	24.68%	$29.1
B-777	$ 101	5.201	11.50%	$11.2
A-300	$ 65	9.764	21.60%	$15.8
A-310	$ 60	3.853	8.48%	$ 5.5
TOTAL		**45.234**		**$81.0**

IV.G.3.c. Benefits from Preventing a Cargo Airplane On-the-Ground Explosion

As shown in Table IV-28, the "average" direct benefits from preventing an on-the-ground air carrier cargo airplane explosion range from $11 million to $103 million. As previously noted, we assume that the flight crew will be able to escape the airplane before it is totally destroyed.

TABLE IV-28

DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND CARGO AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Value of Airplane	Value of Cargo	Cost of Investigation	Total Cost of Accident
B-737-Classic	$ 10	$0.345	$1	$ 11
B-757	$ 25	$0.485	$1	$ 26
B-767	$ 45	$0.740	$1	$ 47
B-747-100/200/300	$ 35	$1.679	$1	$ 38
B-747-400	$100	$1.824	$1	$103
B-747-800	$100	$1.976	$1	$103
B-777	$ 80	$1.748	$1	$ 83
A-300	$ 45	$0.740	$1	$ 47
A-310	$ 40	$0.740	$1	$ 42

As shown in Table IV-29, the weighted average of the direct benefits from preventing an on-the-ground air carrier cargo airplane explosion will be $63 million.

TABLE IV-29

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER CARGO AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	**Total Accident Cost**	**Total Num. Flight Hours (2008-2043)**	**Percent of All Flight Hours**	**Weighted Accident Cost**
B-737-Classic	$ 11	2.100	4.64%	$ 0.2
B-757	$ 26	2.277	5.04%	$ 1.3
B-767	$ 47	3.795	8.39%	$ 3.9
B-747-100/200/300	$ 38	4.797	10.61%	$ 4.0
B-747-400	$103	2.286	5.06%	$ 5.2
B-747-800	$103	11.161	24.68%	$25.4
B-777	$ 83	5.201	11.50%	$ 9.5
A-300	$ 47	9.764	21.60%	$10.1
A-310	$ 42	3.853	8.48%	$ 3.5
TOTAL		**46.234**		**$63.1**

IV.H.3.d. <u>Present Value of the Benefits from Preventing an Air Carrier Cargo Airplane Explosion</u>

We use an 80 percent probability that an explosion will occur in flight and a 20 percent probability that it will occur on the ground. As shown in Table IV-30, the weighted average present value of the direct benefits from preventing an air carrier cargo airplane explosion is $77 million in 2007 (80 percent times $81 million plus 20 percent times $63.1 million).

TABLE IV-30

PRESENT VALUE OF THE DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER CARGO AIRPLANE EXPLOSION
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
	7% DISCOUNT RATE
2007	$77.400

2008	$72.336
2009	$67.604
2010	$63.181
2011	$59.048
2012	$55.185
2013	$51.575
2014	$48.201
2015	$45.048
2016	$42.100
2017	$39.346
2018	$36.772
2019	$34.367
2020	$32.118
2021	$30.017
2022	$28.053
2023	$26.218
2024	$24.503
2025	$22.900
2026	$21.402
2027	$20.002
2028	$18.693
2029	$17.470
2030	$16.327
2031	$15.259
2032	$14.261
2033	$13.328
2034	$12.456
2035	$11.641
2036	$10.880
2037	$10.168
2038	$ 9.503
2039	$ 8.881
2040	$ 8.300
2041	$ 7.757
2042	$ 7.250

IV.H.4. Air Carrier Cargo Airplane Flight Hours

As shown in Table IV-31, which summarizes Appendix IV-4, the air carrier cargo fleet through 2042 will accumulate about 49 million flight hours. Of these 49 million flight hours, 20.1 million will be flown by existing cargo airplanes, 21.2 million will be flown by conversion cargo airplanes, and 7.7 million will be flown by production cargo airplanes. Of the 7.7 million flight hours by production cargo airplanes, Boeing airplanes will fly 5.7 million and Airbus airplanes will fly 2 million of them.

TABLE IV-31

SUMMARY OF THE AIR CARRIER CARGO AIRPLANE FLIGHT HOURS

(in Millions of Hours)

AIRPLANE CATEGORY	NUMBER OF FLIGHT HOURS
TOTAL	**49.0**
BOEING	33.1
AIRBUS	15.9
PRODUCTION AIRPLANES	**7.7**
BOEING	5.7
AIRBUS	2.0
CONVERSION AIRPLANES	**21.2**
BOEING	16.1
AIRBUS	5.1
EXISTING AIRPLANES	**20.1**
BOEING	11.3
AIRBUS	8.8
TOTAL AFFECTED BY RULE	**7.7**

Based on the 7.7 million flight hours affected by the rule, there would be 0.077 air carrier cargo airplane explosions. Using a 50 percent SFAR 88 effectiveness rate, the final rule will prevent 0.0385 explosions. Based on an expected benefit of $77 million for an air carrier cargo airplane explosion, the undiscounted benefits of the rule for air carrier cargo airplanes will be $3 million. We did not calculate present values for this small benefit.

IV.I. DIRECT BENEFITS PROBABILITY DISTRIBUTION BY AIRPLANE SIZE

In this section, we provide an analysis that focuses on a more concrete discussion of the benefits probability distribution. Appendix D contains a Monte Carlo analysis of the distribution of these benefits.

To simplify the calculations, we segmented the airplanes into three groups: large, medium, and small. The large airplane group consists of the A-330, A-340, A-380, B-747 and B-777. The medium airplane group consists of the A-300/310, A-350, B-757, and B-767. The small airplane group consists of the A-320 family and the B-737 family. As shown in Appendix IV-5, the individual benefit (weighted by the number of flight hours for the individual airplanes models in that group) in 2007 for an in-flight explosion would be $1.890 billion for a large airplane, $1.117 billion for a medium airplane, and $710 million for a small airplane. Incorporating the 20 percent probability that the explosion would occur on-the-ground, the individual benefit in 2007 would be $1.588 billion for a large airplane, $955 million for a medium airplane, and $610 million for a small airplane

We continue to assume that each accident is independent of airplane size and that all HCWT airplanes have the same explosion risk per flight hour. As shown in Appendix IV-6, based on the ratio of the expected number of flight hours in each of the three groups divided by the total fleet expected number of flight hours, the following are the probabilities of an accident by airplane size:

- Accident Probability for a Large Airplane = 7.1%
- Accident Probability for a Medium Airplane = 11.8%
- Accident Probability for a Small Airplane = 81.1%.

For 3 accidents and 3 different airplane sizes there exist 27 unique independent outcomes (3*3*3 = 27). In Table IV-28, these outcomes are represented by L for Large, M for Medium, and S for Small airplanes. Thus, the outcome L,L,L represents the possibility that all three accidents would happen to large airplanes, while L,L,M represents the possibility that the first two accidents would happen to large airplanes and the third accident would happen to a medium sized airplane, S,S,S represents the possibility that all three accidents would happen to small airplanes, etc. Given the probabilities for the individual airplane groups, we calculated the probability that each of the 27 outcomes would occur. For instance, the probability that all 3 accidents would happen to large airplanes (L,L,L) is 0.0352 (.071*.071*.071) percent while the probability that all 3 accidents would occur on small airplanes (S,S,S) is 53.357 (.811*.811*.811) percent.

In order to simplify the calculations, as discussed in Section IV.G.2., we determined that the expected years of these explosions would be 2012, 2019, and 2026.

The average benefits from preventing an accident by these three airplane size categories are:

- Large: $1.588 billion
- Medium: $955 million

- Small: $610 million

There are two additional factors that need to be included in this benefits analysis. The first factor is that there is an approximately 50 percent probability that the airplane involved in the first accident[51] would not have FRM. As a result, each of the 27 potential outcomes needs to be doubled to account for the fact that half of the potential first accidents would occur to airplanes without FRM.[52]

The second factor is the impact of SFAR 88. Under a 50 percent SFAR 88 effectiveness rate, each accident has an equal probability of being prevented by FRM or being prevented by SFAR 88. In calculating the benefits of the final rule, each of the 3 accidents has 2 outcomes associated with it. It is either prevented by the final rule or it is prevented by SFAR 88. Thus, there are 8 possibilities associated with each outcome.

Consequently, when coupled with the factor of 2 associated with the first accident for the non-FRM equipped airplanes, there are 16 different permutations associated with each outcome, for a total of 432 permutations. All of these combinations are shown in Appendix IV-6.

Table IV-27 illustrates one of these combinations, using the outcome of L,L,L (all three events occurring to a large airplane). The first column lists the outcome. For example, the second line outcome L,L,L, (Y) (1,1,0), (Y) indicates that the first accident occurred to a large airplane that had FRM while an (N) would indicate that the first accident happened to an airplane without FRM. The first (1) and second (1) indicate that the first and second accidents were prevented by FRM. The (0) indicates that the third accident was prevented by SFAR 88. Thus, each of the 27 outcomes (for example, L, L, L,) has 16 permutations (2)*(2*2*2), for a total number of 432 potential events (27 outcomes times 16 permutations of each outcome).

The second column supplies the probabilities that any one of these outcomes would occur. As shown, in Appendix IV-6, the probabilities that one of these 432 potential events could occur range from .0022 percent to 3.3348 percent.

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[51] The specific probability is 51.3 percent that the airplane would not have FRM.

[52] It should be noted that there is a 50 percent probability that SFAR 88 would prevent the accident that would occur to an airplane without FRM.

The third column sums the present values of a large airplane prevented accident (80 percent probability that it would have in flight and 20 percent probability that it would have occurred on the ground) by the final rule. For example, the permutation (Y) (1,0,1) would add the present values of a large airplane in-flight accident prevented by the final rule in 2012 and in 2026.[53] Similarly, the permutation (N) (1,0,1) would add the present value of a large airplane in-flight accident prevented in 2026 because the airplane in 2012 would not have had FRM.

TABLE IV-28

PROBABILITIES OF AN IN-FLIGHT EXPLOSION OCCURRING TO A LARGE AIRPLANE BEING PREVENTED BY FRM AND BY SFAR 88 AND THE PRESENT VALUE OF THE FINAL RULE BENEFITS FOR EACH OF THE OUTCOMES

OUTCOME	PROBABILITY	PRESENT VALUE FRM BENEFITS
L,L,L	**0.035%**	
L,L,L (Y) (1,1,1)	0.002%	$3,412.905
L,L,L (Y) (1,1,0)	0.002%	$2,752.199
L,L,L (Y) (1,0,1)	0.002%	$2,391.553
L,L,L (Y) (1,0,0)	0.002%	$1,730.847
L,L,L (Y) (0,1,1)	0.002%	$1,825.090
L,L,L (Y) (0,1,0)	0.002%	$1,164.384
L,L,L (Y) (0,0,1)	0.002%	$ 803.738
L,L,L (Y) (0,0,0)	0.002%	$ 143.032
L,L,L (N) (1,1,1)	0.002%	$1,825.090
L,L,L (N) (1,1,0)	0.002%	$1,164.384
L,L,L (N) (1,0,1)	0.002%	$ 803.738
L,L,L (N) (1,0,0)	0.002%	$ 143.032
L,L,L (N) (0,1,1)	0.002%	$1,825.090
L,L,L (N) (0,1,0)	0.002%	$1,164.384
L,L,L (N) (0,0,1)	0.002%	$ 665.738
L,L,L (N) (0,0,0)	0.002%	$ 143.032

Finally, as shown in Appendix IV-6, we summed the probabilities of each of the 432 outcomes that were larger than the $1.012 billion present value of the final rule cost. On that basis, we calculated that there is a 26 percent probability that the final rule's direct plus demand benefits would be greater than its costs. Finally, we calculated that

[53] Rather than doubling the 432 outcomes to 864 outcomes, we took a 50 percent average of the present value of preventing the 0.64 of an accident that would occur during the last 64 million flight hours

there is a 12 percent probability that the final rule's direct benefits alone would be greater than its costs.

V. AIR CARRIER PASSENGER AIRPLANE COMPLIANCE COSTS

V.A. INTRODUCTION

In this Section we discuss and estimate the cost of compliance to manufacturers and to air carrier passenger operators. We first summarize the total compliance costs and then develop the individual costs. The referenced Appendices provide the detailed spreadsheets used to calculate these costs. We follow this same methodology for air carrier cargo costs in section VI.

It should be noted that, in this section, we estimate the costs for a specific FRM system – the fuel tank inerting (FTI) system. When we use the term FRM we are referring to the final rule requirement, which is FRM. When we use the term FTI, we are referring to the costs of a specific FRM system.

V.B. SUMMARY OF AIR CARRIER PASSENGER AIRPLANE COMPLIANCE COST

As shown in Table V-1, the undiscounted compliance costs for air carrier passenger airplane operators are about $2.076 billion, which has a present value of $975 million using a 7 percent discount rate and a present value of $1.448 billion using a 3 percent discount rate. The undiscounted compliance costs for retrofitted airplanes are $839 million, which has a present value of $436 million using a 7 percent discount rate and a present value of $623 million using a 3 percent discount rate. The undiscounted costs for production airplanes (excluding the B-787) are $1.237 billion, which has a present value of $539 million using a 7 percent discount rate and a present value of $825 million using a 3 percent discount rate. In present value terms using a 7 percent discount rate and excluding the engineering costs, retrofitted airplanes incur about 43 percent of the costs while production airplanes incur about 57 percent of the costs.

TABLE V-1

COMPLIANCE COSTS FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
RETROFITTED			
ENGINEERING	$ 19	$ 16	$ 18
INSTALLATION	$ 346	$220	$ 283
INVENTORY	$ 9	$ 6	$ 7
FUEL	$ 216	$ 93	$ 149
OPERATIONAL	$ 112	$ 49	$ 77
ASM REPLACEMENT	$ 137	$ 52	$ 89
TOTAL	**$ 839**	**$436**	**$ 623**
PRODUCTION			
ENGINEERING	$ 107	$100	$ 103
INSTALLATION	$ 230	$152	$ 191
INVENTORY	$ 7	$ 4	$ 5
FUEL	$ 459	$149	$ 272
OPERATIONAL	$ 197	$ 63	$ 116
ASM REPLACEMENT	$ 237	$ 71	$ 138
TOTAL	**$1,237**	**$539**	**$ 825**
GRAND TOTAL	**$2,076**	**$975**	**$1,448**

As shown in Table V-2, the engineering and installation costs are a little more than half of the present value compliance costs for all airplanes. However, the installation costs are more than half (50.5 percent) of the costs for retrofitted airplanes while they are 28.2 percent of the costs for production airplanes. The engineering costs are so much larger for production airplanes than for retrofitted airplanes because, once the engineering and development of a production airplane model fuel tank inerting kit is completed, there is minimal engineering costs to apply that kit to the previously produced airplanes of that model. The fuel costs are about a quarter (24.8 percent) of the total costs, 21.3 percent of the costs for retrofitted airplanes and 28.2 percent of the costs for production airplanes. The operational costs are 11.5 percent of the total and the air supply module (ASM) replacement costs are 12.6 percent of the total.

TABLE V-2

PERCENTAGE OF PRESENT VALUE (USING A 7 PERCENT DISCOUNT RATE) COMPLIANCE COSTS BY COST CATEGORIES FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

COST CATEGORY	PRESENT VALUE COSTS (7%)	PERCENTAGE OF TOTAL
RETROFITTED		
ENGINEERING	$ 16	3.7%
INSTALLATION	$220	50.5%
INVENTORY	$ 6	1.4%
FUEL	$ 93	21.3%
OPERATIONAL	$ 49	11.2%
ASM REPLACEMENT	$ 52	11.9%
RETROFITTED TOTAL	**$436**	100.0%
PRODUCTION		
ENGINEERING	$100	18.6%
INSTALLATION	$152	28.2%
INVENTORY	$ 4	0.7%
FUEL	$149	27.6%
OPERATIONAL	$ 63	11.7%
ASM REPLACEMENT	$ 71	13.2%
PRODUCTION TOTAL	**$539**	100.0%
ALL AIRPLANES		
ENGINEERING	$116	11.9%
INSTALLATION	$372	38.2%
INVENTORY	$ 10	1.0%
FUEL	$242	24.8%
OPERATIONAL	$112	11.5%
ASM REPLACEMENT	$123	12.6%
ALL AIRPLANES TOTAL	**$975**	100.0%

As shown in Table V-3, the undiscounted compliance costs for air carrier Boeing passenger airplane operators are $1.187 billion, which has a present value of $568 million using a 7 percent discount rate and a present value of $836 million using a 3 percent discount rate. The undiscounted compliance costs for air carrier Airbus passenger airplane operators are $890 million, which has a present value of $407 million using a 7 percent discount rate and a present value of $612 million using a 3 percent discount rate.

TABLE V-3

COMPLIANCE COSTS FOR AIR CARRIER PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING			
ENGINEERING	$ 76	$ 69	$ 73
RETROFITTING	$ 241	$153	$ 197
PRODUCTION	$ 127	$ 83	$ 104
INVENTORY	$ 9	$ 6	$ 8
FUEL	$ 333	$119	$ 207
OPERATIONAL	$ 184	$ 67	$ 115
ASM REPLACEMENT	$ 217	$ 71	$ 132
TOTAL	**$1,187**	**$568**	**$ 836**
AIRBUS			
ENGINEERING	$ 50	$ 47	$ 48
RETROFITTING	$ 105	$ 67	$ 86
PRODUCTION	$ 103	$ 71	$ 87
INVENTORY	$ 6	$ 4	$ 5
FUEL	$ 344	$123	$ 213
OPERATIONAL	$ 125	$ 44	$ 78
ASM REPLACEMENT	$ 157	$ 51	$ 95
TOTAL	**$ 890**	**$407**	**$ 612**
GRAND TOTAL	**$2,076**	**$975**	**$1,448**

V.C. RESPONSIBILITY FOR AND METHODS OF COMPLIANCE

Boeing and Airbus are responsible for compliance with the certification requirements for future type certificated airplanes. Although operators are responsible for ensuring that production airplanes under existing type certificates are in compliance with the operating rules, Boeing and Airbus will equip their production airplanes to be in compliance with the requirements if they intend to sell them in the United States. Finally, although operators are responsible for compliance with the retrofitting requirements, Boeing and Airbus will likely develop and sell most of the service bulletins and kits necessary for the retrofits.

V.D. BASELINES, METHODOLOGY, AND DATA SOURCES

V.D.1. Baselines

The baseline used to compute the incremental compliance costs is not the minimum compliance with the current FAA regulations but, rather, the current and expected future industry practices in the absence of the rule.

In the IRE, we had noted that Boeing had informed us of their intention to install FRM in their production airplanes by 2008. Consequently, we had not included the cost of installing FRM in Boeing production airplanes as an incremental compliance cost of the rule. However, recent developments have indicated that, in the absence of the rule, US airlines would not operate FRM unless the FAA required it. As a result, we now include Boeing production costs as incremental costs of the rule in this Regulatory Evaluation. However, the B-787 is required to have FRM under its certification even if the FRM final rule is not promulgated. Therefore, we exclude the B-787 from the cost and benefit analyses.

V.D.2. Methodology

Although the rule does not require fuel tank inerting (FTI), at this time it is the only practical system available to implement FRM. Consequently, the compliance costs of the rule are based on the cost to install and operate FTI. Should a less-expensive FRM system be developed, then we will have overestimated the compliance cost.

The incremental compliance costs can be expressed in one of two analytically equivalent methods: (1) the discounted present value; and (2) the annualized cost. The discounted present value is the sum of each future year's costs over the time period discounted by the rate of return back to the first year. The annualized cost is calculated by transforming the discounted total present value into a yearly cost based on the annual rate of return.

For this analysis, we used the discounted present value approach because, as will be shown, about 75 percent of the present value costs are incurred during the first 10 years. Using an annualized cost presents a misleading picture because it implies that the compliance costs could be evenly distributed over the entire time-period, when, in fact, the costs are front-end loaded.

Finally, as was used to discount the quantified benefits, we used the OMB-mandated discount rates of 7 percent and 3 percent,[54] with 7 percent serving as the baseline value and 3 percent serving as part of the sensitivity analysis.

V.D.3. Data Sources

The data sources for the FTI unit casts are those reported in the IRE, which were based on the ARAC groups, and the costs reported in the Boeing, Airbus, and ATA comments.

V.E. FINAL RULE COMPLIANCE DATES

In completing these cost calculations, we assumed that the final rule will be published on January 1, 2008. The rule requires production airplanes to be in compliance within 2 years (January 1, 2010) and all airplanes to be in compliance within 7 years after retrofitting kits become available (but no later than 9 years after the final rule publication date (January 1, 2018)).

As it is more expensive to retrofit equipment than to install it as original equipment, we anticipate that Boeing and Airbus customers will pressure them to install FRM systems in their production airplanes as soon as possible in order for the air carriers to avoid retrofitting costs. Using that logic, we determined that all engineering and prototype work will be completed and all associated parts and components necessary for production airplane models will be available within 1 year, while it will take the manufacturers 2 years to perform these tasks for airplane models no longer in production. We also determined that the retrofitting kits will be available in 2 years. Thus, we determined that production airplanes will be in compliance starting on January 1, 2009, and that retrofitting will begin on January 1, 2010.

V.F. SOURCES OF COMPLIANCE COSTS

In the IRE, we evaluated the following 8 potential general compliance cost categories:

1. One-time costs to reengineer, redesign, test, and recertificate FTI systems;

[54] Office of Management and Budget, OMB Circular No. A-4, New Guidelines for the Conduct of Regulatory Analysis, Mar. 2, 2004.

2. One-time equipment and labor costs to retrofit airplanes;
3. One-time losses from additional out-of-service time to complete the retrofits;
4. Yearly costs to install FTI on production airplanes;
5. Annual additional fuel consumption costs due to the FTI system weight;
6. Annual additional fuel consumption costs due to the increased amount of bleed air and increased drag;
7. Annual inspection, maintenance, and replacement costs of the FTI equipment; and
8. Periodic air separation module (ASM) replacement.

No one reported any additional cost categories that we had overlooked in the IRE. Finally, the several spreadsheets containing the data and calculations for the compliance costs are provided in Appendices V-1 through V-16.

V.G. UNIT LABOR COSTS

For an engineer's compensation rate, we used an aerospace manufacturer engineer's average hourly wage rate. This average wage rate was then adjusted to include fringe benefits, which transforms it into an hourly compensation rate. This hourly compensation rate was further adjusted to include the supervisory, clerical, administrative, and legal time not otherwise included necessary to complete an engineering analysis for an amended type certificate (TC). As an engineering specialist in fuel tanks is highly paid, we determined that the typical manufacturer engineer is paid at the 90th percentile of the Department of Labor category of Aviation Engineer. On that basis, we calculated an adjusted engineer total compensation rate of $110[55] an hour. At an average engineer work year of 2,000 hours, the engineer-year adjusted compensation rate is $220,000.[56]

We used the same approach for airplane mechanics in the manufacturers, major airlines, and large repair stations that will perform the installations and retrofits. Fringe benefits are added to the hourly airplane mechanic wage rate to obtain an hourly compensation rate. Then, rather than estimating individual hours and costs of additional supervisory, clerical, and administrative labor, we factored those costs into the airplane

[55] The two ARAC working groups used the same approach.
[56] We had used an engineer hourly compensation rate of $115 in the IRE.

mechanic hourly compensation rate. Finally, we determined that the typical air carrier and large repair station aviation mechanic is paid at the 90th percentile of the Department of Labor category of Airplane Mechanic. Therefore, we calculated an adjusted total compensation rate of $80 an hour for an airplane mechanic.[57] At an average airplane mechanic work year of 2,000 hours, the mechanic-year adjusted compensation rate is $160,000.[58]

V.H. ONE-TIME ENGINEERING COSTS TO DESIGN FTI SYSTEMS

V.H.1. Introduction

The rule will require Boeing and Airbus to:

1. engineer FTI systems for their airplane models;
2. provide documents (specifications, ICDs, etc.)
3. provide manuals (flight manuals, maintenance manuals, etc.)
4. lab and flight/ground test these systems;
5. submit the drawings, data, and test results for FAA approval of the FTI system amended TC.

With respect to future type certificated airplanes, the rule imposes minimal incremental engineering costs on these future designs.

V.H.2. Types of Engineering Assessments

In the IRE, we had developed a methodology for estimating the engineering assessment costs that anticipated significant carryover of the data and results from the first engineering assessment to later engineering assessments, resulting in fewer labor hours and less testing for these later assessments. We also anticipated that FTI system amended TCs would be issued on an airplane "model" (e.g., a B-767) basis. However, minor modifications of the amended TCs will need to be made for each "model series" (e.g., a B-737-700, a B-737-800, etc. In the IRE, we labeled the very first FTI assessment the "initial" assessment, the airplane model FTI assessments as the “model”

[57] In the IRE we had used a rate of $80 an hour. The EASA used an estimated mechanic rate of $78 an hour based on 15 of its European airlines.
[58] Only skilled airplane mechanics employed by the manufacturers, the major airlines, and the large repair stations will work on these FTI installations.

assessments, and the airplane model series FTI assessments as the "derivative" assessments.

The Boeing and Airbus comments used this same approach and terminology and we continue its use in this Regulatory Evaluation.

The Boeing production airplane models are the B-737-NG, the B-747, the B-767, the B-777, and the B-787[59] while their out-of-production models are the B-737-Classic, the B-747-100/200/300, and the B-757. The Airbus production airplane models are the A-320 family, the A-330, the A-340, the A-350, and the A-380[60] while their out-of-production models are the A-300 and the A-310.

In the IRE, we had determined that the initial Airbus FTI system assessment would be the prototype for all Airbus models. For Boeing, we had determined that two different FTI system initial assessments would be needed – one for the B-747 and one for all their other models.

Airbus commented that we had underestimated the number of FTI engineering assessments they needed to complete. We incorporate the Airbus numbers into this analysis with the exception of lowering their reported 3 models and 5 derivatives for the A-330 and A-340 models to 3 models (which includes the A-350) and 3 derivatives.

Boeing commented that the B-737-200 fuel system was such that the B-737-Classic design could not be adapted for it and an entirely new FTI assessment is necessary for the B-737-200. They similarly commented that the B-747-100/200/300 fuel systems were such that the B-747-400 FTI assessment could not be adapted for those earlier B-747 models. We agree with the Boeing comments. However, in practice, as we determined that B-737-200s and B-747-100/200/300s will no longer be in air carrier scheduled passenger service by 2018, we calculated no engineering FTI assessment costs for them.

In distributing the FTI engineering assessment costs between passenger and cargo airplanes, we exclusively attributed the engineering costs to the passenger operation

[59] As the B-787 is required to have FRM to comply with its existing certification, this model would incur no incremental engineering assessment costs due to the final rule.
[60] The engineering work for FRM has been completed for the A-380. However, it will not be installed unless required by a final rule.

when a model is used in both passenger and cargo operations because the passenger operation nearly always provides the bulk of the production.

As shown in Table V-4, which summarizes Appendix V-1, Boeing will complete 2 initial, 3 model, and 6 derivative FTI engineering assessments for their production passenger airplane models and 2 model and 3 derivative FTI assessments for their out-of-production models. Airbus will perform 1 initial, 4 model, and 6 derivative FTI engineering assessments for their production passenger airplane models. The 3 model and 1 derivative FTI assessments for the out-of-production A-300/A-300-600 and the A-310 apply only to air carrier cargo airplanes because these models will not be in US air carrier passenger service.

TABLE V-4

NUMBERS OF PASSENGER AIRPLANE ENGINEERING ASSESSMENTS FOR FTI AMENDED TCs BY TYPE OF ASSESSMENT AND PRODUCTION STATUS

MODEL	INITIAL	FIRST MODEL	DERIVATIVE
B-737-300/4/5	0	1	2
B-737-NG	1	1	2
A-320 FAMILY	1	1	3
B-757-200/300	0	1	1
B-767-200/3/4	0	1	2
B-787	0	0	0
A-300/A-300-600	0	0	0
A-310	0	0	0
A-350	0	1	0
A-330-200	0	1	0
A-330-300	0	0	0
A-340-200/3/5/6	0	1	3
A-380	0	0	0
B-747-100/200/300	0	0	0
B-747-400	1	0	0
B-747-800	0	0	1
B-777-200/3	0	1	1
TOTAL	**3**	**9**	**15**
BOEING	2	5	9
AIRBUS	1	4	6
TOTAL	**3**	**9**	**15**
BOEING OUT-OF-PRODUCTION	0	2	3
AIRBUS OUT-OF-PRODUCTION	0	0	0
TOTAL OUT-OF-PRODUCTION	**0**	**2**	**3**

BOEING PRODUCTION	2	3	6
AIRBUS PRODUCTION	1	4	6
TOTAL PRODUCTION	**3**	**7**	**12**

V.H.3. Engineering Costs per FTI Engineering Assessment

The breakdown for the number of hours to complete each engineering task and their associated dollar costs plus the testing costs for each of the 3 FTI engineering assessments by airplane category is presented in Appendix V-2.

In summary, 81,200 engineering and 25,000 lab and ground/flight test hours will be needed for the initial engineering assessment (a cost of $11.732 million), 46,175 engineering and 3,200 lab and ground/flight test hours will be needed for a first model engineering assessment (a cost of $5,456), and 23,250 engineering and 1,600 to 2,000 lab and ground/flight test hours will be needed for a derivative engineering assessment (at a cost of $2.744 million to $2.788 million).

V.H.4. Total FTI Passenger Airplane Engineering Assessment Costs

All of the Boeing FTI engineering assessment costs are incremental costs of the final rule. Although the EASA has indicated it intends to require FRM on production airplanes, it has not promulgated that rule. Consequently, all of the Airbus FTI engineering assessment costs are incremental compliance costs.

The FTI engineering assessments for production airplanes will be completed in 2008 in order to start installation in 2009. It will take 2 years (2009 and 2010) to complete the FTI engineering assessments for out-of-production airplane models because they will be lower priority than the ones for production airplanes.[61]

As shown in Table V-5, which summarizes Appendix V-1, the final rule total FTI engineering assessment costs to develop and obtain the amended TCs will be about $126 million,[62] which has a present value of $116 million using a 7 percent discount rate and a present value of $121 million using a 3 percent discount rate. The engineering assessment costs for retrofitting airplanes will be about $19 million, which has a present

[61] Many of the same engineers will be used on both types of projects and the production models will be given priority.

[62] If the final rule included retrofitting cargo airplanes then the engineering costs would increase by the costs for A-300 & A-310 models because they are the only exclusively cargo models. This increase would be about $22 million, which has a present value of $18.5 million using a 7 percent discount rate and a present value of $20 million using a 3 percent discount rate.

value of $16 million using a 7 percent discount rate and a present value of $18 million using a 3 percent discount rate. The engineering assessment costs for production airplanes will be about $107 million, which has a present value of $100 million using a 7 percent discount rate and a present value of $103 million using a 3 percent discount rate.

TABLE V-5

UNDISCOUNTED AND PRESENT VALUE ENGINEERING ASSESSMENT COSTS FOR AIR CARRIER PASSENGER AIRPLANE AMENDED TCs
(in Millions of 2007 Dollars)

		TOTAL ENGINEERING COSTS		
MODEL	PRODUCTION (P) RETROFIT (R)	UNDISCOUNTED	PRESENT VALUE COST (7%)	PRESENT VALUE COST (3%)
Small				
B-737-300/4/5	R	$ 10.943	$ 9.246	$ 10.165
B-737-NG	P	$ 22.675	$ 21.192	$ 22.015
A-320 FAMILY	P	$ 25.419	$ 23.756	$ 24.678
Total		**$ 59.037**	**$ 54.193**	**$ 56.858**
Medium				
B-757-200/300	R	$ 8.222	$ 6.946	$ 7.637
B-767-200/3/4	P	$ 10.987	$ 10.268	$ 10.667
B-787	P	$ 0.000	$ 0.000	$ 0.000
A-300/A-300-600	R	$ 0.000	$ 0.000	$ 0.000
A-310	R	$ 0.000	$ 0.000	$ 0.000
A-350	P	$ 5.456	$ 5.099	$ 5.297
Total		**$ 24.665**	**$ 22.314**	**$ 23.601**
Large				
A-330-200	P	$ 5.456	$ 5.099	$ 5.297
A-330-300	P	$ 0.000	$ 0.000	$ 0.000
A-340-200/3/5/6	P	$ 13.819	$ 12.915	$ 13.416
A-380	P	$ 0.000	$ 0.000	$ 0.000
B-747-100/200/300	R	$ 0.000	$ 0.000	$ 0.000
B-747-400	P	$ 11.732	$ 10.964	$ 11.390
B-747-800	P	$ 2.788	$ 2.605	$ 2.706
B-777-200/3	P	$ 8.244	$ 7.704	$ 8.004
Total		**$ 42.038**	**$ 39.288**	**$ 40.814**
GRAND TOTAL		**$125.741**	**$115.795**	**$121.273**
BOEING		**$ 75.591**	**$ 68.926**	**$ 72.584**
AIRBUS		**$ 50.150**	**$ 46.869**	**$ 48.689**
BOEING OUT-OF-PRODUCTION		**$ 19.165**	**$ 16.192**	**$ 17.802**

AIRBUS OUT-OF-PRODUCTION		**$ 0.000**	**$ 0.000**	**$ 0.000**
TOTAL OUT-OF-PRODUCTION		**$ 19.165**	**$ 16.192**	**$ 17.802**
BOEING PRODUCTION		**$ 56.426**	**$ 52.734**	**$ 54.782**
AIRBUS PRODUCTION		**$ 50.150**	**$ 46.869**	**$ 48.689**
TOTAL PRODUCTION		**$106.576**	**$ 99.603**	**$103.471**

V.I. UNIT COSTS TO RETROFIT FTI IN A PASSENGER AIRPLANE

V.I.1. Airplane Model Categories

In the IRE, we had estimated the unit FTI retrofitting costs using the following 3 generic airplane model categories:

1. Large (B-747, B-777, and A-330/340);
2. Medium (B-767 and A-300/310); and
3. Small (B-737, B-757, and A-320 "family").

Although the Appendices are based on a 17 model system, in accordance with the docket comments, we revised our generic airplane model categories into the following 9 categories:

1. B-737-300/400/500 (B-737 Classic);
2. B-737-600/700/800/900 (B-737 NG) until January 2006;
3. B-737-600/700/800/900 (B-737 NG) from January 2006 through 2008;
4. A-318/319/320/321 (A-320 Family);
5. B-757;
6. B-767, B-787; A-300, A-310, & A-350;
7. B-777, A-330
8. B-747-100/200/300; and
9. B-747-400/800, A-340, & A-380.

V.I.2. Unit Retrofitting Costs

V.G.2.a. Retrofitting Kit Costs

In the IRE, we relied primarily on Boeing and ARAC data for the unit retrofitting kit costs. Boeing, the ATA, and Airbus commented on these unit costs and we have revised our unit costs in this Final Regulatory Evaluation as appropriate. While Boeing did not provide individual cost components (as had been provided by ARAC 2) due to proprietary concerns, they reported their aggregate kit costs and noted that most of their individual component costs were similar to the ARAC costs.[63] The ATA reported the prices that some of their members had been quoted by Boeing. Airbus did not provide individual kit component estimates or specific kit costs, but made a general comment that we had underestimated the retrofitting costs in the IRE by "a factor of 2 or 3".

However, United/Shaw Aero Devices/Air Liquide has recently developed an FTI to retrofit in airplanes and they have reported kit costs of about 30 percent less than the Boeing kit costs. As they have a patent for the system and operational prototypes, we have used the United/Shaw Aero Devices/Air Liquide retrofitting kit costs in this analysis.

In the IRE, the kit costs were $164,000 for a large airplane, $123,000 for a medium-sized airplane, and $105,000 for a small airplane. As shown in Table V-6, we use the United/Shaw Aero Devices/Air Liquide retrofitting kit costs of $175,000 to $192,500 for a large airplane, $164,500 for a medium-sized airplane, and $77,000 for a small airplane.

TABLE V-6[64]

COMPARISON OF BOEING AND UNITED/SHAW AEROSPACE/AIR LIQUIDE RETROFITTING KIT COSTS TO THE ESTIMATED ARAC RETROFITTING KIT COST

MODEL	ARAC RETROFIT KIT COST	BOEING RETROFIT KIT COST	BOEING KIT COST/ARAC KIT COST	UNITED RETROFIT KIT COST	UNITED KIT COST/ARAC KIT COST
B-737-CLASSIC	$105,398	$110,000	1.044	$ 77,000	0.731
B-737-NG	$105,398	$110,000	1.044	$ 77,000	0.731
B-737-NG Late	$105,398	$110,000	1.044	$ 77,000	0.731
B-757	$105,398	$235,000	2.230	$120,750	1.104
B-767	$123,356	$235,000	1.905	$164,500	1.334
B-747-1/2/300	$163,854	$250,000	1.526	$175,000	1.068
B-747-400	$163,854	$250,000	1.526	$175,000	1.068
B-747-800	$163,854	$250,000	1.526	$175,000	1.068

[63] Appendix V-3 contains a list of the individual retrofitting kit components with their draft ARAC unit costs that were used in the IRE.
[64] The large increase in the Boeing estimated B-757 kit cost is a result of Boeing reclassifying it as a B-767-sized airplane whereas it had been classified as a "small" airplane by ARAC. United has classified it as well as the A-300 and A-310 as midway between a small airplane and a B-767.

B-777	$163,854	$275,000	1.678	$192,500	1.175
B-787	$0	$0	0.000	$0	0.000
A-300/300-600	$123,356	$235,000	1.905	$120,750	0.979
A-310	$123,356	$235,000	1.905	$120,750	0.979
A-320 FAMILY	$105,398	$110,000	1.044	$ 77,000	0.731
A-330	$163,854	$275,000	1.678	$192,500	1.175
A-340	$163,854	$250,000	1.526	$175,000	1.068
A-350	$123,356	$235,000	1.905	$164,500	1.334
A-380	$163,854	$250,000	1.526	$175,000	1.068

A major cause for these increases is the significantly increased unit cost of the air separation modules (ASMs) for all models (except for small airplanes) and the increased number of ASMs needed for a FTI system. In the IRE, the estimated unit ASM costs were $29,000 for a large airplane, $19,000 for a medium airplane, and $5,275 for a small airplane. Boeing reported that the ASM spares costs will be between $135,000 and $150,000 for a large airplane, about $150,000 for a medium-sized airplane, and between $30,000 and $45,000 for a small airplane.[65]

V.I.2.b. Labor Costs

As noted in the IRE, the labor hours to retrofit an airplane depend upon whether the retrofit would be completed during a major check or during a dedicated maintenance session. A significant amount of the labor (such as opening the tank, venting the tank, closing the tank, etc) for a FTI retrofit will have been done during a major check in order for the mechanics to complete other mandatory maintenance tasks (such as tank inspections). These activities to open up the airplane will need to be re-done if the retrofit were performed during a dedicated maintenance session.

In the IRE, we used the ARAC-reported labor hours to complete a retrofit (see Appendix V-3). These labor hours had been provided by airlines' representatives to the ARAC. In the IRE, a retrofit done during a major check was estimated to take 416 hours for a large airplane, 409 hours for a medium-sized airplane, and 356 hours for a small airplane. A retrofit done during a dedicated maintenance session was estimated to take

[65] These are "spares" costs, which are generally 1.5 to 2 times greater than the component cost when it is part of the original kit. As Boeing did not provide a kit ASM component cost, we used the spares costs to illustrate the probable ASM cost increase. Airbus did not provide any specific costs, but they commented that the ASMs had become significantly more expensive than the ARAC group had been informed by suppliers.

527 hours for a large airplane, 520 for a medium-sized airplane, and 467 hours for a small airplane.

The ATA commented that their airlines had reported that their FTI retrofitting labor hours for the FTI system were greater than the labor hours that had been supplied to ARAC. They reported that it will take 694 labor hours to retrofit a large airplane during a major check, 674 labor hours to retrofit a medium-sized airplane during a major check, and 594 hours to retrofit a small airplane during a major check. We accept the ATA comment as the number of labor hours necessary to install the FTI system that was in development.

Since the NPRM, Boeing has reported that it has begun manufacturing B-737-NGs equipped with the in-take plumbing, some of the wiring, and the bracketing to install FTI. They reported that these pre-installations will have a minimal effect on the kit cost and a minimal impact on the airplane's weight, but they will reduce the retrofitting labor hours by half. They further anticipate equipping the 225 post-January 2006 B-737-NGs with this FTI pre-installation set. We accept the Boeing statements and cut the retrofitting labor hours for these 225 B-737-NGs by half.[66]

United/Shaw Aero Devices/Air Liquide report that it will take 294 labor hours to retrofit its system during a major maintenance check. We accept their base estimate for their system. However, it is generally the case that the supplier may not completely consider all of the installers labor hours. Consequently, we adjust the United/Shaw Aero Devices/Air Liquide labor estimate upward by the same percentage that the ATA reported for the labor hours necessary to install FTI relative to those reported by the supplier.

On that basis, we calculated that retrofitting an airplane during a dedicated maintenance session will take 347 labor hours for a large airplane, 337 labor hours for a medium-sized airplane, and 294 labor hours for a small airplane. These results are detailed in Appendix V-4.

[66] It should be noted that Boeing is placing these FTI pre-installations in only B-737-NGs that have been sold to U.S. operators. These pre-installations are not being equipped on non-US registered B-737-NGs.

However, those labor hours are based on the labor time needed to retrofit the first several airplanes. As far back as 1939[67], T.P. Wright recognized the repetition of the same operation results in reduced efforts expended on that operation.[68] Direct labor man-hours necessary to complete a unit of production would decrease by a constant percentage each time the production quantity is doubled. Learning or cost improvement occurs due to worker increases in efficiency and the implicit training in repetition. T.P. Wright found that an 80% learning efficiency has been a common occurrence in airplane production. We assume that this 80 percent learning efficiency also applies to retrofitting operations.

We estimate the labor hour efficiencies for retrofitting FTI on the xth set of airplanes (Y_x) as follows:

$$Y_x = a * x^b$$

Where Y_x = cumulative average time to install a number of units,

a = time to install the first unit by equipment group,

x = the sequential period of installation time,

b = index of learning (b = log (learning curve) / log (2)),

learning curve = 80.

In order to estimate the learning efficiency savings for installing ADS-B Out on newly delivered and active aircraft, we used the initial hours by model to retrofit FTI systems. The learning efficiencies begin in 2010 and extend to the start of 2018, the time in which the retrofits will be installed.

[67] The learning curve effect states that the more times a task has been performed, the less time will be required on each subsequent iteration. This relationship was first quantified in 1936 at Wright-Patterson Air Force Base in the United States. In the late 1960s Bruce Henderson of the Boston Consulting Group (BCG) began to emphasize the implications of the experience curve for strategy and in 1972 published “Perspectives on Experience”. This book explains the experience curve effect, which is an observation that the costs of virtually every class of products decline by a constant and predictable percentage over time, as a function of experience. Recently, in 1991, Charles J. Teplitz published the “The Learning Curve Deskbook” which provides a basic understanding of the underlying theory of learning curves, as well as ready access to commonly used learning curve models, formulas, and tables. .

[68]“American Methods of Aircraft Production”, T.P. Wright, 1939.

By way of example, assume that 10 airplanes are retrofitted every year and it takes 100 hours for each retrofit. After the second year, when a total of 20 airplanes have been retrofitted, the labor hours will decrease by 20 percent starting in year 3 to 80 hours an airplane. After the fourth year, when a total of 40 airplanes have been retrofitted, the 80 labor hours will decrease by 20 percent starting in year 5 to 64 hours an airplane. After year 8 when a total of 80 airplanes have been retrofitted, the 64 labor hours will decrease by 20 percent starting in year 9 to 51.2 hours an airplane, etc.[69]

Using an airline mechanic burdened compensation rate of $80 an hour, the labor costs for the first FTI retrofits based on the United/Shaw Aero Devices/Air Liquide estimates done during a major check range from $23,520 to $27,760 an airplane. For a retrofit done during a dedicated maintenance session, these labor costs range from $30,853 to $34,277 an airplane.[70] For one of the 225 post-January 2006 B-737-NGs with the pre-installation, the labor costs during a major check will be $11,760 and will be $15,427 during a dedicated maintenance session.

V.I.2.c. Equipment and Labor Costs

Thus, the equipment and labor costs to retrofit FTI during a major check will be between $100,520 and $220,260. For a retrofit completed during a dedicated maintenance session, these equipment and labor costs will be between $107,853 and $227,667. For one of the 225 post-January 2006 B-737-NG retrofits, these equipment and labor costs will be $88,760 during a major check and $92,427 during a dedicated maintenance session. However, the actual labor costs will decrease over time as the learning curve reduces the number of labor hours to complete these retrofits.

V.I.2.c. Out of Service Losses

Even if the retrofit were completed during a major check, the airplane will incur additional out-of-service time and economic loss. In the IRE, we had estimated that the average increase in out-of-service time during a major check would be 1 day while a

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[69] Of course, using natural logs means that this is a continuous improvement function. The discrete example in the text is to help the reader understand the underlying principle.

[70] However, as these labor hours will occur in 2016 and 2017, the learning curve effects will have reduced the number of hours by about 45 percent. This, paradoxically, makes the actual labor hours higher for airplanes retrofitted during a regular maintenance session in the early years (2010 – 2012) greater than the labor hours for airplanes retrofitted during special maintenance sessions in 2016 and 2017.

dedicated maintenance visit would keep the airplane out of service for 4 days.

The ATA and Airbus commented that a retrofit completed during a major check will add 2 days of out-of-service time. We agree with their comments and incorporate them into this analysis. However, for one of the 225 post-January 2006 B-737-NG retrofits, the additional out-of-service time will be 1 day. The ATA did not comment on the number of out-of-service days for a dedicated visit, while Airbus commented that a retrofit during a medium check will add 5 out-of-service days and a retrofit during a dedicated session will involve 7 days out-of-service. We determined that the average number of out-of-service days from a dedicated visit will be 6 days for all airplanes, including the United/Shaw Aero Devices/Air Liquide package.

However, as the labor hours to retrofit decline, so does the time out-of-service. We determined that there is a direct correlation between the percentage reduction in labor hours and the amount of time an airplane will be out of service for the retrofit. Thus, we apply the same 80 percent learning curve to the amount of out-of-service time.

In the IRE, we used a pro-rated monthly lease rate to estimate the economic losses from an airplane being out of service. Both the ATA and Airbus commented that we should have used net operating revenue loss. We disagree. Our analysis of the economic losses from an out-of-service airplane is based on the overall aviation system losses, which is not the same as an airline's lost net operating revenue. For example, most passengers who would have flown Airline A but for Airline A's airplane being retrofitted would book passage on Airline B. Thus, one airline's net operating revenue loss is largely offset by another airline's net operating revenue gain. The losses to the aviation system from out-of-service time are from the passengers who would have flown, but did not fly due to the retrofitted airplane's unavailability or who incurred losses from not traveling at their ideal price or time.

We use the average lease rates to proxy the aviation system losses from out-of-service time.[71] Lease rates reflect the average amount an operator would pay to maintain

[71] This does not mean that an air carrier can actually lease an airplane for a day because there are substantial transactions costs in transporting the airplane, completing the paperwork, etc.

its schedule. Based on the FAA economic values,[72] we calculated that the average daily lease rate ranges from $4,776 to $13,915 an airplane.[73] As shown in Table V-5, we calculated that two days out-of-service losses will be between $9,552 and $27,829. Six days out-of-service losses will be between $28,656 and $83,448.

As shown in Table V-6, the costs plus out-of-service losses for a retrofit performed during a major check will be between $111000 and $249,000 an airplane and between $121,000 and $311,000 for an airplane retrofitted during a dedicated session. For one of the 225 post-January 2006 B-737-NGs, the costs plus out-of-service losses will be $98,000 during a major check and $121,000 during a dedicated session.

TABLE V-6

COSTS TO INITIALLY RETROFIT FTI BY AIRPLANE MODEL
(in Thousands of 2007 Dollars)

	HEAVY CHECK				DEDICATED VISIT			
MODEL	TOTAL	KIT	LABOR	OUT-OF-SERVICE	TOTAL	KIT	LABOR	OUT-OF-SERVICE
B-737-CLASSIC	$111	$ 77	$24	$10	$137	$ 77	$31	$29
B-737-NG	$111	$ 77	$24	$10	$137	$ 77	$31	$29
B-737-NG Late	$ 98	$ 77	$15	$ 6	$121	$ 77	$15	$29
B-757	$167	$121	$27	$19	$211	$121	$34	$56
B-767	$214	$165	$27	$22	$264	$165	$34	$65
B-747-1/2/300	$219	$175,	$28	$26	$289	$175,	$35	$79
B-747-400	$229	$175	$28	$26	$289	$175	$35	$79
B-747-800	$229	$175	$28	$26	$289	$175	$35	$79
B-777	$249	$193	$28	$28	$311	$193	$35	$83
B-787	$0	$0	$0	$0	$0	$0	$0	$0
A-300/300-600	$214	$165	$27	$22	$220	$121	$34	$65
A-310	$214	$165	$27	$22	$220	$121	$34	$65
A-320 FAMILY	$111	$ 77	$24	$10	$137	$ 77	$31	$29
A-330	$249	$193	$28	$28	$311	$193	$35	$83
A-340	$229	$175	$28	$26	$289	$175	$35	$79
A-350	$214	$165	$27	$22	$264	$165	$34	$65
A-380	$229	$175	$28	$26	$289	$175	$35	$79

By way of illustration, as shown in Table V-7, we provide the undiscounted cost of retrofitting an airplane in 2010 and the cost of retrofitting an airplane in 2017, after applying the learning curve. If the retrofit is done during a scheduled maintenance

[72] GRA, Incorporated, Draft Final Report, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Table 5-2, p. 5-4, December 31, 2004.

[73] Lease rates are functions of both the number of seats and the costs of operating the airplane. Newer airplanes cost less to operate and, on average, the medium airplane fleet is several years younger than the large airplane fleet.

session, the undiscounted costs fall by $10,000 to $28,000 an airplane from 2020 to 2017. If the retrofit is done during a dedicated visit, the undiscounted costs fall by $21,000 to $56,000 an airplane from 2020 to 2017.[74]

TABLE V-7

UNDISCOUNTED COSTS TO RETROFIT FTI BY AIRPLANE MODEL IN 2010 AND IN 2017
(in Thousands of 2007 Dollars)

	HEAVY CHECK			DEDICATED VISIT		
MODEL	2010	2017	DIFFERENCE	2010	2017	DIFFERENCE
B-737-CLASSIC	$111	$ 94	$17	$137	$107	$30
B-737-NG	$111	$ 94	$17	$137	$107	$30
B-737-NG Late	$98	$ 88	$10	$121	$100	$21
B-757	$167	$144	$23	$211	$152	$59
B-767	$214	$190	$24	$264	$216	$48
B-747-1/2/300	$219	$203	$16	$289	$233	$56
B-747-400	$229	$203	$26	$289	$233	$56
B-747-800	$229	$203	$26	$289	$233	$56
B-777	$249	$221	$28	$311	$253	$58
B-787	$0	$0	$0	$0	$0	$0
A-300/300-600	$214	$190	$24	$264	$216	$48
A-310	$214	$190	$24	$264	$216	$48
A-320 FAMILY	$111	$ 94	$17	$137	$107	$30
A-330	$249	$221	$28	$311	$253	$58
A-340	$229	$203	$26	$289	$233	$56
A-350	$214	$190	$24	$264	$216	$48
A-380	$229	$203	$26	$289	$233	$56

V.J. TOTAL COSTS TO RETROFIT FTI

V.J.1. Assumptions

We made the following assumptions to calculate the total retrofitting costs.

1. The retrofitted airplanes will be those in service as of January 1, 2018, and manufactured before January 1, 2009, the date at which FTI will be installed on all affected production airplanes.
2. Airplanes from out-of-production models will be retired first because they are generally the oldest.
3. Retrofitting will begin on January 1, 2010.

[74] In present value terms, the savings from completing the retrofit in 2017 rather than in 2010 would be between $18,000 and $51,000 per airplane if done during a scheduled maintenance check and between $39,000 and $103,000 if done during a special maintenance session.

4. Eighty five percent of the retrofits will be completed during a scheduled major maintenance check because the operator has 7 to 8 years after the amended TCs have been issued to retrofit the airplane.
5. Fifteen percent of the retrofits will be completed during a dedicated maintenance session. These will occur primarily because an operator or a lessor had planned to retire an airplane, but changed its plans and wants to continue the airplane in active service. The dedicated maintenance session retrofits will occur during the last 2 years for compliance; i.e., during 2016 and 2017.

V.J.2. <u>Numbers of Retrofitted Airplanes</u>

As shown in Table V-8, which summarizes Appendix V-5 that contains these numbers by model, we determined that 2,732 air carrier passenger airplanes will be retrofitted with FTI. Of the 2,732 airplanes, 2,322 will be retrofitted during a major check and 410 will be retrofitted during a dedicated maintenance session, while 1,780 will be Boeing airplanes and 952 will be Airbus airplanes

An average of 290 air carrier passenger airplanes will be retrofitted in each year during a “D” check. Finally, an average of 205 airplanes will be retrofitted during a special maintenance session in 2016 and in 2017.

TABLE V-8

NUMBER OF RETROFITTED AIR CARRIER PASSENGER AIRPLANES BY TYPE OF MAINTENANCE SESSION

	NUMBER OF RETROFITS COMPLETED		
YEAR	TOTAL	“D” CHECK	SPECIAL SESSION
2010	290	290	0
2011	290	290	0
2012	290	290	0
2013	290	290	0
2014	290	290	0
2015	290	290	0
2016	496	291	205
2017	496	291	205
TOTAL	**2,732**	**2,322**	**410**

BOEING	**1,780**	**1,513**	**267**
AIRBUS	**952**	**809**	**143**

V.J.3. Total Retrofitting Costs

We multiplied the number of retrofitted airplanes by model for each year (Table V-8) by the unit costs per model per type of retrofit (Tables V-6 and V-7) as modified by the learning curve. As shown in Table V-9, the total costs to retrofit passenger airplanes will be $346 million, which has a present value of $220 million using a 7 percent discount rate and a present value of $283 million using a 3 percent discount rate. As presented in Appendix V-5, the costs for airplanes retrofitted between 2010-2017 during major checks will be $291 million which has a present value of $191 million using a 7 percent discount rate and a present value of $242 million using a 3 percent discount rate. Further, as presented in Appendix V-5, of the undiscounted $125 million spent in 2016 and 2017 for retrofitting costs, $70 million will be spent during regularly scheduled maintenance sessions and $55 million will be spent during special maintenance sessions.

TABLE V-9

SUMMARY OF THE UNDISCOUNTED AND PRESENT VALUE ANNUAL COSTS TO RETROFIT FTI ON AIR CARRIER PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	$ 39.980	$ 32.635	$ 36.587
2011	$ 37.825	$ 28.856	$ 33.607
2012	$ 36.770	$ 26.216	$ 31.718
2013	$ 36.101	$ 24.055	$ 30.234
2014	$ 35.623	$ 22.184	$ 28.964
2015	$ 35.257	$ 20.520	$ 27.832
2016	$ 62.725	$ 34.118	$ 48.074
2017	$ 62.182	$ 31.610	$ 46.269
TOTAL	**$346.462**	**$220.196**	**$283.285**

As shown in Table V-10, which summarizes Appendix V-5, of the undiscounted costs of $346 million, Boeing airplane operators will incur $241 million and Airbus airplane operators will incur $105 million. Of the present value costs of $220 million using a 7 percent discount rate, Boeing airplane operators will incur $153 million and Airbus airplane operators will incur $67 million. Of the present value of $283 million using a 3 percent discount rate, Boeing airplane operators will incur $197 million and Airbus airplane operators will incur $86 million.

TABLE V-10

TOTAL AND PRESENT VALUE OF THE COSTS TO RETROFIT FTI ON AIR CARRIER PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$241	$153	$197
AIRBUS	$105	$ 67	$ 86
TOTAL	**$346**	**$220**	**$283**

V.K. COSTS TO INSTALL FTI ON A PRODUCTION PASSENGER AIRPLANE

V.K.1. Unit Cost to Install on a Production Airplane

In the IRE, we used the ARAC production FTI installation costs detailed in Appendix V-6. Neither Boeing nor Airbus provided data on the cost to install FTI on their production airplanes because they consider those data to be proprietary. In this Regulatory Evaluation we used the initial ARAC production kit cost estimate as the basis for the production airplane equipment cost and assumed that the percentage increases in the Boeing retrofitting kit costs over the initial ARAC retrofitting kit costs will be the same percentage increases for the Boeing production kit costs over the initial ARAC production kit costs. We then applied these estimated kit costs for the Boeing models to the similar Airbus models.

We use the same number of labor hours reported by ARAC and used in the IRE (ranging from 80 to 94 labor hours ($6,400 to $7,520) per airplane) for this Regulatory Evaluation because no comments were made about them. We also applied the learning curve methodology to the labor hours to install FTI.

Finally, as in the IRE, installing FTI does not increase the number of days to manufacture an airplane.

Thus, as shown in Table V-11, which summarizes Appendix V-7, the costs to install FTI on a production airplane range from about $95,000 to about $213,000.

TABLE V-11

INITIAL COSTS TO INSTALL FTI ON A PRODUCTION PASSENGER AIRPLANE BY MODEL

	COST		
MODEL	TOTAL	KIT	LABOR
B-737-CLASSIC	$0	$0	$0
B-737-NG	$ 98,333	$ 91,933	$6,400
B-737-NG-NEW	$ 94,533	$ 91,933	$3,200
B-757	$0	$0	$0
B-767	$0	$0	$0
B-747-1/2/300	$0	$0	$0
B-747-400	$193,951	$186,431	$7,520
B-747-800	$193,951	$186,431	$7,520
B-777	$212,594	$205,074	$7,520
B-787	$193,160	$185,640	$7,520
A-300/300-600	$0	$0	$0
A-310	$0	$0	$0
A-320 FAMILY	$ 98,333	$ 91,933	$6,400
A-330	$212,594	$205,074	$7,520
A-340	$193,951	$186,431	$7,520
A-350	$193,160	$185,640	$7,520
A-380	$193,951	$186,431	$7,520

V.K.2. Numbers of Production Airplanes

The final rule requires all affected Boeing and Airbus air carrier airplanes manufactured as of January 1, 2009, to have FRM. However, as previously noted, the B-787 is required to have FRM by the existing Part 25 certification requirements and its FRM costs are not an incremental cost of this rule. The projected numbers of air carrier production airplanes was described in Section II. As shown in Table V-12, which summarizes Appendix II-5, 2,290 airplanes will be manufactured (excluding the B-787) that will be affected by the final rule. Of these 2,290 airplanes, 1,268 will be Boeing production passenger airplanes and 1,022 will be Airbus production passenger airplanes.

TABLE V-12

NUMBERS OF AIR CARRIER PRODUCTION PASSENGER AIPLANES BY MANUFACTURER

YEAR	TOTAL	BOEING	AIRBUS
2009	244	104	140
2010	199	90	109
2011	192	79	114
2012	205	107	98
2013	225	141	84
2014	291	175	116
2015	333	190	143
2016	289	194	95
2017	312	189	123
TOTAL	**2,290**	**1,268**	**1,022**

V.K.3. Total Production Passenger Airplane Costs

We multiplied the forecasted number of each production model (Table V-12) by its unit costs (Table V-11 adjusted for the learning curve) to install FTI as original factory equipment. As shown in Table V-13, which summarizes Appendix V-8, the undiscounted cost for air carrier production passenger airplanes will be $230 million, which has a present value of $152 million using a 7 percent discount rate and a present value of $191 million using a 3 percent discount rate.

TABLE V-13

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL COSTS TO INSTALL FTI ON AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$ 25.216	$ 22.024	$ 23.768
2010	$ 19.899	$ 16.243	$ 18.210
2011	$ 19.561	$ 14.923	$ 17.379
2012	$ 20.510	$ 14.623	$ 17.692
2013	$ 22.823	$ 15.208	$ 19.114
2014	$ 29.155	$ 18.157	$ 23.706
2015	$ 33.186	$ 19.315	$ 26.197
2016	$ 28.620	$ 15.567	$ 21.935
2017	$ 30.744	$ 15.628	$ 22.876

TOTAL	**$229.714**	**$151.688**	**$190.877**

As shown in Table V-14, which summarizes Appendix V-8, the undiscounted costs for air carrier production passenger airplanes will be $230 million, of which Boeing airplane operators will incur $127 million and Airbus airplane operators will incur $103 million. Of the present value of about $154 million using a 7 percent discount rate, Boeing airplane operators will incur $83 million and Airbus airplane operators will incur $71 million. Of the present value of about $191 million using a 3 percent discount rate, Boeing airplane operators will incur $104 million and Airbus airplane operators will incur $87 million.

TABLE V-14

TOTAL AND PRESENT VALUE COSTS TO INSTALL FTI ON AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$127	$ 83	$104
AIRBUS	$103	$ 71	$ 87
TOTAL	**$230**	**$154**	**$191**

V.L. TOTAL COMPLIANCE COSTS TO INSTALL FTI ON AIR CARRIER PASSENGER AIRPLANES

As shown in Table V-15, which sums Tables V-8 and V-12, the undiscounted cost for air carrier retrofitted and production passenger airplanes will be $576 million, which has a present value of $372 million using a 7 percent discount rate and a present value of $474 using a 3 percent discount rate.

TABLE V-15

UNDISCOUNTED AND PRESENT VALUES OF THE AIR CARRIER RETROFITTED AND PRODUCTION PASSENGER AIRPLANE FTI INSTALLATION COSTS

(in Millions of 2007 Dollars)

		TOTAL COSTS		
YEAR	RETROFITTED AND PRODUCTION AIRPLANES	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	140	$ 25.216	$ 22.024	$ 23.768
2010	399	$ 59.879	$ 48.878	$ 54.797
2011	404	$ 57.386	$ 43.779	$ 50.986
2012	388	$ 57.280	$ 40.839	$ 49.410
2013	374	$ 58.924	$ 39.263	$ 49.348
2014	406	$ 64.778	$ 40.341	$ 52.670
2015	433	$ 68.443	$ 39.835	$ 54.029
2016	592	$ 91.345	$ 49.685	$ 70.009
2017	619	$ 92.926	$ 47.238	$ 69.145
TOTAL	**3,755**	**$576.176**	**$371.884**	**$474.162**

As shown in Table V-16, which sums Tables V-10 and V-14, of the undiscounted costs of about $576 million, $368 million will be incurred by Boeing airplane operators and $208 million will be incurred by Airbus airplane operators. Of the present value costs of $372 million using a 7 percent discount rate, $235 million will be incurred by Boeing airplane operators and $137 million will be incurred by Airbus airplane operators. Of the present value of $474 million using a 3 percent discount rate, $301 million will be incurred by Boeing airplane operators and $173 million will be incurred by Airbus airplane operators.

TABLE V-16

UNDISCOUNTED AND PRESENT VALUES FOR RETROFITTED AND PRODUCTION AIR CARRIER PASSENGER AIRPLANES FTI COSTS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$368	$235	$301
AIRBUS	$208	$137	$173
TOTAL	**$576**	**$372**	**$474**

V.M. INVENTORY COSTS

V.M.1. Introduction

Air carriers will need an inventory of replacement FTI system components for unexpected component failures. In the IRE, we believed that this inventory cost would consist of spare water separator/filters that could be safely replaced while the FTI system was still on the airplane. However, Boeing commented that the water separator/filters can only be safely replaced outside of the airplane, which requires the removal of the entire FTI water separator/filter assembly. The air carrier will then install a complete spare assembly on the airplane while a new water separator/filter is installed in the assembly that had been removed. Thus, the inventory cost is the cost of the entire assembly rather than just the cost of the water separator/filter.

V.M.2. Cost of a Water Separator/filter Assembly

Boeing reported the inventory costs of water separator/filter assemblies for several of its models. We accept the Boeing cost estimates. As Airbus did not report any similar costs, we determined that the Boeing estimates can be applied to similarly-sized Airbus airplanes. These unit inventory costs are shown in Table V-17.

TABLE V-17

INVENTORY COST OF A WATER SEPARATOR/FILTER ASSEMBLY BY MODEL

MODEL	COST
B-737-CLASSIC	$18,433
B-737-NG	$18,433
B-757	$26,000
B-767	$26,000
B-747-1/2/300	$30,467
B-747-400	$30,467
B-747-800	$30,467
B-777	$30,467
B-787	$26,000
A-300/300-600	$26,000
A-310	$26,000
A-320 FAMILY	$18,433
A-330	$30,467
A-340	$30,467
A-350	$26,000
A-380	$30,467

V.M.3. Total Inventory Costs for Water Separator/filter Assemblies

V.M.3.a. Inventory Costs for Retrofitted Airplanes

In the IRE we assumed a water separator/filter assembly inventory rate of 15 percent (the general industry standard for inventory) of the air carrier passenger airplanes retrofitted in each year. There were no comments and we use that assumption in this Regulatory Evaluation. In the last two years (2016 and 2017) the total number of inventoried assemblies will include those for airplanes retrofitted during a dedicated maintenance visit. As shown in Table V-18, which summarizes Appendix V-9, air carriers will add 410 assemblies to inventory by 2018, of which 268 will be for Boeing airplanes and 142 will be for Airbus airplanes.

TABLE V-18

ANNUAL NUMBERS OF WATER SEPARATOR/FILTER ASSEMBLY INVENTORY FOR AIR CARRIER RETROFITTED PASSENGER AIPLANES BY MANUFACTURER

	ASSEMBLIES ADDED		
YEAR	TOTAL	BOEING	AIRBUS
2010	43	28	15
2011	43	28	15
2012	43	28	15
2013	43	28	15
2014	43	28	15
2015	43	28	15
2016	76	50	26
2017	76	50	26
TOTAL	**410**	**268**	**142**

As shown in Table V-19, the undiscounted cost will be $8.7 million, which has a present value of $5.5 million using a 7 percent discount rate and a present value of $7.1 million using a 3 percent discount rate.

TABLE V-19

UNDISCOUNTED AND PRESENT VALUE OF THE WATER SEPARATOR/FILTER ASSEMBLY INVENTORY COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

		TOTAL COSTS		
YEAR	NUMBER OF ASSEMBLIES ADDED	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	43	$0.925	$0.755	$0.846
2011	43	$0.925	$0.705	$0.821
2012	43	$0.925	$0.659	$0.798
2013	43	$0.925	$0.616	$0.774
2014	43	$0.925	$0.576	$0.752
2015	43	$0.925	$0.538	$0.730
2016	76	$1.578	$0.858	$1.209
2017	76	$1.578	$0.802	$1.174
TOTAL	**410**	**$8.706**	**$5.509**	**$7.104**

As shown in Table V-20, which summarizes Appendix V-9, we calculated that of the undiscounted costs of $8.7 million, $6 million will be incurred by Boeing airplane operators and $2.7 million will be incurred by Airbus airplane operators. Of the present value costs of $5.5 million using a 7 percent discount rate, $3.8 million will be incurred by Boeing airplane operators and $1.7 million will be incurred by Airbus airplane operators. Of the present value of $7.1 million using a 3 percent discount rate, $4.9 million will be incurred by Boeing airplane operators and $2.2 million will be incurred by Airbus airplane operators.

TABLE V-20

UNDISCOUNTED AND PRESENT VALUE OF THE INVENTORY COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANE WATER SEPARATOR/FILTER ASSEMBLIES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$5.984	$3.786	$4.882
AIRBUS	$2.722	$1.723	$2.222
TOTAL	**$8.706**	**$5.509**	**$7.104**

V.M.3.b. Inventory Costs for Production Airplanes

As shown in Table V-21, which summarizes Appendix V-10, air carriers will add 404 water separator/filter assemblies for production airplanes, of which 249 will be for Boeing airplanes and 155 will be for Airbus airplanes.

TABLE V-21

ANNUAL NUMBERS OF INVENTORY WATER SEPARATOR/FILTER ASSEMBLIES FOR AIR CARRIER PRODUCTION PASSENGER AIPLANES BY MANUFACTURER

	NUMBER OF ASSEMBLIES		
YEAR	TOTAL	BOEING	AIRBUS
2009	39	18	21
2010	33	17	16
2011	35	18	17
2012	37	22	15
2013	42	29	13
2014	52	34	18
2015	59	37	22
2016	52	38	14
2017	55	36	19
TOTAL	**404**	**249**	**155**

As shown in Table V-22, which summarizes Appendix V-10, the undiscounted water separator/filter assembly inventory cost for air carrier production passenger airplanes will be $6.5 million, which has a present value of $4.3 million using a 7 percent discount rate and a present value of $5.9 million using a 3 percent discount rate.

TABLE V-22

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL WATER SEPARATOR/FILTER ASSEMBLY INVENTORY COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$0.700	$0.611	$0.660

2010	$0.563	$0.460	$0.515
2011	$0.551	$0.420	$0.490
2012	$0.583	$0.415	$0.503
2013	$0.643	$0.428	$0.539
2014	$0.826	$0.515	$0.672
2015	$0.944	$0.549	$0.745
2016	$0.818	$0.445	$0.627
2017	$0.880	$0.447	$0.655
TOTAL	**$6.506**	**$4.290**	**$5.405**

As shown in Table V-23, which summarizes Appendix V-10, we calculated that of the undiscounted costs of $6.5 million, $4.3 million will be incurred by Boeing airplane operators and $2.9 million will be incurred by Airbus airplane operators. Of the present value costs of $3.6 million using a 7 percent discount rate, $2.3 million will be incurred by Boeing airplane operators and $2 million will be incurred by Airbus airplane operators. Of the present value of $5.4 million using a 3 percent discount rate, $3 million will be incurred by Boeing airplane operators and $2.4 million will be incurred by Airbus airplane operators.

TABLE V-23

UNDISCOUNTED AND PRESENT VALUE OF THE INVENTORY COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANE WATER SEPARATOR/FILTER ASSEMBLIES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$3.607	$2.321	$2.964
AIRBUS	$2.899	$1.969	$2.438
TOTAL	**$6.506**	**$4.290**	**$5.403**

V.M.3.c. Inventory Costs for All Airplanes

As shown in Table V-24, which sums Tables V-18 and V-21, air carriers will add 814 water separator/filter assemblies for production airplanes, of which 517 will be for Boeing airplanes and 297 will be for Airbus airplanes.

TABLE V-24

ANNUAL NUMBERS OF INVENTORY WATER SEPARATOR/FILTER ASSEMBLIES FOR ALL AIR CARRIER PASSENGER AIPLANES BY MANUFACTURER AND BY YEAR

	NUMBER OF ASSEMBLIES		
YEAR	TOTAL	BOEING	AIRBUS
2009	39	18	21
2010	76	45	31
2011	78	46	32
2012	80	50	30
2013	85	57	28
2014	95	62	33
2015	102	65	37
2016	128	88	40
2017	131	86	45
TOTAL	**814**	**517**	**297**

As shown in Table V-25, which summarizes Appendix V-10, the undiscounted water separator/filter assembly inventory cost for all retrofitted and production air carrier passenger airplanes will be $15.2 million, which has a present value of $9.8 million using a 7 percent discount rate and a present value of $13.0 million using a 3 percent discount rate.

TABLE V-25

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL WATER SEPARATOR/FILTER ASSEMBLY INVENTORY COSTS FOR ALL AIR CARRIER PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$ 0.700	$0.611	$ 0.659
2010	$ 1.488	$1.215	$ 1.505
2011	$ 1.476	$1.125	$ 1.480
2012	$ 1.508	$1.074	$ 1.457
2013	$ 1.568	$1.044	$ 1.433
2014	$ 1.751	$1.091	$ 1.411
2015	$ 1.869	$1.087	$ 1.389
2016	$ 2.396	$1.303	$ 1.868
2017	$ 2.458	$1.249	$ 1.833

TOTAL	**$15.212**	**$9.799**	**$13.039**

As shown in Table V-26, which summarizes Appendix V-10, we calculated that of the undiscounted costs of $15.2 million, $9.6 million will be incurred by Boeing airplane operators and $5.6 million will be incurred by Airbus airplane operators. Of the present value costs of $9.8 million using a 7 percent discount rate, $6.1 million will be incurred by Boeing airplane operators and $3.7 million will be incurred by Airbus airplane operators. Of the present value of $13 million using a 3 percent discount rate, $8.1 million will be incurred by Boeing airplane operators and $4.9 million will be incurred by Airbus airplane operators.

TABLE V-26

UNDISCOUNTED AND PRESENT VALUE OF THE INVENTORY COSTS OF WATER SEPARATOR/FILTER ASSEMBLIES FOR AIR CARRIER PASSENGER AIRPLANES OPERATORS BY AIRPLANE MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 9.591	$6.107	$ 8.146
AIRBUS	$ 5.621	$3.692	$ 4.893
TOTAL	**$15.212**	**$9.799**	**$13.039**

V.N. ANNUAL OPERATIONAL COSTS FOR PASSENGER AIRPLANES WITH FTI

The remaining compliance cost sections are annual operating costs associated with FTI. These general annual cost categories are increased fuel consumption, increased maintenance, and ASM replacement. As such, these annual costs depend upon the numbers of airplanes with FTI incurring these costs. The total costs are the sum of the airplanes in service over time multiplied by the annual cost elements.

Table V-27 provides the number of airplanes of the affected fleet with FTI for each year until all the airplanes will be retired. In general, we assumed an average 25-year life-span so that the older airplanes with retrofitted FTIs will be retired before the production airplanes will be retired. As shown in Table V-27, the affected air carrier passenger airplane fleet will accumulate 90,484 flight years, of which retrofitted airplanes will accumulate 30,941 flight years and production airplanes will accumulate 59,543 flight years.

TABLE V-27

NUMBER OF AIR CARRIER PASSENGER AIRPLANES IN SERVICE BY TYPE OF FTI INSTALLATION

	NUMBER OF AIRPLANES IN SERVICE		
YEAR	TOTAL	RETROFITTED	PRODUCTION
2009	244	0	244
2010	711	268	443
2011	1,172	537	635
2012	1,646	805	840
2013	2,139	1,074	1,065
2014	2,698	1,342	1,356
2015	3,300	1,611	1,689
2016	4,047	2,069	1,978
2017	5,041	2,751	2,290
2018	4,851	2,561	2,290
2019	4,680	2,390	2,290
2020	4,509	2,219	2,290
2021	4,339	2,048	2,290
2022	4,168	1,878	2,290
2023	3,997	1,707	2,290
2024	3,826	1,536	2,290
2025	3,656	1,366	2,290
2026	3,485	1,195	2,290
2027	3,314	1,024	2,290
2028	3,144	854	2,290
2029	2,973	683	2,290
2030	2,802	512	2,290
2031	2,632	341	2,290
2032	2,461	171	2,290
2033	2,290	0	2,290
2034	2,290	0	2,290
2035	2,046	0	2,046
2036	1,847	0	1,847
2037	1,655	0	1,655
2038	1,450	0	1,450
2039	1,225	0	1,225
2040	934	0	934
2041	601	0	601
2042	312	0	312
TOTAL	**90,484**	**30,941**	**59,543**

V.O. ADDITIONAL AIRPLANE FUEL CONSUMPTION COSTS

V.O.1. Introduction

An FTI increases fuel consumption for the following three reasons:

1. The FTI weight.
2. The reduced aerodynamic efficiency from the additional bleed air drawn for the FTI.
3. The increased aerodynamic drag (ram drag) due to the openings drilled into the hull to remove the oxygen-enriched air from the airplane after the ASM has extracted the nitrogen.

V.O.2. Additional Fuel Consumption from FTI Weight

Additional airplane weight results in increased fuel burn because, all other things being equal, a heavier airplane burns more fuel per mile than does a lighter airplane. The following details the bases for the additional fuel consumption estimates.

V.O.2.a. Summary of Unit Fuel Burn Due to Weight Data

Table V-28 summarizes the underlying data, which are subsequently discussed in the succeeding sections, used to calculate the additional fuel consumption due to FTI weight.

TABLE V-28

DATA FOR THE INCREASED ANNUAL FUEL CONSUMPTION DUE TO THE FTI WEIGHT FOR AN AIR CARRIER PASSENGER AIRPLANE BY MODEL

	FTI WEIGHT (UNITED)	FTI WEIGHT (BOEING)	FLIGHT HOURS (Yr.) (BOEING)	FUEL BURN (MAC)	GAL/(Yr.) (UNITED)	GAL/(Yr.) (BOEING)
MODEL	WEIGHT (lbs.)	WEIGHT (lbs.)	PASSENGER	GAL/LB/FL. HR.	PASSENGER	PASSENGER
B-737-Classic	84	105	3,000	0.0045	1,134	1,418
B-737-NG	84	105	3,250	0.0045	1,229	1,536
B-757	117	280	3,000	0.0060	2,106	5,040
B-767	150	280	4,000	0.0050	3,000	5,600
B-747-1/2/300	182	257	4,250	0.0065	5,028	7,100
B-747-400	182	257	4,250	0.0065	5,028	7,100
B-747-800	182	257	4,250	0.0065	5,028	7,100
B-777	215	300	4,000	0.0040	3,440	4,800
B-787	0	0	4,000	0.0045	0	0
A-300	117	280	4,000	0.0040	1,872	4,480

A-310	117	280	4,000	0.0040	1,872	4,480
A-320 Family	84	105	3,250	0.0095	2,594	3,242
A-330	182	300	4,000	0.0040	2,912	4,800
A-340	182	300	4,250	0.0040	3,094	5,100
A-350	150	280	4,000	0.0050	3,000	5,600
A-380	182	257	4,250	0.0065	5,028	7,100

V.O.2.b. Fuel Tank Inerting System Weight

In the IRE, we had used the ARAC FTI weights of 218 pounds for a large airplane, 148 pounds for a medium-sized airplane, and 95 pounds for a small airplane. Boeing commented that their latest FTIs weighed more than the ARAC had projected. Airbus did not specifically report an FTI system weight although they commented that the IRE had substantially underestimated the FTI weights and, if the airframes needed to be reinforced to carry the additional weight, we had underestimated the weight by several hundred pounds. We disagree with the Airbus comment that the airframe will need to be reinforced because that has not been necessary for the FTI system amended TCs that have been submitted to the FAA.

We used the United/Shaw Aero Devices/Air Liquide FTI system for all retrofitted airplanes. We accept the Boeing FTI weights for production airplanes, and in the absence of Airbus FTI production airplane data, applied the Boeing production airplane weights to similarly-sized Airbus production airplanes.

As shown in Table V-28, the United/Shaw Aero Devices/Air Liquide FTI system weights for retrofitted airplanes range from 84 pounds to 215 pounds while the Boeing FTI system weights for production airplanes range from 105 pounds to 300 pounds.

V.O.2.c. Annual Flight Hours

In the IRE, we used the annual U.S. passenger fleet flight hours by airplane model compiled by Back Aviation Solutions. In their comments, Boeing provided alternative annual flight hours. Airbus and the ATA did not comment. We accept the Boeing flight hours and apply them to similarly-sized Airbus airplanes. Thus, as shown in Table V-28, the number of annual flight hours range from 3,000 to 4,250.

V.O.2.d. Gallons of Additional Fuel Per Additional Pound Per Flight Hour

GRA, Incorporated, conducted a survey of the major US air carriers to determine the average gallons of aviation fuel consumed per pound of additional weight per flight hour. Their survey incorporated the variety of missions flown by these air carriers, which allowed them to obtain fleet-wide estimates by airplane model. An industry group under the Aviation Rulemaking Cost Committee reviewed the GRA Findings. As seen in Table V-28, the gallons of additional fuel consumed per pound of additional weight per flight hour ranged from 0.0045 gallons to 0.0095 gallons.[75]

In order to obtain the average fuel burn per retrofitted airplane model, we multiplied the United/Shaw Aero Devices/Air Liquide FTI system weights times the average fuel burn per pound per year times the number of flight hours to obtain the average annual increased fuel burn. These ranged from 1,134 gallons per year to 5,028 gallons per year for retrofitted airplane models.

Similarly, in order to obtain the average fuel burn per production airplane model, we multiplied the Boeing FTI system weights times the average fuel burn per pound per year times the number of flight hours to obtain the average annual increased fuel burn for each retrofitted airplane model. These ranged from 1,418 gallons per year to 7,100 gallons per year for production airplane models.

V.O.3. Additional Fuel Consumption from Increased Bleed Air Intake and Ram Drag

Increasing the bleed air volume to supply air for the nitrogen to inert the fuel tank increases wind resistance and, consequently, fuel consumption in order for the airplane to attain the same performance. Ram drag results from the holes bored into the hull for the

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[75] GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report, December 31, 2004, Table 6-1, p. 6-7. The specific HCWT models listed were the following:

AIRPLANE MODEL	GALLONS PER POUND PER FLIGHT HOUR
B-737 “Classic”	0.0045
B-747 “NG”	0.0065
B-757	0.0060
B-767	0.0050
B-777	0.0040
A-300	0.0040
A-320 Family	0.0095

For models that were not specifically reported, we applied these values for similarly-sized airplanes. Thus, the B-737 “NG” was assigned the B-737 “Classic” value, the B-747-100/200/300 was assigned the B-747-400 value, the B-787 was assigned the B-767 value, the A-310 model was assigned the A-300 value, and the A-330 was assigned the B-777 value, the A-340 and the A-380 models were assigned the B-747 value, and the A-350 was assigned the B-767 value.

outflow of the oxygen-enriched air from the ASM filtering process, which reduces the hull's aerodynamic efficiency and, similarly, increases fuel consumption.

In the IRE, we used a preliminary estimate that the average fuel consumption increase due to increased bleed air drag would be 0.2941 gallons per flight hour for all airplane models. We did not include a fuel cost component for ram drag.

Based on their more recent analyses, Boeing estimated the increased annual fuel consumption from the combination of increased bleed air and ram drag for individual airplane models. Airbus did not provide specific estimates. United/Shaw Aero Devices/Air Liquide did not provide us with any corresponding values for its FTI system.

Consequently, we accept the Boeing estimates for both retrofitted and production airplanes and applied them to similarly-sized Airbus airplanes. Thus, as shown in Table V-29, the increased bleed air and ram drag will increase fuel consumption by 854 gallons to 2,049 gallons.[76]

TABLE V-29

INCREASED FUEL CONSUMPTION DUE TO INCREASED BLEED AIR AND RAM DRAG FOR AN AIR CARRIER PASSENGER AIRPLANES BY MODEL

MODEL	GAL/(Yr.)
B-737-Classic	905
B-737-NG	1,379
B-757	854
B-767	1,123
B-747-1/2/300	1,508
B-747-400	1,508
B-747-800	1,508
B-777	2,049
B-787	1,123
A-300	1,123
A-310	1,123
A-320 Family	1,379
A-330	1,508
A-340	1,508
A-350	1,123
A-380	1,508

V.O.4. Additional Fuel Consumption Due to FTI

[76] In the IRE, these estimated ranges were from 761 gallons to 1,346 gallons per year.

The additional annual fuel consumption due to weight, bleed air, and ram drag are presented in Tables V-30 and V-31 using the values in Tables V-28 and V-29. As shown in Table V-30, the annual increased air carrier passenger airplane fuel consumption due to FTI will be between 2,039 gallons and 6,536 gallons for retrofitted airplanes. As shown in Table V-31, the annual increased air carrier passenger airplane fuel consumption due to FTI will be between 2,323 gallons and 8,608 gallons.[77]

V.O.5. Fuel Consumption Costs Due to FTI

Aviation fuel prices fluctuate. In the last 10 years, price has varied from $0.60 to $2.00 a gallon. ARAC and the IRE used a $1 per gallon price. The ATA and Airbus both commented that the $1 per gallon price was too low and although the current price of aviation fuel was about $2 a gallon, they felt that a price of $1.75 a gallon was appropriate. We agreed that the IRE price was too low and selected a price of $1.65 a gallon and calculated the spreadsheets on that price.

However, after the economic analysis was largely completed and the rule was being reviewed, aviation fuel prices have incurred an unforeseen sudden and large increase. As is detailed in Appendix F, we now forecast a ten-year average price of $2.01 a gallon for aviation fuel. In light of this new forecast, we re-calculated the final rule total fuel costs. Given the time constraints, we have not re-calculated the detailed fuel cost Appendix spreadsheets but, rather, applied a ratio of a $1.65 a gallon price with a fuel price of $2.01 a gallon (an increase by a factor of 1.218). Consequently, the Appendices, where the detailed methodology is presented, use the $1.65 value, while the compliance costs presented in the Regulatory Evaluation are based on the $2.01 value. Although this $2.01 fuel price is based on the most recently published FAA forecast, we recognize that, given the current record high oil prices, this estimated may underestimate the long-term aviation fuel cost.

Using our US aviation fuel prices forecast for the time period 2008-2018, [78] we determined that the long-term average aviation fuel price is $2.01 per gallon.[79][80] Thus, as

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[77] In the IRE, the estimated increased fuel consumptions for passenger airplanes were 1,478 gallons to 5,339 gallons.

[78] Federal Aviation Administration, FAA Aerospace Forecast Fiscal Years 2008-2025, Table 18, p. 77, 2007.

shown in Table V-30, FTI will increase the annual air carrier passenger fuel cost for retrofitted airplanes by $4,098 to $13,137. Finally, as shown in Table V-31, FTI will increase the annual air carrier passenger fuel cost by $4,669 for a B-737 Classic to $17,302 for a production A-380 airplane.

TABLE V-30

ANNUAL INCREASED RETROFITTED PASSENGER AIRPLANE MODEL FUEL CONSUMPTION AND COSTS

		INCREASED GALLONS PER YEAR		
MODEL	ANNUAL COST	TOTAL	WEIGHT	BLEED AIR AND RAM DRAG
B-737-Classic	$ 4,098	2,039	1,134	905
B-737-NG	$ 5,242	2,608	1,229	1,379
B-757	$ 5,950	2,960	2,106	854
B-767	$ 8,287	4,123	3,000	1,123
B-747-1/2/300	$13,137	6,536	5,028	1,508
B-747-400	$13,137	6,536	5,028	1,508
B-747-800	$13,137	6,536	5,028	1,508
B-777	$11,033	5,489	3,440	2,049
B-787	$0	0	0	0
A-300	$ 6,020	2,995	1,872	1,123
A-310	$ 6,020	2,995	1,872	1,123
A-320 Family	$ 7,986	3,973	2,594	1,379
A-330	$ 8,884	4,420	2,912	1,508
A-340	$ 9,250	4,602	3,094	1,508
A-350	$ 8,287	4,123	3,000	1,123
A-380	$13,137	6,536	5,028	1,508

TABLE V-31

ANNUAL INCREASED PRODUCTION PASSENGER AIRPLANE MODEL FUEL CONSUMPTION AND COSTS

		INCREASED GALLONS PER YEAR		
MODEL	ANNUAL COST	TOTAL	WEIGHT	BLEED AIR AND RAM DRAG
B-737-Classic	$ 4,669	2,323	1,418	905

[79] The methodology and calculations for this average aviation fuel cost per gallon is provided in Appendix F.
[80] This $2.01 a gallon price applies for air carriers. The price for part 91 operators will be greater - as discussed in Appendix E.

B-737-NG	$ 5,859	2,915	1,536	1,379
B-757	$11,847	5,894	5,040	854
B-767	$13,513	6,723	5,600	1,123
B-747-1/2/300	$17,302	8,608	7,100	1,508
B-747-400	$17,302	8,608	7,100	1,508
B-747-800	$17,302	8,608	7,100	1,508
B-777	$13,766	6,849	4,800	2,049
B-787	$12,388	6,163	5,040	1,123
A-300	$11,262	5,603	4,480	1,123
A-310	$11,262	5,603	4,480	1,123
A-320 Family	$ 9,288	4,621	3,242	1,379
A-330	$12,679	6,308	4,800	1,508
A-340	$13,282	6,608	5,100	1,508
A-350	$13,513	6,723	5,600	1,123
A-380	$17,302	8,608	7,100	1,508

V.O.6. Total Increased Fuel Consumption Costs

V.O.6.a. Total Increased Fuel Consumption Costs for Retrofitted Airplanes

As shown in Table V-32, which summarizes Appendix V-11, the total increase in air carrier retrofitted passenger airplanes fuel consumption will be 107 million gallons.[81] At $2.01 per gallon, the undiscounted cost will be $215 million, which has a present value of $94 million using a 7 percent discount rate and a present value of $148 million using a 3 percent discount rate.

TABLE V-32

TOTAL INCREASED FUEL COST AND CONSUMPTION FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY YEAR
(All Numbers in Millions)

	TOTAL COST			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2010	$ 1.894	$ 1.546	$ 1.733	0.942
2011	$ 3.787	$ 2.890	$ 3.365	1.884
2012	$ 5.682	$ 4.050	$ 4.901	2.827
2013	$ 7.575	$ 5.048	$ 6.344	3.769
2014	$ 9.469	$ 5.897	$ 7.699	4.711
2015	$ 11.363	$ 6.614	$ 8.969	5.653
2016	$ 14.594	$ 7.938	$ 11.184	7.260
2017	$ 19.001	$ 9.659	$ 14.139	9.454

81 We assumed that the entire year's flight hours are attributed to a retrofitted airplane in the year that it is retrofitted. This generates a slight upward bias to the estimated costs because the airplane would have flown part of the year without FTI.

2018	$ 17.757	$ 8.436	$ 12.829	8.834
2019	$ 16.573	$ 7.359	$ 11.624	8.245
2020	$ 15.389	$ 6.386	$ 10.480	7.656
2021	$ 14.205	$ 5.509	$ 9.392	7.068
2022	$ 13.022	$ 4.719	$ 8.358	6.479
2023	$ 11.838	$ 4.010	$ 7.377	5.890
2024	$ 10.654	$ 3.373	$ 6.447	5.301
2025	$ 9.470	$ 2.802	$ 5.563	4.712
2026	$ 8.286	$ 2.291	$ 4.725	4.123
2027	$ 7.103	$ 1.836	$ 3.932	3.534
2028	$ 5.919	$ 1.429	$ 3.182	2.945
2029	$ 4.735	$ 1.068	$ 2.472	2.356
2030	$ 3.551	$ 0.749	$ 1.799	1.767
2031	$ 2.368	$ 0.467	$ 1.165	1.178
2032	$ 1.184	$ 0.218	$ 0.565	0.589
TOTAL	**$215.422**	**$94.295**	**$148.244**	**107.175**

Further, as shown in Table V-33, which summarizes Appendix V-11, operators of Boeing airplanes will incur undiscounted costs of $127 million which has a present value of $55 million using a 7 percent discount rate and a present value of $86 using a 3 percent discount rate. Operators of Airbus airplanes will incur undiscounted costs of $89 million which has a present value of $39 million using a 7 percent discount rate and a present value of $62 using a 3 percent discount rate.

TABLE V-33

UNDISCOUNTED AND PRESENT VALUE OF THE INCREASED FUEL COST FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY MANUFACTURER
(All Values in Millions)

	TOTAL COSTS			
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
BOEING	$127	$55	$ 86	63
AIRBUS	$ 89	$39	$ 62	44
TOTAL	**$216**	**$94**	**$148**	**107**

V.O.6.b. <u>Total Increased Fuel Consumption Costs for Production Airplanes</u>

As shown in Table V-34, which summarizes Appendix V-12, the total increased fuel consumption by air carrier production passenger airplanes will be 229 million gallons. At an average price of $2.01 per gallon, the undiscounted cost will be $460 million, which has a present value of $148 million using a 7 percent discount rate and a present value of $271 million using a 3 percent discount rate.

TABLE V-34

TOTAL INCREASED FUEL CONSUMPTION AND COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(All Numbers in Millions)

	TOTAL COSTS			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2009	$ 1.994	$ 1.741	$ 1.880	0.992
2010	$ 3.596	$ 2.936	$ 3.292	1.789
2011	$ 5.202	$ 3.968	$ 4.622	2.588
2012	$ 6.813	$ 4.857	$ 5.877	3.389
2013	$ 8.513	$ 5.672	$ 7.129	4.235
2014	$ 10.713	$ 6.671	$ 8.710	5.329
2015	$ 13.256	$ 7.715	$ 10.464	6.595
2016	$ 15.359	$ 8.354	$ 11.771	7.641
2017	$ 17.687	$ 8.991	$ 13.161	8.799
2018	$ 17.687	$ 8.403	$ 12.778	8.799
2019	$ 17.687	$ 7.854	$ 12.405	8.799
2020	$ 17.687	$ 7.340	$ 12.044	8.799
2021	$ 17.687	$ 6.860	$ 11.693	8.799
2022	$ 17.687	$ 6.410	$ 11.352	8.799
2023	$ 17.687	$ 5.991	$ 11.022	8.799
2024	$ 17.687	$ 5.599	$ 10.701	8.799
2025	$ 17.687	$ 5.233	$ 10.389	8.799
2026	$ 17.687	$ 4.891	$ 10.087	8.799
2027	$ 17.687	$ 4.571	$ 9.793	8.799
2028	$ 17.687	$ 4.272	$ 9.508	8.799
2029	$ 17.687	$ 3.992	$ 9.230	8.799
2030	$ 17.687	$ 3.731	$ 8.962	8.799
2031	$ 17.687	$ 3.486	$ 8.700	8.799
2032	$ 17.687	$ 3.259	$ 8.447	8.799
2033	$ 17.687	$ 3.045	$ 8.201	8.799
2034	$ 17.687	$ 2.847	$ 7.962	8.799
2035	$ 15.694	$ 2.361	$ 6.860	7.808
2036	$ 14.091	$ 1.981	$ 5.979	7.010
2037	$ 12.486	$ 1.640	$ 5.144	6.212
2038	$ 10.875	$ 1.335	$ 4.350	5.410
2039	$ 9.175	$ 1.053	$ 3.563	4.565
2040	$ 6.975	$ 0.748	$ 2.630	3.470
2041	$ 4.432	$ 0.445	$ 1.623	2.205
2042	$ 2.328	$ 0.218	$ 0.827	1.158
TOTAL	**$459.861**	**$148.467**	**$271.154**	**228.787**

As shown in Table V-35, which summarizes Appendix V-12, we calculated that of the additional 229 million gallons of fuel, Boeing production airplanes will consume 102 million and Airbus production airplanes will consume 127 million. Of the undiscounted costs of $460 million, $206 million will be incurred by Boeing airplane operators and $255 million will be incurred by Airbus airplane operators. Of the present value costs of $149 million using a 7 percent discount rate, $65 million will be incurred by Boeing airplane operators and $84 million will be incurred by Airbus airplane operators. Of the present value of $272 million using a 3 percent discount rate, $119 million will be incurred by Boeing airplane operators and $152 million will be incurred by Airbus airplane operators.

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TABLE V-35

TOTAL INCREASED FUEL CONSUMPTION AND COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANE BY MANUFACTURER
(All Values in Millions)

MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
BOEING	$206	$65	$119	102
AIRBUS	$255	$84	$152	127
TOTAL	**$460**	**$149**	**$272**	**229**

V.O.6.c. Total Increased Fuel Consumption Costs for All Passenger Airplanes

As shown in Table V-36, which sums Tables V-32 and V-34, total air carrier retrofitted and production passenger airplane fuel consumption will increase by 336 million gallons. At an average price of $2.01 per gallon, the undiscounted cost will be $675 million, which has a present value of $243 million using a 7 percent discount rate and a present value of $419 million using a 3 percent discount rate.

TABLE V-36

TOTAL INCREASED FUEL COST AND CONSUMPTION FOR AIR CARRIER PASSENGER AIRPLANES
(All Numbers in Millions)

	TOTAL COSTS			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2009	$1.994	$1.741	$1.880	0.992
2010	$5.490	$4.482	$5.025	2.731
2011	$8.989	$6.858	$7.987	4.472
2012	$12.495	$8.907	$10.778	6.216
2013	$16.088	$10.720	$13.473	8.004
2014	$20.182	$12.568	$16.409	10.040
2015	$24.619	$14.329	$19.433	12.248
2016	$29.953	$16.292	$22.955	14.901
2017	$36.688	$18.650	$27.300	18.253
2018	$35.444	$16.839	$25.607	17.633
2019	$34.260	$15.213	$24.029	17.044
2020	$33.076	$13.726	$22.524	16.455
2021	$31.892	$12.369	$21.085	15.867
2022	$30.709	$11.129	$19.710	15.278
2023	$29.525	$10.001	$18.399	14.689
2024	$28.341	$8.972	$17.148	14.100
2025	$27.157	$8.035	$15.952	13.511
2026	$25.973	$7.182	$14.812	12.922
2027	$24.790	$6.407	$13.725	12.333
2028	$23.606	$5.701	$12.690	11.744
2029	$22.422	$5.060	$11.702	11.155
2030	$21.238	$4.480	$10.761	10.566
2031	$20.055	$3.953	$9.865	9.977
2032	$18.871	$3.477	$9.012	9.388
2033	$17.687	$3.045	$8.201	8.799
2034	$17.687	$2.847	$7.962	8.799
2035	$15.694	$2.361	$6.860	7.808
2036	$14.091	$1.981	$5.979	7.010
2037	$12.486	$1.640	$5.144	6.212
2038	$10.875	$1.335	$4.350	5.410
2039	$9.175	$1.053	$3.563	4.565
2040	$6.975	$0.748	$2.630	3.470
2041	$4.432	$0.445	$1.623	2.205
2042	$2.328	$0.218	$0.827	1.158
TOTAL	**$675.287**	**$242.764**	**$419.400**	**335.955**

Further, as shown in Table V-37, which sums Tables V-33 and V-35, operators of Boeing airplanes will incur undiscounted costs of $333 million which has a present value of $120 million using a 7 percent discount rate and a present value of $205 million using a 3 percent discount rate. Operators of Airbus airplanes will incur undiscounted costs of $343 million which has a present value of $123 million using a 7 percent discount rate and a present value of $214 million using a 3 percent discount rate.

TABLE V-37

UNDISCOUNTED AND PRESENT VALUE OF THE INCREASED FUEL COST FOR AIR CARRIER PASSENGER AIRPLANES
(Monetary Numbers in Millions of 2007 Dollars)

	TOTAL COSTS			
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
BOEING	$333	$120	$205	165
AIRBUS	$344	$123	$214	171
TOTAL	**$676**	**$243**	**$420**	**336**

V.P. ANNUAL OPERATIONAL COSTS

V.P.1. <u>Unit Operational Costs</u>

V.P.1.a. <u>Additional Inspection and Scheduled Maintenance Time</u>

In the IRE, we had estimated that the scheduled inspection and maintenance time would be 33 labor hours for a large passenger airplane, 27 labor hours for a medium-sized passenger airplane, and 26 labor hours for a small passenger airplane. Boeing commented that 6 labor hours of scheduled maintenance are needed for an airplane. Airbus did not provide an estimate for this cost. United/Shaw Aero Devices/Air Liquide did not provide an estimate for this cost. Thus, we accept the Boeing estimate and apply it to all airplanes with FTI

V.P.1.b. <u>Additional Unscheduled Maintenance Time</u>

In the IRE, we had estimated annual unscheduled maintenance time of 17 labor hours for a large passenger airplane and 11 labor hours for a medium-sized and small passenger airplane. The Boeing comment subsumed the unscheduled maintenance time within a category that included scheduled maintenance costs and materials costs. Neither Airbus nor United/Shaw Aero Devices/Air Liquide provided an estimate for this cost. As we were unable to differentiate the unscheduled maintenance component cost in the Boeing comment, we used the values in the IRE for all airplanes with FTI.

V.P.1.c. <u>Costs of Unscheduled Delays Due to Fuel Tank Inerting System Failure</u>

In the IRE, we used 3,500 flight hours as the mean time between failure (MTBF) for the FTI and coupled that with an ATA-provided cost of a delayed flight. On that basis, we estimated that the annual delay cost for FTI would be $1,002 for a large airplane, $1,173 for a medium-sized airplane, and $1,759 for a small airplane. Boeing commented that unscheduled flight delays will occur only for system failures that require locking the Nitrogen Gas System (NGS) shutoff valve closed and that the majority of system failures do not require NGS shutoff valve closure. They reported annual costs from $116 to $518 by airplane model. Neither Airbus nor United/Shaw Aerospace/Air Liquide provided an estimate for this cost. Thus, we accept the Boeing estimates and apply it to all airplanes with FTI.

V.P.1.d. Annual Materials Costs

With the exception of the ASM replacement, which will be evaluated in Section V.Q., replacing the water separator/filter is the only materials cost. In the IRE, we had used the ARAC determination that the water separator/filter would be replaced every 2 years at an annual cost of $2,273 for a large passenger airplane, $1,603 for a medium-sized passenger airplane, and $1,042 for a small passenger airplane. Although Boeing commented that "the expected filter maintenance interval is greater than 1 year for average environmental conditions," the Boeing cost estimate assumed an annual filter replacement and that the spares cost of a water separator/filter will be $5,480 for the B-747 and B-777 and $3,511 for the B-737. We determined that the water separator/filter be replaced every two years, but we use the Boeing replacement costs in this Regulatory Evaluation.[82] Neither Airbus nor United/Shaw Aero Devices/Air Liquide provided an estimate for this cost.

V.P.1.e. Summary of Total Unit Operational Costs

In summary, as shown in Table V-38, the unit annual maintenance, delays, and materials costs will be between $3,316 and $5,263 for an air carrier passenger airplane.

[82] We took the average of the two costs ($4,495) as the cost for the B-757 and B-767. We assigned these costs to similarly-sized other Boeing and Airbus models. The Boeing costs were divided by 2 to obtain an annual cost.

TABLE V-38

ANNUAL AIR CARRIER PASSENGER AIRPLANE FTI SYSTEM MAINTENANCE, DELAY, AND MATERIALS COSTS

MODEL	SCHEDULED MAINTENANCE	UNSCHEDULED MAINTENANCE	DELAYS	WATER SEPARATOR/FILTER REPLACEMENT	TOTAL COST
B-737-200	$480	$ 880	$116	$1,755	$3,231
B-737-Classic	$480	$ 880	$116	$1,755	$3,231
B-737-NG	$480	$ 880	$116	$1,755	$3,231
B-757	$480	$1,360	$149	$2,250	$4,239
B-767	$480	$1,360	$237	$2,250	$4,327
B-747-1/2/300	$480	$1,360	$568	$2,740	$5,148
B-747-400	$480	$1,360	$568	$2,740	$5,148
B-747-800	$480	$1,360	$568	$2,740	$5,148
B-777	$480	$1,360	$366	$2,740	$4,946
B-787	$480	$1,360	$237	$2,250	$4,327
A-300	$480	$1,360	$237	$2,250	$4,327
A-310	$480	$1,360	$237	$2,250	$4,327
A-320 Family	$480	$ 880	$116	$1,755	$3,231
A-330	$480	$1,360	$366	$2,740	$4,946
A-340	$480	$1,360	$568	$2,740	$5,148
A-350	$480	$1,360	$237	$2,250	$4,327
A-380	$480	$1,360	$568	$2,740	$5,148

V.P.2. Total Operational Costs

V.P.2.a. Total Operational Costs for Retrofitted Passenger Airplanes

The total operational costs are determined by multiplying each model's annual average maintenance, delay, and material costs by the number of these models and then summing the individual model costs to obtain the total maintenance cost. As shown in Table V-39, which summarizes Appendix V-13, the total operational costs for air carrier retrofitted passenger airplanes will be $112 million, which has a present value of $49 million using a 7 percent discount rate and a present value of $77 million using a 3 percent discount rate.

TABLE V-39

ANNUAL OPERATIONAL COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE	PRESENT VALUE

		(7%)	(3%)
2010	$ 0.986	$ 0.805	$ 0.902
2011	$ 1.971	$ 1.504	$ 1.751
2012	$ 2.957	$ 2.108	$ 2.550
2013	$ 3.942	$ 2.627	$ 3.302
2014	$ 4.928	$ 3.069	$ 4.007
2015	$ 5.913	$ 3.442	$ 4.668
2016	$ 7.595	$ 4.131	$ 5.821
2017	$ 9.899	$ 5.032	$ 7.366
2018	$ 9.280	$ 4.409	$ 6.704
2019	$ 8.662	$ 3.846	$ 6.075
2020	$ 8.043	$ 3.337	$ 5.477
2021	$ 7.424	$ 2.879	$ 4.908
2022	$ 6.805	$ 2.467	$ 4.368
2023	$ 6.187	$ 2.096	$ 3.855
2024	$ 5.568	$ 1.763	$ 3.369
2025	$ 4.949	$ 1.464	$ 2.907
2026	$ 4.331	$ 1.197	$ 2.470
2027	$ 3.712	$ 0.959	$ 2.055
2028	$ 3.093	$ 0.747	$ 1.663
2029	$ 2.475	$ 0.559	$ 1.292
2030	$ 1.856	$ 0.392	$ 0.940
2031	$ 1.237	$ 0.244	$ 0.609
2032	$ 0.619	$ 0.114	$ 0.295
TOTAL	**$112.432**	**$49.189**	**$77.354**

Further, as shown in Table V-40, which summarizes Appendix V-13, operators of Boeing retrofitted airplanes will incur undiscounted operational costs of $75 million which has a present value of $33 million using a 7 percent discount rate and a present value of $52 million using a 3 percent discount rate. Operators of Airbus retrofitted airplanes will incur undiscounted operational costs of $37 million which has a present value of $16 million using a 7 percent discount rate and a present value of $25 million using a 3 percent discount rate.

TABLE V-40

UNDISCOUNTED AND PRESENT VALUE OF THE OPERATIONAL COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)

BOEING	$ 75	$33	$52
AIRBUS	$ 37	$16	$25
TOTAL	**$112**	**$49**	**$77**

V.O.2.b. Total Operational Costs for Production Passenger Airplanes

The annual production passenger airplane operating costs equals the unit operating costs from Table V-39 multiplied by the production airplanes in service that year from Table V-11 and summed across all models for each year. As shown in Table V-41, which summarizes Appendix V-13, the undiscounted operational costs for production passenger airplanes will be $197 million, which has a present value of $63 million using a 7 percent discount rate and a present value of $116 million using a 3 percent discount rate.

TABLE V-41

ANNUAL OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$ 0.812	$ 0.710	$ 0.766
2010	$ 1.468	$ 1.198	$ 1.344
2011	$ 2.108	$ 1.608	$ 1.873
2012	$ 2.787	$ 1.987	$ 2.404
2013	$ 3.534	$ 2.355	$ 2.960
2014	$ 4.495	$ 2.800	$ 3.655
2015	$ 5.594	$ 3.256	$ 4.416
2016	$ 6.547	$ 3.561	$ 5.018
2017	$ 7.572	$ 3.849	$ 5.634
2018	$ 7.572	$ 3.597	$ 5.470
2019	$ 7.572	$ 3.362	$ 5.311
2020	$ 7.572	$ 3.142	$ 5.156
2021	$ 7.572	$ 2.936	$ 5.006
2022	$ 7.572	$ 2.744	$ 4.860
2023	$ 7.572	$ 2.565	$ 4.718
2024	$ 7.572	$ 2.397	$ 4.581
2025	$ 7.572	$ 2.240	$ 4.448
2026	$ 7.572	$ 2.094	$ 4.318
2027	$ 7.572	$ 1.957	$ 4.192

2028	$ 7.572	$ 1.829	$ 4.070
2029	$ 7.572	$ 1.709	$ 3.952
2030	$ 7.572	$ 1.597	$ 3.836
2031	$ 7.572	$ 1.493	$ 3.725
2032	$ 7,572	$ 1.395	$ 3.616
2033	$ 7.572	$ 1.304	$ 3.511
2034	$ 7.572	$ 1.219	$ 3.409
2035	$ 6.759	$ 1.017	$ 2.954
2036	$ 6.103	$ 0.858	$ 2.590
2037	$ 5.463	$ 0.718	$ 2.251
2038	$ 4.785	$ 0.587	$ 1.914
2039	$ 4.038	$ 0.463	$ 1.568
2040	$ 3.076	$ 0.330	$ 1.160
2041	$ 1.977	$ 0.198	$ 0.724
2042	$ 1.025	$ 0.096	$ 0.364
TOTAL	**$196.862**	**$63.170**	**$115.771**

As shown in Table V-42, which summarizes Appendix V-13, of the undiscounted costs of $197 million, $109 million will be incurred by Boeing airplane operators and $88 million will be incurred by Airbus airplane operators. Of the present value costs of $63 million using a 7 percent discount rate, $34 million will be incurred by Boeing airplane operators and $29 million will be incurred by Airbus airplane operators. Of the present value of $116 million using a 3 percent discount rate, $64 million will be incurred by Boeing airplane operators and $52 million will be incurred by Airbus airplane operators.

TABLE V-42

TOTAL OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANE BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$109	$34	$ 64
AIRBUS	$ 88	$29	$ 52
TOTAL	**$197**	**$63**	**$116**

V.O.3. Total Operational Costs for All Passenger Airplanes

As shown in Table V-43 which sums Tables V-39 and V-41, the undiscounted operational cost for all air carrier passenger airplanes will be $309 million, which has a present value of $112 million using a 7 percent discount rate and a present value of $193 million using a 3 percent discount rate.

TABLE V-43

ANNUAL OPERATIONAL COSTS FOR AIR CARRIER PASSENGER AIRPLANES
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$ 0.812	$ 0.710	$ 0.766
2010	$ 2.454	$ 2.003	$ 2.246
2011	$ 4.080	$ 3.112	$ 3.625
2012	$ 5.743	$ 4.095	$ 4.954
2013	$ 7.476	$ 4.982	$ 6.261
2014	$ 9.423	$ 5.868	$ 7.662
2015	$ 11.508	$ 6.698	$ 9.084
2016	$ 14.141	$ 7.692	$ 10.838
2017	$ 17.470	$ 8.881	$ 13.000
2018	$ 16.852	$ 8.006	$ 12.174
2019	$ 16.233	$ 7.208	$ 11.386
2020	$ 15.614	$ 6.479	$ 10.633
2021	$ 14.996	$ 5.816	$ 9.914
2022	$ 14.377	$ 5.211	$ 9.228
2023	$ 13.758	$ 4.660	$ 8.574
2024	$ 13.140	$ 4.160	$ 7.950
2025	$ 12.521	$ 3.705	$ 7.355
2026	$ 11.902	$ 3.291	$ 6.788
2027	$ 11.284	$ 2.916	$ 6.248
2028	$ 10.665	$ 2.576	$ 5.733
2029	$ 10.046	$ 2.268	$ 5.243
2030	$ 9.428	$ 1.989	$ 4.777
2031	$ 8.809	$ 1.737	$ 4.333
2032	$ 8.190	$ 1.509	$ 3.912
2033	$ 7.572	$ 1.304	$ 3.511
2034	$ 7.572	$ 1.219	$ 3.409
2035	$ 6.759	$ 1.017	$ 2.954
2036	$ 6.103	$ 0.858	$ 2.590
2037	$ 5.463	$ 0.718	$ 2.251
2038	$ 4.785	$ 0.587	$ 1.914
2039	$ 4.038	$ 0.463	$ 1.568
2040	$ 3.076	$ 0.330	$ 1.160
2041	$ 1.977	$ 0.198	$ 0.724

2042	$ 1.025	$ 0.096	$ 0.364
TOTAL	**$309.294**	**$112.359**	**$193.126**

Further, as shown in Table V-44, which sums Tables V-40 and V-42, Boeing passenger airplane operators will incur undiscounted operational costs of $184 million which has a present value of $67 million using a 7 percent discount rate and a present value of $115 million using a 3 percent discount rate. Airbus passenger airplane operators will incur undiscounted operational costs of $125 million which has a present value of $45 million using a 7 percent discount rate and a present value of $78 million using a 3 percent discount rate.

TABLE V-44

UNDISCOUNTED AND PRESENT VALUE OF THE OPERATIONAL COSTS FOR AIR CARRIER PASSENGER AIRPLANES BY MANUFACTURER
(All Values in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$184	$ 67	$115
AIRBUS	$125	$ 45	$ 78
TOTAL	**$309**	**$112**	**$193**

V.Q. AIR SEPARATION MODULE (ASM) REPLACEMENT COSTS

V.Q.1. Unit Costs to Replace ASMs

In the IRE, we had noted that the FTI design goal was to replace the ASMs every 27,000 flight hours. Using an average of 3,000 annual flight hours, we calculated that the average ASM would be replaced every 9 years. Boeing commented that, although the current service evaluations of FTIs are based on replacing the ASM every 9,000 flight hours, they believe the goal of 27,000 flight hours between replacements will be attained. Neither Airbus nor United/Shaw Aero Devices/Air Liquide provided an estimate for this cost.

We agree with Boeing that the goal of an ASM replacement every 27,000 flight hours will be reached and we use that interval for the ASM replacement frequency in this

Regulatory Evaluation. Consequently, for a new B-737-NG and a new B-747-800 built in the same year, the B-737-NG will have 2 ASM replacements during its lifetime while the B-747-800 will have 3 ASM replacements during its lifetime. As shown in Table V-45, based on the average annual flight hours per model, ASMs will be replaced in air carrier passenger service every 6 to 9 years.

TABLE V-45

ASM REPLACEMENT INTERVALS FOR AIR CARRIER PASSENGER AIRPLANES BY MODEL

MODEL	ASM REPLACEMENT (in Yrs.)
B-737-200	9
B-737-Classic	9
B-737-NG	8
B-757	9
B-767	7
B-747-1/2/300	6
B-747-400	6
B-747-800	6
B-777	7
B-787	7
A-300	7
A-310	7
A-320 Family	8
A-330	7
A-340	6
A-350	7
A-380	6

The ASM replacement cost depends upon the volume of bleed air it must process to inert the HCWT. A larger fuel tank requires more nitrogen, which requires a larger ASM to process the greater volume of bleed air. In the IRE, the ARAC had been informed by ASM suppliers that a replacement ASM would cost $28,814 for a large airplane, $18,761 for a medium airplane, and $5,275 for a small airplane. Since the ARAC meetings, Boeing reported that the fuel tanks need a higher volume of nitrogen for inerting than originally expected, which has increased the ASM size. ASM suppliers have also increased the ASM cost and that replacement ASMs cost between $30,520 and $152,600 per airplane. Airbus also commented that the ASMs were much more expensive than reported in the IRE, but did not provide quantitative estimates. We agree with the Boeing comment and their reported ASM replacement costs are provided in Table V-46.[83]

TABLE V-46

ASM REPLACEMENT COSTS FOR AN AIR CARRIER PASSENGER AIRPLANE BY MODEL

MODEL	COST PER ASM	NUMBER OF ASMs	ASM REPLACEMENT COST
B-737-200	$30,520	1	$ 30,520
B-737-Classic	$30,520	1	$ 30,520
B-737-NG	$45,052	1	$ 45,052
B-757	$37,886	4	$151,144
B-767	$37,886	4	$151,144
B-747-1/2/300	$45,052	3	$135,156
B-747-400	$45,052	3	$135,156
B-747-800	$45,052	3	$135,156
B-777	$30,520	5	$152,600
B-787	$37,886	4	$151,144
A-300	$37,886	4	$151,144
A-310	$37,886	4	$151,144
A-320 Family	$45,052	1	$ 45,052
A-330	$30,520	5	$152,600
A-340	$45,052	3	$135,156
A-350	$37,886	4	$151,144
A-380	$45,052	3	$135,156

V.Q.2. ASM Replacement Costs for Retrofitted Airplanes

Given a 25-year lifespan in air carrier passenger service, many of the retrofitted airplanes will have their ASMs replaced only once before they are retired and many airplanes will be retired before their ASM will need to be replaced. For example, the last B-737 Classic was manufactured in 1998, which means that all will be retired by 2023. If a B-737 Classic manufactured in 1998 were retrofitted in 2010, its first ASM replacement would be in 2018. Before its second scheduled ASM replacement in 2026, the airplane would have been retired. Similarly, if it were manufactured in 1995 (scheduled for retirement in 2020) and retrofitted in 2013, it would have been retired before its first ASM replacement (scheduled for 2021) would have been made. We anticipate that one of the factors affecting an air carrier's FTI retrofit schedule will be to

[83] For Airbus models and for Boeing models for which Boeing did not provide an estimate, we assigned values based on the Boeing comment for similarly-sized models.

minimize the number of ASM replacements. The ASM replacements will begin in 2016 for airplanes retrofitted in 2010 that need to have their ASMs replaced every 6 years. Thus, as all of the retrofitted airplanes will be retired by 2033, there will be no ASM replacements after 2027 because the last ASM replacement will be scheduled to maximize the number of years the ASM operates.

As shown in Table V-47, 2,731 retrofitted airplanes will have 2,138 ASM replacements. This is an average of about 3 ASM replacements for every 4 air carrier retrofitted passenger airplanes. Of these 2,138 ASM replacements, 1,171 will be on Boeing airplanes and 967 will be on Airbus airplanes.

TABLE V-47

NUMBERS OF ASM REPLACEMENTS ON AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY MANUFACTURER AND BY YEAR

		MANUFACTURER	
YEAR	TOTAL	BOEING	AIRBUS
2016	19	19	0
2017	41	36	5
2018	227	126	101
2019	227	126	101
2020	227	126	101
2021	210	109	101
2022	224	123	101
2023	228	123	105
2024	345	172	173
2025	341	172	169
2026	25	20	5
2027	25	20	5
2028	0	0	0
TOTAL	**2,138**	**1,171**	**967**

As shown in Table V-48, which summarizes Appendix V-15, the undiscounted ASM replacement costs for air carrier retrofitted passenger airplanes will be about $137 million, which has a present value of $52 million using a 7 percent discount rate and a present value of $89 million using a 3 percent discount rate.

TABLE V-48

ASM REPLACEMENT COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2016	$ 2.842	$ 1.546	$ 2.178
2017	$ 6.108	$ 3.105	$ 4.545
2018	$ 14.478	$ 6.878	$10.459
2019	$ 14.478	$ 6.428	$10.154
2020	$ 14.478	$ 6.008	$ 9.859
2021	$ 12.023	$ 4.663	$ 7.949
2022	$ 14.029	$ 5.085	$ 9.005
2023	$ 14.602	$ 4.946	$ 9.099
2024	$ 18.504	$ 5.858	$11.195
2025	$ 17.931	$ 5.305	$10.533
2026	$ 3.653	$ 1.010	$ 2.083
2027	$ 3.653	$ 0.944	$ 2.023
2028	$ 0.000	$ 0.000	$ 0.000
TOTAL	**$136.779**	**$51.776**	**$89.082**

Further, as shown in Table V-49, which summarizes Appendix V-15, Boeing retrofitted passenger airplane operators will incur undiscounted costs of $86 million which has a present value of $33 million using a 7 percent discount rate and a present value of $56 million using a 3 percent discount rate. Airbus retrofitted passenger airplane operators will incur undiscounted costs of $51 million which has a present value of $19 million using a 7 percent discount rate and a present value of $33 million using a 3 percent discount rate.

TABLE V-49

UNDISCOUNTED AND PRESENT VALUE OF ASM REPLACEMENT COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 86	$33	$56
AIRBUS	$ 51	$19	$33

TOTAL	$137	$52	$89

V.Q.3. Total ASM Replacement Costs for Air Carrier Production Airplanes

As shown in Table V-50, 4,647 ASM replacements will be made on production passenger airplanes of which 2,570 will be on Boeing airplanes and 2,078 will be on Airbus airplanes. In Table V-11, we forecasted that 2,290 production passenger airplanes will be affected by the final rule of which 1,268 will be Boeing airplanes and 1,022 will be Airbus airplanes. With a 25 year lifespan in air carrier passenger service, all production passenger airplanes will need at least 2 ASM replacements before the airplane is retired. Dividing the totals in Table V-49 by the totals in Table V-11, we calculate that 2,222 production passenger airplanes will have 2 ASM replacements and 68 production passenger airplanes will have 3 ASM replacements. Further, 1,234 Boeing airplanes will have 2 ASM replacements and 34 will have 3 ASM replacements while 988 Airbus airplanes will have 2 ASM replacements and 34 Airbus will have 3 ASM replacements.

TABLE V-50

ASM REPLACEMENTS ON AIR CARRIER PRODUCTION PASSENGER AIRPLANES BY YEAR

YEAR	TOTAL ASM REPLACEMENTS	BOEING ASM REPLACEMENTS	AIRBUS ASM REPLACEMENTS
2015	2	2	0
2016	17	5	12
2017	238	104	134
2018	200	93	108
2019	190	78	113
2020	211	107	104
2021	228	143	85
2022	294	177	118
2023	346	194	151
2024	294	197	96
2025	312	190	122
2026	239	106	133
2027	204	92	113
2028	196	78	119
2029	213	108	104
2030	239	146	93
2031	294	179	115
2032	329	191	138

2033	288	194	94
2034	313	188	126
2035	0	0	0
TOTAL	**4,647**	**2,570**	**2,078**

As shown in Table V-51, which summarizes Appendix V-16, the undiscounted ASM replacement costs for air carrier production passenger airplanes will be $237 million, which has a present value of $71 million using a 7 percent discount rate and a present value of $138 million using a 3 percent discount rate.

TABLE V-51

UNDISCOUNTED AND PRESENT VALUE ASM REPLACEMENT COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES BY YEAR
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2015	$ 0.229	$ 0.133	$ 0.181
2016	$ 2.466	$ 1.341	$ 1.890
2017	$ 11.435	$ 5.813	$ 8.508
2018	$ 9.978	$ 4.741	$ 7.208
2019	$ 9.422	$ 4.183	$ 6.608
2020	$ 10.982	$ 4.557	$ 7.478
2021	$ 11.876	$ 4.606	$ 7.852
2022	$ 15.059	$ 5.458	$ 9.666
2023	$ 18.316	$ 6.204	$ 11.414
2024	$ 14.725	$ 4.662	$ 8.909
2025	$ 15.093	$ 4.466	$ 8.866
2026	$ 11.605	$ 3.209	$ 6.618
2027	$ 10.581	$ 2.734	$ 5.859
2028	$ 10.313	$ 2.491	$ 5.544
2029	$ 11.211	$ 2.530	$ 5.851
2030	$ 13.524	$ 2.853	$ 6.853
2031	$ 15.027	$ 2.962	$ 7.392
2032	$ 15.909	$ 2.931	$ 7.598
2033	$ 13.929	$ 2.398	$ 6.459
2034	$ 15.369	$ 2.473	$ 6.919
TOTAL	**$237.049**	**$70.747**	**$137.672**

As shown in Table V-52, which summarizes Appendix V-16, of the undiscounted costs of $237 million, $131 million will be incurred by Boeing airplane operators and

$106 million will be incurred by Airbus airplane operators. Of the present value costs of $71 million using a 7 percent discount rate, $38 million will be incurred by Boeing airplane operators and $33 million will be incurred by Airbus airplane operators. Of the present value of $138 million using a 3 percent discount rate, $75 million will be incurred by Boeing airplane operators and $63 million will be incurred by Airbus airplane operators.

TABLE V-52

TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANE BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$131	$38	$ 75
AIRBUS	$106	$33	$ 63
TOTAL	**$237**	**$71**	**$138**

V.Q.4. <u>Total ASM Replacement Costs for All Air Carrier Passenger Airplanes</u>

As shown in Table V-53, which sums Tables V-47 and V-50, 6,785 ASM replacements will be made on air carrier passenger airplanes of which 2,138 will be on retrofitted airplanes and 4,647 will be on production airplanes.

TABLE V-53

NUMBERS OF ASM REPLACEMENTS ON AIR CARRIER PASSENGER AIRPLANES BY INSTALLATION AND BY YEAR

YEAR	TOTAL	RETROFITTED	PRODUCTION
2015	2	0	2
2016	36	19	17
2017	279	41	238
2018	427	227	200
2019	417	227	190
2020	438	227	211
2021	438	210	228
2022	518	224	294
2023	574	228	346

2024	639	345	294
2025	653	341	312
2026	264	25	239
2027	229	25	204
2028	196	0	196
2029	213	0	213
2030	239	0	239
2031	294	0	294
2032	329	0	329
2033	288	0	288
2034	313	0	313
TOTAL	**6,785**	**2,138**	**4,647**

As shown in Table V-54, which sums Tables V-48 and V-51, the undiscounted ASM replacement cost for all air carrier retrofitted and production passenger airplanes will be $374 million, which has a present value of $123 million using a 7 percent discount rate and a present value of $227 million using a 3 percent discount rate.

TABLE V-54

UNDISCOUNTED AND PRESENT VALUE TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER PASSENGER AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2015	$ 0.229	$ 0.133	$ 0.181
2016	$ 5.308	$ 2.887	$ 4.068
2017	$ 17.543	$ 8.918	$ 13.053
2018	$ 24.456	$ 11.619	$ 17.667
2019	$ 23.900	$ 10.611	$ 16.762
2020	$ 25.460	$ 10.565	$ 17.337
2021	$ 23.899	$ 9.269	$ 15.801
2022	$ 29.088	$ 10.543	$ 18.671
2023	$ 32.918	$ 11.150	$ 20.513
2024	$ 33.229	$ 10.520	$ 20.104
2025	$ 33.024	$ 9.771	$ 19.399
2026	$ 15.258	$ 4.219	$ 8.701
2027	$ 14.234	$ 3.678	$ 7.882
2028	$ 10.313	$ 2.491	$ 5.544
2029	$ 11.211	$ 2.530	$ 5.851
2030	$ 13.524	$ 2.853	$ 6.853
2031	$ 15.027	$ 2.962	$ 7.392
2032	$ 15.909	$ 2.931	$ 7.598
2033	$ 13.929	$ 2.398	$ 6.459

2034	$ 15.369	$ 2.473	$ 6.919
TOTAL	**$373.828**	**$122.521**	**$226.755**

Further, as shown in Table V-55, which sums Tables V-49 and V-52 Boeing passenger airplane operators will incur undiscounted ASM replacement costs of $217 million which has a present value of $71 million using a 7 percent discount rate and a present value of $132 million using a 3 percent discount rate. Airbus passenger airplane operators will incur undiscounted ASM replacement costs of $157 million which has a present value of $51 million using a 7 percent discount rate and a present value of $95 million using a 3 percent discount rate.

TABLE V-55

UNDISCOUNTED AND PRESENT VALUE ASM REPLACEMENT COSTS FOR AIR CARRIER PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$217	$ 71	$132
AIRBUS	$157	$ 51	$ 95
TOTAL	**$374**	**$122**	**$227**

V.R. TOTAL AIR CARRIER PASSENGER AIRPLANE COMPLIANCE COSTS

V.R.1. Total Costs for Retrofitted Airplanes

The total costs for retrofitted passenger airplane operators, as shown in Table V-56, are the engineering assessment costs (Table V-5), the retrofit costs (Table V-9), the water separator/filter assembly inventory costs (Table V-19, the additional fuel consumption costs (Table V-32), the operational costs (Table V-39), and the ASM replacement costs (Table V-48). The undiscounted costs for air carrier retrofitted passenger airplane operators will be $839 million, which has a present value of $437 million using a 7 percent discount rate and a present value of $623 million using a discount rate of 3 percent.

TABLE V-56

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$19.165	$16.192	$17.802
2010	$43.785	$35.741	$40.068
2011	$44.508	$33.955	$39.544
2012	$46.334	$33.033	$39.967
2013	$48.543	$32.346	$40.654
2014	$50.945	$31.726	$41.422
2015	$53.458	$31.114	$42.199
2016	$89.334	$48.591	$68.466
2017	$98.768	$50.208	$73.493
2018	$41.515	$19.723	$29.992
2019	$39.713	$17.633	$27.853
2020	$37.910	$15.731	$25.816
2021	$33.652	$13.051	$22.249
2022	$33.856	$12.271	$21.731
2023	$32.627	$11.052	$20.331
2024	$34.726	$10.994	$21.011
2025	$32.350	$9.571	$19.003
2026	$16.270	$4.498	$9.278
2027	$14.468	$3.739	$8.010
2028	$9.012	$2.176	$4.845
2029	$7.210	$1.627	$3.764
2030	$5.407	$1.141	$2.739
2031	$3.605	$0.711	$1.774
2032	$1.803	$0.332	$0.860
TOTAL	**$838.964**	**$437.156**	**$622.871**

As shown in Table V-57, which sums Tables V-5, V-10, V-20, V-33, V-40, and V-49, the undiscounted costs for all air carrier retrofitted Boeing passenger airplane operators will be $554 million, which has a present value of $294 million using a 7 percent discount rate and a present value of $414 million using a 3 percent discount rate. The undiscounted costs for all air carrier retrofitted Airbus passenger airplane operators will be $285 million, which has a present value of $143 million using a 7 percent discount rate and a present value of $208 million using a 3 percent discount rate.

TABLE V-57

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$554	$294	$414
AIRBUS	$285	$143	$208
TOTAL	**$839**	**$437**	**$622**

Finally, as shown in Table V-58, 52.4 percent of the compliance costs (in present value times using a 7 percent discount rate) for retrofitted airplanes are the $220 million for installation costs. The engineering costs ($16 million) represent only 3.8 percent of the total costs. The fuel costs ($77 million) represent 18.3 percent of the total costs, operational costs ($49 million) represent 11.7 percent of the total costs, and ASM replacement costs ($52 million) represent 12.4 percent of the total costs.

TABLE V-58

PERCENTAGE OF PRESENT VALUE (USING A 7 PERCENT DISCOUNT RATE) COMPLIANCE COSTS BY COST CATEGORIES FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

COST CATEGORY	PRESENT VALUE COSTS (7%)	PERCENTAGE OF TOTAL
RETROFITTED		
ENGINEERING	$ 16	3.7%
INSTALLATION	$220	50.3%
INVENTORY	$ 6	1.4%
FUEL	$ 94	21.5%
OPERATIONAL	$ 49	11.2%
ASM REPLACEMENT	$ 52	11.9%
RETROFITTED TOTAL	**$437**	100.0%

V.R.2. <u>Total Costs for Production Airplanes</u>

The total costs for production passenger airplane operators, as shown in Table V-59, are the costs the engineering assessment (Table V-5) the FTI installation costs (Table V-13), the water separator/filter assembly inventory costs (Table V-22), the additional fuel consumption costs (Table V-34), the operational costs (Table V-41), and the ASM replacement costs (Table V-51). The undiscounted costs for air carrier production passenger airplane operators will be $1.237 billion, which has a present value of $538 million using a 7 percent discount rate and a present value of $824 million using a 3 percent discount rate.

TABLE V-59

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2008	$106.576	$99.603	$103.471
2009	$28.722	$25.086	$27.074
2010	$25.526	$20.837	$23.361
2011	$27.422	$20.919	$24.364
2012	$30.693	$21.882	$26.476
2013	$35.513	$23.663	$29.742
2014	$45.189	$28.143	$36.743
2015	$53.209	$30.968	$42.003
2016	$53.810	$29.268	$41.241
2017	$68.318	$34.728	$50.834
2018	$35.237	$16.741	$25.456
2019	$34.681	$15.399	$24.324
2020	$36.241	$15.039	$24.678
2021	$37.135	$14.402	$24.551
2022	$40.318	$14.612	$25.878
2023	$43.575	$14.760	$27.154
2024	$39.984	$12.658	$24.191
2025	$40.352	$11.939	$23.703
2026	$36.864	$10.194	$21.023
2027	$35.840	$9.262	$19.844
2028	$35.572	$8.592	$19.122
2029	$36.470	$8.231	$19.033
2030	$38.783	$8.181	$19.651
2031	$40.284	$7.941	$19.817
2032	$41.166	$7.585	$19.661
2033	$39.188	$6.747	$18.171
2034	$40.628	$6.539	$18.290

2035	$22.453	$3.378	$9.814
2036	$20.194	$2.839	$8.569
2037	$17.949	$2.358	$7.395
2038	$15.660	$1.922	$6.264
2039	$13.213	$1.516	$5.131
2040	$10.051	$1.078	$3.790
2041	$6.409	$0.643	$2.347
2042	$3.353	$0.314	$1.191
TOTAL	**$1,236.578**	**$537.967**	**$824.357**

As shown in Table V-60, which sums Tables V-13, V-23, V-35, V-42, and V-52, the undiscounted costs for all air carrier production Boeing passenger airplane operators will be $6336 million, which has a present value of $275 million using a 7 percent discount rate and a present value of $420 million using a 3 percent discount rate. The discounted costs for all air carrier Airbus production passenger airplane operators will be $605 million, which has a present value of $266 million using a 7 percent discount rate and a present value of $4056 million using a 3 percent discount rate.

TABLE V-60

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 633	$275	$420
AIRBUS	$ 605	$266	$405
TOTAL	**$1,237**	**$541**	**$826**

Finally, as shown in Table V-61, 28.2 percent of the compliance costs (in present value times using a 7 percent discount rate) for production airplanes are the $152 million for installation costs. In addition, the engineering costs ($100 million) represent 19.5 percent of the total costs. The fuel costs ($149 million) represent 27.6 percent of the total costs, operational costs ($63 million) represent 11.7 percent of the total costs, and ASM replacement costs ($71 million) represent 13.2 percent of the total costs.

TABLE V-61

PERCENTAGE OF PRESENT VALUE (USING A 7 PERCENT DISCOUNT RATE) COMPLIANCE COSTS BY COST CATEGORIES FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

COST CATEGORY	PRESENT VALUE COSTS (7%)	PERCENTAGE OF TOTAL
PRODUCTION		
ENGINEERING	$100	18.6%
INSTALLATION	$152	28.2%
INVENTORY	$ 4	0.7%
FUEL	$149	27.6%
OPERATIONAL	$ 63	11.7%
ASM REPLACEMENT	$ 71	13.2%
PRODUCTION TOTAL	**$539**	100.0%

V.R.3. Total Costs for All Affected Air Carrier Passenger Airplanes

As shown in Table V-62, which sums Tables V-56 and V-59, the undiscounted cost for all air carrier airplane operators will be $2.076 billion, which has a present value of $975 million using a 7 percent discount rate and a present value of $1.447 billion using a 3 percent discount rate.

TABLE V-62

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER PASSENGER AIRPLANE OPERATORS BY YEAR
(All Values in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2008	$106.576	$99.603	$103.471
2009	$47.887	$41.278	$44.876
2010	$69.311	$56.578	$63.429
2011	$71.930	$54.874	$63.908
2012	$77.027	$54.915	$66.443
2013	$84.056	$56.009	$70.396
2014	$96.134	$59.869	$78.165
2015	$106.667	$62.082	$84.202
2016	$143.144	$77.859	$109.707
2017	$167.086	$84.936	$124.327

2018	$76.752	$36.464	$55.448
2019	$74.394	$33.032	$52.177
2020	$74.151	$30.770	$50.494
2021	$70.787	$27.453	$46.800
2022	$74.174	$26.883	$47.609
2023	$76.202	$25.812	$47.485
2024	$74.710	$23.652	$45.202
2025	$72.702	$21.510	$42.706
2026	$53.134	$14.692	$30.301
2027	$50.308	$13.001	$27.854
2028	$44.584	$10.768	$23.967
2029	$43.680	$9.858	$22.797
2030	$44.190	$9.322	$22.390
2031	$43.889	$8.652	$21.591
2032	$42.969	$7.917	$20.521
2033	$39.188	$6.747	$18.171
2034	$40.628	$6.539	$18.290
2035	$22.453	$3.378	$9.814
2036	$20.194	$2.839	$8.569
2037	$17.949	$2.358	$7.395
2038	$15.660	$1.922	$6.264
2039	$13.213	$1.516	$5.131
2040	$10.051	$1.078	$3.790
2041	$6.409	$0.643	$2.347
2042	$3.353	$0.314	$1.191
TOTAL	**$2,075.542**	**$975.123**	**$1,447.228**

Further, as shown in Table V-63, which sums Tables V-57 and V-60, air carrier Boeing passenger airplanes will incur undiscounted costs of $1.187 billion which has a present value of $569 million using a 7 percent discount rate and a present value of $833 million using a 3 percent discount rate. Air carrier Airbus passenger airplanes will incur undiscounted costs of $890 million which has a present value of $409 million using a 7 percent discount rate and a present value of $613 million using a 3 percent discount rate.

TABLE V-63

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER PASSENGER AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$1,187	$569	$ 833

AIRBUS	$ 890	$409	$ 613
TOTAL	**$2,076**	**$978**	**$1,448**

Finally, as shown in Table V-64, which combines Tables V-57 and V-60, the engineering and installation costs are a little less than half (49.2 percent) of the present value of the compliance costs for all airplanes. The installation costs are more than half (50.3 percent) of the costs for retrofitted airplanes while they are 28.2 percent of the costs for production airplanes. The engineering costs are so much larger for production airplanes ($100 million) than for retrofitted airplanes ($16 million) because, after completing the engineering and development of a production airplane model fuel tank inerting kit, there are minimal engineering costs in applying that kit to previously produced airplanes of that model. Thus, the incremental engineering costs for retrofitted airplanes are minimal. The fuel costs are 24.8 percent of the total costs, 121.5 percent of the costs for retrofitted airplanes and 27.6 percent of the costs for production airplanes. The operational costs are 11.5 percent of the total and the air supply module (ASM) replacement costs are 12.6 percent of the total.

TABLE V-64

PERCENTAGE OF PRESENT VALUE (USING A 7 PERCENT DISCOUNT RATE) COMPLIANCE COSTS BY COST CATEGORIES FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES
(in Millions of 2007 Dollars)

COST CATEGORY	PRESENT VALUE COSTS (7%)	PERCENTAGE OF TOTAL
RETROFITTED		
ENGINEERING	$ 16	3.7%
INSTALLATION	$220	50.3%
INVENTORY	$ 6	1.4%
FUEL	$ 94	21.5%
OPERATIONAL	$ 49	11.2%
ASM REPLACEMENT	$ 52	11.9%
RETROFITTED TOTAL	**$437**	100.0%
PRODUCTION		
ENGINEERING	$100	18.6%

INSTALLATION	$152	28.2%
INVENTORY	$ 4	0.7%
FUEL	$149	27.6%
OPERATIONAL	$ 63	11.7%
ASM REPLACEMENT	$ 71	13.2%
PRODUCTION TOTAL	**$539**	100.0%
ALL AIRPLANES		
ENGINEERING	$116	11.9%
INSTALLATION	$372	38.2%
INVENTORY	$ 10	1.0%
FUEL	$242	24.8%
OPERATIONAL	$112	11.5%
ASM REPLACEMENT	$123	12.6%
ALL AIRPLANES TOTAL	**$975**	100.0%

V.S. AVERAGE COST PER MODEL

V.S.1. Total Cost Per Retrofitted Air Carrier Passenger Airplane

As shown in Table V-65, the average lifetime cost per air carrier retrofitted passenger airplane is $377,000 (ranging from $234,000 to $744,000 depending upon the model), of which $195,000 is for the engineering and retrofitting costs and $182,000 is the average annual (fuel, operational, and ASM replacement) costs. The present value of these costs using a 7 percent discount rate is $217,000, of which $139,000 is for the engineering and retrofitting costs and $78,000 is for the annual costs.[84]

TABLE V-65

AVERAGE UNDISCOUNTED AND PRESENT VALUE COSTS PER RETROFITTED AIRPLANE BY MODEL

	UNDISCOUNTED			PRESENT VALUE (7%)		
MODEL	TOTAL	INSTALLATION	OPERATIONAL	TOTAL	INSTALLATION	OPERATIONAL
B-737-200	$0	$0	$0	$0	$0	$0
B-737-Classic	$233,903	$149.559	$ 84,344	$144,545	$106,376	$ 38,169
B-737-NG	$289,505	$149.559	$139,946	$166,113	$106,376	$ 59,737
B-737-NG-NEW	$273,563	$133.617	$139,946	$95,037	$95,037	
B-757	$451,041	$285.856	$165,185	$277,508	$203,319	$ 74,189
B-767	$534,691	$288.454	$246,237	$311,102	$205,166	$105,936
B-747-100/200/300	$536,299	$308.230	$228,069	$321,415	$219,232	$102,183

[84] However, if the cost were per year of future service, older airplanes would have greater installation costs but lower operational costs.

B-747-400	$728,897	$308.230	$420,667	$394,320	$219,232	$175,088
B-747-800	$0	$0.	$0	$0	$0	$0
B-777	$744,092	$334.416	$409,676	$406,511	$237,857	$168,654
B-787	$0	$0	$0	$0	$0	$0
A-300	$0	$0	$0	$0	$0	$0
A-310	$0	$0	$0	$0	$0	$0
A-320 Family	$322,756	$149.559	$173,197	$180,926	$106,376	$ 74,550
A-330	$682,357	$288.895	$393,462	$367,997	$205,480	$162,517
A-340	$0	$0	$0	$0	$0	$0
A-350	$0	$0	$0	$0	$0	$0
A-380	$0	$0	$0	$0	$0	$0
					$0	
AVERAGE	**$376,768**	**$194.699**	**$182,069**	**$216,719**	**$138,482**	**$78,237**

V.S.2. Total Cost Per Production Air Carrier Passenger Airplane

As shown in Table V-66, the average lifetime cost per air carrier production passenger airplane is $494,000 (ranging from $397,000 to $1.1 million depending upon the model), of which $100,000 is for the installation costs and $394,000 is for the annual (fuel, operational, and ASM replacement) costs. The primary factor that radically increases the average engineering and installation cost is that some of the models have few production airplanes over which to average the cost. This was specifically noted by Airbus and Boeing in their comments.

The present value of these costs using a 7 percent discount rate is $183,325, of which $74,750 is for the retrofitting costs and $108,500 is for the annual costs. As expected, the present values of the retrofitted airplanes installation costs are higher than those for production airplanes. As also expected, the annual fuel and operational costs per airplane are approximately the same. Thus, the present values of the operational costs are higher for production airplanes than for retrofitted airplanes because all production airplanes will have a 25-year service life while the remaining service lives of retrofitted airplanes range from 8 to 17 years.

TABLE V-66
AVERAGE UNDISCOUNTED AND PRESENT VALUE COSTS PER PRODUCTION AIRPLANE BY MODEL

	UNDISCOUNTED			PRESENT VALUE (7%)		
MODEL	TOTAL	INSTALLATION	OPERATIONAL	TOTAL	INSTALLATION	OPERATIONAL
B-737-200	$0	$0	$0	$0	$0	$0
B-737-Classic	$0	$0	$0	$0	$0	$0

B-737-NG	$0	$0		$0	$0	
B-737-NG-NEW	$397,045	$95,133	$301,912	$162,055	$70,891	$91,164
B-757	$0	$0	$0	$0	$0	$0
B-767	$0	$0	$0	$0	$0	$0
B-747-100/200/300	$0	$0	$0	$0	$0	$0
B-747-400	$1,081,204	$191,387	$889,817	$414,078	$142,617	$271,461
B-747-800	$0	$0	$0	$0	$0	$0
B-777	$1,021,904	$209,783	$812,121	$402,944	$156,325	$246,619
B-787	$0	$0	$0	$0	$0	$0
A-300	$0	$0	$0	$0	$0	$0
A-310	$0	$0	$0	$0	$0	$0
A-320 Family	$471,242	$96,132	$375,110	$186,431	$71,635	$114,796
A-330	$1,097,382	$212,594	$884,788	$426,726	$158,420	$268,306
A-340	$0	$0	$0	$0	$0	$0
A-350	$482,012	$189,695	$292,317	$234,472	$141,356	$93,116
A-380	$564,884	$191,047	$373,837	$261,583	$142,364	$119,219
AVERAGE	**$494,138**	**$100,307**	**$393,831**	**$183,325**	**$74,746**	**$108,579**

V.T. AUXILIARY TANK COSTS

The final rule will also impose both engineering and, potentially, retrofitting costs on airplane operators who have airplanes with auxiliary tanks. The final rule excludes auxiliary tanks installed by STC from developing FRM. An auxiliary fuel tank has the potential to be flammable by itself or it can create a fuel delivery system that can make a CWT flammable.

The FAA surveyed 18 US air carriers[85] and they reported a total of 46 airplanes[86] (out of 3,130) with an auxiliary fuel tank. None of these auxiliary fuel tanks are expected to require FTI because the airplane will either be retired by 2017 or the auxiliary fuel tank is pressurized, which makes it a low flammability tank.

The auxiliary fuel tank will need a standard engineering flammability assessment of its impact on the air it discharges into the CWT. Currently, we believe that 3 designs (the B-737 business jet, the B-747-400, and the A-321) will each need 1,000 engineering hours at a cost of $110,000 each for this flammability assessment. Thus, the undiscounted cost will be $330,000 which has a present value of $308,000 using a 7 percent discount rate and a present value of $321,000 using a 3 percent discount rate.

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[85] Comair, America West, ExpressJet, Southwest, Pinnacle, Continental, US Airways, Alaska, Delta, Atlantic, Southeast, JetBlue, Atlas, Polar Air Cargo, North American, EOS, Orbis, Northwest, and United.

[86] 28 of these are on A-321s, 14 on B-737s, and 4 on MD 83s.

VI. AIR CARRIER PRODUCTION CARGO AIRPLANES COMPLIANCE COSTS

VI.A. INTRODUCTION

In this Section we discuss and estimate the cost of compliance to manufacturers and to air carrier cargo operators. We first summarize the total compliance costs and then develop the individual costs in more detail. The referenced Appendices provide the more detailed spreadsheets used to calculate these costs.

In Appendix C, we discuss and estimate the potential compliance costs for 3 alternative rules for cargo airplanes. Alternative A would require conversion cargo airplanes to have FTI installed on all passenger airplanes being converted to cargo airplanes, but not on installed on existing cargo airplanes. Alternative B would require all existing cargo airplanes to have FTI by 2017. Alternative C would require both conversion cargo airplanes and existing cargo airplanes to have FTI by 2017.

Much of the background discussion and unit cost data in Section V for air carrier passenger airplanes also applies for air carrier cargo airplanes. We generally will not repeat these data unless they differ for cargo airplanes.

VI.B. SUMMARY OF AIR CARRIER CARGO AIRPLANE COMPLIANCE COST

As shown in Table VI-1, the undiscounted compliance costs for air carrier production cargo airplanes are $100 million, which has a present value of $38 million using a 7 percent discount rate and a present value of $63 million using a 3 percent discount rate.

TABLE VI-1

COMPLIANCE COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COST		
FTI COSTS	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	$ 0	$ 0	$ 0
INSTALLATION	$ 15	$10	$13
INVENTORY	<$1	<$1	<$1

FUEL	$ 22	$ 8	$13
OPERATIONAL	$ 39	$13	$23
ASM REPLACEMENT	$ 24	$ 7	$14
TOTAL	**$100**	**$38**	**$63**

As shown in Table VI-2, the undiscounted compliance costs for air carrier Boeing cargo airplane operators are $76 million, which has a present value of $29 million using a 7 percent discount rate and a present value of $48 million using a 3 percent discount rate. The undiscounted compliance costs for air carrier Airbus cargo airplane operators are $24 million, which has a present value of $9 million using a 7 percent discount rate and a present value of $15 million using a 3 percent discount rate.

TABLE VI-2

COMPLIANCE COSTS FOR AIR CARRIER CARGO AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING			
ENGINEERING	$ 0	$ 0	$ 0
PRODUCTION	$ 11	$ 7	$ 9
INVENTORY	<$1	<$1	<$1
FUEL	$ 18	$ 7	$11
OPERATIONAL	$ 28	$ 9	$17
ASM REPLACEMENT	$ 19	$ 6	$11
TOTAL	**$ 76**	**$29**	**$48**
AIRBUS			
ENGINEERING	$ 0	$ 0	$ 0
PRODUCTION	$ 4	$ 3	$ 4
INVENTORY	<$1	<$1	<$1
FUEL	$ 4	$ 1	$ 2
OPERATIONAL	$ 11	$ 4	$ 6
ASM REPLACEMENT	$ 5	$ 1	$ 3
TOTAL	**$ 24**	**$ 9**	**$15**
GRAND TOTAL	**$100**	**$38**	**$63**

VI.C ONE-TIME ENGINEERING COSTS TO DESIGN CARGO AIRPLANE FTI SYSTEMS

There will be minimal engineering assessment costs to develop FTI systems for production cargo airplanes because all of these assessments will have been completed for the passenger airplane model variant.

VI.D UNIT COSTS TO INSTALL FTI ON PRODUCTION CARGO AIRPLANES

From a construction perspective, the kit costs and the labor hours to install FTI on a production passenger airplane are the same as they are for a production cargo airplane.

VI.E. TOTAL COSTS TO INSTALL FTI ON AIR CARRIER PRODUCTION CARGO AIRPLANES

VI.E.1. Numbers of Production Cargo Airplanes

As noted earlier, the ESG Aviation forecast (and, by extension, the FAA forecast) for new cargo airplanes does not distinguish between production and conversion cargo airplanes, either by individual model or in the aggregate. This distinction is critical for a compliance cost analysis because the rule does not require FRM on conversion cargo airplanes[87] while it does require production cargo airplanes to have FRM.

Boeing forecasts that the new cargo fleet will be 75 percent conversion cargo airplanes and 25 percent production cargo airplanes. We apply these percentages to each airplane model to determine the numbers of conversion and production cargo airplanes.

As shown in Table VI-3, which repeats Table II-10, we project there will be 352 new cargo airplanes of which 262 will be conversion airplanes and 90 will be production airplanes. Of the 90 production airplanes, 68 will be Boeing production airplanes and 22 will be Airbus production airplanes.

TABLE VI-3

NUMBERS OF AIR CARRIER CONVERSION AND PRODUCTION CARGO AIPLANES BY MANUFACTURER AND BY YEAR

[87] Although if FRM were on the pre-conversion passenger version of the airplane, it cannot be removed when the airplane is converted.

YEAR	ALL AIRPLANES			BOEING			AIRBUS		
	TOTAL	CON	PROD	TOTAL	CON	PROD	TOTAL	CON	PROD
2009	22	17	5	12	9	3	10	8	2
2010	41	30	11	30	22	8	11	8	3
2011	38	28	10	28	21	7	10	7	3
2012	40	30	10	28	21	7	12	9	3
2013	42	31	11	32	24	8	10	7	3
2014	37	28	9	32	24	8	5	4	1
2015	35	26	9	31	23	8	4	3	1
2016	47	35	12	34	25	9	13	10	3
2017	50	37	13	39	29	10	11	8	3
TOTAL	**352**	**262**	**90**	**266**	**198**	**68**	**86**	**64**	**22**

VI.E.2. Total Production Cargo Airplane Operator Costs

In order to obtain the production cargo airplane FTI installation costs, we multiplied the numbers of new cargo airplanes by the installation costs for each model and then summed those results to obtain a total new cargo airplane installation cost. We then took 25 percent of that total as the costs of production cargo airplane operators and 75 percent as the costs of conversion cargo airplane operators. As shown in Table VI-4, which summarizes Appendix VI-1, the undiscounted costs for air carrier production cargo airplane operators will be $15.5 million, which has a present value of $10.3 million using a 7 percent discount rate and a present value of $12.9 million using a 3 percent discount rate.

TABLE VI-4

UNDISCOUNTED AND PRESENT VALUE COSTS TO INSTALL FTI ON AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$1.061	$0.927	$1.000
2010	$1.923	$1.570	$1.760
2011	$1.778	$1.356	$1.579
2012	$1.711	$1.220	$1.476
2013	$1.752	$1.168	$1.468
2014	$1.535	$0.956	$1.248
2015	$1.438	$0.837	$1.135
2016	$2.022	$1.100	$1.550

2017	$2.267	$1.152	$1.687
TOTAL	**$15.486**	**$10.285**	**$12.902**

As shown in Table VI-5, of the undiscounted costs of $15.5 million, $11.3 million will be incurred by Boeing airplane operators and $4.1 million will be incurred by Airbus airplane operators. Of the present value costs of $10.3 million using a 7 percent discount rate, $7.5 million will be incurred by Boeing airplane operators and $2.9 million will be incurred by Airbus airplane operators. Of the present value of $12.9 million using a 3 percent discount rate, $9.4 million will be incurred by Boeing airplane operators and $3.5 million will be incurred by Airbus airplane operators.

TABLE VI-5

UNDISCOUNTED AND PRESENT VALUE COSTS FOR OPERATORS TO INSTALL FTI ON AIR CARRIER PRODUCTION CARGO AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$11.342	$ 7.451	$9.406
AIRBUS	$ 4.144	$ 2.834	$3.496
TOTAL	**$15.486**	**$10.285**	**$12.902**

VI.E.3. Inventory Costs for Airbus Production Cargo Airplane Operators

As shown in Table VI-3, there will be only 90 production cargo airplanes which, at a 15 percent inventory rate, results in a total inventory of 13-14 assemblies at a total undiscounted cost of less than $500,000. This is a relatively minimal cost and is not included in the analysis.

VI.F. AIR CARRIER PRODUCTION CARGO AIRPLANE FUEL COSTS

VI.F.1. Additional Fuel Consumption

As was true for passenger airplanes, the additional weight of the FTI system will increase an airplane's average fuel consumption. Further, the additional bleed air and the ram drag will increase fuel consumption by increasing the airplane's wind resistance, thereby reducing engine efficiency.

VI.F.1.a. Unit Fuel Burn Data

Table VI-6 provides the underlying data to develop the additional fuel burn due the FTI system. These data are discussed in the sections following the Table.

TABLE VI-6

DATA FOR THE INCREASED FUEL CONSUMPTION FOR AN AIR CARRIER PRODUCTION CARGO AIRPLANE MODEL

	FTI WEIGHT	FL. HRS. (BOEING)	FUEL BURN (MAC)	GALLONS PER YEAR DUE TO		
MODEL	WEIGHT (lbs.)	CARGO	GAL/LB/FL. HR.	WEIGHT	BLEED AIR & RAM DRAG	TOTAL
B-737-Classic	105	1,500	0.0045	709	453	1,162
B-737-NG	105	1,500	0.0045	709	453	1,162
B-757	280	1,000	0.0060	473	424	897
B-767	280	1,500	0.0050	2,520	427	2,947
B-747-1/2/300	257	2,600	0.0065	3,640	730	4,370
B-747-400	257	4,250	0.0065	7,100	1,388	8,488
B-747-800	257	4,250	0.0065	7,100	1,388	8,488
B-777	300	4,250	0.0040	7,100	1,388	8,488
B-787	280	4,000	0.0045	4,800	2,049	6,849
A-300	280	2,600	0.0040	3,276	730	4,006
A-310	280	2,600	0.0040	2,912	730	3,642
A-320 Family	105	2,600	0.0095	2,912	730	3,642
A-330	300	1,000	0.0040	998	424	1,422
A-340	300	4,000	0.0040	4,800	2,049	6,849
A-350	280	4,250	0.0050	5,100	2,049	7,149
A-380	257	2,600	0.0065	3,640	730	4,370

VI.F.1.b. FTI Weight

FTI weighs the same in both cargo and passenger airplanes.

VI.F.1.c. Annual Flight Hours

In the IRE, we used the annual U.S. cargo fleet flight hours by airplane model compiled by Back Aviation Services. In its comment, Boeing provided a different set of annual cargo flight hours that we use in this Regulatory Evaluation. As shown in Table VI-6, air carrier cargo airplanes annually fly 1,000 to 4,250 hours per year.

VI.F.1.d. Gallons of Fuel Per Additional Pound Per Flight Hour

We used the GRA estimates of the average gallons of additional aviation fuel consumed per pound of additional weight per flight hour for a passenger airplane, which ranges from 0.0045 gallons to 0.0095 gallons. As seen in Table VI-6, the average air carrier cargo airplane will annually consume an additional 473 gallons to 7,100 gallons due to the FTI system weight.

VI.F.2. Fuel Consumption from Increased Bleed Air Intake and Ram Drag

As they did for passenger airplanes, Boeing provided estimates for the additional fuel burn from increased bleed air intake and ram drag for air carrier cargo airplanes. We applied their estimates to similarly-sized Airbus and Boeing airplanes. As shown in Table VI-6, the increased bleed air and ram drag will increase annual fuel consumption by 424 gallons to 2,049 gallons per airplane.

VI.F.3. Additional Fuel Consumption Due to FTI

As shown in Table VI-6, the annual increased air carrier cargo airplane fuel consumption due to FTI will be between 897 gallons and 8,488 gallons. This fuel consumption will be the same for a production cargo, conversion cargo, or retrofitted cargo airplane.

VI.F.4. Fuel Consumption Costs

As previously discussed, we used an aviation fuel cost of $2.01 a gallon.[88] As shown in Table VI-7, we calculated that FTI will increase the annual air carrier cargo airplane fuel cost by $2,336 to $17,061.

TABLE VI-7

INCREASED AIR CARRIER PRODUCTION CARGO AIRPLANE FUEL CONSUMPTION DUE TO FTI

MODEL	ANNUAL COST	ANNUAL GALLONS
B-737-Classic	$ 2,336	1,162

[88] This price applies for air carriers. The price to part 91 operators will be greater as discussed in that section.

B-737-NG	$ 2,336	1,162
B-757	$ 1,803	897
B-767	$ 5,923	2,947
B-747-1/2/300	$ 8,784	4,370
B-747-400	$17,061	8,488
B-747-800	$17,061	8,488
B-777	$17,061	8,488
B-787	$13,766	6,849
A-300	$ 8,052	4,006
A-310	$ 7,320	3,642
A-320 Family	$ 7,320	3,642
A-330	$ 2,858	1,422
A-340	$13,766	6,849
A-350	$14,369	7,149
A-380	$ 8,784	4,370

VI.F.5. Total Increased Fuel Consumption Costs for Production Cargo Airplanes

As shown in Table VI-8, which summarizes Table II-12, air carrier production cargo airplanes will fly 6.338 million flight hours, of which Boeing airplanes will fly 4.826 million hours and Airbus airplanes will fly 1.512 million hours.

TABLE VI-8

ANNUAL NUMBER OF PRODUCTION CARGO AIRPLANE FLIGHT HOURS BY MANUFACTURER
(in Millions of Flight Hours)

YEAR	TOTAL	BOEING	AIRBUS
2009	0.018	0.011	0.007
2010	0.052	0.038	0.014
2011	0.083	0.063	0.020
2012	0.112	0.084	0.028
2013	0.144	0.109	0.035
2014	0.171	0.133	0.038
2015	0.198	0.157	0.041
2016	0.231	0.182	0.049
2017	0.268	0.212	0.056
2018	0.250	0.194	0.056
2019	0.249	0.193	0.056
2020	0.247	0.191	0.056
2021	0.246	0.190	0.056
2022	0.244	0.188	0.056
2023	0.243	0.187	0.056
2024	0.241	0.185	0.056
2025	0.240	0.184	0.056
2026	0.238	0.182	0.056
2027	0.237	0.181	0.056

2028	0.235	0.179	0.056
2029	0.234	0.178	0.056
2030	0.232	0.176	0.056
2031	0.231	0.175	0.056
2032	0.230	0.174	0.056
2033	0.228	0.172	0.056
2034	0.227	0.171	0.056
2035	0.220	0.164	0.056
2036	0.194	0.143	0.051
2037	0.163	0.119	0.044
2038	0.140	0.102	0.038
2039	0.113	0.082	0.031
2040	0.087	0.062	0.025
2041	0.059	0.041	0.018
2042	0.035	0.023	0.012
TOTAL	**6.338**	**4.826**	**1.512**

As shown in Table VI-9, which summarizes Appendix VI-2, multiplying the production cargo airplane flight hours in Table II-10 by the increased fuel consumption per airplane results in an increased fuel consumption of 10.721 million gallons. At an average price of $2.01 per gallon, the undiscounted cost will be $21.550 million, which has a present value of $7.150 million using a 7 percent discount rate and a present value of $12.860 million using a 3 percent discount rate.

TABLE VI-9

TOTAL INCREASED FUEL COST AND CONSUMPTION FOR AIR CARRIER PRODUCTION CARGO AIRPLANES
(All Numbers in Millions)

	TOTAL COST			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2009	$0.057	$0.050	$0.054	0.029
2010	$0.180	$0.147	$0.164	0.090
2011	$0.292	$0.223	$0.259	0.145
2012	$0.385	$0.274	$0.331	0.191
2013	$0.485	$0.324	$0.407	0.242
2014	$0.579	$0.361	$0.470	0.288
2015	$0.668	$0.389	$0.526	0.332
2016	$0.774	$0.421	$0.593	0.385
2017	$0.899	$0.457	$0.669	0.447
2018	$0.839	$0.398	$0.605	0.417
2019	$0.836	$0.372	$0.586	0.416
2020	$0.833	$0.346	$0.568	0.414

2021	$0.830	$0.322	$0.548	0.413
2022	$0.827	$0.300	$0.531	0.411
2023	$0.823	$0.279	$0.513	0.410
2024	$0.821	$0.259	$0.497	0.408
2025	$0.817	$0.242	$0.480	0.407
2026	$0.815	$0.225	$0.464	0.405
2027	$0.811	$0.210	$0.450	0.404
2028	$0.809	$0.195	$0.435	0.402
2029	$0.805	$0.182	$0.420	0.401
2030	$0.803	$0.169	$0.407	0.399
2031	$0.799	$0.157	$0.393	0.398
2032	$0.797	$0.146	$0.380	0.396
2033	$0.794	$0.136	$0.368	0.395
2034	$0.791	$0.127	$0.356	0.393
2035	$0.755	$0.113	$0.330	0.376
2036	$0.658	$0.093	$0.279	0.327
2037	$0.551	$0.072	$0.227	0.274
2038	$0.470	$0.057	$0.188	0.234
2039	$0.375	$0.043	$0.146	0.187
2040	$0.281	$0.030	$0.106	0.140
2041	$0.188	$0.018	$0.068	0.093
2042	$0.102	$0.010	$0.037	0.051
TOTAL	**$21.550**	**$7.150**	**$12.860**	**10.721**

As shown in Table VI-10, of the additional 10.7 million gallons of fuel, Boeing production airplanes will consume 8.7 million and Airbus production airplanes will consume 2 million. Of the undiscounted costs of $17.7 million, $14.3 million will be incurred by Boeing airplane operators and $3.4 million will be incurred by Airbus airplane operators. Of the present value costs of $5.9 million using a 7 percent discount rate, $4.8 million will be incurred by Boeing airplane operators and $1.1 million will be incurred by Airbus airplane operators. Of the present value of $10.6 million using a 3 percent discount rate, $8.6 million will be incurred by Boeing airplane operators and $2 million will be incurred by Airbus airplane operators.

TABLE VI-10

TOTAL INCREASED FUEL CONSUMPTION AND COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(All Values in Millions)

	TOTAL COSTS			
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS

BOEING	$17.437	$5.785	$10.406	8.675
AIRBUS	$ 4.113	$1.364	$ 2.455	2.046
TOTAL	**$21.550**	**$7.150**	**$12.860**	**10.721**

VI.G. OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

VI.G.1. Operational Cost Components

We define the operational costs to consist of the following 4 components:

1. Scheduled Maintenance;
2. Unscheduled Maintenance;
3. Unscheduled Flight Delays; and
4. Annual Materials Costs

VI.G.2. Additional Inspection and Scheduled Maintenance Time

Boeing commented that the scheduled maintenance time for a passenger or a cargo airplane will be 6 labor hours. We accept the Boeing comment and use it in this Regulatory Evaluation

VI.G.3. Additional Unscheduled Maintenance Time

We used the same values for cargo airplanes as we used for passenger airplanes - 17 labor hours for a large airplane and 11 labor hours for a medium-sized and small passenger airplane.

VI.G.4. Costs of Unscheduled Delays Due to Fuel Tank Inerting System Failure

In the IRE, we assumed that the annual delay cost due to a FTI system failure would be minimal. Boeing reported annual costs from $116 to $518 by cargo airplane model. We disagree with the Boeing comment because air carrier cargo operations have more flexibility than air carrier passenger operations. Thus, we have no unscheduled cargo airplane delay costs in this Regulatory Evaluation

VI.G.5. Annual Materials Costs

We determined that the average water separator/filter replacement is based on the number of flight hours. On that basis, the B-747s, B-777, A-330, A-340, and A-380 cargo airplanes will replace their filters every two years because they fly similar hours to their passenger airplane counterparts. As all other cargo airplanes fly about one half the hours of their passenger model counterparts, we determined that their filters will be replaced an average of every four years.

VI.G.6. Maintenance, Unscheduled Delays, and Materials Costs

In summary, as shown in Table VI-11, the annual FTI maintenance and materials costs will be $1,806 to $4,148 for an air carrier cargo production airplane operators.

TABLE VI-11

MAINTENANCE, DELAY, AND MATERIALS COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS

MODEL	SCHEDULED MAINTENANCE	UNSCHEDULED MAINTENANCE	DELAYS	WATER SEPARATOR/FILTER REPLACEMENT	TOTAL COST
B-737-200	$48	$ 880	$0	$ 878	$1,806
B-737-Classic	$48	$ 880	$0	$ 878	$1,806
B-737-NG	$48	$ 880	$0	$ 878	$1,806
B-757	$48	$1,360	$0	$1,125	$2,533
B-767	$48	$1,360	$0	$1,125	$2,533
B-747-1/2/300	$48	$1,360	$0	$2,740	$4,148
B-747-400	$48	$1,360	$0	$2,740	$4,148
B-747-800	$48	$1,360	$0	$2,740	$4,148
B-777	$48	$1,360	$0	$2,740	$4,148
B-787	$48	$1,360	$0	$1,125	$2,533
A-300	$48	$1,360	$0	$1,125	$2,533
A-310	$48	$1,360	$0	$1,125	$2,533
A-320 Family	$48	$ 880	$0	$ 878	$1,806
A-330	$48	$1,360	$0	$2,740	$4,148
A-340	$48	$1,360	$0	$2,740	$4,148
A-350	$48	$1,360	$0	$1,125	$2,533
A-380	$48	$1,360	$0	$2,740	$4,148

VI.G.6. Total Operational Costs for Air Carrier Production Cargo Airplane Operators

As shown in Table VI-12, which summarizes Appendix VI-3, the undiscounted operational costs for air carrier production cargo airplane operators will be $38.6 million, which has a present value of $13 million using a 7 percent discount rate and a present value of $23.2 million using a 3 percent discount rate.

TABLE VI-12

OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COST		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$0.110	$0.096	$0.104
2010	$0.317	$0.259	$0.290
2011	$0.509	$0.388	$0.452
2012	$0.699	$0.498	$0.603
2013	$0.897	$0.597	$0.751
2014	$1.071	$0.667	$0.871
2015	$1.236	$0.719	$0.976
2016	$1.457	$0.793	$1.117
2017	$1.700	$0.864	$1.265
2018	$1.584	$0.752	$1.144
2019	$1.569	$0.697	$1.101
2020	$1.555	$0.645	$1.059
2021	$1.540	$0.597	$1.018
2022	$1.525	$0.553	$0.979
2023	$1.511	$0.512	$0.941
2024	$1.496	$0.474	$0.905
2025	$1.481	$0.438	$0.870
2026	$1.467	$0.406	$0.836
2027	$1.452	$0.375	$0.804
2028	$1.437	$0.347	$0.773
2029	$1.423	$0.321	$0.743
2030	$1.408	$0.297	$0.714
2031	$1.394	$0.275	$0.686
2032	$1.379	$0.254	$0.659
2033	$1.364	$0.235	$0.633
2034	$1.350	$0.217	$0.608
2035	$1.269	$0.191	$0.555
2036	$1.104	$0.155	$0.469
2037	$0.929	$0.122	$0.383
2038	$0.786	$0.096	$0.314
2039	$0.626	$0.072	$0.243
2040	$0.467	$0.050	$0.176
2041	$0.308	$0.031	$0.113
2042	$0.159	$0.015	$0.056
TOTAL	**$38.578**	**$13.009**	**$23.207**

As shown in Table VI-13, of the undiscounted costs of $38.6 million, $27.6 million will be incurred by Boeing airplane operators and $11 million will be incurred by Airbus airplane operators. Of the present value costs of $13 million using a 7 percent discount rate, $9.3 million will be incurred by Boeing airplane operators and $3.7 million will be incurred by Airbus airplane operators. Of the present value of $23.2 million using a 3 percent discount rate, $16.6 million will be incurred by Boeing airplane operators and $6.6 million will be incurred by Airbus airplane operators.

TABLE VI-13

TOTAL OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$27.542	$ 9.349	$16.624
AIRBUS	$11.036	$ 3.661	$ 6.583
TOTAL	**$38.578**	**$13.010**	**$23.207**

VI.H. ASM REPLACEMENT COSTS

VI.H.1. Unit Costs to Replace ASMs

The ASM replacement costs for cargo airplanes are the same as the ASM replacement costs for passenger airplanes reported in Table V-35 (between $30,520 and $151,144 per replacement).

VI.H.2. Total Costs to Replace ASMs in Air Carrier Production Cargo Airplanes

As discussed in Section V, there will be an average of 27,000 flight hours between ASM replacements. As shown in Table VI-14, using the average number of annual flight hours per cargo airplane model, ASMs will be replaced every 6 to 27 years.

TABLE VI-14

ASM REPLACEMENT INTERVALS FOR AIR CARRIER CARGO AIRPLANES BY MODEL

MODEL	ANNUAL FLIGHT HOURS	ASM REPLACEMENT (Yrs.)
B-737-200	1,500	18
B-737-Classic	1,500	18
B-737-NG	1,000	27

B-757	1,500	18
B-767	2,600	10
B-747-1/2/300	4,250	6
B-747-400	4,250	6
B-747-800	4,250	6
B-777	4,000	7
B-787	2,600	10
A-300	2,600	10
A-310	2,600	10
A-320 Family	1,000	27
A-330	4,000	7
A-340	4,250	6
A-350	2,600	10
A-380	1,500	6

We determined that, as was the case for passenger airplanes, air carriers will arrange their ASM replacement schedules such that the airplane's last ASM replacement will last the full 6 to 27 years before the airplane is retired. That is, a B-747-100/200/300 scheduled to retire in 2035 will receive its last ASM replacement in 2029 and no B-747-100/200/300 will have an ASM replacement after 2029 because all of them will be retired by 2035.

As shown in Table VI-15, which summarizes Appendix VI-4, the undiscounted ASM replacement cost for air carrier production cargo airplane operators will be $24 million, which has a present value of $7.2 million using a 7 percent discount rate and a present value of $14 million using a 3 percent discount rate.

TABLE VI-15

ASM REPLACEMENT COSTS FOR AIR CARRIER AIRBUS PRODUCTION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COST		
YEAR	UNDISCOUNTED	PERSENT VALUE (7%)	PRESENT VALUE (3%)
2015	$0.135	$0.079	$0.107
2016	$0.799	$0.435	$0.612
2017	$0.731	$0.372	$0.544
2018	$0.529	$0.251	$0.382
2019	$1.084	$0.481	$0.760
2020	$1.122	$0.466	$0.764
2021	$1.692	$0.656	$1.119

2022	$1.733	$0.628	$1.112
2023	$1.509	$0.511	$0.940
2024	$1.238	$0.392	$0.749
2025	$0.818	$0.242	$0.481
2026	$1.706	$0.472	$0.973
2027	$1.875	$0.484	$1.038
2028	$1.035	$0.250	$0.557
2029	$0.936	$0.211	$0.489
2030	$1.165	$0.246	$0.590
2031	$1.791	$0.353	$0.881
2032	$1.486	$0.274	$0.710
2033	$1.207	$0.208	$0.559
2034	$0.745	$0.120	$0.335
2035	$0.630	$0.101	$0.284
TOTAL	**$23.966**	**$7.232**	**$13.986**

As shown in Table VI-16, of the undiscounted costs of $24 million, $19 million will be incurred by Boeing airplane operators and $5 million will be incurred by Airbus airplane operators. Of the present value costs of $7.2 million using a 7 percent discount rate, $5.7 million will be incurred by Boeing airplane operators and $1.5 million will be incurred by Airbus airplane operators. Of the present value of $14 million using a 3 percent discount rate, $11.1 million will be incurred by Boeing airplane operators and $2.9 million will be incurred by Airbus airplane operators.

TABLE VI-16

TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(All Values in Millions)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$18.959	$5.760	$11.087
AIRBUS	$ 5.006	$1.472	$ 2.899
TOTAL	**$23.965**	**$7.232**	**$13.986**

VI.I. TOTAL AIR CARRIER PRODUCTION CARGO AIRPLANE COMPLIANCE COSTS

The total costs for production cargo airplane operators, as shown in Table VI-17, are the costs for installing FTI (Table VI-4), the additional fuel consumption (Table VI-9), the operational costs (Table VI-11), and the ASM replacement costs (Table VI-15). The undiscounted compliance costs for air carrier production cargo airplane operators will be $100 million, which has a present value of $38 million using a 7 percent discount rate and a present value of $63 million using a 3 percent discount rate.

TABLE VI-17

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$1.228	$1.073	$1.158
2010	$2.420	$1.976	$2.214
2011	$2.579	$1.967	$2.290
2012	$2.795	$1.992	$2.410
2013	$3.134	$2.089	$2.626
2014	$3.185	$1.984	$2.589
2015	$3.477	$2.024	$2.744
2016	$5.052	$2.749	$3.872
2017	$5.597	$2.845	$4.165
2018	$2.952	$1.401	$2.131
2019	$3.489	$1.550	$2.447
2020	$3.510	$1.457	$2.391
2021	$4.062	$1.575	$2.685
2022	$4.085	$1.481	$2.622
2023	$3.843	$1.302	$2.394
2024	$3.555	$1.125	$2.151
2025	$3.116	$0.922	$1.831
2026	$3.988	$1.103	$2.273
2027	$4.138	$1.069	$2.292
2028	$3.281	$0.792	$1.765
2029	$3.164	$0.714	$1.652
2030	$3.376	$0.712	$1.711
2031	$3.984	$0.785	$1.960
2032	$3.662	$0.674	$1.749
2033	$3.365	$0.579	$1.560
2034	$2.886	$0.464	$1.299
2035	$2.654	$0.405	$1.169

2036	$1.762	$0.248	$0.748
2037	$1.480	$0.194	$0.610
2038	$1.256	$0.153	$0.502
2039	$1.001	$0.115	$0.389
2040	$0.748	$0.080	$0.282
2041	$0.496	$0.049	$0.181
2042	$0.261	$0.025	$0.093
TOTAL	**$99.581**	**$37.673**	**$62.955**

As shown in Table VI-18, which sums Tables VI-5, VI-10, VI-13, and VI-15, the undiscounted costs for all air carrier production Boeing cargo airplane operators will be $76 million, which has a present value of $29 million using a 7 percent discount rate and a present value of $48 million using a 3 percent discount rate. The undiscounted costs for all air carrier Airbus production cargo airplanes will be $24 million, which has a present value of $9 million using a 7 percent discount rate and a present value of $15 million using a 3 percent discount rate.

TABLE VI-18

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 76	$29	$48
AIRBUS	$ 24	$ 9	$15
TOTAL	**$100**	**$38**	**$63**

Finally, as shown in Table VI-19, of the present value of $38 million using a 7 percent discount rate for the production cargo airplane compliance costs, about 26 percent will be due to the installation and about 74 percent will be due to the annual fuel, operational, and ASM replacement costs.

TABLE VI-19

COMPLIANCE COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

(in Millions of 2007 Dollars)

	TOTAL COST		
FTI COSTS	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	$ 0	$ 0	$ 0
INSTALLATION	$ 15	$10	$13
INVENTORY	<$1	<$1	<$1
FUEL	$ 22	$ 6	$11
OPERATIONAL	$ 39	$13	$23
ASM REPLACEMENT	$ 24	$ 7	$14
TOTAL	**$100**	**$38**	**$63**

VII. COST-BENEFIT ANALYSIS OF THE RULE AND ALTERNATIVES

INTRODUCTION

In this section, we analyze the costs and expected benefits of the final rule and some alternatives. We provide a sensitivity analysis that employs combinations of 3 values for a prevented fatality, 2 discount rates, and 3 SFAR 88 effectiveness rates for the final rule. For the analyses of the alternatives, we analyze only the baseline case using a $5.5 million value for a prevented fatality, a 7 percent discount rate, and a 50 percent SFAR 88 effectiveness rate. All of the analyses are performed in present value terms.

FINAL RULE

It needs to be emphasized that the expected benefits are the mean of the benefits probability distribution. For example, the final rule benefits would be greater than its costs if, through 2012, it were to prevent one accident that would have involved 180 fatalities. The airplanes that fall into this potential category are the size of a B-757 and larger. In addition, there is a 25.7 percent probability that the final rule will have benefits that will be greater than its costs.

With that as background, as shown in Table VII-1, using the baseline of a $5.5 million value for a prevented fatality, a 7 percent discount rate, and a 50 percent SFAR 88 effectiveness rate, the present value of the rule's expected benefit cost ratio is 0.67. That is, the expected benefits are $327 million less than the costs. At a 3 percent discount rate, the expected benefit-cost ratio is 0.82, which illustrates that the costs tend to be front-end loaded while the benefits occur later in time.

At a discount rate of 7 percent, the rule's expected benefit-cost ratios are about equal or greater than 1.00 for SFAR 88 effectiveness rates of 25 percent and fatality values of $5.5 million and $8 million. The rule's expected benefit-cost ratios are less than 1.00 for all other combinations.

At a discount rate of 3 percent, the rule's expected benefit-cost ratios are nearly one (0.95) or greater for a fatality value of $8 million and SFAR 88 effectiveness rates of 50 percent and 25 percent and for a fatality value of $5.5 million and an SFAR 88 effectiveness rate of 25 percent.

TABLE VII-1

PRESENT VALUES OF THE BENEFITS AND COSTS FOR ALL AFFECTED AIRPLANES BY DISCOUNT RATE, VALUE OF A PREVENTED FATALITY, AND SFAR 88 EFFECTIVENESS RATE
(in Millions of 2007 Dollars)

			PRESENT VALUES		
DISCOUNT RATE	VALUE OF FATALITY	SFAR 88 EFFECTIVENESS	BENEFITS	COSTS	BENEFIT/COST RATIO
7%	$5.5	50%	$ 657	$1,012	0.65
7%	$ 3	50%	$ 469	$1,012	0.46
7%	$ 8	50%	$ 828	$1,012	0.82
7%	$5.5	25%	$ 989	$1,012	0.98
7%	$ 3	25%	$ 704	$1,012	0.70
7%	$ 8	25%	$1,242	$1,012	1.23
7%	$5.5	75%	$ 330	$1,012	0.33
7%	$ 3	75%	$ 235	$1,012	0.23
7%	$ 8	75%	$ 414	$1,012	0.41
3%	$5.5	50%	$1,141	$1,509	0.76
3%	$ 3	50%	$ 842	$1,509	0.56
3%	$ 8	50%	$1,434	$1,509	0.95
3%	$5.5	25%	$1,658	$1,509	1.10
3%	$ 3	25%	$1,263	$1,509	0.84
3%	$ 8	25%	$2,151	$1,509	1.43
3%	$5.5	75%	$ 517	$1,509	0.34
3%	$ 3	75%	$ 421	$1,509	0.28
7%	$5.5	75%	$ 717	$1,509	0.48

ALTERNATIVES

As shown in Table VII-2, we evaluated the baseline costs and benefits for the following 8 alternatives to the final rule using a value of $5.5 million for a prevented fatality, a 7 percent discount rate, and a 50 percent SFAR 88 effectiveness rate:

ALTERNATIVE 1. cover only air carrier passenger airplanes

ALTERNATIVE 2. exclude auxiliary fuel tanks

ALTERNATIVE 3. cover only air carrier retrofitted passenger airplanes

ALTERNATIVE 4. cover only air carrier production passenger airplanes

ALTERNATIVE 5. cover only air carrier production passenger and cargo airplanes

ALTERNATIVE 6. final rule plus part 91 airplanes

ALTERNATIVE 7. final rule plus conversion cargo airplanes

ALTERNATIVE 8. final rule plus conversion and retrofitted cargo airplanes

TABLE VII-2

BENEFITS AND COST SUMMARIES FOR 8 ALTERNATIVES TO THE FINAL RULE USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY, A 7 PERCENT DISCOUNT RATE, AND A 50 PERCENT SFAR 88 EFFECTIVENESS RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE (7%)		BENEFIT/COST RATIO
OPTION	BENEFITS	COSTS	
FINAL RULE	**$657**	**$1,012**	**0.65**
ALTERNATIVES			
1. Cover Only Part 121 Passenger Airplanes (excludes Part 121 cargo and Part 91)	$657	$ 975	0.67
2. Cover Only Part 121 Passenger Airplanes but No Auxiliary Tanks	$657	$ 975	0.67
3. Cover Only Part 121 Retrofitted Passenger Airplanes (excludes All Production Passenger, all Cargo, and Part 91 Airplanes)	$271	$ 438	0.62
4. Cover Only Part 121 Production Passenger Airplanes	$386	$ 537	0.72
5. Cover Only Part 121 Production Passenger and Cargo Airplanes	$386	$ 574	0.67
6. Final Rule Plus Part 91 Airplanes	$657	$1,026	0.64
7. Final Rule Plus Conversion Cargo Airplanes	$657	$1,109	0.59
8. Final Rule Plus Conversion and Retrofitted Cargo Airplanes	$657	$1,229	0.53

ALTERNATIVE 1 : COVER ONLY AIR CARRIER PASSENGER AIRPLANES

Not covering air carrier production cargo airplanes would reduce the present value of the costs by $37 million while the benefits would be the same. However, that would leave pilots flying production cargo airplanes at a greater risk than the pilots flying production passenger airplanes. Given the goal of one level of safety, we included these commercial cargo pilots in the rule because it costs substantially less to install FTI on production airplanes than on existing airplanes. Further, these production cargo airplanes will be flying for 40 more years, whereas a retrofitted cargo airplane will have fewer years in service.

ALTERNATIVE 2 : EXEMPT AUXILIARY TANKS

Boeing commented there are few auxiliary tanks in air carrier passenger service and nearly all of those airplanes will be retired by 2017. As a result, there would be minimal aggregate costs and benefits from exempting auxiliary fuel tanks from the final rule.

ALTERNATIVE 3 : COVER ONLY RETROFITTED AIR CARRIER PASSENGER AIRPLANES

Although this is not really an alternative, it is included to determine the impact of the final rule specifically on air carrier retrofitted passenger airplanes. The present value of the final rule's costs would decrease from $1.012 billion to $438 million and the expected benefits would decrease from $657 million to $271 million, which lowers the benefit-cost ratio from 0.65 to 0.62.

ALTERNATIVE 4 : COVER ONLY AIR CARRIER PRODUCTION PASSENGER AIRPLANES

If the final rule were to cover only air carrier production passenger airplanes, the present value of the final rule's costs would decrease from $1.012 billion to $537 million and the expected benefits would decrease from $657 million to $386 million. The benefit-cost ratio would increase from 0.65 to 0.72. However, when evaluating the case where a large airplane were to explode by 2012 with a loss of 180 people, there is an 89 percent probability that such an accident would happen to an existing airplane and only an 11 percent probability that it would happen to a production airplane. Thus, we did not select this alternative because it has a much lower chance of preventing a major explosion in the immediate future.

ALTERNATIVE 5 : COVER ONLY AIR CARRIER PRODUCTION PASSENGER AND CARGO AIRPLANES

In comparison to Alternative 4, including air carrier production cargo airplanes with air carrier production passenger airplanes would increase the final rule's costs from

$537 million to $574 million and the benefits would remain the same. The benefit-cost ratio would decrease from 0.76 to 0.71.

ALTERNATIVE 6 : INCLUDE PART 91 OPERATIONS

Including Part 91 operations would increase the present value costs by $14 million while having a minimal benefit because these airplanes fly an average of less than 750 hours a year and transport few people.

ALTERNATIVE 7 : INCLUDE AIR CARRIER CONVERSION CARGO AIRPLANES

Including conversion air carrier conversion cargo airplanes would increase the final rule's costs from $1.012 billion to $1.109 billion and the benefits would remain the same. The benefit-cost ratio would decrease from 0.65 to 0.59. Although we are committed to the «one level of safety « principle, the costs to retrofit these airplens that will fly many fewer hours than production cargo airplanes is not justified by the costs.

ALTERNATIVE 8 : INCLUDE AIR CARRIER CONVERSION AND RETROFITTED CARGO AIRPLANES

Including air carrier retrofitted cargo airplanes would increase the rule's (plus conversion cargo) costs from $1.109 billion to $1.229 billion while the benefits would not change. The benefit-cost ratio would decrease from 0.59 to 0.53. The average existing cargo airplane will fly even fewer hours than the average future conversion cargo airplanes because conversion cargo airplanes are younger than the average existing airplane.

COST-EFFECTIVENESS ANALYSIS

Another way to analyze these alternatives is to evaluate them on an incremental cost per life saved; i.e., a cost-effectiveness analysis. For this rule, the effectiveness metric is the number of expected prevented fuel tank explosions, which is then converted into the present value of the number of fatalities prevented. The mid-point of the time-frame in which an accident would happen is 2022 for production airplanes and 2019 for retrofitted airplanes. For all other airplanes, the mid-point would be about 100 years from today, or 2110. In Table 8, the first column lists the specific types of airplanes that could have FRM installed. The second column reports the number of fuel tank explosions that FRM would prevent using an SFAR 88 effectiveness rate of 50 percent. The third column provides the present value of the total costs to install FRM on those airplanes minus the present value of the destroyed airplane and minus the demand benefits weighted by the number of flight hours. The passenger airplane hull value is $50, which gives present values of $19 million for production airplanes and $24 million for retrofitted airplanes. The present value of the demand benefits would be $100 million for retrofitted airplanes and $151 million for production airplanes. The fourth column takes the number of prevented explosions and divides it into the costs to calculate the present value of the cost to prevent one explosion. The fifth column provides the number of fatalities that would be prevented if FRM were installed on the airplane assuming that 80 percent of the explosions would be in-flight and 20 percent would be on the ground. These numbers are then adjusted by the discount rate to reflect the present value of the fatalities for production and retrofitted passenger airplanes. The final column supplies the average present value of the cost for that option to prevent one fatality. As shown in Table VII-3, the two most cost-effective options would be to install FRM on production passenger airplanes and on existing passenger airplanes. The final rule contains all of the options except conversion cargo airplanes and retrofitted cargo airplanes.

TABLE VII-3

INCREMENTAL COST EFFECTIVENESS ANALYSIS OF THE INDIVIDUAL ALTERNATIVES USING A PRESENT VALUE ANALYSIS WITH A 7 PERCENT DISCOUNT RATE AND A 50 PERCENT SFAR 88 EFFECTIVENESS RATE
(Total Costs in Millions of 2007 Dollars)

		PV	PV		PV
OPTIONS	NUMBER OF EXPLOSIONS PREVENTED	COSTS – HULL and DEMAND LOSS	COST TO PREVENT ONE ACCIDENT	AVERAGE NUMBER OF FATALITIES	COST TO PREVENT 1 STATISTICAL FATALITY
Production Passenger Airplanes	1.00	$367	$ 367	46	$ 8
Production Cargo Airplanes	0.0385	$ 37	$ 961	.055	$17,473
Production Part 91 Airplanes	0.00082	$ 2	$2,439	.249	$9,785
Retrofitted Passenger Airplanes	0.52	$314	$ 604	56	$ 11
Conversion Cargo Airplanes	0.095	$ 83	$ 874	.055	$15,891
Retrofitted Cargo Airplanes	0.064	$110	$1,719	.055	$31,255
Retrofitted Part 91 Airplanes	0.0194	$ 12	$6,186	.249	$24,843
Final Rule	1.5585	$741	$ 475	49	$ 10

CONCLUSION

We determined that the final rule provides the best balance between the costs and benefits of providing FRM. In particular, although the benefit-cost ratio is the highest when only air carrier production passenger airplanes are covered, the greatest probability of preventing the most catastrophic accident in the near future requires the inclusion of the existing fleet.

VIII. REGULATORY FLEXIBILITY ANALYSIS

<u>Introduction and Purpose of This Analysis</u>

The Regulatory Flexibility Act of 1980 (Public Law 96-354) (RFA) establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration." The RFA covers a wide-range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA.

We believe that this final rule will have a significant economic impact on a substantial number of small entities. The purpose of this analysis is to provide the reasoning underlying the FAA determination. The FAA has determined that:

-There will not be a significant impact on a substantial number of manufacturers.

-There will be a significant impact on a substantial number of operators.

To make this determination in this final rule, we perform a Regulatory Flexibility Analysis (RFA). Under Section 63(b) of the RFA, the analysis must address:

Description of reasons the agency is considering the action

Statement of the legal basis and objectives for the rule

Significant issues raised during public comment

Description of the record keeping and other compliance requirements of the rule

All federal rules that may duplicate, overlap, or conflict with the rule

Description and an estimated number of small entities

Analysis of small firms' ability to afford the rule

Conduct a disproportionality analysis

Conduct a competitive analysis

Estimation of the potential for business closures

Describe the alternatives considered

Description of reasons the agency is considering the action

Fuel tank explosions have been a constant threat with serious aviation safety implications for many years. Since 1960, 18 airplanes have been damaged or destroyed as the result of a fuel tank explosion. A recent explosion involving a Boeing Model 747 (TWA Flight 800) off Long Island, New York in 1996 occurred in-flight and led to the deaths of 230 people. Two other recent explosions on airplanes operated by Philippine Airlines and Thai Airlines occurred on the ground (resulting in nine fatalities). While the accident investigations of the TWA, Philippine Airlines and Thai Airlines accidents failed to identify the ignition source that caused the explosion, the investigations found several similarities

The requirements contained in this final rule will reduce the likelihood of fuel tank fires, and mitigate the effects of a fire if one occurs.

Statement of the legal basis and objectives for the rule

The FAA's authority to issue rules regarding aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106 describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in Subtitle VII, Part A, Subpart III, Section 44701, "General requirements." Under that section, the FAA is charged with promoting safe flight of civil aircraft in air commerce by prescribing minimum standards required in the interest of safety for the design and performance of aircraft; regulations and minimum standards in the interest of aviation safety for inspecting, servicing, and overhauling aircraft; and regulations for other practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This regulation is within the scope of that authority because it prescribes—

New safety standards for the design of transport category airplanes, and

New requirements necessary for safety for the design, production, operation and maintenance of those airplanes, and for other practices, methods, and procedures related to those airplanes.

Accordingly, this final rule amends Title 14 of the Code of Federal Regulations and address deficiencies in current regulations regarding airplane designs of the current and future fleet. The rule will require transport category airplanes to minimize flammability of fuel tanks.

Significant issues raised during public comment

Individuals and companies commented that they will incur costs as a result of the requirements contained in the rule. Although no small entities commented, we have incorporated commenter cost information in our final regulatory evaluation and accompanying RFA.

Description of the record keeping and other compliance requirements of the rule

We expect no more than minimal new reporting and record-keeping compliant requirements to result from this rule. The rule will require additional entries in existing required maintenance records to account for either the additional maintenance requirements or the installation of nitrogen-inerting systems and the addition of insulation between heat-generating equipment and fuel tanks.

All federal rules that may duplicate, overlap, or conflict with the rule

SFAR 88 was enacted to ensure no ignition source could ignite the fuel tank. After that rule was promulgated, we continued to find ignition sources that we had not know existed. Thus, SFAR 88 cannot eliminate all future ignition sources. This rule is designed to work in conjunction with SFAR 88 to prevent future HCWT explosions. We are unaware that the rule will overlap, duplicate, or conflict with any other existing Federal Rules.

Description and an estimated number of small entities

The FAA uses the size standards from the Small Business Administration for Air Transportation and Aircraft Manufacturing specifying companies having less than 1,500 employees as small entities. Boeing is the sole U.S. manufacturer affected by this final rule. As Boeing has more than 1,500 employees and is not considered a small entity, there will not be a significant impact on a substantial number of manufacturers.

In addition, we considered the economic impact on small-business part 91 operators89. Boeing airplanes are operated in part 91 service. Most of these affected airplanes are owned by large businesses that operate these airplanes as corporate jets. Given the ownership and operating expense of these airplanes, we do not believe these firms will incur a significant economic impact.

We identified 15 U.S. operators who will be affected by this final rule and qualify as small businesses because they have less than 1,500 employees.90 These entities operate a total of 214 airplanes. Once the firms were classified as small entities, we gathered information on their annual revenues.

We obtained the small entities' fleets using data from FAA Flight Standards and BACK Associates Fleet Database. The number of employees and revenues were obtained from the U.S. Department of Transportation Form 41 filings, BTS Office of Airline Information, Hoovers Online, and Thomas Gale Business and Company Resource Center.

Analysis of small firms' ability to afford the rule

To assess the cost impact to small business part 121 airlines, we estimated the present value retrofit cost for the affected aircraft in the small entities fleet. The following table summarizes the cost to retrofit per airplane and the associated model types.

Retrofit Cost Per Model	
Model	Present Value Cost

[89] Foreign operators of U.S. registered aircraft operating under part 129 have the option of registering these aircraft outside the U.S. and avoiding compliance with the rule.
[90] World Aviation Directory and Reference USA

B-737-Classic	$137,000
B-737-NG	$121,000
B-757	$211,000
B-767	$264,000
B747-100/100/300	$289,000
B-747-400	$289,000
B-777	$311,000
A-320 Family	$137,000
A-330	$311,000

We estimated each operator's compliance cost by multiplying the average retrofit cost per airplane by the total number of each type of airplane the operator currently has. Then we measured the economic impact on small entities by dividing the firms' total estimated present value compliance cost by its annual revenue. We believe that if the retrofit cost exceeds 2% of a firm's annual revenue, then there is a significant economic impact. As shown in the following table, the present value of the retrofitting costs is estimated to be greater than two percent of annual revenues for three small operators. Thus, we determined that this final rule will have a significant impact on a substantial number of small entities.

Airplane Model	Small Entity Operator	Number of Affected Aircraft	Cost	Annual Revenue	Cost as a % of Revenue
BOEING 737-700	ALOHA AIRLINES	2	$242,000		
BOEING 737-700	ALOHA AIRLINES	5	$605,000		
BOEING 737-700	ALOHA AIRLINES	1	$121,000		
		Total	$968,000	$300,601,582	0.32%
BOEING 737-300	ATA AIRLINES	3	$411,000		
BOEING 737-800	ATA AIRLINES	11	$1,331,000		
BOEING 737-800	ATA AIRLINES	1	$121,000		
BOEING 757-200	ATA AIRLINES	4	$1,055,000		
BOEING 757-200	ATA AIRLINES	2	$422,000		
BOEING 757-300	ATA AIRLINES	4	$844,000		
		Total	$4,184,000	$330,177,135	1.27%

BOEING 757-200	EOS AIRLINES	3	$633,000	$1,084,907	58.350%
AIRBUS A318-100	FRONTIER AIRLINES [CO-USA]	8	$1,096,000		
AIRBUS A319-100	FRONTIER AIRLINES [CO-USA]	39	$5,343,000		
AIRBUS A319-100	FRONTIER AIRLINES [CO-USA]	10	$1,370,000		
		Total	$7,809,000	$1,130,837,682	0.69%
BOEING 767-300	HAWAIIAN AIRLINES	4	$1,056,000		
BOEING 767-300	HAWAIIAN AIRLINES	8	$2,112,000		
BOEING 767-300	HAWAIIAN AIRLINES	3	$792,000		
BOEING 767-300	HAWAIIAN AIRLINES	3	$792,000		
		Total	$4,752,000	$881,599,398	0.54%
BOEING 767-200	MAXJET AIRWAYS	1	$264,000		
BOEING 767-200	MAXJET AIRWAYS	1	$264,000		
BOEING 767-200	MAXJET AIRWAYS	1	$264,000		
		Total	$792,000	$2,422,199	32.70%
BOEING 737-400	MIAMI AIR INTERNATIONAL	2	$274,000		
BOEING 737-800	MIAMI AIR INTERNATIONAL	3	$363,000		
BOEING 737-800	MIAMI AIR INTERNATIONAL	1	$121,000		
BOEING 737-800	MIAMI AIR INTERNATIONAL	1	$121,000		
BOEING 737-800	MIAMI AIR INTERNATIONAL	2	$121,000		
		Total	$1,000,000	$73,403,477	1.36%
BOEING 757-200	PRIMARIS AIRLINES	1	$211,000	$19,403,658	1.09%
BOEING 737-300	RYAN INTERNATIONAL AIRLINES	1	$137,000		
BOEING 737-400	RYAN INTERNATIONAL AIRLINES	1	$137,000		

BOEING 737-800	RYAN INTERNATIONAL AIRLINES	2	$242,000		
BOEING 737-800	RYAN INTERNATIONAL AIRLINES	1	$121,000		
BOEING 737-800	RYAN INTERNATIONAL AIRLINES	1	$121,000		
BOEING 757-200	RYAN INTERNATIONAL AIRLINES	1	$211,000		
BOEING 757-200	RYAN INTERNATIONAL AIRLINES	1	$211.000		
BOEING 757-200	RYAN INTERNATIONAL AIRLINES	2	$422,000		
		Total	$1,602,000	$101,560,750	1.58%
AIRBUS A319-100	SPIRIT AIRLINES [USA]	30	$4,100,000		
AIRBUS A321-100	SPIRIT AIRLINES [USA]	6	$822,000		
		Total	$4,922,000	$540,426,363	0.91%
BOEING 737-800	SUN COUNTRY AIRLINES	2	$242,000		
BOEING 737-800	SUN COUNTRY AIRLINES	6	$726,000		
BOEING 737-800	SUN COUNTRY AIRLINES	2	$242,000		
BOEING 737-800	SUN COUNTRY AIRLINES	3	$363,000		
		Total	$1,573,000	$225,789,595	0.70%
AIRBUS A320-100	USA 3000 AIRLINES	1	$137,000		
AIRBUS A320-100	USA 3000 AIRLINES	1	$137,000		
AIRBUS A320-100	USA 3000 AIRLINES	9	$1,233,000		
		Total	$1,507,000	$132,077,603	1.14%
B-737-429	Casino Express	1	$137,000		
B-737-46B	Casino Express	1	$137,000		
B-737-4S3	Casino Express	1	$137,000		

B-737-8Q8	Casino Express	2	$242,000		
B-737-8Q8	Casino Express	1	$121,000		
B-737-86N	Casino Express	1	$121,000		
		Total	$895,000	$34,178,453	2.62%
B-737-3Y0	Pace Airlines	1	$137,000		
B-757-256	Pace Airlines	1	$137,000		
B-757-236	Pace Airlines	1	$137,000		
		Total	$411,000	$40,411,353	1.02%

<u>Disproportionality Analysis</u>

Due to the potential lower cost that could arise from fleet discounts, large operators may be able to negotiate better pricing. The result is that small operators could bear a disproportionate cost compared to larger operators.

<u>Competitive Analysis</u>

Given the specialization and target markets for some of these small entities, we do not believe that this final rule will reduce the ability of small operators to compete.

Two small business airlines (MAXjet and EOS) are beginning to establish service in the market for business class operations. Maxjet is a business class, transatlantic airline with service to Stansted Airport in London. It has been in business since 2005. EOS airlines was founded in 2004 and also services Stansted Airport.

Other operators who will be significantly affected by this final rule operate in primarily international travel, vacation travel and specialized travel markets. Because these small business airlines operate in a niche market, there is expected to be little change in competition or market share resulting from this final rule.

<u>Estimation of the potential for business closures</u>

For affected small entity operators, the ratio of present-value costs to annual revenue shows that four of the U.S. small business air operators analyzed will have ratios in excess of two percent. Such a ratio could have a significant financial impact. To fully assess whether this final rule will force a small entity into bankruptcy requires more financial information than is readily available. However, we believe the compliance cost of this rule will not force these firms into bankruptcy.

Describe the alternatives considered

The section titled "Analysis of Alternatives" can be found in the Final Regulatory Evaluation. It contains discussion and cost estimates for alternatives that were considered.

Regulatory Flexibility Analysis Summary

Therefore, as the FAA Administrator, I certify that this rule:

-will not be a significant impact on a substantial number of manufacturers.

-will be a significant impact on a substantial number of operators.

IX. INTERNATIONAL TRADE IMPACT ANALYSIS

The Trade Agreements Act of 1979 (Public Law 96-39) prohibits Federal agencies from establishing any standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Legitimate domestic objectives, such as safety, are not considered unnecessary obstacles. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the effects of this rule and note the purpose is to ensure the safety of the American public and thus the rule is not considered as creating an unnecessary obstacle to foreign commerce.

X. UNFUNDED MANDATES REFORM ACT ASSESSMENT

Title II of the Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (adjusted annually for inflation with the base year 1995) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a "significant regulatory action." The FAA currently uses an inflation-adjusted value of $128.1 million in lieu of $100 million.

There will be 3 years (2015, 2016, and 2017) in which the undiscounted costs will be greater than $128.5 million. Consequently, as shown in Table 1 in the Executive Summary, we evaluated the costs and benefits of 8 alternatives to the final rule.

APPENDIX A:

POTENTIAL QUANTIFIED BENEFITS FROM MISTAKING A HCWT EXPLOSION FOR THE RESULT OF A TERRORIST ATTACK

A.I. SUMMARY

This Appendix evaluates a reasonable quantitative estimate for the economic impacts from a potential government and industry mistaken preliminary interpretation that an in-flight HCWT explosion was the consequence of a terrorist action. As will be shown, adding this quantitative benefit estimate would increase the present value of the benefits to $1.582 billion while the present value costs would be $986 million, resulting in a benefit cost ratio of 1.60. Thus, the rule would be cost-beneficial with the inclusion of the precautionary action benefits.

A.2. BACKGROUND

As an in-flight explosion caused by a HCWT ignition is initially indistinguishable from an explosion caused by a terrorist bomb in the cargo or passenger area, the initial government and public reaction to an explosion could be to assume the worst – that the accident is part of a larger terrorist plot requiring immediate action to thwart an imminent danger to other air travelers.

A cautious government and industry response to an in-flight passenger airplane fuel tank explosion would be to re-examine passengers and cargo on airplanes that have not left the airport for potential bombs until a preliminary determination could be made that the explosion was an accident and not a terrorist attack. The effect of a potential terrorist threat may also cause individual airlines to react cautiously. For example, after the August 9 late night arrests of the liquid bomb plotters in England, British Airways cancelled 360 of its 550 flights out of Heathrow on August 10, 2006, 110 of its flights out of Heathrow on August 11, and 80 of its flights out of Heathrow on August 12. Easy Jet cancelled 300 flights on August 10 and 112 flights on August 11. The conclusion is that public trust concerns will likely result in risk minimizing decision making by all concerned.

It is also possible that, if it takes an extended time to determine that the explosion was a HCWT explosion and not the result of a terrorist act, more extensive and stringent cargo requirements would be mandated, as well as more intrusive passenger screening for all airplanes – even for McDonnell-Douglas airplanes, regional jets, and commuter turboprops that do not have HCWTs.

A.3. POTENTIAL BENEFITS FROM NOT REACTING TO A MISTAKEN TERRORIST THREAT

A.3.a. Quantified Benefits from Preventing a Mistaken Reaction

We have estimated that it cost the aviation industry about $2 billion for grounding all airplanes for two and a half days after the September 11, 2001, terrorist attacks. This estimate does not include subsequent security costs. The effects on the aviation industry of an in-flight air carrier passenger airplane HCWT fuel tank explosion could be $1.2 billion until it can be established that the explosion was not the result of a terrorist act. We have also determined that the effects on the aviation industry of an on-the-ground passenger airplane explosion could be $400 million. Thus, the average aviation system losses could be $1.04 billion (the 80 percent probability of an in-flight explosion times $1.2 billion plus the 20 percent probability of an on-the-ground explosion times $400 million) as the consequence of mistakenly believing the explosion to be the result of a terrorist act.

The ancillary benefits from preventing an air carrier in-flight cargo airplane explosion will be less than those for a passenger airplane explosion because a cargo airplane explosion, which is more likely to occur at night will not have the media coverage or fatalities that a passenger airplane explosion would have. Thus, the disruption to the US aviation system will be minimal.

Similarly, the ancillary benefits from preventing a Part 91 passenger airplane explosion will be minimal because the government would not likely view it as a terrorist plot and it would have a minimal effect on the aviation system.

Thus, there could be economic losses if security or other measures are taken by the aviation authorities and the airlines in response to a mistaken belief that a HCWT in-flight explosion was the consequence of a terrorist bomb.

The experience of the past 30 years combating acts of air piracy and terrorist actions confirms that the losses associated with aircraft bombings and hijackings are identifiable, measurable, and confined. The enormous economic cost of a catastrophic terrorist act against a passenger airplane can be estimated in terms of lives lost, property damage, decreased public utilization of air transportation, etc. as demonstrated by the September 11, 2001, attacks.

Several studies analyzing the economic impact of the September 11 attacks offer important insights for this analysis. One study[91] estimated that shutting down the entire air transportation network for two-and-a-half days cost almost $1.5 billion in 2001 just from lost airfares and cargo-shipping revenues. Although a solitary explosion likely would not shut down the entire air transportation network for two-and-a-half days, the government's immediate reaction to a potential terrorist attack from a mid-air passenger airplane explosion may be to ground all passenger and cargo airplanes not in the air until we could ascertain that this event is not part of a larger terrorist plot. In the mid-1990s, there was a terrorist plan to simultaneously explode bombs in cargo holds aboard a dozen US passenger airplanes flying over the Pacific Ocean and that parallel would be applicable in this case. Once the airplanes were grounded, the would likely want to re-examine all cargo (particularly cargo in passenger airplanes) and baggage would likely be re-examined to make certain that there were no terrorist bombs. Further, there would be long-term costs of the probable increased inspections of cargo (X-rays, more physical inspections, plastic explosive sensing machines, etc.

Brian S. Wesbury, Chief Economist, Griffin, Kubik, Stephens & Thompson, Inc., estimated that the short-term impact of the September 11, 2001, attacks in terms of total life and property losses was an estimated $40 billion. This direct cost pales in comparison to certain indirect costs, which included:

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[91] Source: Peter Navarro and Aron Spencer, "September 11, 2001: Assessing the Costs of Terrorism," Milken Institute Review, Fourth Quarter 2001, Milken Institute, as quoted in The Cost of Terrorism, Daily Policy Digest, Terrorism Issues, May 15, 2002.

- "Shopping centers and restaurants across the country were closed for at least 24 hours;
- High-risk office buildings (such as the Sears Tower in Chicago) were evacuated;
- The stock market ceased trading for four consecutive days;
- Airlines immediately received a $15 billion government assistance loan;
- Insurance costs skyrocketed, with some premiums up 300 percent or more from pre-attack levels. An insurance gradient has been created that increases the cost of doing business the closer companies are to centers of political and financial power; and
- The costs of security also increased sharply; in addition to an increase in the number of security guards at most major urban buildings, time-consuming security procedures have been implemented. Some firms have gone as far as installing X-ray machines and metal detectors."[92]

There were specific effects in September 2001 and for the last 4 months of the year that were influenced, to a large extent, by the September 11th events. It is difficult to isolate out those effects that were directly as a result of 9/11 and what would be attributable to other events; however, in September 2001:

- "Retail sales fell by $6 billion (2.1 percent);
- Durable goods new orders fell $11.6 billion (6.8 percent);
- New claims for unemployment insurance surged by 50,000, the biggest monthly jump since August 1982;
- Industrial production fell 1.0 percent in September; and
- Because of closer scrutiny at border crossings and shipping terminals, bottlenecks appeared in supply-chain management systems; durable goods shipments fell $9.2 billion in September 2001 as transportation issues played havoc with order flows and drove up shipping costs."[93]

And, in terms of the economic effects for the rest of the year:

- "Major airlines immediately cut scheduled flights by 30 percent, and even with fewer flights, planes were not full;

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[92] Ibid.
[93] Ibid.

- Hotels experienced a surge in vacancies and the economy shed 1.1 million jobs in the final four months of 2001; and
- Through December 29, 2001, the Bureau of Labor Statistics attributed 408 major layoff events (defined as those shedding 50 or more jobs) as a direct or indirect result of the attacks, with 70 percent of those layoffs in the air transportation and travel industries."[94]

Today, if an airplane explodes one of the first things examined will be whether the cause is terrorism and the public will likely want assurances that there would not be another explosion.

As previously noted, the air transportation network lost almost $1.5 billion for the two-and-a-half days that the network was shut down in 2001,[95] which is a loss of $600 million per day. We believe that a day and a half of lost flights after an in-flight explosion (a half a day on the day of the explosion and one day to evaluate the situation and begin to resume many aviation operations) is a reasonable average response for a loss of $900 million in 2001 dollars. This response may be done either by government fiat or by the individual airlines. For example, after the August 9 late night arrests of the liquid bomb plotters in England, British Airways cancelled 360 of its 550 flights out of Heathrow on August 10, 2006, of its flights out of Heathrow on August 11, and 80 of its flights out of Heathrow on August 12. Easy Jet cancelled 300 flights on August 10 and 112 flights on August 11. Public trust concerns will likely result in risk minimizing decision making by all concerned.

For an on-the-ground explosion on a passenger airplane, we believe that a half a day loss ($300 million in 2001 dollars) would be likely because the passengers and cargo would need to be taken off of airplanes preparing to depart and re-inspected. This reverse flow will also result in delays and cancellations of flights scheduled for later in the day. Further, there will be disruption of crew schedules that would cascade through the system.

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[94] Ibid.

[95] Industry analysts estimated that the anticipated accumulated losses for the airline industry from 2001 to 2004 at more than $30 billion

The undiscounted real value of these losses, however, is not a fixed number but a percentage of the economy at the time the accident would occur. As the economy grows, the absolute real value of the loss resulting from that fixed percentage will similarly grow. Consequently, the undiscounted value is updated for each year to account for economic growth.

As shown in Table A-1, updating the 2001 value of a $900 million loss to 2007 values to incorporate the average annual real growth rate of 3 percent results in a real loss of $1.075 billion in 2001 dollars. We updated the $1.075 billion 2001 dollars by the Consumer Price Index 6-year cumulative inflation rate of 11.6 percent for the years 2002 through 2007 in order to value it in 2007 dollars, which results in the current value of the loss at $1.2 billion in 2007. Thus, the loss per day is $800 million. As 80 percent of the explosions are expected to occur in flight and 20 percent on the ground, the expected loss from the system reaction to terrorism has a weighted average of $1.04 billion. We continued to modify the loss in real 2007 dollars by the annual growth rate of 3 percent, which we then discounted by 7 percent and 3 percent.[96]

TABLE A-1

PRESENT VALUE OF THE BENEFITS USING A 7 PERCENT DISCOUNT RATE FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION INITIALLY BELIEVED TO HAVE BEEN CAUSED BYA TERRORIST ACT
(in Millions of 2007 Dollars)

YEAR	UNDISCOUNTED	PRESENT VALUE
2007	$1,040	$1,040
2008	$1,071	$1,001
2009	$1,103	$964
2010	$1,136	$928
2011	$1,171	$893
2012	$1,206	$860
2013	$1,242	$827
2014	$1,279	$797
2015	$1,317	$767
2016	$1,357	$738
2017	$1,398	$711
2018	$1,440	$684

[96] Obviously, a 3 percent growth rate exactly cancels out a 3 percent discount rate, so that the present value of the benefit will always be $1.04 billion.

2019	$1,483	$658
2020	$1,527	$634
2021	$1,573	$610
2022	$1,620	$587
2023	$1,669	$565
2024	$1,719	$544
2025	$1,771	$524
2026	$1,824	$504
2027	$1,878	$485
2028	$1,935	$467
2029	$1,993	$450
2030	$2,053	$433
2031	$2,114	$417
2032	$2,178	$401
2033	$2,243	$386
2034	$2,310	$372
2035	$2,379	$358
2036	$2,451	$344
2037	$2,524	$332
2038	$2,600	$319
2039	$2,678	$307
2040	$2,758	$296
2041	$2,841	$285
2042	$2,926	$274

A.3.b. Potential Benefits

Using the same analysis used in Section IV-G, we established the 3.64 mean expected accident years are 2012, 2019, 2026, and (0.64 of an accident) in 2035. In Table C-2, we sum the undiscounted and present values of preventing an air carrier passenger airplane explosion in each of those three years from Table C-1 and Table IV-11. The present value of these potential benefits will be $3.982 billion, of which $2.251 billion are from not reacting as if the explosion were a terrorist plot, $629 million are prevented aviation demand losses, and $1.102 billion are direct benefits.

TABLE A-2

UNDISCOUNTED AND PRESENT VALUE OF THE POTENTIAL BENEFITS FROM PREVENTING 3.64 AIR CARRIER PASSENGER AIRPLANE EXPLOSIONS USING A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	TOTAL		REACTION		DEMAND		DIRECT	
YEAR	UNDIS-COUNTED	PRESENT VALUE	UNDIS-COUNTED	PRESENT VALUE	UNDIS-COUNTED	PRESENT VALUE	UNDIS-COUNTED	PRESENT VALUE

2012	$ 2,240	$1,597	$1,206	$ 860	$ 338	$241	$ 696	$ 496
2019	$ 2,595	$1,150	$1,483	$ 658	$ 416	$183	$ 696	$ 309
2026	$ 3,032	$ 835	$1,824	$ 504	$ 512	$139	$ 696	$ 192
2035	$ 2,397	$ 359	$1,523	$ 229	$ 429	$ 63	$ 445	$ 67
TOTAL	**$10,264**	**$3,941**	**$6,036**	**$2,251**	**$1,695**	**$626**	**$2,533**	**$1,064**

A.3.c. Discounted Potential and Realized Quantified Total Benefits

As shown in Table C-3, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each category to the values in Table C-2 results in a present value of the potential benefits (if all HCWT explosions were prevented) of $1.970 billion for SFAR 88 and $1.971 billion for the final rule. Of this $1.971 billion potential benefits for the final rule, airplanes with FRM will account for (hence, prevent) $1.562 billion while airplanes without FRM will account for (and not prevent) $409 million.

TABLE A-3

PRESENT VALUE OF THE POTANTIAL TOTAL BENEFITS FOR AIR CARRIER PASSENGER AIRPLANES
(in Millions of Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$1,597	$ 798	$ 799	$ 390	$409
2019	$1,150	$ 575	$ 575	$ 575	$ 0
2026	$ 835	$ 417	$ 417	$ 417	$ 0
2035	$ 359	$ 180	$ 180	$ 180	$ 0
TOTAL	**$3,941**	**$1,970**	**$1,971**	**$1,562**	**$409**

As shown in Table A-4, of the rule's total realized benefits of $1.562 billion, $625 million (40.0 percent of the total benefits) will be attributable to retrofitted airplanes and $937 million (60 percent of the total benefits) will be attributable to production airplanes.

TABLE A-4

PRESENT VALUE OF THE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE
(in Millions of Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$ 390	$207	$183
2019	$ 575	$310	$265
2026	$ 417	$108	$309
2035	$ 180	$ 0	$180
TOTAL	**$1,562**	**$625**	**$937**
PERCENT OF TOTAL		**40.0%**	**59.9%**

As shown in Table A-5, of the potential present value total reaction benefits of $1.126 billion, $906 million (80.5 percent) will be realized by airplanes with FRM and $220 million (19.5 percent) will not be realized because those hours will be flown by airplanes without FRM. Of the $906 million in realized reaction benefits, $354 million (39 percent) will be realized by retrofitted airplanes and $552 million (61 percent) will be realized by production airplanes.

TABLE A-5

PRESENT VALUE OF THE POTENTIAL AND REALIZED **REACTION BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY FRM INSTALLATION TYPE
(in Millions of Dollars)

	PRESENT VALUE (7 %)				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$ 430	$210	$112	$ 98	$220
2019	$ 329	$329	$177	$152	$ 0
2026	$ 252	$252	$ 65	$187	$ 0
2035	$ 115	$115	$ 0	$115	$ 0
TOTAL	**$1,126**	**$906**	**$354**	**$552**	**$220**
PERCENT OF POTENTIAL		**80.5%**	**31.4%**	**49.1%**	**19.5%**
PERCENT OF REALIZED			**39.0%**	**61.0%**	

A.4. BENEFIT-COST ANALYSIS

As shown in Table C-6, the rule's total quantified benefits have a present value of $1.562 billion, all of which are related to a prevented air carrier passenger airplane explosion. Of the $1.562 billion, $625 million is attributable to air carrier retrofitted passenger airplanes and $957 million is attributable to air carrier production passenger airplanes. The rule's present value of the total cost is $986 million, of which $937 million will be incurred by air carrier passenger airplane operators. Of this $937 million, $423 million will be incurred by operators of air carrier retrofitted passenger airplanes and $514 million will be incurred by operators of air carrier production passenger airplanes.

The rule's total benefits have a present value that is $581 million greater than its total present value costs. For air carrier passenger airplanes, the present value benefits are $630 million greater than its total present value costs.

The overall benefit-cost ratio for the final rule is 1.59. The overall benefit-cost ratio for air carrier passenger airplanes is 1.68. It is 1.48 for air carrier retrofitted passenger airplanes and 1.83 for air carrier production airplanes. The cost benefit ratio is lower for retrofitted airplanes because it is more expensive to retrofit FTI on an airplane than it is to install it on a production airplane. Further, all production airplanes will fly 25 years whereas retrofitted airplanes will fly fewer than 25 years after being retrofitted.

TABLE A-6

TOTAL PRESENT VALUE BENEFITS AND COSTS
(in Millions of 2007 Dollars)

		PRESENT VALUE (7%)		
TYPE OF OPERATION	NUMBER OF PREVENTED ACCIDENTS	BENEFITS	COSTS	BENEFIT/COST RATIO
AIR CARRIER PASSENGER				
RETROFITTED	0.52	$ 625	$421	1.48
PRODUCTION	1.00	$ 937	$511	1.83
TOTAL	**1.52**	**$1,562**	**$932**	**1.68**
AUXILIARY TANKS	**0**	**$0**	**<$1**	

AIR CARRIER CARGO	**0.03**	**<$0.1**	**$ 36**	
PART 91				
RETROFITTED	<.0025		$ 11	
PRODUCTION	<.0025		$ 2	
TOTAL	**0.00375**	**<$0.1**	**$ 13**	
GRAND TOTAL	**1.55**	**$1,562**	**$981**	**1.59**

As shown in Table A-7, the prevented costs to society from a reaction mistaking a terrorist threat for a HCWT explosion is $906 million, the prevented loss of aviation demand is $273 million and the direct benefits from the prevented deaths and property losses are $384 million. Thus, 58.0 percent of the benefits arise from preventing mistaken reactions, 17.5 percent arise from preventing the loss in overall demand for air travel resulting from HCWT explosions, and 24.6 percent arise from preventing the direct loss of life and property from the HCWT explosions.

TABLE A-7

PRESENT VALUE OF TOTAL BENEFITS BY SOURCE OF BENEFITS
(in Millions of 2007 Dollars)

	TOTAL	REACTION	DEMAND	DIRECT
AIR CARRIER				
RETROFITTED	$ 605	$354	$100	$151
PRODUCTION	$ 958	$552	$173	$233
TOTAL	**$1,563**	**$906**	**$273**	**$384**
PERCENT OF TOTAL		**58.0%**	**17.5%**	**24.6%**

APPENDIX B:

SENSITIVITY ANALYSIS OF BENEFITS

INTRODUCTION

This Appendix reports the following five alternate estimated benefits using $3 million, $5.5 million, and $8 million for the value of a prevented fatality and 3 percent and 7 percent discount rates:

Section A . Value of a prevented fatality: $5.5 million
Discount rate: 3 percent

Section B . Value of a prevented fatality: $3 million
Discount rate: 7 percent

Section C . Value of a prevented fatality: $3 million
Discount rate: 3 percent

Section D . Value of a prevented fatality: $8 million
Discount rate: 7 percent

Section E . Value of a prevented fatality: $8 million
Discount rate: 3 percent

The methodology used in calculating these estimates follows the methodology in Section 4 and is not repeated in the 5 sensitivity analysis section.

SECTION A. ESTIMATED BENEFITS USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE

A.1. Demand Benefits

A 3 percent discount rate exactly offsets a 3 percent real economic growth rate. Thus, the present value of a $292 million demand impact in 2007 remains the same for every year.

A.2. Direct Benefits

As shown in Table A-1, we calculated the direct weighted average benefits (based on an 80 percent probability of an in-flight explosion and a 20 percent probability of an on-the-ground explosion) from an average HCWT explosion using a $5.5 million value for a prevented fatality.

TABLE A-1

PRESENT VALUE OF THE **DIRECT BENEFITS** FROM PREVENTING AN AIR CARRIER AIRPLANE EXPLOSION USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE
	DISCOUNT RATE
YEAR	3%
2007	$696.123
2008	$675.848
2009	$656.163
2010	$637.051
2011	$618.496
2012	$600.482
2013	$582.992
2014	$566.012
2015	$549.526
2016	$533.520
2017	$517.981
2018	$502.894
2019	$488.247
2020	$474.026
2021	$460.219
2022	$446.815
2023	$433.801

2024	$421.166
2025	$408.899
2026	$396.989
2027	$385.426
2028	$374.200
2029	$363.301
2030	$352.720
2031	$342.446
2032	$332.472
2033	$322.789
2034	$313.387
2035	$304.259
2036	$295.397
2037	$286.793
2038	$278.440
2039	$270.330
2040	$262.457
2041	$254.812
2042	$247.391

A.3. Total Benefits

As shown in Table A-2, the present values of the potential total benefits from preventing an air carrier passenger airplane explosion in each of the years (2012, 2019, 2026, and 2035) in which a statistical accident would occur will be $2.748 billion, of which $1.057 billion will be from demand benefits, and $1.691 billion will be from direct benefits.

TABLE A-2

PRESENT VALUE OF THE **POTENTIAL TOTAL BENEFITS** FROM PREVENTING AIR CARRIER HCWT PASSENGER AIRPLANE EXPLOSIONS USING A $5.5 MILLION VALUE OF A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	POTENTIAL BENEFITS		
YEAR	TOTAL	DEMAND	DIRECT
2012	$ 893	$ 292	$ 601
2019	$ 780	$ 292	$ 488
2026	$ 689	$ 292	$ 397
2035	$ 386	$ 181	$ 205
TOTAL	**$2,748**	**$1,057**	**$1,691**

As shown in Table A-3, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each airplane category presented in Table IV-14 to the total benefits in Table A-2 results in a present value of the rule's potential benefits (if all HCWT explosions were prevented) of $1.374 billion for SFAR 88 and $1.374 billion for the final rule. Of this $1.374 billion potential benefits for the final rule, airplanes with FRM will account for $1.141 billion while $263 million will not be realized due to airplanes flying without FRM. Thus, final rule total benefits will be $1.141 billion.

TABLE A-3

POTENTIAL PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $5.5 MILLION VALUE OF A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$ 893	$ 446	$ 447	$ 214	$263
2019	$ 780	$ 390	$ 390	$ 390	$ 0
2026	$ 689	$ 345	$ 344	$ 344	$ 0
2035	$ 386	$ 193	$ 193	$ 193	$ 0
TOTAL	**$2,748**	**$1,374**	**$1,374**	**$1,141**	**$263**

As shown in Table A-4, of the final rule's total benefits of $1.141 billion, $412 million (36.1 percent of the total benefits) will be attributable to retrofitted airplanes and $729 million (63.9 percent of the total benefits) will be attributable to production airplanes.

TABLE A-4

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $5.5 VALUE OF A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION

2012	$ 214	$114	$100
2019	$ 390	$210	$180
2026	$ 344	$ 89	$255
2035	$ 193	$ 0	$193
TOTAL	**$1,141**	**$412**	**$729**
PERCENT OF TOTAL		**36.1%**	**63.9%**

As shown in Table A-5, of the final rule's demand benefits of $452 million, $153 million (33.9 percent of the total demand benefits) will be attributable to retrofitted airplanes and $299 million (66.1 percent of the total demand benefits) will be attributable to production airplanes.

TABLE A-5

PRESENT VALUE OF THE FINAL RULE **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $5.5 VALUE OF A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$ 69	$ 37	$ 32
2019	$146	$ 78	$ 68
2026	$146	$ 38	$108
2035	$ 91	$ 0	$ 91
TOTAL	**$452**	**$153**	**$299**
PERCENT OF TOTAL		**33.9%**	**66.1%**

As shown in Table A-6, multiplying the direct benefits in Table A-3 by the percentages in Table IV-13, results in the present value of $846 million for the potential direct benefits, of which $688 million (81.3 percent) will be realized by airplanes with FRM and $158 million (18.7 percent) will not be realized. Of the $688 million in realized direct benefits, $256 million (37.2 percent) will be realized by retrofitted airplanes and $432 million (62.8 percent) will be realized by production airplanes.

TABLE A-6

PRESENT VALUE OF THE FINAL RULE **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE OF DIRECT BENEFITS				
		WITH FRM			NO FRM
YEAR	TOTAL RULE	TOTAL	RETROFIT	PRODUCTION	
2012	$301	$143	$ 72	$ 71	$158
2019	$244	$244	$122	$122	$ 0
2026	$199	$199	$ 62	$137	$ 0
2035	$103	$103	$ 0	$103	$ 0
TOTAL	**$846**	**$688**	**$256**	**$432**	**$158**
PERCENT OF POTENTIAL		**81.3%**			**18.7%**
PERCENT OF REALIZED			**37.2%**	**62.8%**	

A.4. Benefits by Manufacturer

As shown in Table A-7, Boeing airplanes will accumulate present value benefits of $664 million of which $268 million will be attributable to retrofitted airplanes and $396 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $477 billion of which $144 million will be attributable to retrofitted airplanes and $333 million will be attributable to production airplanes.

TABLE A-7

PRESENT VALUE OF THE FINAL RULE TOTAL BENEFITS FOR AIR CARRIER PASSENGER AIRPLANES USING A $5.5 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION AND BY MANUFACTURER
(Numbers in Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS
RETROFITTED	**104.3**		**$412**
BOEING	67.9	65.10%	$268
AIRBUS	36.4	34.90%	$144

PRODUCTION	**199.3**		**$729**
BOEING	108.3	54.34%	$396
AIRBUS	91	45.66%	$333
TOTAL	**303.6**		**$1.141**
BOEING	176.2	58.04%	$ 664
AIRBUS	127.4	41.96%	$ 477

SECTION B.

ESTIMATED BENEFITS USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCEMT DISCOUNT RATE

B.1. Demand Benefits

As the demand benefits are not affected by the value of a prevented fatality, they are the same as those presented in Table IV-6 .

B.2. Direct Benefits from Preventing an Air Carrier Passenger Airplane Explosion

B.2.a. An In-Flight Accident

As shown in Table B-1, the "average" quantified direct benefits from preventing an air carrier passenger airplane in-flight explosion using a $3 million value for a prevented fatality ranges from $353 million to $1.239 billion.[97]

TABLE B-1

DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE IN-FLIGHT EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	99	$ 297	$ 1	$8	$ 306
B-737-Classic	110	$ 330	$ 15	$8	$ 353
B-737-NG	123	$ 369	$ 30	$8	$ 407
B-757	176	$ 528	$ 34	$8	$ 570
B-767	224	$ 672	$ 50	$8	$ 730
B-747-100/200/300	332	$ 996	$ 15	$8	$1,019
B-747-400	372	$1,116	$ 85	$8	$1,209
B-747-800	372	$1,116	$115	$8	$1,239
B-777	290	$ 870	$100	$8	$ 978
B-787	224	$ 672	$ 75	$8	$ 755
A-300	224	$ 672	$ 34	$8	$ 714
A-310	204	$ 612	$ 25	$8	$ 645

[97] This excludes the B-737-200 and the A-380.

A-320 Family	123	$ 369	$ 30	$8	$ 407
A-330	290	$ 870	$ 85	$8	$ 963
A-340	332	$ 996	$100	$8	$1,104
A-350	224	$ 672	$ 75	$8	$ 755
A-380	502	$1,506	$150	$8	$1,664

As shown in Table B-2, the average of the direct benefits weighted by the number of flight hours and using a $3 million value for a prevented fatality is $479 million.

TABLE B-2

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Airplane Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 306	0.643	0.18%	$ 0.544
B-737-Classic	$ 353	14.782	4.08%	$ 14.415
B-737-NG	$ 407	150.505	40.49%	$164.789
B-757	$ 570	26.430	7.30%	$ 41.618
B-767	$ 730	14.350	3.96%	$ 28.938
B-747-100/200/300	$1,019	0.798	0.22%	$ 2.248
B-747-400	$1,209	4.997	1.36%	$ 16.499
B-747-800	$1,239	0.000	0.00%	$ 0.000
B-777	$ 978	13.485	3.68%	$ 35.978
B-787	$ 755	0.000	0.00%	$ 0.000
A-300	$ 714	0.149	0.04%	$ 0.294
A-310	$ 645	0.000	0.00%	$ 0.000
A-320 Family	$ 407	134.776	36.36%	$147.978
A-330	$ 963	4.413	1.21%	$ 11.643
A-340	$1,104	0.000	0.00%	$ 0.000
A-350	$ 755	1.976	0.52%	$ 3.963
A-380	$1,664	2.210	0.59%	$ 9.768
TOTAL		**363.784**		**$478.676**

B.2.b. <u>An On-The-Ground Accident</u>

As shown in Table B-3, the direct benefits from preventing an on-the-ground air carrier passenger airplane explosion range from $49 million to $234 million.[98]

TABLE B-3

[98] This excludes the B-737-200 and the A-380,

DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	10	$ 30	$ 1	$1	$ 32
B-737-Classic	11	$ 33	$ 15	$1	$ 49
B-737-NG	12	$ 36	$ 30	$1	$ 67
B-757	18	$ 54	$ 34	$1	$ 89
B-767	22	$ 66	$ 50	$1	$117
B-747-100/200/300	33	$ 99	$ 15	$1	$115
B-747-400	37	$111	$ 85	$1	$197
B-747-800	37	$111	$115	$1	$227
B-777	29	$ 87	$100	$1	$188
B-787	22	$ 66	$ 75	$1	$142
A-300	22	$ 66	$ 34	$1	$101
A-310	20	$ 60	$ 25	$1	$ 86
A-320 Family	12	$ 36	$ 30	$1	$ 67
A-330	29	$ 87	$ 85	$1	$173
A-340	33	$ 99	$100	$1	$200
A-350	22	$ 66	$ 75	$1	$142
A-380	50	$150	$150	$1	$301

As shown in Table B-4, the average of the direct benefits weighted by the number of flight hours from preventing an on-the-ground air carrier passenger airplane explosion will be $79 million.

TABLE B-4

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Total Accident Cost	Total Num. Flight Hours	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 32	0.643	0.18%	$ 0.057
B-737-Classic	$ 49	14.782	4.08%	$ 2.001
B-737-NG	$ 67	150.505	40.49%	$27.128
B-757	$ 89	26.430	7.30%	$ 6.498
B-767	$117	14.350	3.96%	$ 4.638
B-747-100/200/300	$115	0.798	0.22%	$ 0.254
B-747-400	$197	4.997	1.36%	$ 2.688
B-747-800	$227	0.000	0.00%	$ 0.000

B-777	$188	13.485	3.68%	$ 6.916
B-787	$142	0.000	0.00%	$ 0.000
A-300	$101	0.149	0.04%	$ 0.042
A-310	$ 86	0.000	0.00%	$ 0.000
A-320 Family	$ 67	134.776	36.36%	$24.360
A-330	$173	4.413	1.21%	$ 2.092
A-340	$200	0.000	0.00%	$ 0.000
A-350	$142	1.976	0.52%	$ 0.745
A-380	$301	2.210	0.59%	$ 1.767
TOTAL		**363.784**		**$79.185**

B.2.c. Direct Benefits Weighted by the Probabilities of an Air Carrier Passenger Airplane Explosion Happening In-Flight and On the Ground

As shown in Table B-5, the weighted average value of the expected direct benefits from preventing an air carrier passenger explosion is $399 million in 2007 (80 percent times $478.676 million plus 20 percent times $79.185 million). Table B-5 also contains the present values of these benefits for each year through 2042 using a 7 percent discount rate.

TABLE B-5

PRESENT VALUE OF THE WEIGHTED AVERAGE **DIRECT BENEFITS** FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
	7 % DISCOUNT RATE
2007	$398.778
2008	$372.690
2009	$348.308
2010	$325.522
2011	$304.226
2012	$284.323
2013	$265.723
2014	$248.339
2015	$232.092
2016	$216.909
2017	$202.718
2018	$189.456
2019	$177.062
2020	$165.479

2021	$154.653
2022	$144.535
2023	$135.080
2024	$126.243
2025	$117.984
2026	$110.265
2027	$103.052
2028	$96.310
2029	$90.009
2030	$84.121
2031	$78.618
2032	$73.474
2033	$68.668
2034	$64.175
2035	$59.977
2036	$56.053
2037	$52.386
2038	$48.959
2039	$45.756
2040	$42.763
2041	$39.965
2042	$37.351

B.3. Potential Benefits from Preventing Air Carrier Passenger Airplane Explosions

In Table B-6, we provide the present values of preventing an air carrier passenger airplane explosion in each of the years 2012, 2019, 2026, and 2035 from Tables IV-16 and B-5. The present value of the potential total benefits will be $1.231 billion of which $622 million will be demand losses and $609 million will be direct losses.

TABLE B-6

PRESENT VALUE OF THE POTENTIAL BENEFITS FROM PREVENTING AIR CARRIER HCWT PASSENGER AIRPLANE EXPLOSIONS USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	TOTAL	DEMAND	DIRECT
2012	$ 524	$240	$284
2019	$ 359	$182	$177
2026	$ 248	$138	$110
2035	$ 100	$ 62	$ 38
TOTAL	**$1,231**	**$622**	**$609**

B.4. Discounted Potential and Realized Quantified Benefits

As shown in Table B-7, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each airplane category presented in Table IV-14 to the total benefits in Table B-6 results in a present value of the final rule's potential benefits (if all HCWT explosions were prevented) will be $605 million for SFAR 88 and $606 million for the final rule. Of this $606 million potential benefits for the final rule, airplanes with FRM will account for $469 million while $137 million will not be realized due to airplanes flying without FRM. Thus, the present value of the final rule total benefits will be $469 million.

TABLE B-7

PRESENT VALUE OF THE **POTENTIAL TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$ 524	$262	$262	$125	$137
2019	$ 359	$169	$170	$170	$ 0
2026	$ 248	$124	$124	$124	$ 0
2035	$ 100	$ 50	$ 50	$ 50	$ 0
TOTAL	**$1,231**	**$605**	**$606**	**$469**	**$137**

As shown in Table B-8, of the final rule's total benefits of $469 million, $190 million (40.6 percent of the total benefits) will be attributable to retrofitted airplanes and $279 million (59.4 percent of the total benefits) will be attributable to production airplanes.

TABLE B-8

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION

(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$125	$ 67	$ 58
2019	$170	$ 92	$ 78
2026	$124	$ 32	$ 92
2035	$ 50	$ 0	$ 50
TOTAL	**$469**	**$190**	**$279**
PERCENT OF TOTAL		**40.6%**	**59.4%**

As shown in Table B-9, which replicates Table IV-16, the total potential demand benefits will be $311 million, of which $251 million (80.7 percent) will be realized by airplanes with FRM and $61 million (19.6 percent) will occur to airplanes without FRM. Of the $251 million in realized demand benefits, $99 million (39.5 percent) will be realized by retrofitted airplanes and $151 million (60.9 percent) will be realized by production airplanes.

TABLE B-9

PRESENT VALUE OF THE FINAL RULE **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE (7 %)				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$120	$ 59	$32	$ 27	$61
2019	$ 91	$ 91	$49	$ 42	$ 0
2026	$ 69	$ 69	$18.	$ 51	$ 0
2035	$ 31	$ 31	$ 0	$ 31	$ 0
TOTAL	**$311**	**$250**	**$99**	**$151**	**$61**
PERCENT OF POTENTIAL		**80.4%**			**19.6%**
PERCENT OF REALIZED			**39.5%**	**60.5%**	

Finally, as shown in Table B-10, the present value of the potential direct benefits will be $305 million, of which $231 million (75.7 percent) will be realized by airplanes with FRM and $75 million (24.3 percent) would occur to airplanes without FRM. Of the $231 million in realized direct benefits, $96 million will be attributable to retrofitted airplanes and $135 million will be attributable to production airplanes.

TABLE B-10

PRESENT VALUE OF THE FINAL RULE **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$142	$ 67	$34	$ 33	$75
2019	$ 89	$ 90	$45	$ 45	$ 0
2026	$ 55	$ 55	$17	$ 38	$ 0
2035	$ 19	$ 19	$ 0	$ 19	$ 0
TOTAL	**$305**	**$231**	**$96**	**$135**	**$75**
PERCENT OF POTENTIAL		**75.7%**			**24.3%**
PERCENT OF REALIZED			**41.5%**	**58.5%**	

B.5. Benefits by Manufacturer

As shown in Table B-11, Boeing airplanes will accumulate present value benefits of $279 million of which $124 million will be attributable to retrofitted airplanes and $152 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $194 million of which $66 million will be attributable to retrofitted airplanes and $127 million will be attributable to production airplanes.

TABLE B-11

PRESENT VALUE OF THE FINAL RULE TOTAL BENEFITS FOR AIR CARRIER PASSENGER AIRPLANES BY TYPE OF FRM INSTALLATION AND BY MANUFACTURER USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(Numbers in 2007 Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS
RETROFITTED	**104.3**		**$190**
BOEING	67.9	65.10%	$124
AIRBUS	36.4	34.90%	$ 66
PRODUCTION	**199.3**		**$279**
BOEING	108.3	54.34%	$152
AIRBUS	91	45.66%	$127
TOTAL	**303.6**		**$469**
BOEING	176.2	58.04%	$275
AIRBUS	127.4	41.96%	$194

SECTION C.

ESTIMATED BENEFITS USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE

C.1. Demand Benefits

A 3 percent discount rate exactly offsets a 3 percent real economic growth rate. Thus, the present values of a $292 million for the demand impact in 2007 remains the same for every year.

C.2. Direct Benefits

As shown in Table C-1, we calculated the direct weighted average benefits (based on an 80 percent probability of an in-flight explosion and a 20 percent probability of an on-the-ground explosion) from an average HCWT explosion using a $3 million value for a prevented fatality.

TABLE C-1

PRESENT VALUE OF THE **DIRECT BENEFITS** FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
	DISCOUNT RATE
	3%
2007	$398.778
2008	$387.163
2009	$375.887
2010	$364.938
2011	$354.309
2012	$343.989
2013	$333.970
2014	$324.243
2015	$314.799
2016	$305.630
2017	$296.728
2018	$288.086
2019	$279.695

2020	$271.548
2021	$263.639
2022	$255.960
2023	$248.505
2024	$241.267
2025	$234.240
2026	$227.418
2027	$220.794
2028	$214.363
2029	$208.119
2030	$202.058
2031	$196.172
2032	$190.459
2033	$184.911
2034	$179.525
2035	$174.297
2036	$169.220
2037	$164.291
2038	$159.506
2039	$154.860
2040	$150.350
2041	$145.971
2042	$141.719

C.3. Total Benefits

As shown in Table C-2, the present values of the potential total benefits from preventing an air carrier passenger airplane explosion in each of the years (2012, 2019, 2026, and 2035) in which a statistical accident would occur will be $2.016 billion, of which $1.057 billion will be from demand benefits and $959 million will be from direct benefits.

TABLE C-2

PRESENT VALUE OF THE **POTENTIAL TOTAL BENEFITS** FROM PREVENTING AIR CARRIER HCWT PASSENGER AIRPLANE EXPLOSIONS USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	POTENTIAL BENEFITS		
YEAR	TOTAL	DEMAND	DIRECT
2012	$ 636	$ 292	$344
2019	$ 572	$ 292	$280
2026	$ 519	$ 292	$227
2035	$ 289	$ 181	$108

TOTAL	**$2,016**	**$1,057**	**$959**

As shown in Table C-3, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each airplane category in Table IV-16 to the total benefits in Table C-2 results in a present value of the rule's potential benefits (if all HCWT explosions were prevented) of $1.008 billion for SFAR 88 and $1.008 billion for the final rule. Of this $1.008 billion potential benefits for the final rule, airplanes with FRM will account for $842 million while $166 million will not be realized due to airplanes flying without FRM. Thus, the present value of the final rule total benefits will be $842 million.

TABLE C-3

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$ 636	$ 318	$ 318	$152	$166
2019	$ 572	$ 286	$ 286	$286	$ 0
2026	$ 519	$ 259	$ 260	$260	$ 0
2035	$ 289	$ 145	$ 144	$144	$ 0
TOTAL	**$2,016**	**$1,008**	**$1,008**	**$842**	**$166**

As shown in Table C-4, of the final rule's total benefits of $842 million, $304 million (36.1 percent of the total benefits) will be attributable to retrofitted airplanes and $528 million (63.9 percent of the total benefits will be attributable to production airplanes.

TABLE C-4

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED

FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION (in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$152	$ 82	$ 70
2019	$286	$154	$132
2026	$260	$ 68	$192
2035	$144	$ 0	$144
TOTAL	**$842**	**$304**	**$538**
PERCENT OF TOTAL		**36.1%**	**63.9%**

As shown in Table C-5, of the final rule's demand benefits of $452 million, $153 million (33.9 percent of the total benefits) will be attributable to retrofitted airplanes and $299million (66.1 percent of the total benefits will be attributable to production airplanes.

TABLE C-5

PRESENT VALUE OF THE FINAL RULE **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$ 69	$ 37	$ 32
2019	$146	$ 78	$ 68
2026	$146	$ 38	$108
2035	$ 91	$ 0	$ 91
TOTAL	**$452**	**$153**	**$299**
PERCENT OF TOTAL		**33.9%**	**66.1%**

As shown in Table C-6, multiplying the direct benefits in Table C-2 by the percentages in Table IV-14, results in the present value of the potential direct benefits of $480 million, of which $392 million (81.7 percent) will be realized by airplanes with FRM and $88 million (18.3 percent) will not be realized due to airplanes flying without FRM. Of the $392 million in realized direct benefits, $149 million (38.1 percent) will be realized by retrofitted airplanes and $243 million (61.9 percent) will be realized by production airplanes.

TABLE C-6

PRESENT VALUE OF THE FINAL RULE **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $3 MILLION FOR THE VALUE OF A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE OF DIRECT BENEFITS				
		WITH FRM			NO FRM
YEAR	TOTAL RULE	TOTAL	RETROFIT	PRODUCTION	
2012	$172	$ 84	$ 45	$ 39	$88
2019	$140	$140	$ 75	$ 65	$ 0
2026	$114	$114	$ 29	$ 85	$ 0
2035	$ 54	$ 54	$ 0	$ 54	$ 0
TOTAL	**$480**	**$392**	**$149**	**$243**	**$88**
PERCENT OF POTENTIAL		**81.7%**			**18.3%**
PERCENT OF REALIZED			**38.1%**	**61.9%**	

C.4. Benefits by Manufacturer

As shown in Table C-7, Boeing airplanes will accumulate present value benefits of $492 million of which $198 million will be attributable to retrofitted airplanes and $294 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $353 million of which $106 million will be attributable to retrofitted airplanes and $247 million will be attributable to production airplanes.

TABLE C-7

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING $3 MILLION FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY FRM INSTALLATION AND BY MANUFACTURER
(Numbers in Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS

RETROFITTED	**104.3**		**$304**
BOEING	67.9	65.10%	$198
AIRBUS	36.4	34.90%	$106
PRODUCTION	**199.3**		**$541**
BOEING	108.3	54.34%	$294
AIRBUS	91	45.66%	$247
TOTAL	**303.6**		**$845**
BOEING	176.2	58.04%	$492
AIRBUS	127.4	41.96%	$353

SECTION D.

ESTIMATED BENEFITS USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE

D.1. Demand Benefits

As the demand benefits are not affected by the value of a prevented fatality, they are the same as those presented in Table IV-6 .

D.2. Direct Benefits from Preventing an Air Carrier Passenger Airplane Explosion

D.2.a. In-Flight Accident

As shown in Table D-1, the "average" quantified benefits from preventing an air carrier passenger airplane in-flight explosion using an $8 million value for a prevented fatality range from $900 million to $3.1 billion.[99]

TABLE D-1

DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE IN-FLIGHT EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	99	$ 792	$ 1	$8	$ 801
B-737-Classic	110	$ 880	$ 15	$8	$ 903
B-737-NG	123	$ 984	$ 30	$8	$1,022
B-757	176	$1,408	$ 34	$8	$1,450
B-767	224	$1,792	$ 50	$8	$1,850
B-747-100/200/300	332	$2,656	$ 15	$8	$2,679
B-747-400	372	$2,976	$ 85	$8	$3,069
B-747-800	372	$2,976	$115	$8	$3,099
B-777	290	$2,320	$100	$8	$2,428
B-787	224	$1,792	$ 75	$8	$1,875
A-300	224	$1,792	$ 34	$8	$1,834
A-310	204	$1,632	$ 25	$8	$1,665
A-320 Family	123	$ 984	$ 30	$8	$1,022

[99] This excludes the B-737-200 and the A-380.

A-330	290	$2,320	$ 85	$8	$2,413
A-340	332	$2,656	$100	$8	$2,764
A-350	224	$1,792	$ 75	$8	$1,875
A-380	502	$4,016	$150	$8	$4,174

As shown in Table D-2, the weighted average of the benefits using an $8 million value for a prevented fatality is $1.2 billion.

TABLE D-2

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Airplane Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 801	0.643	0.18%	$ 1.442
B-737-Classic	$ 903	14.782	4.08%	$ 36.842
B-737-NG	$1,022	150.505	40.49%	$ 413.808
B-757	$1,450	26.430	7.30%	$ 105.850
B-767	$1,850	14.350	3.96%	$ 73.260
B-747-100/200/300	$2,679	0.798	0.22%	$ 5.894
B-747-400	$3,069	4.997	1.36%	$ 41.738
B-747-800	$3,099	0.000	0.00%	$ 0.000
B-777	$2,428	13.485	3.68%	$ 89.350
B-787	$1,875	0.000	0.00%	$ 0.000
A-300	$1,834	0.149	0.04%	$ 0.734
A-310	$1,665	0.000	0.00%	$ 0.000
A-320 Family	$1,022	134.776	36.36%	$371.599
A-330	$2,413	4.413	1.21%	$ 29.197
A-340	$2,764	0.000	0.00%	$ 0.000
A-350	$1,875	1.976	0.52%	$ 9.750
A-380	$4,174	2.210	0.59%	$ 24.627
TOTAL		**363.784**		**$1,204**

D.2.b. <u>An On-The-Ground Accident</u>

As shown in Table D-3 the benefits from preventing an on-the-ground air carrier passenger airplane explosion range from $104 million to $412 million.[100]

TABLE D-3

[100] This excludes the B-737-200 and the A-380,

DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	10	$80	$ 1	$1	$ 82
B-737-Classic	11	$88	$ 15	$1	$104
B-737-NG	12	$96	$ 30	$1	$127
B-757	18	$144	$ 34	$1	$179
B-767	22	$176	$ 50	$1	$227
B-747-100/200/300	33	$264	$ 15	$1	$280
B-747-400	37	$296	$ 85	$1	$382
B-747-800	37	$296	$115	$1	$412
B-777	29	$232	$100	$1	$333
B-787	22	$176	$ 75	$1	$252
A-300	22	$176	$ 34	$1	$211
A-310	20	$160	$ 25	$1	$186
A-320 Family	12	$96	$ 30	$1	$127
A-330	29	$232	$ 85	$1	$318
A-340	33	$264	$100	$1	$365
A-350	22	$176	$ 75	$1	$252
A-380	50	$400	$150	$1	$551

As shown in Table D-4, the average of the direct benefits weighted by the number of flight hours from preventing an on-the-ground air carrier passenger airplane explosion will be $151 million.

TABLE D-4

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Total Accident Cost	Total Num. Flight Hours	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 82	0.643	0.18%	$ 0.148
B-737-Classic	$104	14.782	4.08%	$ 4.243
B-737-NG	$127	150.505	40.49%	$ 51.422
B-757	$179	26.430	7.30%	$ 13.067
B-767	$227	14.350	3.96%	$ 8.989
B-747-100/200/300	$280	0.798	0.22%	$ 0.616
B-747-400	$382	4.997	1.36%	$ 5.195
B-747-800	$412	0.000	0.00%	$ 0.000

B-777	$333	13.485	3.68%	$ 12.254
B-787	$252	0.000	0.00%	$ 0.000
A-300	$211	0.149	0.04%	$ 0.084
A-310	$186	0.000	0.00%	$ 0.000
A-320 Family	$127	134.776	36.36%	$ 46.177
A-330	$318	4.413	1.21%	$ 3.848
A-340	$365	0.000	0.00%	$ 0.000
A-350	$252	1.976	0.52%	$ 1.310
A-380	$551	2.210	0.59%	$ 3.251
TOTAL		**363.784**		**$150.606**

D.2.c. Present Benefits Weighted by the Probabilities of an Air Carrier Passenger Airplane Explosion Happening In-Flight and On the Ground

As shown in Table D-5, the weighted average value of the expected direct benefits from preventing an air carrier passenger explosion is $993 million in 2007 (80 percent times $1.204 billion plus 20 percent times $151 million). Table D-5 also contains the present values of these benefits for each year through 2042 using a 7 percent discount rate.

TABLE D-5

PRESENT VALUE OF THE WEIGHTED AVERAGE **DIRECT BENEFITS** FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
	7% DISCOUNT RATE
2007	$993.400
2008	$928.411
2009	$867.674
2010	$810.910
2011	$757.860
2012	$708.280
2013	$661.944
2014	$618.640
2015	$578.168
2016	$540.344
2017	$504.994
2018	$471.957
2019	$441.081
2020	$412.226

2021	$385.258
2022	$360.054
2023	$336.499
2024	$314.485
2025	$293.911
2026	$274.683
2027	$256.713
2028	$239.919
2029	$224.223
2030	$209.555
2031	$195.845
2032	$183.033
2033	$171.059
2034	$159.868
2035	$149.410
2036	$139.635
2037	$130.500
2038	$121.963
2039	$113.984
2040	$106.527
2041	$ 99.558
2042	$ 93.045

D.3. Potential Benefits from Preventing Air Carrier Passenger Airplane Explosions

In Table D-6, we provide the present values of preventing an air carrier passenger airplane explosion in each of the years 2012, 2019, 2026, and 2035 from Tables IV-16 and D-5. The present value of the potential total benefits will be $4.3 billion of which $2.25 billion are reactions to terrorism, $561 million are aviation demand losses, and $1.5 billion are direct losses.

TABLE D-6

PRESENT VALUE OF THE POTENTIAL **TOTAL BENEFITS** FROM PREVENTING AIR CARRIER HCWT PASSENGER AIRPLANE EXPLOSIONS USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	TOTAL	DEMAND	DIRECT
2012	$ 948	$240	$ 708
2019	$ 623	$182	$ 441
2026	$ 413	$138	$ 275
2035	$ 156	$ 62	$ 94

TOTAL	**$2,140**	**$622**	**$1,518**

D.4. Discounted Potential and Realized Quantified Benefits

As shown in Table D-7, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each airplane category presented in Table IV-14 to the total benefits in Table D-6 results in a present value of the potential benefits (if all HCWT explosions were prevented) of $1.070 billion for SFAR 88 and $1.070 billion for the final rule. Of this $1.070 billion in potential benefits for the final rule, airplanes with FRM will account for $828 million while $242 million will not be realized due to airplanes flying without FRM. Thus, the final rule total benefits will be $828 million.

TABLE D-7

PRESENT VALUE OF THE **POTENTIAL TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$ 948	$ 474	$ 474	$232	$242
2019	$ 623	$ 311	$ 312	$312	$ 0
2026	$ 413	$ 207	$ 206	$206	$ 0
2035	$ 156	$ 78	$ 78	$ 78	$ 0
TOTAL	**$2,140**	**$1,070**	**$1,070**	**$828**	**$242**

As shown in Table D-8, of the rule's total benefits of $828 million, $344 million (41.6 percent of the total benefits) will be attributable to retrofitted airplanes and $484 million (58.4 percent of the total benefits) will be attributable to production airplanes.

TABLE D-8

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED

FATALITY AND A 7 PERCENT DISCOUNT RATE BY FRM INSTALLATION TYPE
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$232	$123	$108
2019	$312	$168	$144
2026	$206	$ 53	$153
2035	$ 78	$ 0	$ 78
TOTAL	**$828**	**$344**	**$484**
PERCENT OF TOTAL		**41.6%**	**58.4%**

As shown in Table B-9, which replicates Table IV-16, the total potential demand benefits will be $311 million, of which $251 million (80.7 percent) will be realized by airplanes with FRM and $61 million (19.6 percent) will occur to airplanes without FRM. Of the $251 million in realized demand benefits, $99 million (39.5 percent) will be realized by retrofitted airplanes and $151 million (60.9 percent) will be realized by production airplanes.

TABLE D-9

PRESENT VALUE OF THE FINAL RULE **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING A $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE (7 %)				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$120	$ 59	$32	$ 27	$61
2019	$ 91	$ 91	$49	$ 42	$ 0
2026	$ 69	$ 69	$18.	$ 51	$ 0
2035	$ 31	$ 31	$ 0	$ 31	$ 0
TOTAL	**$311**	**$250**	**$99**	**$151**	**$61**
PERCENT OF POTENTIAL		**80.4%**			**19.6%**
PERCENT OF REALIZED			**39.5%**	**60.5%**	

Finally, as shown in Table D-10, the present value of the potential direct benefits will be $759 million, of which $578 million (76.2 percent) will be realized by airplanes with FRM and $181 million (23.8 percent) would occur to airplanes without FRM. Of the $578 million in realized direct benefits, $246 million (42.6 percent) will be attributable to retrofitted airplanes and $332 million (57.4 percent) will be attributable to production airplanes.

TABLE D-10

PRESENT VALUE OF THE FINAL RULE **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUES				
		REALIZED WITH FRM			
YEAR	POTENTIAL	TOTAL	RETROFIT	PRODUCTION	NO FRM
2012	$354	$173	$ 92	$ 81	$181
2019	$221	$221	$119	$102	$ 0
2026	$137	$137	$ 35	$102	$ 0
2035	$ 47	$ 47	$ 0	$ 47	$ 0
TOTAL	**$759**	**$578**	**$246**	**$332**	**$181**
PERCENT OF TOTAL		**76.2%**			**23.8%**
			42.6%	**57.4%**	

D.5. <u>Benefits by Manufacturer</u>

As shown in Table D-11, Boeing airplanes will accumulate present value benefits of $487 million of which $224 million will be attributable to retrofitted airplanes and $263 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $341 million of which $120 million will be attributable to retrofitted airplanes and $221 million will be attributable to production airplanes.

TABLE D-11

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES BY TYPE OF FRM INSTALLATION AND BY

MANUFACTURER USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 7 PERCENT DISCOUNT RATE
(Numbers in Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS
RETROFITTED	**104.3**		**$344**
BOEING	67.9	65.10%	$224
AIRBUS	36.4	34.90%	$120
PRODUCTION	**199.3**		**$484**
BOEING	108.3	54.34%	$263
AIRBUS	91	45.66%	$221
TOTAL	**303.6**		**$828**
BOEING	176.2	58.04%	$487
AIRBUS	127.4	41.96%	$341

SECTION E.

ESTIMATED BENEFITS USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE

E.1. Demand Benefits

A 3 percent discount rate exactly offsets a 3 percent real economic growth rate. Thus, the present value of a $292 million for the demand impact in 2007 remains the same for every year.

E.2. Direct Benefits

As shown in Table E-1, we calculated the direct weighted average benefits (based on an 80 percent probability of an in-flight explosion and a 20 percent probability of an on-the-ground explosion) from an average HCWT explosion using an $8 million value for a prevented.

TABLE E-1

PRESENT VALUE OF THE **DIRECT BENEFITS** FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE EXPLOSION USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	PRESENT VALUE
	DISCOUNT RATE
	3%
2007	$993.400
2008	$964.466
2009	$936.375
2010	$909.102
2011	$882.623
2012	$856.916
2013	$831.957
2014	$807.725
2015	$784.199
2016	$761.358
2017	$739.183
2018	$717.653

2019	$696.751
2020	$676.457
2021	$656.754
2022	$637.626
2023	$619.054
2024	$601.023
2025	$583.518
2026	$566.522
2027	$550.021
2028	$534.001
2029	$518.448
2030	$503.348
2031	$488.687
2032	$474.453
2033	$460.634
2034	$447.218
2035	$434.192
2036	$421.546
2037	$409.268
2038	$397.347
2039	$385.774
2040	$374.538
2041	$363.629
2042	$353.038

E.3. Total Benefits

As shown in Table E-2, the present values of the potential total benefits from preventing an air carrier passenger airplane explosion in each of the years (2012, 2019, 2026, and 2035) in which a statistical accident would occur will be $73.456 billion of which, $1.057 billion will be from demand benefits, and $2.399 billion will be from direct benefits.

TABLE E-2

PRESENT VALUE OF THE POTENTIAL TOTAL BENEFITS FROM PREVENTING AIR CARRIER PASSENGER AIRPLANE HCWT EXPLOSIONS USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

YEAR	TOTAL	DEMAND	DIRECT
2012	$1,149	$ 292	$ 857
2019	$ 989	$ 292	$ 697
2026	$ 859	$ 292	$ 567

2035	$ 459	$ 181	$ 278
TOTAL	**$3,456**	**$1,057**	**$2,399**

As shown in Table E-3, applying the SFAR 88 effectiveness rate of 50 percent and the percentages of flight hours for each airplane category in Table IV-14 to the total benefits in Table E-2 results in a present value of the rule's potential benefits (if all HCWT explosions were prevented) of $1.728 billion for SFAR 88 and $1.728 billion for the final rule. Of this $1.728 billion potential benefits for the final rule, airplanes with FRM will account for $1.434 billion while $294 million will not be realized due to airplanes flying without FRM. Thus, the present value of the final rule total benefits will be $1.434 billion.

TABLE E-3

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VLAUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE
(in Millions of 2007 Dollars)

	PRESENT VALUE POTENTIAL TOTAL BENEFITS				
		ATTRIBUTABLE TO			
			FINAL RULE		
YEAR	TOTAL	SFAR 88	TOTAL	WITH FRM	NO FRM
2012	$1,149	$ 574	$ 575	$ 281	$294
2019	$ 989	$ 495	$ 494	$ 494	$ 0
2026	$ 859	$ 429	$ 430	$ 430	$ 0
2035	$ 459	$ 230	$ 229	$ 229	$ 0
TOTAL	**$3,456**	**$1,728**	**$1,728**	**$1,434**	**$294**

As shown in Table E-4, of the final rule's total benefits of $1.434 billion, $526 million (36.7 percent of the total benefits) will be attributable to retrofitted airplanes and $908 million (63.3 percent of the total benefits) will be attributable to production airplanes.

TABLE E-4

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED

FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION (in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$ 281	$149	$132
2019	$ 494	$266	$228
2026	$ 430	$111	$319
2035	$ 229	$ 0	$229
TOTAL	**$1,434**	**$526**	**$908**
PERCENT OF TOTAL		**36.7%**	**63.3%**

As shown in Table E-5, of the final rule's demand benefits of $452 million, $153 million (33.9 percent of the total benefits) will be attributable to retrofitted airplanes and $299million (66.1 percent of the total benefits will be attributable to production airplanes.

TABLE E-5

PRESENT VALUE OF THE FINAL RULE **DEMAND BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

YEAR	FRM TOTAL	RETROFIT	PRODUCTION
2012	$ 69	$ 37	$ 32
2019	$146	$ 78	$ 68
2026	$146	$ 38	$108
2035	$ 91	$ 0	$ 91
TOTAL	**$452**	**$153**	**$299**
PERCENT OF TOTAL		**33.9%**	**66.1%**

As shown in Table E-6, multiplying the direct benefits in Table E-2 by the percentages in Table IV-14, results in the present value of the potential direct benefits of $1.2 billion, of which $981 million (81.8 percent) will be realized by airplanes with FRM and $219 million (18.2 percent) will not be realized due to airplanes flying without FRM. Of the $981 million in realized direct benefits, $372 million (37.9 percent) will be realized by retrofitted airplanes and $609 million (62.1 percent) will be realized by production airplanes.

TABLE E-6

PRESENT VALUE OF THE FINAL RULE **DIRECT BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION
(in Millions of 2007 Dollars)

	PRESENT VALUE OF DIRECT BENEFITS				
		WITH FRM			NO FRM
YEAR	TOTAL RULE	TOTAL	RETROFIT	PRODUCTION	
2012	$ 429	$210	$112	$ 98	$219
2019	$ 348	$348	$187	$161	$ 0
2026	$ 284	$284	$ 73	$211	$ 0
2035	$ 139	$139	$ 0	$139	$ 0
TOTAL	**$1,200**	**$981**	**$372**	**$609**	**$219**
PERCENT OF POTENTIAL		**81.8%**			**18.2%**
PERCENT OF REALIZED			**37.9%**	**62.1%**	

E.4. Benefits by Manufacturer

As shown in Table E-7, Boeing airplanes will accumulate present value benefits of $835 million of which $342 million will be attributable to retrofitted airplanes and $493 million will be attributable to production airplanes. Airbus airplanes will accumulate present value benefits of $599 million of which $184 million will be attributable to retrofitted airplanes and $415 million will be attributable to production airplanes.

TABLE E-6

PRESENT VALUE OF THE FINAL RULE **TOTAL BENEFITS** FOR AIR CARRIER PASSENGER AIRPLANES USING AN $8 MILLION VALUE FOR A PREVENTED FATALITY AND A 3 PERCENT DISCOUNT RATE BY TYPE OF FRM INSTALLATION AND BY MANUFACTURER
(Numbers in Millions)

CATEGORY	TOTAL FLIGHT HOURS	PERCENTAGE OF FLIGHT HOURS	TOTAL BENEFITS

RETROFITTED	**104.3**		**$ 526**
BOEING	67.9	65.10%	$ 342
AIRBUS	36.4	34.90%	$ 184
PRODUCTION	**199.3**		**$ 908**
BOEING	108.3	54.34%	$ 493
AIRBUS	91	45.66%	$ 415
TOTAL	**303.6**		**$1,434**
BOEING	176.2	58.04%	$ 835
AIRBUS	127.4	41.96%	$ 599

APPENDIX C:

COMPLIANCE COSTS FOR THREE ALTERNATIVES TO THE FINAL RULE FOR AIR CARRIER CARGO AIRPLANES

INTRODUCTION

In this Appendix we discuss and estimate the compliance costs for the following 3 alternatives to the final rule:

Alternative A. Final rule requires FTI on conversion cargo airplanes;

Alternative B. Final rule requires FTI on existing cargo airplanes by 2017; and

Alternative C. Final rule requires FTI on conversion cargo airplanes and retrofitting on existing cargo airplanes.

ALTERNATIVE A:

REQUIRE FTI FOR AIR CARRIER CONVERSION cargo AIRPLANES

SUMMARY OF THE AIR CARRIER CONVERSION CARGO AIRPLANES COMPLIANCE COST

As shown in Table A-1, the undiscounted compliance costs for air carrier conversion cargo airplane operators would be $211 million, which has a present value of $95 million using a 7 percent discount rate and a present value of $146 million using a 3 percent discount rate.

TABLE A-1

COMPLIANCE COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COST		
FTI COSTS	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	$ 19	$16	$ 18
INSTALLATION	$ 46	$31	$ 39
INVENTORY	$ 1	$ 1	$ 1
FUEL	$ 53	$18	$ 33
OPERATIONAL	$ 22	$ 8	$ 14
ASM REPLACEMENT	$ 70	$21	$ 41
TOTAL	**$211**	**$95**	**$146**

As shown in Table A-2, the undiscounted compliance costs for air carrier Boeing cargo airplane operators would be $151 million, which has a present value of $60 million using a 7 percent discount rate and a present value of $99 million using a 3 percent discount rate. The undiscounted compliance costs for air carrier Airbus cargo airplane operators would be $60 million, which has a present value of $34 million using a 7 percent discount rate and a present value of $47 million using a 3 percent discount rate.

TABLE A-2

COMPLIANCE COSTS FOR AIR CARRIER CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	**$151**	**$60**	**$ 99**
ENGINEERING	<$1	<$1	<$1
CONVERSION	$ 34	$22	$ 28
INVENTORY	$ 1	$ 1	$ 1
FUEL	$ 43	$14	$ 27
OPERATIONAL	$ 18	$ 6	$ 11
ASM REPLACEMENT	$ 55	$17	$ 32
AIRBUS	**$ 60**	**$34**	**$ 47**
ENGINEERING	$ 19	$16	$ 18
CONVERSION	$ 12	$ 9	$ 11
INVENTORY	<$1	<$1	<$1
FUEL	$ 10	$ 3	$ 6
OPERATIONAL	$ 4	$ 2	$ 3
ASM REPLACEMENT	$ 15	$ 4	$ 9
GRAND TOTAL	**$211**	**$94**	**$146**

A.I. INDIVIDUAL FTI SYSTEM COMPLIANCE COST COMPONENTS

Most of the background discussion and basic data reported in Section VI for air carrier production cargo airplanes applies to air carrier conversion cargo airplanes. We will not generally repeat that information in this section.

A.I.a. FTI Engineering Assessment Costs

As described in Section V.G., all of the engineering costs to design production cargo models are allocated to their passenger model counterparts. However, as shown in Table A-3, Airbus would need to perform 3 model and 1 derivative FTI engineering assessments for the out-of-production A-300/A-300-600 and the A-310 that will be converted from passenger to cargo use.

TABLE A-3

NUMBERS OF AIRBUS CARGO AIRPLANE FTI ENGINEERING ASSESSMENTS

	NUMBER OF ASSESSMENTS		
MODEL	INITIAL	MODEL	DERIVATIVE
A-300/A-300-600	0	2	1
A-310	0	1	0
TOTAL	**0**	**3**	**1**

A.I.b. Engineering Costs per FTI Engineering Assessment

FTI engineering assessments for cargo airplanes cost the same as FTI engineering assessments for passenger airplanes, which are $11.732 million for an initial assessment, $5.456 million for a model assessment, and $2.744 to $2.788 million for a derivative assessment.

A.I.c. Total FTI Engineering Assessment Costs

All of the FTI engineering assessments for Airbus conversion cargo airplanes would be completed by 2009 in order to start retrofitting in 2010. As shown in Table A-4, the total FTI engineering assessment costs to develop and obtain the amended TCs would be $19.2 million, which has a present value of $16.2 million using a 7 percent discount rate and a present value of $17.8 million using a 3 percent discount rate.

TABLE A-4

FTI ENGINEERING ASSESSMENT COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MODEL	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
A-300/A-300-600	$13.678	$11.556	$12.705
A-310	$ 5.456	$ 4.610	$ 5.068
TOTAL	**$19.134**	**$16.166**	**$17.773**

A.II. FTI COSTS FOR CONVERSION CARGO AIRPLANE OPERATORS

A.II.a. Costs to Install FTI

Converting a passenger airplane to a cargo airplane requires the hull to be opened and the interior to be gutted. From a construction perspective, installing FTI on a conversion cargo airplane is similar to installing it on a production airplane. We assume that FTI would be retrofitted during the conversion construction because it would be extremely expensive to first convert the airplane to cargo, close it, and then re-open it to retrofit FTI . Thus, the kit costs and the labor hours to install FTI on a production or a conversion cargo airplane would be the same. As shown in Table V-9, the costs to install FTI on a conversion cargo airplane would range from $98,333 to $212,574.

We used the Boeing forecast that 75 percent of the new cargo fleet will be conversion airplanes and 25 percent will be production airplanes.

As shown in Table A-5, which reprises Table V-3, we project that there will be 352 new cargo airplanes of which 262 will be conversion airplanes (CON) and 90 will be production airplanes (PROD). Of the 262 conversion airplanes, 198 will be Boeing conversion cargo airplanes and 64 will be Airbus conversion cargo airplanes.

TABLE A-5

ANNUAL NUMBERS OF AIR CARRIER CONVERSION AND PRODUCTION CARGO AIPLANES BY MANUFACTURER AND BY YEAR
("CON" is conversion and "PROD" is production)

YEAR	ALL AIRPLANES			BOEING			AIRBUS		
	TOTAL	CON	PROD	TOTAL	CON	PROD	TOTAL	CON	PROD
2009	22	17	5	12	9	3	10	8	2
2010	41	30	11	30	22	8	11	8	3
2011	38	28	10	28	21	7	10	7	3
2012	40	30	10	28	21	7	12	9	3
2013	42	31	11	32	24	8	10	7	3
2014	37	28	9	32	24	8	5	4	1
2015	35	26	9	31	23	8	4	3	1
2016	47	35	12	34	25	9	13	10	3
2017	50	37	13	39	29	10	11	8	3
TOTAL	**352**	**262**	**90**	**266**	**198**	**68**	**86**	**64**	**22**

As no conversion cargo airplane would have had FTI installed while it was in passenger service,[101] every conversion cargo airplane would have FTI installed while it is being converted. As shown in Table A-6, which summarizes Appendix A-1, the undiscounted costs for retrofitting FTI on air carrier conversion cargo airplanes would be $46.5 million, which has a present value of $30.9 million using a 7 percent discount rate and a present value of $38.7 million using a 3 percent discount rate.

TABLE A-6

UNDISCOUNTED AND PRESENT VALUE COSTS TO INSTALL FTI ON AIR CARRIER CONVERSION CARGO AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COST		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$3.182	$2.780	$3.000
2010	$5.770	$4.710	$5.281
2011	$5.333	$4.068	$4.738
2012	$5.132	$3.659	$4.427
2013	$5.257	$3.503	$4.403
2014	$4.606	$2.868	$3.745
2015	$4.313	$2.510	$3.404
2016	$6.067	$3.300	$4.650
2017	$6.800	$3.457	$5.060
TOTAL	**$46.459**	**$30.855**	**$38.707**

As shown in Table A-7, of the undiscounted costs of $46.5 million, $34 million would be for Boeing airplane operators and $12.4 million would be for Airbus airplane operators. Of the present value costs of $30.9 million using a 7 percent discount rate, $22.4 million would be for Boeing airplane operators and $8.5 million would be for Airbus airplane operators. Of the present value of $38.7 million using a 3 percent discount rate, $28.2 million would be for Boeing airplane operators and $10.5 million would be for Airbus airplane operators.

TABLE A-7

[101] If FTI had been installed for the airplane when it was in passenger service, then there would be no costs attributable to the Alternative Rule because the costs were already incurred.

TOTAL AND PRESENT VALUE OF THE COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED COST	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$34.028	$22.354	$28.219
AIRBUS	$12.431	$ 8.501	$10.488
TOTAL	**$46.459**	**$30.855**	**$38.707**

A.II.b. Water Separator/filter Assembly Inventory Cost

We determined that the inventory cost for a conversion cargo airplane water separator/filter assembly would be the same as it would cost for a passenger airplane. As shown in Table A-8, the unit cost would range from $18,433 to $30,467.

TABLE A-8

INVENTORY COST OF A WATER SEPARATOR/FILTER ASSEMBLY BY MODEL

MODEL	TOTAL
B-737-CLASSIC	$18,433
B-737-NG	$18,433
B-757	$26,000
B-767	$26,000
B-747-1/2/300	$30,467
B-747-400	$30,467
B-747-800	$30,467
B-777	$30,467
B-787	$26,000
A-300/300-600	$26,000
A-310	$26,000
A-320 FAMILY	$18,433
A-330	$30,467
A-340	$30,467
A-350	$26,000
A-380	$30,467

We determined that the production cargo airplane 15 percent inventory rate would be the same rate for conversion cargo airplanes. As shown in Table A-9, which summarizes Appendix A-2, we determined that air carriers would add 39 assemblies for conversion cargo airplanes, of which 30 would be for Boeing conversion airplanes and 9 would be for Airbus conversion airplanes.

TABLE A-9

ANNUAL NUMBERS OF INVENTORY ADDED BY OPERATORS FOR AIR SEPARATOR/FILTER ASSEMBLIES FOR AIR CARRIER CONVERSION CARGO AIPLANES BY MANUFACTURER AND BY YEAR

YEAR	TOTAL	BOEING	AIRBUS
2009	2	1	1
2010	5	3	2
2011	4	3	1
2012	5	3	2
2013	5	4	1
2014	4	4	0
2015	4	4	0
2016	5	4	1
2017	5	4	1
TOTAL	**39**	**30**	**9**

As shown in Table A-10, the undiscounted cost of the water separator/filter assembly inventory for conversion cargo airplanes would be $1.1 million, which has a present value of $0.7 million using a 7 percent discount rate and a present value of $0.9 million using a 3 percent discount rate.

TABLE A-10

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL AIR SEPARATOR/FILTER ASSEMBLY INVENTORY COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

		TOTAL COST		
YEAR	NUMBER OF ASSEMBLIES ADDED	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	2	$0.069	$0.060	$0.065
2010	5	$0.130	$0.107	$0.119
2011	4	$0.121	$0.092	$0.107
2012	5	$0.118	$0.084	$0.102
2013	5	$0.122	$0.081	$0.102
2014	4	$0.109	$0.068	$0.089

2015	4	$0.103	$0.060	$0.081
2016	5	$0.138	$0.075	$0.106
2017	5	$0.152	$0.078	$0.113
TOTAL	**39**	**$1.062**	**$0.704**	**$0.885**

As shown in Table A-11, of the inventory costs of $1.1 million for conversion cargo airplane operators, $0.8 million would be for Boeing airplane operators and $0.3 million would be for Airbus airplane operators. Of the present value costs of $0.7 million using a 7 percent discount rate, $0.5 million would be for Boeing airplane operators and $0.2 million would be for Airbus airplane operators. Of the present value of $0.9 million using a 3 percent discount rate, $0.7 million would be for Boeing airplane operators and $0.2 million would be for Airbus airplane operators.

TABLE A-11

UNDISCOUNTED AND PRESENT VALUE OF THE INVENTORY COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE AIR SEPARATOR/FILTER ASSEMBLIES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$0.802	$0.526	$0.665
AIRBUS	$0.268	$0.178	$0.220
TOTAL	**$1.062**	**$0.704**	**$0.885**

A.II.c. <u>Fuel Consumption Costs</u>

As shown in Table A-12, which summarizes Table IV-27, air carrier Airbus and Boeing conversion cargo airplanes will fly 19.1 million flight hours of which 15.7 million will be flown by Boeing airplanes and 3.4 million will be flown by Airbus airplanes.

TABLE A-12

ANNUAL NUMBER OF FLIGHT HOURS BY AIRBUS AND BOEING CONVERSION CARGO AIRPLANE OPERATORS BY MANUFACTURER AND YEAR
(in Millions of Flight Hours)

	FLIGHT HOURS		
YEAR	TOTAL	BOEING	AIRBUS
2009	0.105	0.053	0.052
2010	0.158	0.085	0.072
2011	0.261	0.168	0.094
2012	0.357	0.243	0.114
2013	0.443	0.306	0.137
2014	0.536	0.379	0.157
2015	0.619	0.452	0.167
2016	0.699	0.524	0.175
2017	0.796	0.598	0.198
2018	0.908	0.688	0.220
2019	0.790	0.629	0.161
2020	0.778	0.624	0.154
2021	0.766	0.618	0.147
2022	0.754	0.613	0.141
2023	0.741	0.607	0.134
2024	0.729	0.602	0.127
2025	0.717	0.596	0.121
2026	0.705	0.591	0.114
2027	0.693	0.585	0.107
2028	0.680	0.580	0.100
2029	0.668	0.574	0.094
2030	0.656	0.569	0.087
2031	0.644	0.563	0.080
2032	0.632	0.558	0.074
2033	0.619	0.552	0.067
2034	0.607	0.547	0.060
2035	0.595	0.541	0.054
2036	0.555	0.508	0.047
2037	0.471	0.430	0.040
2038	0.392	0.359	0.033
2039	0.333	0.306	0.027
2040	0.265	0.245	0.020
2041	0.196	0.183	0.013
2042	0.127	0.121	0.007
2043	0.065	0.065	0.000
TOTAL	**19.061**	**15.666**	**3.395**

Using the same unit cost data provided in Tables V-5 and V-6 multiplied by the flight hours in Table A-12, as shown in Table A-13, which summarizes Appendix A-3, the total increased fuel consumption by air carrier conversion cargo airplanes would be about 32.2 million gallons. At an average price of $1.65 per gallon, the undiscounted cost would be $53.1 million, which has a present value of $17.6 million using a 7 percent discount rate and a present value of $31.7 million using a 3 percent discount rate.

TABLE A-13

TOTAL INCREASED FUEL COST AND CONSUMPTION FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS
(All Numbers in Millions)

	TOTAL COST			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2009	$0.142	$0.125	$0.134	0.086
2010	$0.443	$0.362	$0.406	0.269
2011	$0.720	$0.549	$0.639	0.436
2012	$0.947	$0.675	$0.817	0.574
2013	$1.195	$0.797	$1.001	0.725
2014	$1.424	$0.887	$1.157	0.863
2015	$1.643	$0.956	$1.297	0.996
2016	$1.906	$1.037	$1.461	1.155
2017	$2.214	$1.125	$1.647	1.342
2018	$2.066	$0.981	$1.492	1.252
2019	$2.058	$0.914	$1.444	1.247
2020	$2.051	$0.851	$1.397	1.243
2021	$2.044	$0.793	$1.351	1.238
2022	$2.036	$0.738	$1.307	1.234
2023	$2.029	$0.687	$1.264	1.230
2024	$2.021	$0.640	$1.223	1.225
2025	$2.014	$0.596	$1.183	1.221
2026	$2.006	$0.555	$1.144	1.216
2027	$1.999	$0.517	$1.107	1.212
2028	$1.992	$0.481	$1.071	1.207
2029	$1.984	$0.448	$1.036	1.203
2030	$1.977	$0.417	$1.002	1.198
2031	$1.969	$0.388	$0.969	1.194
2032	$1.962	$0.361	$0.937	1.189
2033	$1.955	$0.337	$0.906	1.185
2034	$1.947	$0.313	$0.877	1.180
2035	$1.861	$0.280	$0.814	1.128
2036	$1.619	$0.228	$0.687	0.981
2037	$1.356	$0.178	$0.559	0.822
2038	$1.157	$0.142	$0.463	0.701
2039	$0.925	$0.106	$0.359	0.561
2040	$0.694	$0.074	$0.262	0.420
2041	$0.462	$0.046	$0.169	0.280
2042	$0.252	$0.024	$0.090	0.153

TOTAL	**$53.071**	**$17.609**	**$31.671**	**32.164**

Further, as shown in Table A-14, Boeing conversion cargo airplane operators would incur undiscounted fuel costs of $43 million which has a present value of $14.2 million using a 7 percent discount rate and a present value of $26.6 using a discount rate of 3 percent. Airbus conversion cargo airplane operators would incur undiscounted costs of $10.1 million which has a present value of $3.4 million using a 7 percent discount rate and a present value of $6.0 using a 3 percent discount rate.

TABLE A-14

UNDISCOUNTED AND PRESENT VALUE OF THE INCREASED FUEL COST FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$42.941	$14.248	$26.626
AIRBUS	$10.130	$ 3.361	$ 6.045
TOTAL	**$53.071**	**$17.609**	**$32.671**

A.II.d. <u>Operational Costs</u>

The unit operational costs for a conversion cargo airplane would be the same as the unit operational costs for a production cargo airplane (See Table V-8). As shown in Table A-15, which summarizes Appendix A-4, the undiscounted operational costs for conversion cargo airplane operators would be $22.4 million, which has a present value of $8.1 million using a 7 percent discount rate and a present value of $13.9 million using a 3 percent discount rate.

TABLE A-15

OPERATIONAL COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$0.185	$0.161	$0.174
2010	$0.306	$0.250	$0.280
2011	$0.418	$0.319	$0.371
2012	$0.523	$0.373	$0.451
2013	$0.635	$0.423	$0.531
2014	$0.735	$0.458	$0.598
2015	$0.832	$0.484	$0.657
2016	$0.952	$0.518	$0.730
2017	$1.088	$0.553	$0.810
2018	$0.948	$0.451	$0.685
2019	$0.932	$0.414	$0.654
2020	$0.916	$0.380	$0.624
2021	$0.900	$0.349	$0.595
2022	$0.884	$0.320	$0.567
2023	$0.867	$0.294	$0.541
2024	$0.851	$0.269	$0.515
2025	$0.835	$0.247	$0.491
2026	$0.819	$0.226	$0.467
2027	$0.803	$0.207	$0.444
2028	$0.786	$0.190	$0.423
2029	$0.770	$0.174	$0.402
2030	$0.754	$0.159	$0.382
2031	$0.738	$0.145	$0.363
2032	$0.722	$0.133	$0.345
2033	$0.706	$0.121	$0.327
2034	$0.689	$0.111	$0.310
2035	$0.641	$0.096	$0.280
2036	$0.544	$0.077	$0.231
2037	$0.454	$0.060	$0.187
2038	$0.385	$0.047	$0.154
2039	$0.306	$0.035	$0.119
2040	$0.226	$0.024	$0.085
2041	$0.146	$0.015	$0.054
2042	$0.074	$0.007	$0.026
TOTAL	**$22.371**	**$8.091**	**$13.872**

Further, as shown in Table A-16, Boeing airplane operators would incur undiscounted operational costs of $18.4 million which has a present value of $6.4 million using a 7 percent discount rate and a present value of $11.2 million using a 3 percent discount rate. Airbus airplane operators would incur undiscounted operational costs of $4.0 million which has a present value of $1.7 million using a 7 percent discount rate and a present value of $2.7 million using a 3 percent discount rate.

TABLE A-16

UNDISCOUNTED AND PRESENT VALUE OF THE OPERATIONAL COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$18.411	$6.358	$11.186
AIRBUS	$ 3.960	$1.733	$ 2.686
TOTAL	**$22,371**	**$8.091**	**$13.872**

A.II.e. <u>ASM Replacement Costs</u>

As shown in Table V-35, an ASM replacement for a cargo airplane costs between $30,520 and $151,144.

We used the same methodology to determine the number of ASM replacements that was used in Section VI and that the ASM will be replaced every 27,000 flight hours. We also determined that all of the 86 B-737-Classics and the 12 B-757 conversion cargo airplanes will be retired before they would need an ASM replacement. As shown in Table A-17, which summarizes Appendix A-5, we determined that there would be 492 ASM replacements for conversion cargo airplanes, of which 393 would be on Boeing airplanes and 99 would be on Airbus airplanes.

TABLE A-17

ANNUAL NUMBERS OF ASM REPLACEMENTS FOR AIR CARRIER CONVERSION CARGO AIPLANES BY MANUFACTURER AND BY YEAR

YEAR	TOTAL	BOEING	AIRBUS
2015	3	3	0
2016	17	17	0
2017	16	16	0
2018	11	11	0
2019	23	15	8
2020	23	15	8
2021	36	28	8
2022	37	28	9

2023	32	24	8
2024	26	22	4
2025	17	14	3
2026	36	27	9
2027	39	31	8
2028	23	23	0
2029	20	14	6
2030	24	17	7
2031	38	32	6
2032	32	24	8
2033	26	20	6
2034	16	14	2
TOTAL	**492**	**393**	**99**

As shown in Table A-18, which summarizes Appendix A-5, the undiscounted ASM replacement costs for air carrier conversion cargo airplane operators would be $70 million, which has a present value of $21.4 million using a 7 percent discount rate and a present value of $41.1 million using a 3 percent discount rate.

TABLE A-18

TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2015	$0.406	$0.236	$0.320
2016	$2.397	$1.304	$1.837
2017	$2.194	$1.115	$1.633
2018	$1.586	$0.754	$1.146
2019	$3.252	$1.444	$2.281
2020	$3.367	$1.397	$2.293
2021	$5.077	$1.969	$3.356
2022	$5.198	$1.884	$3.337
2023	$4.527	$1.534	$2.821
2024	$3.714	$1.176	$2.247
2025	$2.455	$0.726	$1.442
2026	$5.117	$1.415	$2.918
2027	$5.624	$1.454	$3.114
2028	$3.107	$0.750	$1.670
2029	$2.809	$0.634	$1.466
2030	$3.496	$0.737	$1.772
2031	$5.372	$1.059	$2.643
2032	$4.458	$0.821	$2.129

2033	$3.620	$0.623	$1.679
2034	$2.234	$0.359	$1.006
TOTAL	**$70.007**	**$21.391**	**$41.106**

As shown in Table A-19, Boeing airplane operators would incur undiscounted ASM replacement costs of $55.0 million which has a present value of $17.0 million using a 7 percent discount rate and a present value of $32.4 million using a 3 percent discount rate. Airbus airplane operators would incur undiscounted operational costs of about $15.0 million which has a present value of $4.4 million using a 7 percent discount rate and a present value of $8.7 million using a 3 percent discount rate.

TABLE A-19

UNDISCOUNTED AND PRESENT VALUE OF THE ASM REPLACEMENT COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$54.989	$16.975	$32.410
AIRBUS	$15.018	$ 4.416	$ 8.696
TOTAL	**$70.007**	**$21.391**	**$41.106**

A.III. TOTAL AIR CARRIER CONVERSION CARGO AIRPLANE COMPLIANCE COSTS

The total costs for production cargo airplane operators, as shown in Table A-20, are the costs for retrofitting FTI (Table A-5), the water separator/filter assemblies for inventory (Table A-9), the additional fuel consumption (Table A-12), the operational costs (Table A-14), and the ASM replacement costs (Table A-17). The undiscounted compliance costs for air carrier production cargo airplane operators would be $193 million, which has a present value of $79 million using a 7 percent discount rate and a present value of $126 million using a 3 percent discount rate.

TABLE A-20

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANE OPERATORS BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$3.578	$3.126	$3.373
2010	$6.649	$5.429	$6.086
2011	$6.592	$5.028	$5.855
2012	$6.720	$4.791	$5.797
2013	$7.209	$4.804	$6.037
2014	$6.874	$4.281	$5.589
2015	$7.297	$4.246	$5.759
2016	$11.460	$6.234	$8.784
2017	$12.448	$6.328	$9.263
2018	$4.600	$2.186	$3.323
2019	$6.242	$2.772	$4.379
2020	$6.334	$2.628	$4.314
2021	$8.021	$3.111	$5.302
2022	$8.118	$2.942	$5.211
2023	$7.423	$2.515	$4.626
2024	$6.586	$2.085	$3.985
2025	$5.304	$1.569	$3.116
2026	$7.942	$2.196	$4.529
2027	$8.426	$2.178	$4.665
2028	$5.885	$1.421	$3.164
2029	$5.563	$1.256	$2.904
2030	$6.227	$1.313	$3.156
2031	$8.079	$1.592	$3.975
2032	$7.142	$1.315	$3.411
2033	$6.281	$1.081	$2.912
2034	$4.870	$0.783	$2.193
2035	$2.502	$0.376	$1.094
2036	$2.163	$0.305	$0.918
2037	$1.810	$0.238	$0.746
2038	$1.542	$0.189	$0.617
2039	$1.231	$0.141	$0.478
2040	$0.920	$0.098	$0.347
2041	$0.608	$0.061	$0.223
2042	$0.326	$0.031	$0.116
TOTAL	**$192.972**	**$78.649**	**$126.247**

As shown in Table A-21, which sums the costs in Tables A-6, A-10, A-13, A-15, and A-18, the undiscounted costs for all air carrier production Boeing cargo airplane operators would be $151.2 million, which has a present value of $60.5 million using a 7 percent discount rate and a present value of $99.1 million using a 3 percent discount rate. The undiscounted costs for all air carrier Airbus production cargo airplane operators would be $41.8 million, which has a present value of $18.2 million using a 7 percent discount rate and a present value of $28.1 million using a 3 percent discount rate.

TABLE A-21

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$151.171	$60.461	$ 99.106
AIRBUS	$ 41.807	$18.189	$ 28.135
TOTAL	**$192.978**	**$78.650**	**$127.241**

A.IV. ADDITIONAL BENEFITS FROM ALTERNATIVE A

Based on the 19.1 million flight hours for conversion cargo airplanes, if these airplanes were included in the rule, there would be 0.191 air carrier conversion cargo airplane accidents between 2008 and 2043. Using a 50 percent SFAR 88 effectiveness rate, we calculated that SFAR 88 will prevent 0.095 air carrier cargo airplane explosions and the final rule will prevent 0.095 explosions.[102]

We did not calculate the quantified present value of benefits from preventing 0.095 air carrier cargo airplane explosions, which has a 2007 undiscounted value of $7 million, over a 35 year period.

[102] All of the conversion cargo airplanes will enter the fleet with FTI, so there will be no conversion cargo airplanes without FTI flight hours.

ALTERNATIVE B:

REQUIRE FTI TO BE RETROFITTED ON AIR CARRIER CARGO AIRPLANES

SUMMARY OF THE RETROFITTED CARGO AIRPLANE COMPLIANCE COSTS

As shown in Table B-1, the undiscounted compliance costs for air carrier retrofitted cargo airplane operators would be $213 million, which has a present value of $118 million using a 7 percent discount rate and a present value of $163 million using a 3 percent discount rate.

TABLE B-1

COMPLIANCE COSTS FOR RETROFITTED AIR CARRIER CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COST		
FTI COSTS	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	<$1	<$1	<$1
INSTALLATION	$126	$ 82	$105
INVENTORY	$ 2	$ 1	$ 1
FUEL	$ 36	$ 16	$ 25
OPERATIONAL	$ 16	$ 7	$ 11
ASM REPLACEMENT	$ 33	$ 12	$ 21
TOTAL	**$213**	**$118**	**$163**

As shown in Table B-2, the undiscounted compliance costs for operators of retrofitted air carrier Boeing cargo airplanes are $120 million, which has a present value of $68 million using a 7 percent discount rate and a present value of $93 million using a 3 percent discount rate. The undiscounted compliance costs for operators of air carrier retrofitted Airbus cargo airplane are $93 million, which has a present value of $50 million using a 7 percent discount rate and a present value of $70 million using a 3 percent discount rate.

TABLE B-2

COMPLIANCE COSTS FOR RETROFITTED AIR CARRIER CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	**$120**	**$ 68**	**$ 93**
ENGINEERING	<$1	<$1	<$1
RETROFIT	$ 74	$ 48	$ 61
INVENTORY	$ 1	$ 1	$ 1
FUEL	$ 24	$ 11	$ 17
OPERATIONAL	$ 10	$ 4	$ 7
ASM REPLACEMENT	$ 11	$ 4	$ 7
AIRBUS	**$ 93**	**$ 50**	**$ 70**
ENGINEERING	<$1	<$1	<$1
RETROFIT	$ 52	$ 34	$ 44
INVENTORY	$ 1	<$1	<$1
FUEL	$ 12	$ 5	$ 8
OPERATIONAL	$ 6	$ 3	$ 4
ASM REPLACEMENT	$ 22	$ 8	$ 14
GRAND TOTAL	**$213**	**$118**	**$163**

B.I. INDIVIDUAL FTI COMPLIANCE COST COMPONENTS

Most of the background discussion and basic data reported in Section V for retrofitted passenger airplanes and in Section VI for production cargo airplanes also applies to retrofitted cargo airplanes. We will not generally repeat that information in this section.

B.I.a. <u>FTI Engineering Assessment Costs</u>

There would be minimal FTI engineering assessment costs to develop FTI systems for retrofitted cargo airplanes because these FTI engineering assessments would have been completed to retrofit FTI in the passenger models.

B.II. FTI COSTS FOR RETROFITTED CARGO AIRPLANES

B.II.a. Cost to Retrofit

The retrofitting kit costs, the number of labor hours, and the down time to retrofit an air carrier cargo airplane would be the same as those for a retrofitted passenger airplane. However, no air carrier cargo retrofit would require a special maintenance session because there is more scheduling flexibility in cargo maintenance operations.

The retrofitting equipment kit and labor cost would be $158,000 to $331,000 an airplane. We also determined that the losses for a day out of service and the number of out-of-service days would be the same for both cargo and passenger airplanes. Thus, the two days out-of-service losses for an air carrier cargo airplane would be between $9,552 and $27,829, resulting in a total retrofit cost of $167,552 to $358,829 an airplane.

As shown in Table B-3, which summarizes Appendix B-1, we determined that 401 air carrier cargo airplanes would need to be retrofitted with FTI. Of the 401 airplanes, 231 would be Boeing airplanes and 170 would be Airbus airplanes.

TABLE B-3

NUMBERS OF AIR CARRIER RETROFITTED CARGO AIRPLANES BY MANUFACTURER

MANUFACTURER	TOTAL
BOEING	231
AIRBUS	170
TOTAL	**401**

We determined that an equal number of these 401 airplanes would be retrofitted in each year. Thus, as shown in Table B-4, which summarizes Appendix B-1, we calculated that the annual undiscounted costs to retrofit air carrier cargo airplanes would be $15.6 million. The total undiscounted retrofitting costs would be $125 million, which has a present value of $81.5 million using a 7 percent discount rate and a present value of $103.4 million using a 3 percent discount rate.

TABLE B-4

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL RETROFITTING COSTS FOR AIR CARRIER CARGO AIRPLANE OPERATORS BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	$ 15.633	$12.761	$ 14.306
2011	$ 15.633	$11.926	$ 13.890
2012	$ 15.633	$11.146	$ 13.485
2013	$ 15.633	$10.417	$ 13.092
2014	$ 15.633	$ 9.735	$ 12.711
2015	$ 15.633	$ 9.098	$ 12.341
2016	$ 15.633	$ 8.503	$ 11.981
2017	$ 15.633	$ 7.947	$ 11.632
TOTAL	**$125.062**	**$81.534**	**$103.438**

As shown in Table B-5, of the undiscounted retrofitting costs of $125 million, $72.7 million would be incurred by operators of Boeing cargo airplanes and $52.3 million would be incurred by operators of Airbus cargo airplanes. Of the present value costs of $81.5 million using a 7 percent discount rate, $47.4 million would be incurred by operators of Boeing cargo airplanes and $34.1 million would be incurred by operators of Airbus cargo airplanes. Of the present value of $103.5 million using a 3 percent discount rate, $60.2 million would be incurred by operators of Boeing cargo airplanes and $43.3 million would be incurred by operators of Airbus cargo airplanes.

TABLE B-5

TOTAL AND PRESENT VALUE OF THE COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 72.748	$47.427	$ 60.169
AIRBUS	$ 52.315	$34.106	$ 43.269
TOTAL	**$125.063**	**$81.533**	**$103.438**

B.II.b. Inventory Costs

As shown in Table B-6, which summarizes Appendix B-2, air carriers would add 60 air separator/filter assemblies as inventory for retrofitted cargo airplanes, of which 35 would be for Boeing airplanes and 25 would be for Airbus airplanes.

TABLE B-6

ANNUAL NUMBERS OF AIR SEPARATOR/FILTER ASSEMBLIES INVENTORY BY AIR CARRIER OPERATORS OF RETROFITTED CARGO AIPLANES BY MANUFACTURER AND BY YEAR

YEAR	TOTAL	BOEING	AIRBUS
2010	8	5	3
2011	7	4	3
2012	8	5	3
2013	7	4	3
2014	8	5	3
2015	7	4	3
2016	8	4	4
2017	7	4	3
TOTAL	**60**	**35**	**25**

As shown in Table B-7, the undiscounted cost of water separator/filter assembly inventory for operators of retrofitted air carrier cargo airplanes would be $1.6 million, which has a present value of $1.1 million using a 7 percent discount rate and a present value of $1.3 million using a 3 percent discount rate.

TABLE B-7

UNDISCOUNTED AND PRESENT VALUE OF THE AIR SEPARATOR/FILTER ASSEMBLY INVENTORY COSTS FOR OPERATORS OF AIR CARRIER RETROFITTED CARGO AIRPLANES
(in Millions of 2007 Dollars)

		TOTAL COSTS		
YEAR	NUMBER OF ASSEMBLIES ADDED	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	8	$0.203	$0.165	$0.185
2011	7	$0.203	$0.155	$0.180

2012	8	$0.203	$0.144	$0.175
2013	7	$0.203	$0.135	$0.170
2014	8	$0.203	$0.126	$0.165
2015	7	$0.203	$0.118	$0.160
2016	8	$0.203	$0.110	$0.155
2017	7	$0.203	$0.103	$0.151
TOTAL	**60**	**$1.624**	**$1.057**	**$1.341**

As shown in Table B-8, of the undiscounted costs of water separator/filter assembly inventory for air carrier operators of retrofitted cargo airplanes of $1.6 million, $1 million would be incurred by operators of Boeing airplanes and $0.6 million would be incurred by operators of Airbus airplanes. Of the present value costs of $1.1 million using a 7 percent discount rate, $0.6 million would be incurred by operators of Boeing airplanes and $0.5 million would be incurred by operators of Airbus airplanes. Of the present value of $1.3 million using a 3 percent discount rate, $0.8 million would be incurred by operators of Boeing airplanes and $0.5 million would be incurred by operators of Airbus airplanes.

TABLE B-8

UNDISCOUNTED AND PRESENT VALUE OF THE INVENTORY COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANE AIR SEPARATOR/FILTER ASSEMBLIES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COST		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$0.958	$0.624	$0.792
AIRBUS	$0.666	$0.433	$0.549
TOTAL	**$1.624**	**$1.057**	**$1.341**

B.II.c. Fuel Consumption Costs

As shown in Table B-9, which summarizes Appendix B-3, air carrier retrofitted cargo airplanes would fly 12.785 million flight hours of which 7.678 million will be flown by Boeing airplanes and 5.107 million will be flown by Airbus airplanes.

TABLE B-9

ANNUAL NUMBER OF FLIGHT HOURS BY RETROFITTED CARGO AIRPLANES BY MANUFACTURER AND YEAR
(in Millions of Flight Hours)

	FLIGHT HOURS		
YEAR	TOTAL	BOEING	AIRBUS
2010	0.118	0.071	0.047
2011	0.235	0.141	0.094
2012	0.353	0.212	0.141
2013	0.470	0.283	0.188
2014	0.588	0.353	0.235
2015	0.706	0.424	0.282
2016	0.906	0.544	0.362
2017	1.107	0.665	0.442
2018	1.038	0.623	0.415
2019	0.969	0.582	0.387
2020	0.899	0.540	0.359
2021	0.830	0.499	0.332
2022	0.761	0.457	0.304
2023	0.692	0.415	0.276
2024	0.623	0.374	0.249
2025	0.553	0.332	0.221
2026	0.484	0.291	0.193
2027	0.415	0.249	0.166
2028	0.346	0.208	0.138
2029	0.277	0.166	0.111
2030	0.208	0.125	0.083
2031	0.138	0.083	0.055
2032	0.069	0.042	0.028
TOTAL	**12.785**	**7.678**	**5.107**

As shown in Table B-10, which summarizes Appendix B-4, the increase in air carrier retrofitted cargo airplane fuel consumption due to FTI weight, bleed air, and ram drag would be 21.8 million gallons.[103] At an average price of $1.65 per gallon, the undiscounted cost would be $35.9 million, which has a present value of $15.8 million using a 7 percent discount rate and a present value of $24.8 million using a 3 percent discount rate.

TABLE B-10

[103] We assumed that the entire year's flight hours are attributed to a retrofitted airplane in the year that it is retrofitted. This generates a slight upward bias to the estimated costs because part of the year will have been flown without FTI equipment.

TOTAL INCREASED FUEL COST AND CONSUMPTION FOR AIR CARRIER RETROFITTED CARGO AIRPLANES BY YEAR
(All Numbers in Millions)

	TOTAL COST			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2010	$0.331	$0.270	$0.303	0.200
2011	$0.661	$0.504	$0.587	0.401
2012	$0.992	$0.707	$0.856	0.601
2013	$1.322	$0.881	$1.107	0.801
2014	$1.653	$1.029	$1.344	1.002
2015	$1.984	$1.154	$1.566	1.202
2016	$2.548	$1.386	$1.952	1.544
2017	$3.111	$1.582	$2.315	1.886
2018	$2.917	$1.386	$2.107	1.768
2019	$2.723	$1.209	$1.910	1.650
2020	$2.528	$1.049	$1.722	1.532
2021	$2.334	$0.905	$1.543	1.414
2022	$2.139	$0.775	$1.373	1.296
2023	$1.945	$0.659	$1.212	1.179
2024	$1.750	$0.554	$1.059	1.061
2025	$1.556	$0.460	$0.914	0.943
2026	$1.361	$0.376	$0.776	0.825
2027	$1.167	$0.302	$0.646	0.707
2028	$0.972	$0.235	$0.523	0.589
2029	$0.778	$0.176	$0.406	0.471
2030	$0.583	$0.123	$0.296	0.354
2031	$0.389	$0.077	$0.191	0.236
2032	$0.194	$0.036	$0.093	0.118
TOTAL	**$35.938**	**$15.835**	**$24.800**	**21.780**

Further, as shown in Table B-11, operators of Boeing retrofitted cargo airplanes would incur undiscounted fuel costs of $24.1 million which has a present value of $10.6 million using a 7 percent discount rate and a present value of $16.7 million using a discount rate of 3 percent. Operators of Airbus retrofitted cargo airplanes would incur undiscounted fuel costs of $11.8 million which has a present value of $5.2 million using a 7 percent discount rate and a present value of $8.1 million using a 3 percent discount rate.

TABLE B-11

UNDISCOUNTED AND PRESENT VALUE OF THE INCREASED FUEL COST FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$24.134	$10.634	$16.654
AIRBUS	$11.804	$ 5.201	$ 8.146
TOTAL	**$35.938**	**$15.835**	**$24.800**

B.II.d. Operational Costs

As shown in Table B-12, which summarizes Appendix B-5, the total operational costs for air carrier operators of retrofitted cargo airplanes would be about $16.0 million, which has a present value of $7.0 million using a 7 percent discount rate and a present value of $11.1 million using a 3 percent discount rate.

TABLE B-12

OPERATIONAL COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	$0.147	$0.120	$0.134
2011	$0.294	$0.224	$0.261
2012	$0.441	$0.314	$0.380
2013	$0.587	$0.391	$0.492
2014	$0.734	$0.457	$0.597
2015	$0.881	$0.513	$0.696
2016	$1.132	$0.616	$0.867
2017	$1.382	$0.703	$1.028
2018	$1.296	$0.616	$0.936
2019	$1.209	$0.537	$0.848
2020	$1.123	$0.466	$0.765
2021	$1.037	$0.402	$0.685
2022	$0.950	$0.344	$0.610
2023	$0.864	$0.293	$0.538
2024	$0.777	$0.246	$0.470
2025	$0.691	$0.204	$0.406
2026	$0.605	$0.167	$0.345

2027	$0.518	$0.134	$0.287
2028	$0.432	$0.104	$0.232
2029	$0.346	$0.078	$0.180
2030	$0.259	$0.055	$0.131
2031	$0.173	$0.034	$0.085
2032	$0.086	$0.016	$0.041
TOTAL	**$15.963**	**$7.034**	**$11.056**

As shown in Table B-13, operators of Boeing retrofitted cargo airplanes would incur undiscounted costs of $9.9 million which has a present value of $4.4 million using a 7 percent discount rate and a present value of $6.9 million using a discount rate of 3 percent. Operators of Airbus retrofitted cargo airplanes would incur undiscounted costs of $6.1 million which has a present value of $2.7 million using a 7 percent discount rate and a present value of $4.2 million using a discount rate of 3 percent.

TABLE B-13

UNDISCOUNTED AND PRESENT VALUE OF THE OPERATIONAL COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$ 9.913	$4.368	$ 6.871
AIRBUS	$ 6.050	$2.666	$ 4.175
TOTAL	**$15.963**	**$7.034**	**$11.056**

B.II.e. ASM Replacement Costs

As shown in Table V-35, replacing an ASM on a cargo airplane costs between $30,520 and $151,144.

As noted in Section VI, we determined that the ASM needs to be replaced every 27,000 flight hours. We used the same methodology to determine the number of ASM replacements used in Section VI. As shown in Table B-14, there would be 220 ASM replacements on retrofitted cargo airplanes, of which 76 would be on Boeing airplanes and 144 would be on Airbus airplanes.

TABLE B-14

ANNUAL NUMBERS OF ASM REPLACEMENTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIPLANES BY MANUFACTURER AND BY YEAR

		MANUFACTURER	
YEAR	TOTAL	BOEING	AIRBUS
2016	1	1	0
2017	13	2	11
2018	13	1	12
2019	13	2	11
2020	19	7	12
2021	20	8	12
2022	28	8	20
2023	28	8	20
2024	20	8	12
2025	19	8	11
2026	23	11	12
2027	23	12	11
TOTAL	**220**	**76**	**144**

As shown in Table B-15, which summarizes Appendix B-6, the undiscounted ASM replacement costs for air carrier operators of retrofitted cargo airplanes would be about $32.9 million, which has a present value of $11.7 million using a 7 percent discount rate and a present value of $20.9 million using a 3 percent discount rate.

TABLE B-15

TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2016	$ 0.201	$ 0.109	$ 0.154
2017	$ 1.953	$ 0.993	$ 1.453
2018	$ 1.953	$ 0.928	$ 1.411
2019	$ 1.953	$ 0.867	$ 1.369
2020	$ 2.856	$ 1.185	$ 1.945
2021	$ 2.856	$ 1.108	$ 1.888
2022	$ 2.998	$ 1.087	$ 1.924
2023	$ 4.235	$ 1.434	$ 2.639

2024	$ 4.093	$ 1.296	$ 2.476
2025	$ 2.856	$ 0.845	$ 1.678
2026	$ 3.494	$ 0.966	$ 1.993
2027	$ 3.494	$ 0.903	$ 1.935
TOTAL	**$32.942**	**$11.720**	**$20.855**

As shown in Table B-16, operators of Boeing cargo airplanes would incur undiscounted ASM replacement costs of $11.2 million which has a present value of $3.8 million using a 7 percent discount rate and a present value of $6.9 million using a 3 percent discount rate. Operators of Airbus cargo airplanes would incur undiscounted operational costs of about $21.7 million which has a present value of $8 million using a 7 percent discount rate and a present value of $13.9 million using a 3 percent discount rate.

TABLE B-16

UNDISCOUNTED AND PRESENT VALUE OF THE ASM REPLACEMENT COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$11.202	$ 3.766	$ 6.926
AIRBUS	$21.740	$ 7.954	$13.929
TOTAL	**$32.942**	**$11.720**	**$20.855**

B.III. TOTAL AIR CARRIER RETROFITTED CARGO AIRPLANE COMPLIANCE COSTS

As shown in Table B-17, which sums Tables B-4, B-7, B-10, B-12, and B-15, the undiscounted compliance costs for air carrier operators of retrofitted cargo airplanes would be $212 million, which has a present value of $117 million using a 7 percent discount rate and a present value of $161 million using a 3 percent discount rate.

TABLE B-17

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	$16.314	$13.316	$14.928
2011	$16.791	$12.809	$14.918
2012	$17.269	$12.311	$14.896
2013	$17.745	$11.824	$14.861
2014	$18.223	$11.347	$14.817
2015	$18.701	$10.883	$14.763
2016	$19.717	$10.724	$15.109
2017	$22.282	$11.328	$16.579
2018	$6.166	$2.930	$4.454
2019	$5.885	$2.613	$4.127
2020	$6.507	$2.700	$4.432
2021	$6.227	$2.415	$4.116
2022	$6.087	$2.206	$3.907
2023	$7.044	$2.386	$4.389
2024	$6.620	$2.096	$4.005
2025	$5.103	$1.509	$2.998
2026	$5.460	$1.509	$3.114
2027	$5.179	$1.339	$2.868
2028	$1.404	$0.339	$0.755
2029	$1.124	$0.254	$0.586
2030	$0.842	$0.178	$0.427
2031	$0.562	$0.111	$0.276
2032	$0.280	$0.052	$0.134
TOTAL	**$211.532**	**$117.179**	**$161.459**

As shown in Table B-18, which sums Tables B-5, B-8, B-11, B-13, and B-16, the undiscounted costs for all air carrier operators of retrofitted Boeing cargo airplanes would be $119 million, which has a present value of $67 million using a 7 percent discount rate and a present value of $91 million using a 3 percent discount rate. The undiscounted costs for air carrier operators of Airbus retrofitted cargo airplanes would be $93 million, which has a present value of $50 million using a 7 percent discount rate and a present value of $70 million using a 3 percent discount rate.

TABLE B-18

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER OPERATORS OF RETROFITTED CARGO AIRPLANES BY MANUFACTURER

(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$118.955	$ 66.819	$ 91.412
AIRBUS	$ 92.575	$ 50.360	$ 70.068
TOTAL	**$211.530**	**$117.179**	**$161.490**

B.IV. ADDITIONAL BENEFITS FROM ALTERNATIVE B

Based on the 12.8 million flight hours for retrofitted cargo airplanes, if these airplanes were included in the rule, there would be 0.128 air carrier conversion cargo airplane accidents between 2008 and 2043. Using a 50 percent SFAR 88 effectiveness rate, we calculated that SFAR 88 will prevent 0.064 air carrier cargo airplane explosions and the final rule will prevent 0.064 explosions.

We did not calculate the quantified present value of benefits from preventing 0.064 air carrier cargo airplane explosions, which has a 2007 undiscounted value of $4.6 million, over a 35 year period.

ALTERNATIVE C:

REQUIRE FTI ON AIR CARRIER CONVERSION CARGO AND RETROFITTED ON EXISTING CARGO AIRPLANES

C.I. TOTAL AIR CARRIER CONVERSION AND RETROFITTED CARGO AIRPLANE COMPLIANCE COSTS

As shown in Table C-1, which sums A-1 and B-1, the undiscounted compliance costs for air carrier conversion and retrofitted cargo airplane operators would be $424 million, which has a present value of $213 million using a 7 percent discount rate and a present value of $309 million using a 3 percent discount rate.

TABLE C-1

COMPLIANCE COSTS FOR AIR CARRIER CONVERSION AND RETROFITTED CARGO AIRPLANE OPERATORS
(in Millions of 2007 Dollars)

	TOTAL COST		
FTI COSTS	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	$ 19	$ 16	$ 18
INSTALLATION	$172	$113	$144
INVENTORY	$ 3	$ 2	$ 2
FUEL	$ 89	$ 34	$ 58
OPERATIONAL	$ 38	$ 15	$ 25
ASM REPLACEMENT	$103	$ 33	$ 62
TOTAL	**$424**	**$213**	**$309**

As shown in Table C-2, which sums A-2 and B-2, the undiscounted compliance costs for operators of air carrier Boeing conversion and retrofitted cargo airplanes would be $271 million, which has a present value of $147 million using a 7 percent discount rate and a present value of $192 million using a 3 percent discount rate. The undiscounted compliance costs for operators of air carrier Airbus conversion and retrofitted cargo airplanes would be $153 million, which has a present value of $84 million using a 7 percent discount rate and a present value of $117 million using a 3 percent discount rate.

TABLE C-2

COMPLIANCE COSTS FOR AIR CARRIER CONVERSION AND RETROFITTED CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
COST CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	**$271**	**$147**	**$ 192**
ENGINEERING			
CONVERSION	$108	$ 70	$ 89
INVENTORY	$ 2	$ 2	$ 2
FUEL	$ 67	$ 25	$ 44
OPERATIONAL	$ 28	$ 10	$ 18
ASM REPLACEMENT	$ 66	$ 21	$ 39
AIRBUS	**$153**	**$ 84**	**$ 117**
ENGINEERING	$ 19	$ 16	$ 18
CONVERSION	$ 64	$ 43	$ 55
INVENTORY	$<1	$<1	$<1
FUEL	$ 22	$ 8	$ 14
OPERATIONAL	$ 10	$ 5	$ 7
ASM REPLACEMENT	$ 37	$ 12	$ 23
GRAND TOTAL	**$424**	**$212**	**$309**

As shown in Table C-3, which sums Tables A-20 and B-17, the undiscounted compliance costs for including air carrier conversion and retrofitted cargo airplanes in the final rule would be $405 million, which has a present value of $196 million using a 7 percent discount rate and a present value of $288 million using a 3 percent discount rate.

TABLE C-3

UNDISCOUNTED AND PRESENT VALUE TOTAL COSTS FOR AIR CARRIER CONVERSION AND RETROFITTED CARGO AIRPLANE OPERATORS BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2009	$ 3.578	$ 3.126	$ 3.373
2010	$22.963	$18.745	$21.014
2011	$23.383	$17.837	$20.773
2012	$23.989	$17.102	$20.693
2013	$24.954	$16.628	$20.898
2014	$25.097	$15.628	$20.406
2015	$25.998	$15.129	$20.522
2016	$31.177	$16.958	$23.893
2017	$34.730	$17.656	$25.842
2018	$10.766	$5.116	$7.777
2019	$12.127	$5.385	$8.506
2020	$12.841	$5.328	$8.746
2021	$14.248	$5.526	$9.418
2022	$14.205	$5.148	$9.118
2023	$14.467	$4.901	$9.015
2024	$13.206	$4.181	$7.990
2025	$10.407	$3.078	$6.114
2026	$13.402	$3.705	$7.643
2027	$13.605	$3.517	$7.533
2028	$7.289	$1.760	$3.919
2029	$6.687	$1.510	$3.490
2030	$7.069	$1.491	$3.583
2031	$8.641	$1.703	$4.251
2032	$7.422	$1.367	$3.545
2033	$6.281	$1.081	$2.912
2034	$4.870	$0.783	$2.193
2035	$2.502	$0.376	$1.094
2036	$2.163	$0.305	$0.918
2037	$1.810	$0.238	$0.746
2038	$1.542	$0.189	$0.617
2039	$1.231	$0.141	$0.478
2040	$0.920	$0.098	$0.347
2041	$0.608	$0.061	$0.223
2042	$0.326	$0.031	$0.116
TOTAL	**$404.504**	**$195.828**	**$287.706**

As shown in Table C-4, which sums Tables A-21 and B-18, the undiscounted costs for all air carrier conversion and retrofitted Boeing cargo airplane operators would be $270 million, which has a present value of $127 million using a 7 percent discount rate and a present value of $191 million using a 3 percent discount rate. The undiscounted costs for air carrier conversion and retrofitted Airbus cargo airplane operators would be $134 million, which has a present value of $69 million using a 7 percent discount rate and a present value of $98 million using a 3 percent discount rate.

TABLE C-4

UNDISCOUNTED AND PRESENT VALUE COSTS FOR AIR CARRIER CONSERSION AND RETROFITTED CARGO AIRPLANE OPERATORS BY MANUFACTURER
(in Millions of 2007 Dollars)

	TOTAL COSTS		
MANUFACTURER	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
BOEING	$270.126	$127.280	$190.518
AIRBUS	$134.382	$68.549	$98.203
TOTAL	**$404.508**	**$195.829**	**$288.731**

C.II. ADDITIONAL BENEFITS FROM ALTERNATIVE C

Based on the 31.8 million flight hours for conversion and retrofitted cargo airplanes, if these airplanes were included in the rule, there would be 0.318 air carrier conversion and retrofitted cargo airplane accidents between 2008 and 2043. Using a 50 percent SFAR 88 effectiveness rate, we calculated that SFAR 88 will prevent 0.159 air carrier cargo airplane explosions and the final rule will prevent 0.159 explosions.

We did not calculate the quantified present value of benefits from preventing 0.064 air carrier cargo airplane explosions, which has a 2007 undiscounted value of $11.4 million.

APPENDIX D:

STATISTICAL VARIATION OF FRM BENEFITS AND BENEFIT-COST RATIO

Our principal analysis is based on the statistical average of FRM benefits. In our base case we calculate the present value of average benefits and the average benefit-cost ratio assuming a discount rate of 7%, SFAR 88 effectiveness of 50%, and the value of a statistical life (VSL) of $5.5 million. We also undertake a sensitivity analysis by varying the discount rate to 3% and, in an appendix of this report, by varying SFAR 88 effectiveness to 25% and 75% and VSL to $3 and $8 million.

In this section we use Crystal Ball to conduct a Monte Carlo simulation of the benefits of the FRM rule. We assume our base case of a 7% discount rate, SFAR 88 effectiveness of 50%, and a VSL of $5.5 million. The Crystal Ball simulation allows us to easily see the important consequences of the natural statistical variation in the FRM benefits. This variation has three sources, number of accidents, size of airplane (and hence variation in value of averted accident), and timing of accident (and hence variation in present value of accident).

The direct benefits of the FRM rule are the value of averting accidents, most importantly the value of averted fatalities, or the value of a statistical life. Since over 98% of the averted accidents and almost 100% of the FRM benefits are for passenger airplanes, we exclude production cargo and part 91 airplanes from our analysis. We assume that 20% of the accidents will take place on the ground, in which case the value of an averted accident is much lower. Accordingly, for the value of an averted accident, for each passenger model, we take a weighted average of the ground and in-air values. (See Tables IV-8 to IV-10.) As discussed in a principal section, for passenger airplanes there are also ancillary benefits of the FRM rule: (1) the avoided losses from demand reductions as a result of an airplane accident and (2) the losses from disruption of the air transportation system from perceptions that a HCWT accident might be a terrorist attack. The basic cost and benefit data are shown in Table 1 below:

Table 1. Basic Costs and Benefits of Preventing an Accident with the FRM Rule

	Direct benefits (2007 $ mil.)	Indirect Benefits (2007 $ mil.)		Total Indirect Benefits (2007 $ mil.)	Present Value of Costs (2007 $ mil.)
	Value of averted accident (weighted avg.)	Avoidance of reduced demand for air transportation ($ mil.)	Avoidance of air transportation network disruption		Discount rate: 7%
PAX	$695	$265	$1,040	$1,305	$1,116

We note that costs are shown in present value 2007 dollars. Direct benefits--the value of averted accident—are discounted in accordance with the year that the simulation model predicts the accident to occur. We expect the air transportation network to have a real growth rate of 3%, so the total value for ancillary benefits increases each year by 3%.

We use the Poisson distribution to model the probability of HCWT accidents since that distribution has been shown to be appropriate for rare event discrete outcomes, e.g. HCWT airplane accidents. The Poisson is a one-parameter distribution whose parameter, λ, is equal to the expected number of accidents. For each year of the analysis (2009-2043), we estimate λ for passenger versions of HCWT models (Boeing 737-200, Boeing 737 Classic, etc.) [104] by multiplying each model's predicted flight hours by our estimated post-SFAR 88 accident rate. Calculating lambdas for each year has the virtue of allowing calculation of benefits year by year. The present value of the rule benefits can then readily be calculated by discounting yearly benefits by their appropriate discount factors and summing. Calculating lambdas for each model allows us to pick up the great variation in the value of an averted accident, which can range from $452 million for a Boeing 737-200 to $2.421 billion for an Airbus A380, with an average of $695 million as shown in our table above.

For our base case we assume a pre-SFAR 88 HCWT accident rate of 0.01 per million miles and 50% SFAR 88 effectiveness, and, therefore, a post-SFAR 88 HCWT accident rate of 0.0050 accidents per million flight hours--or 1 accident in 200 million flight hours. Using these assumptions, we ran 10,000 trials of our simulated Crystal Ball model. In Table 2 we first show the results for the expected number of accidents.

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[104] We exclude the Boeing 787 since it is required to have FRM by its design certificate.

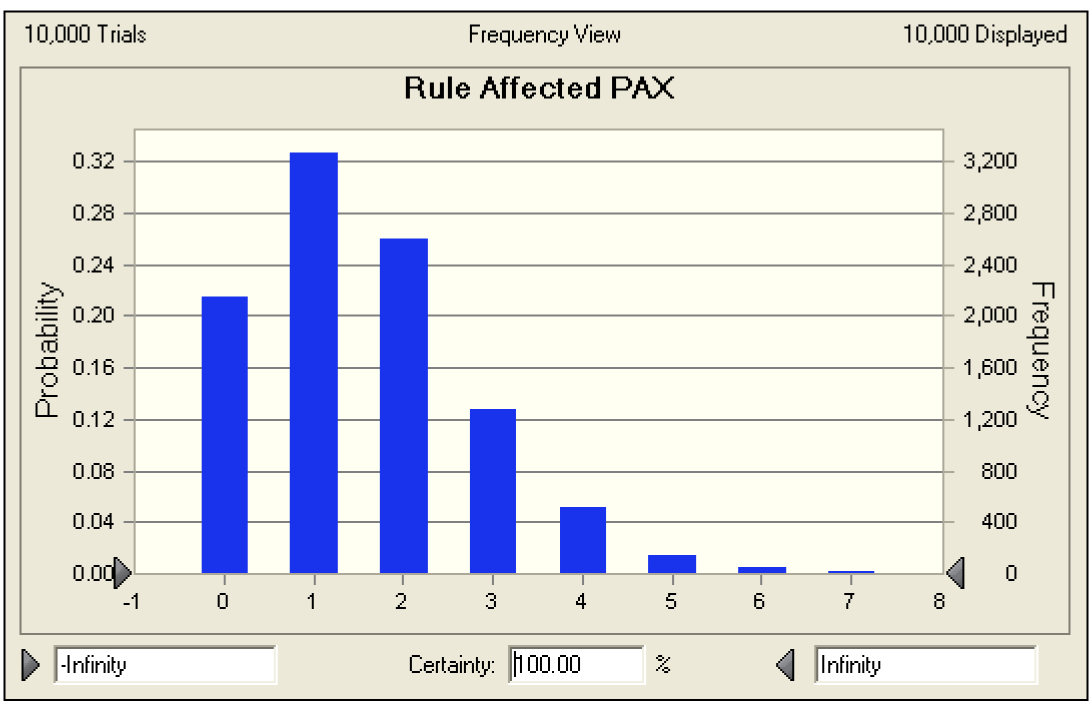
Table 2. Estimated Average No. of HCWT Passenger Airplane Accidents, with and without the FRM Rule (50% SFAR 88 Effectiveness)

	Without Rule	With Rule
PAX	1.81	1.54

The table shows that the FRM rule will prevent 1.54 of the expected 1.81 passenger airplane (The rule does not prevent all accidents because compliance for production airplanes is not required until 2009 and retrofitting for existing airplanes is phased in over the period 2010-2017.) These results are very close to the results we found in our main benefits section.

The value of the Crystal Ball simulation, however, lies not in calculation of averages, but rather to see the variation in the outcomes. In the chart below, we show first the variation for the number of averted passenger airplane accidents.

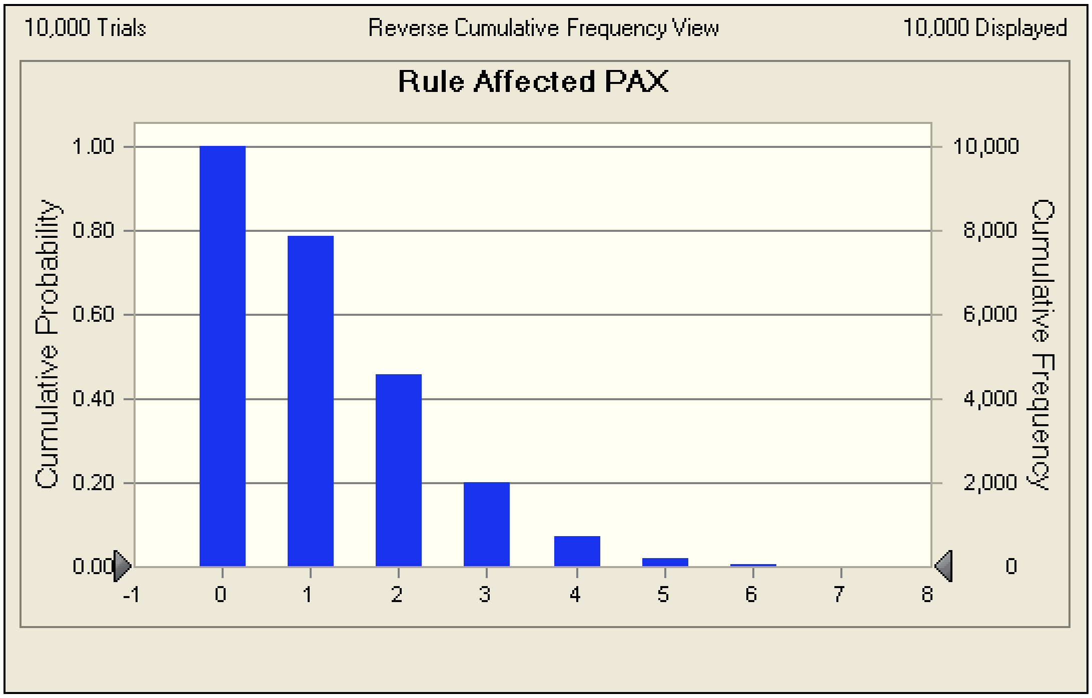
Chart 1. Frequency Distribution of Passenger Airplane Accidents Preventable by FRM Rule
(50% SFAR 88 Effectiveness, Post-SFAR 88 Accident Rate: 0.0050 per million flight hours)



Although the expected number of passenger airplane accidents averted by the rule is 1.54, the chart shows that this is average of highly variable outcomes. Approximately 21% of the time there will be no accidents and there will be no benefit to the rule and over 32% of the time there will be just 1 accident. However, approximately 26% of the time there will be two accidents, over 12% of the time there will be 3 accidents, and 5 % of the time there will be 4 accidents, etc. The important point to derive from this analysis is that ex-post the rule could be much more cost beneficial than indicated by the expected values because without the rule 2, 3, 4, 5, 6, or even 7 preventable accidents could occur. In fact there is a high probability (47%) of 2 or more preventable accidents without the rule.

The latter probability is brought out more clearly in the reverse cumulative frequency, another useful perspective from which to view these results. The reverse cumulative frequency is shown in Chart 2. The reverse cumulative frequency shows us that there is about a 7% chance of 4 or more accidents, a 20% change of 3 or more accidents, and, as already note, a 47% change of 2 or more accidents.

Chart 2. Reverse Cumulative Frequency Distribution of HCWT Passenger Airplane Accidents Preventable by FRM Rule
(50% SFAR 88 Effectiveness, Post-SFAR 88 accident Rate: 0.0050 per million flight hours)



As already noted, this variation in the number of accidents along with variation in accident size and accident timing is what determines variation in the benefits of the FRM rule benefits. Table 3 shows our Crystal Ball results for expected benefits. The expected present value of direct benefits is $384 million, resulting in a benefit-cost ratio of 0.34. The expected present value of indirect benefits is $1.075 billion, resulting in total expected benefits of $1.459 billion and a total benefits benefit-cost ratio of 1.31.

Table 3. Expected PV Benefits of FRM Rule for HCWT Passenger Airplanes (50% SFAR 88 Effectiveness, Post-SFAR 88 Accident Rate: 0.0050 per million flight hours)

Statistics	Direct Benefits @7%	Direct Benefits B/C Ratio @7%	Indirect Benefits @1.07	Total Benefits @7%	Total Benefits B/C Ratio @7%
Mean	$384	0.34	$1,075	$1,459	1.31

Notes: 1. Dollar values are in millions.
2. The undiscounted indirect benefits are avoidance of reduced demand ($265 million) and avoidance of air transportation system shutdown ($1,040 million) for total indirect benefits of $1,305 billion.
3. Costs of the FRM rule are $1,116 million at a discount rate of 7%.

Using the perspective of the reverse cumulative frequency distribution, Chart 3 shows that the mean direct benefit-cost ratio of 0.34 masks tremendous variability in direct benefits. Even though the expected direct benefit-cost is only 0.34, Chart 3 shows that there is a 20% chance the benefit-cost ratio will be 0.8 or better, a 10% chance that it will be 0.9 or better, and even a 5% chance that the benefit-cost ratio will be greater than 1.

Chart 3. Reverse Cumulative Frequency Distribution of FRM Rule Direct Benefit-Cost Ratio (50% SFAR 88 Effectiveness, Post-SFAR 88 accident Rate: 0.0050 per million flight hours)

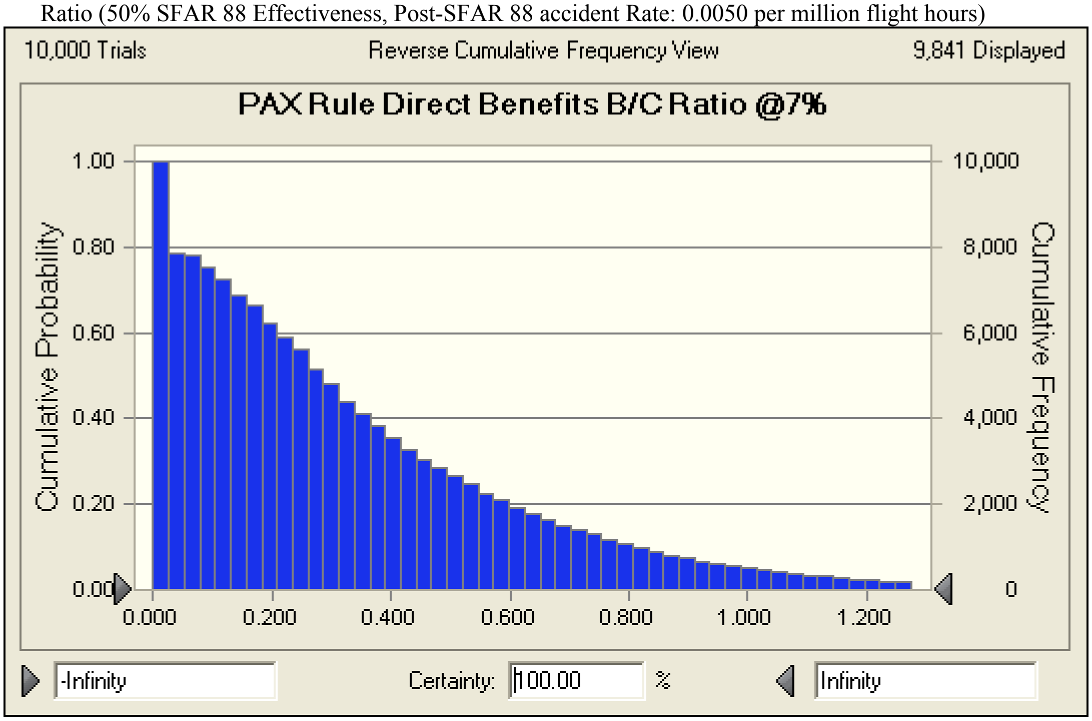
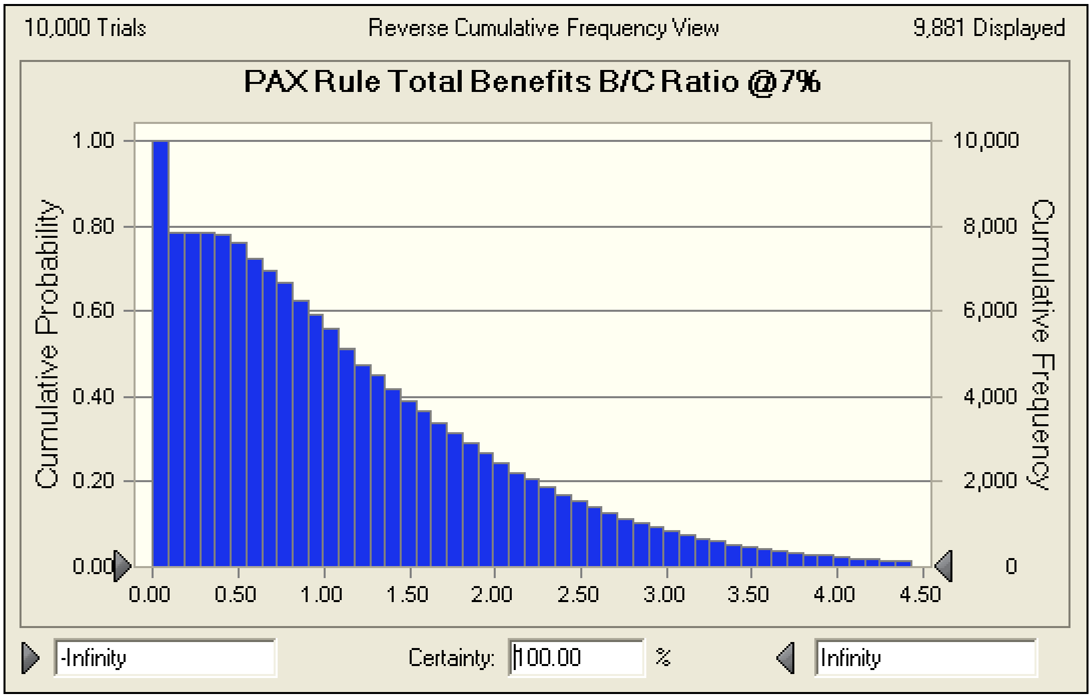


Chart 4 shows the reverse cumulative frequency distribution for the total benefit-cost ratio. Even though the expected total benefit-cost ratio is 1.31, there is an almost 25% chance that the benefit-cost ratio will be 2 or better. In other words, costs could be double their current estimate, and there is still a 25% chance that the rule would turn out to be cost beneficial.

Chart 4. Reverse Cumulative Frequency Distribution of FRM Rule Total Benefit-Cost Ratio
(50% SFAR 88 Effectiveness, Post-SFAR 88 accident Rate: 0.0050 per million flight hours)



10,000 Trials
Reverse Cumulative Frequency View
9,881 Displayed
PAX Rule Total Benefits B/C Ratio @7%
Cumulative Probability
Cumulative Frequency
1.00
0.80
0.60
0.40
0.20
0.00
10,000
8,000
6,000
4,000
2,000
0
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
-Infinity
Certainty: 100.00 %
Infinity

APPENDIX E

QUANTIFIED BENEFITS AND COSTS IF THE FRM RULE APPLIED TO PART 91 AIRPLANES[105]

E.I. QUANTIFIED BENEFITS FROM PREVENTING A PART 91 AIRPLANE EXPLOSION

E.I.1. Risk of an Explosion

We use the risk of one accident every 100 million flight hours for Part 91 airplanes.

E.I.2. Demand Benefits

The impact on passenger demand resulting from a Part 91 airplane explosion will be minimal because the public will likely not relate a private airplane explosion with relatively few fatalities to the impact of a commercial jetliner explosion with hundreds of fatalities.

E.I.3. Assumptions

We made the following assumptions and calculations to quantify the benefits from preventing a Part 91 airplane explosion.

1. Part 91 airplane explosions are in-flight catastrophic accidents in which the crew and passengers die and the airplane is completely destroyed.
2. There will be no Part 91 on-the-ground explosions.
3. As established by DOT, the value for preventing a fatality is $5.5 million in 2007 dollars.
4. There are 2 flight crew members and an average of 8 passengers on a Part 91 airplane.
5. The average Part 91 airplane replacement values are based on a GRA Incorporated report.

[105] Technically, there are no "part 91 airplanes"; there are "airplanes operated under part 91". However, for clarity of exposition, we use "part 91 airplanes" in the text.

6. The airplane real replacement values will remain constant.
7. The average cost to the U.S. government and the manufacturer to investigate an in-flight Part 91 airplane accident will be $8 million.
8. We used a 7 percent discount rate to calculate the present values of these quantified benefits.

E.I.4. Benefits from Preventing an In-Flight Part 91 Passenger Airplane Explosion

As shown in Table E-1, the "average" direct benefits from preventing an in-flight Part 91 airplane explosion range from $64 million to $178 million.

TABLE E-1

DIRECT BENEFITS FROM PREVENTING AN AIR CARRIER PASSENGER AIRPLANE IN-FLIGHT EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Airplane Model	Avg. Num. Fatalities	Value of Fatalities	Value of Airplane	Cost of Investigation	Total Cost of Accident
B-737-200	10	$55	$ 1	$8	**$ 64**
B-737-Classic	10	$55	$ 15	$8	**$ 78**
B-737-NG	10	$55	$ 30	$8	**$ 93**
B-757	10	$55	$ 34	$8	**$ 97**
B-767	10	$55	$ 50	$8	**$113**
B-747-100/200/300	10	$55	$ 15	$8	**$ 78**
B-747-400	10	$55	$ 85	$8	**$148**
B-747-800	10	$55	$115	$8	$178

We followed the same procedure we used to determine the average value of an in-flight accident for an air carrier passenger airplane. As shown in Table E-2, these Part 91 airplanes will accumulate about 764,000 flight hours. Dividing the number of flight hours for each model by the total number of flight hours generated the percentage of all flight hours operated by that model. We multiplied that percentage by the total accident cost and then summed the individual model results to obtain the weighted average of the undiscounted benefits from preventing an in-flight air carrier passenger airplane explosion of $99.8 million.[106]

TABLE E-2

[106] The present value table for this undiscounted value of $74.787 is found in Appendix C-6.

WEIGHTED AVERAGE DIRECT BENEFITS FROM PREVENTING AN IN-FLIGHT PART 91 PASSENGER AIRPLANE EXPLOSION BY AIRPLANE MODEL
(in Millions of 2007 Dollars)

Model	Total Accident Cost	Total Num. Flight Hours (2008-2043)	Percent of All Flight Hours	Weighted Accident Cost
B-737-200	$ 64	0.050	6.54%	$ 4.2
B-737-Classic	$ 78	0.039	5.10%	$ 4.0
B-737-NG	$ 93	0.511	66.88%	$ 62.2
B-757	$ 97	0.015	1.96%	$ 1.9
B-767	$113	0.029	3.80%	$ 4.3
B-747-100/200/300	$ 78	0.032	4.19%	$ 3.3
B-747-400	$148	0.014	1.83%	$ 2.7
B-747-800	$178	0.074	9.69%	$17.2
TOTAL		**0.764**		**$99.8**

E.II. NUMBER OF FLIGHT HOURS

As shown in Table E-3, the Part 91 passenger airplane fleet will accumulate about 763,700 flight hours. Of these 763,700 flight hours, 163,800 will be flown by production airplanes and 599,900 will be flown by existing Part 91 airplanes, of which 388,150 will be flown by retrofitted Part 91 airplanes and 211,750 will be flown by Part 91 airplanes without FTI.

TABLE E-3

ANNUAL NUMBER OF FLIGHT HOURS FOR PART 91 AIRPLANES
(2008-2017 for All Airplanes and 2018-2043 for the 2017 Fleet)

		EXISTING AIRPLANES			
YEAR	TOTAL	TOTAL	NO FTI	RETROFIT	PRODUCT
2008	33,250	33,250	33,250	0	0
2009	33,250	32,550	32,550	0	700
2010	33,250	31,850	30,100	1,750	1,400
2011	33,250	31,150	27,300	3,850	2,100
2012	33,250	30,450	23,800	6,650	2,800
2013	33,250	29,750	20,300	9,450	3,500
2014	33,250	29,050	16,800	12,250	4,200
2015	33,250	28,350	12,950	15,400	4,900
2016	33,250	27,650	9,100	18,550	5,600
2017	33,250	26,950	4,900	22,050	6,300
2018	33,250	26,950	700	26,250	6,300

2019	31,850	25,550	0	25,550	6,300
2020	31,150	24,850	0	24,850	6,300
2021	30,450	24,150	0	24,150	6,300
2022	29,750	23,450	0	23,450	6,300
2023	28,350	22,050	0	22,050	6,300
2024	26,250	19,950	0	19,950	6,300
2025	24,150	17,850	0	17,850	6,300
2026	22,050	15,750	0	15,750	6,300
2027	20,300	14,000	0	14,000	6,300
2028	19,250	12,950	0	12,950	6,300
2029	18,200	11,900	0	11,900	6,300
2030	16,800	10,500	0	10,500	6,300
2031	15,750	9,450	0	9,450	6,300
2032	14,700	8,400	0	8,400	6,300
2033	13,650	7,350	0	7,350	6,300
2034	12,600	6,300	0	6,300	6,300
2035	10,850	5,250	0	5,250	5,600
2036	9,100	4,200	0	4,200	4,900
2037	7,000	2,800	0	2,800	4,200
2038	5,250	1,750	0	1,750	3,500
2039	4,200	1,400	0	1,400	2,800
2040	3,150	1,050	0	1,050	2,100
2041	2,100	700	0	700	1,400
2042	1,050	350	0	350	700
TOTAL	**763,700**	**599,900**	**211,750**	**388,150**	**163,800**

E.III. TOTAL RULE BENEFITS FOR PART 91 HCWT EXPLOSIONS

Based on the 763,700 Part 91 flight hours affected by the rule, there will be 0.0076 Part 91 airplane explosions. Using a 50 percent SFAR 88 effectiveness rate, the final rule will prevent 0.0038 Part 91 airplane explosions. Based on an expected benefit of $99.8 million for a Part 91 airplane explosion, the undiscounted benefit of the rule will be $3.2 million. We did not calculate present values for this small benefit.

E.IV. COST OF COMPLIANCE

E.IV.a. Introduction

In this Section we discuss and estimate the compliance costs to part 91 operators of HCWT airplanes. The first section summarizes the total compliance costs. The rest of the section discusses and develops these costs in more detail. Most of the background discussions and basic data reported in Section V for air carrier passenger airplanes also apply to part 91 airplanes. We do not generally repeat this information unless it differs from the air carrier information.

E.IV.b. <u>Summary of Part 91 Airplane Compliance Costs</u>

As shown in Table E-4, the undiscounted compliance costs for part 91 airplanes are about $20.6 million, which has a present value of $13.0 million using a 7 percent discount rate and a present value of $16.7 million using a 3 percent discount rate. For retrofitted airplanes, the undiscounted costs will be $17 million, which has a present value of $11 million using a 7 percent discount rate and a present value of $14 million using a 3 percent discount rate. For production airplanes, the undiscounted costs will be $3.6 million which has a present value of $2.1 million using a 7 percent discount rate and a present value of $2.7 million using a 3 percent discount rate.

TABLE E-4

COMPLIANCE COSTS FOR PART 91 AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COST		
CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	**$ 0.000**	**$ 0.000**	**$ 0.000**
RETROFITTED			
INSTALLATION	$16.447	$10.712	$13.628
INVENTORY	$ 0.000	$ 0.000	$ 0.000
FUEL	$ 0.573	$ 0.240	$ 0.386
OPERATIONAL	$ 0.000	$ 0.000	$ 0.000
ASM REPLACEMENT	$ 0.000	$ 0.000	$ 0.000
TOTAL	**$17.020**	**$10.952**	**$14.014**
PRODUCTION			
INSTALLATION	$ 2.666	$ 1.800	$ 2.200
INVENTORY	$ 0.000	$ 0.000	$ 0.000
FUEL	$ 0.886	$ 0.275	$ 0.512
OPERATIONAL	$ 0.000	$ 0.000	$ 0.000
ASM REPLACEMENT	$ 0.000	$ 0.000	$ 0.000
TOTAL	**$ 3.552**	**$ 2.075**	**$ 2.712**

GRAND TOTAL	$20.572	$13.027	$16.726

E.IV.c. Engineering Costs to Design Part 91 Airplane FTI Systems

There will be minimal engineering costs to adjust air carrier FTI engineering data to part 91 FTI applications because it will have been completed for their air carrier passenger and cargo airplanes.

E.IV.d. Retrofitting Airplane Costs

E.IV.d.1. Unit Retrofitting Costs

With two differences, the FTI retrofitting costs for part 91 airplanes are the same as those for retrofitting air carrier passenger airplanes. The first exception is that Part 91 airplanes do not generally undergo a "D" check because they do not accumulate enough flight hours to make a total overhaul necessary. Therefore, an FTI retrofit will be completed during a special maintenance session. The second exception is that Part 91 airplanes will incur minimal out-of-service losses because they have greater scheduling flexibility and there are times when the airplane is not used. Thus, as shown in Table E-5, the retrofitting costs range from $176,000 to $350,000.

TABLE E-5

COSTS TO RETROFIT FTI ON A PART 91 AIRPLANE DURING A SPECIAL MAINTENANCE SESSION BY MODEL
(in Thousands of 2007 Dollars)

	COST		
MODEL	TOTAL	KIT	LABOR
B-737-CLASSIC	$176	$110	$66
B-737-NG	$176	$110	$66
B-757	$308	$235	$73
B-767	$308	$235	$73
B-747-1/2/300	$325	$250	$75
B-747-400	$325	$250	$75
B-747-800	$325	$250	$75
B-777	$350	$275	$75
B-787	$308	$235	$73
A-300/300-600	$308	$235	$73
A-310	$308	$235	$73
A-320 FAMILY	$176	$110	$66
A-330	$350	$275	$75

A-340	$325	$250	$75
A-350	$308	$235	$73
A-380	$325	$250	$75

E.IV.d.2. Number of Retrofitted Part 91 Airplanes

We do not have information about retirement rates for Part 91 airplanes. We also do not know how many air carrier passenger airplanes will be converted to Part 91 configurations. Consequently, we assumed that the net retirements will equal the additions from converted passenger airplanes for a net change of zero in the 2006 fleet that will need to be retrofitted by 2017.

As shown in Table E-6, 79 Boeing and no Airbus airplanes currently operate under Part 91. A list of these operators and the number of HCWT airplanes (as of January 1, 2006) is provided in Appendix VII-1. As there are 8 years to retrofit these airplanes, we determined that 10 of them will be retrofitted every year.[107]

TABLE E-6

NUMBERS OF PART 91 HCWT AIRPLANES
(JANUARY 1, 2006)

AIRPLANE MODEL	TOTAL NUMBER OF AIRPLANES
B-737-200	18
B-737-Classic	7
B-737-NG	36
B-747-100/200/300	9
B-747-400	2
B-747-800	0
B-757	6
B-767	1
B-777	0
B-787	0
A-300	0
A-310	0
A-320 Family	0
A-330	0
A-340	0
A-350	0

[107] This averaging implies that there will be fractions of airplane models retrofitted every year, but, for example, we do not know in which specific years each of the 2 B-747-400s will be retrofitted and averaging is simply a method to evenly spread out the costs.

A-380	0
GRAND TOTAL	**79**

E.IV.d.3. Total Part 91 Retrofitting Cost

As shown in Table E-7, which summarizes Appendix VII-1, it will cost $2.1 million a year for the first 8 years to retrofit Part 91 airplanes. The total undiscounted retrofitting costs will be $16.5 million, which has a present value of $10.7 million using a 7 percent discount rate and a present value of $13.6 million using a 3 percent discount rate.

TABLE E-7

UNDISCOUNTED AND PRESENT VALUE OF THE ANNUAL RETROFITTING COSTS FOR PART 91 AIRPLANES BY YEAR
(in Millions of 2007 Dollars)

	TOTAL COSTS		
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
2010	$ 2.060	$ 1.681	$ 1.885
2011	$ 2.060	$ 1.571	$ 1.830
2012	$ 2.060	$ 1.468	$ 1.777
2013	$ 2.060	$ 1.372	$ 1.725
2014	$ 2.060	$ 1.283	$ 1.675
2015	$ 2.060	$ 1.199	$ 1.626
2016	$ 2.060	$ 1.120	$ 1.579
2017	$ 2.060	$ 1.047	$ 1.533
TOTAL	**$16.477**	**$10.742**	**$13.628**

E.IV.e. Production Airplane Costs

E.IV.e.1. Unit Costs for Production Airplanes

Although Boeing has stated they intend to install FTI on their production airplanes, we determined that most purchasers will request that Boeing leave FTI out of their airplane because it is an expensive piece of equipment and they would likely not see a pressing need for it. Unless there is a rule, it is likely that a manufacturer would accede to a customer's request. Thus, the Part 91 Boeing production airplane costs are a cost of the final rule.

The kit costs and the labor hours to install FTI on a Part 91 B-737-NG production passenger airplane are the same as the $98,733 costs to install FTI on an air carrier B-737-NG production passenger airplane.

E.IV.e.2. Numbers of Production Passenger Airplanes

In reviewing the current Part 91 fleet, the only production airplanes are the B-737-NG and the B-747-400. We believe that it is likely that the 2 B-747-400s were originally used in air carrier service and later converted to private use. Consequently, as discussed in Section II, we determined that 3 new B-737-NGs will be annually purchased for Part 91 operators. We cannot distinguish between Part 91 airplanes involved in passenger and in cargo operations, but we assume that all of them will be passenger airplanes.

E.IV.e.2. Total Production Airplane Costs

The annual cost to install FTI on the 3 B-737-NGs will be $296,000, which results in a total cost of $2.666 million, which has a present value of $1.8 million using a 7 percent discount rate and a present value of $2.2 million using a 3 percent discount rate.

E.IV.e.3. Inventory Costs

There will be no water separator/filter assembly costs for the Part 91 airplanes because no operator has more than 6 of them and that is too few to inventory infrequently changed parts. Further, none of these operators will perform their own maintenance.

E.IV.e.4. Additional Fuel Consumption Costs

The Part 91 and the air carrier airplane FTI systems weigh the same. We do not have specific estimates of the additional fuel consumption by pound per flight hour for these airplanes in Part 91 operations. Nor do we have specific estimates for the increased fuel consumption in Part 91 operations due to bleed air and ram drag. In the absence of those data, we adapted the MAC weight and the Boeing bleed air and ram drag fuel consumption rates for Part 91 operations based on numbers of flight hours. The GRA study reports that the average general aviation turbofan airplane weighing more than

60,000 pounds flies about 350 hours a year.[108] As shown in Table E-8, the total increased Part 91 airplane fuel consumption due to FTI ranges from 248 to 625 gallons per year, of which 142 to 504 gallons are due to weight and 98 to 179 gallons are due to bleed air and ram drag.

TABLE E-8

INCREASED FUEL CONSUMPTION DUE TO FTI FOR A PART 91 AIRPLANE MODEL

	FTI WEIGHT	FL. HRS. (Yr.)	FUEL BURN (MAC)	GALLONS PER YEAR		
MODEL	WEIGHT (lbs.)		GAL/LB/FL. HR.	WEIGHT	BLEED AIR & RAM DRAG	TOTAL
B-737-Classic	105	350	0.0045	142	106	248
B-737-NG	105	350	0.0045	142	106	248
B-757	280	350	0.0060	142	149	248
B-767	280	350	0.0050	504	100	604
B-747-1/2/300	257	350	0.0065	420	98	518
B-747-400	257	350	0.0065	501	124	625
B-747-800	257	350	0.0065	501	124	625
B-777	300	350	0.0040	501	124	625
B-787	280	350	0.0045	360	179	539
A-300	280	350	0.0040	378	98	476
A-310	280	350	0.0040	336	98	434
A-320 Family	105	350	0.0095	336	98	434
A-330	300	350	0.0040	299	149	448
A-340	300	350	0.0040	360	179	539
A-350	280	350	0.0050	360	124	484
A-380	257	350	0.0065	420	98	518

Although air carriers can obtain aviation fuel at an average cost of $2.01 a gallon, individual Part 91 operators do not buy in bulk and cannot avail themselves of volume discounts when purchasing aviation fuel. We determined that the average aviation fuel cost to a Part 91 operator will be about $2.50 a gallon.[109] Thus, as shown in Table E-9, we calculated that an FTI system will increase the annual Part 91 passenger fuel cost by $620 to $1,563.

TABLE E-9

[108] GRA, Incorporated, Economic Values for FAA Investment and Regulatory Decisions, A Guide, Draft Final Report, Table 3-10, p. 3-14, December 31, 2004.

[109] In addition, general aviation operators pay an FAA fuel tax to support the air traffic control system.

INCREASED PART 91 AIRPLANE FUEL CONSUMPTION DUE TO FTI BY MODEL

MODEL	ANNUAL COST	ANNUAL GALLONS
B-737-Classic	$ 620	248
B-737-NG	$ 620	248
B-757	$ 620	248
B-767	$1,510	604
B-747-1/2/300	$1,295	518
B-747-400	$1,563	625
B-747-800	$1,563	625
B-777	$1,563	625
B-787	$1,348	539
A-300	$1,190	476
A-310	$1,085	434
A-320 Family	$1,085	434
A-330	$1,120	448
A-340	$1,348	539
A-350	$1,210	484
A-380	$1,295	518

As shown in Table E-10, which summarizes Appendix VII-2, the increased fuel consumption by Part 91 retrofitted and production passenger airplanes will be about 583,000 gallons. At an average price of $3.05 per gallon, the undiscounted cost will be about $1.78 million, which has a present value of $0.6 million using a 7 percent discount rate and a present value of $1.1 million using a 3 percent discount rate.

TABLE E-10

UNDISCOUNTED AND PRESENT VALUE FUEL COST AND CONSUMPTION FOR PART 91 AIRPLANES BY YEAR
(All Numbers in Millions)

	TOTAL COST			
YEAR	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)	GALLONS
2009	$0.00	$0.00	$0.00	0.001
2010	$0.02	$0.01	$0.01	0.005
2011	$0.03	$0.02	$0.03	0.010
2012	$0.04	$0.03	$0.03	0.012
2013	$0.05	$0.03	$0.04	0.015
2014	$0.05	$0.03	$0.04	0.018

2015	$0.06	$0.04	$0.05	0.020
2016	$0.07	$0.04	$0.05	0.023
2017	$0.08	$0.04	$0.06	0.026
2018	$0.08	$0.04	$0.06	0.026
2019	$0.08	$0.04	$0.05	0.026
2020	$0.08	$0.03	$0.05	0.026
2021	$0.08	$0.03	$0.05	0.026
2022	$0.08	$0.03	$0.05	0.026
2023	$0.08	$0.03	$0.05	0.026
2024	$0.08	$0.02	$0.05	0.026
2025	$0.08	$0.02	$0.05	0.026
2026	$0.07	$0.02	$0.04	0.024
2027	$0.07	$0.02	$0.04	0.023
2028	$0.06	$0.02	$0.03	0.021
2029	$0.06	$0.01	$0.03	0.019
2030	$0.05	$0.01	$0.03	0.018
2031	$0.05	$0.01	$0.02	0.016
2032	$0.04	$0.01	$0.02	0.014
2033	$0.04	$0.01	$0.02	0.012
2034	$0.03	$0.00	$0.01	0.011
2035	$0.03	$0.00	$0.01	0.009
2036	$0.18	$0.03	$0.08	0.059
2037	$0.02	$0.00	$0.01	0.007
2038	$0.02	$0.00	$0.01	0.005
2039	$0.01	$0.00	$0.00	0.004
2040	$0.01	$0.00	$0.00	0.003
2041	$0.00	$0.00	$0.00	0.001
2042	$0.00	$0.00	$0.00	0.000
TOTAL	**$1.78**	**$0.63**	**$1.09**	**0.583**

As shown in Table E-11, Part 91 retrofitted airplanes will incur undiscounted costs of $698,000, which has a present value of $292,000 using a 7 percent discount rate and a present value of $470,000 using a 3 percent discount rate. Part 91 production airplanes will incur undiscounted costs of $1.079 million, which has a present value of $335,000 using a 7 percent discount rate and a present value of $624,000 using a 3 percent discount rate.

TABLE E-11

TOTAL AND PRESENT VALUE OF THE FUEL COSTS FOR PART 91 OPERATORS BY FTI INSTALLATION
(in Millions of 2007 Dollars)

	TOTAL COSTS		
INSTALLATION	UNDISCOUNTED	PRESENT VALUE	PRESENT VALUE

		(7%)	(3%)
RETROFITTED	$0.698	$0.292	$0.470
PRODUCTION	$1.079	$0.335	$0.624
TOTAL	**$1.777**	**$0.627**	**$1.094**

E.IV.e.5. Operational Costs

We determined that Part 91 operators will incur minimal operational costs from FTI because they do not fly enough hours to require sufficient operational costs to have a measurable impact.

E.IV.e.6. ASM Replacement Costs

As ASMs will be replaced every 27,000 flight hours, there will be few if any, Part 91 airplanes that will replace an ASM, resulting in minimal costs.

E.V. TOTAL PART 91 AIRPLANE COMPLIANCE COSTS

As shown in Table VII-9, the undiscounted cost for Part 91 operators will be about $21 million, which has a present value of $13 million using a 7 percent discount rate and a present value of $17 million using a 3 percent discount rate. Finally, as shown in Table E-12, of the present value of $13 million using a 7 percent discount rate for the production cargo airplane compliance costs, about 95 percent will be due to the $12.5 million in installation costs and about 5 percent will be due to the annual fuel costs. This result is significantly different from that found for air service passenger and cargo airplanes because part 91 airplanes will fly far fewer hours than will air service airplanes.

TABLE E-12

COMPLIANCE COSTS FOR PART 91 AIRPLANES
(in Millions of 2007 Dollars)

	TOTAL COST		
CATEGORY	UNDISCOUNTED	PRESENT VALUE (7%)	PRESENT VALUE (3%)
ENGINEERING	**$ 0.000**	**$ 0.000**	**$ 0.000**

RETROFITTED			
INSTALLATION	$16.447	$10.712	$13.628
INVENTORY	$ 0.000	$ 0.000	$ 0.000
FUEL	$ 0.698	$ 0.292	$ 0.470
OPERATIONAL	$ 0.000	$ 0.000	$ 0.000
ASM REPLACEMENT	$ 0.000	$ 0.000	$ 0.000
TOTAL	**$17.145**	**$11.004**	**$14.098**
PRODUCTION			
INSTALLATION	$ 2.666	$ 1.800	$ 2.200
INVENTORY	$ 0.000	$ 0.000	$ 0.000
FUEL	$ 1.079	$ 0.335	$ 0.624
OPERATIONAL	$ 0.000	$ 0.000	$ 0.000
ASM REPLACEMENT	$ 0.000	$ 0.000	$ 0.000
TOTAL	**$ 3.745**	**$ 2.135**	**$ 2.824**
GRAND TOTAL	**$20.890**	**$13.139**	**$16.922**

APPENDIX F

REVISED AVIATION FUEL FORECAST

Table F-1 presents our methodology and derivation of an updated aviation fuel cost. In the development of the fuel cost for a version of the final rule that was reviewed by the Office of Management and Budget (OMB). The basis of the fuel costs was a fleet weighted fuel cost derived from the FAA Aerospace Forecast Fiscal Years 2007-2022 forecasts of future fuel costs (Table 18). This resulted in an average cost of $1.65 a gallon. At their suggestion, we derived a new 10-year average fuel cost.

We used the FAA Aerospace Forecast Fiscal Years 2008-2025 (Table 18) as the basis for future year prices. We then multiplied these costs by the numbers of airplanes that we forecast will be equipped FRM in each year by the new fuel price forecast and divided the cumulative fuel price by the cumulative number of airplanes. The new weighted fuel cost is $2.01 a gallon. Thus, the forecast price of fuel has increased 121.8 percent since the $1.65 a gallon estimate for the final rule. We multiplied the $199 million original present value estimate for the total cost of fuel by 121.6 to obtain the $242 million updated present value cost of fuel for the final rule.

This methodology is presented in Table F-1. In that Table, Columns D, E, and F supply the numbers of airplanes that have FRM operating in each year. Column G contains the forecasted price of aviation fuel for each year. Thus, multiplying the total number of airplanes that have FRM in each year times the forecasted aviation fuel price for that year (results presented in Column H) gives a total increased aviation fuel expenditure in that year.

Row 19 then provides the cumulative number of airplane years with FRM (21,325) and the cumulative aviation fuel costs associated with having FRM ($42,776.67). The logic for this is best explained by example. If only one airplane had FRM and paid $2.00 a gallon in 2010 and 5,000 airplanes had FRM in 2011 and paid $1.00 per gallon, you would not use an average fuel cost of $1.50 for these 5,001 airplanes, but, rather a weighted fuel cost average of $1.002 per gallon. In this case, more airplanes with FRM are affected over time by the aviation fuel costs because they are being added to the fleet while non-FRM airplanes are either being retrofitted or retired. After 2017, the total number of airplanes with FRM decline through retirements in this analysis.

Row 21 provides the weighted average fuel cost (cumulative airplane years/cumulative fuel expenditure) of $2.01 a gallon.

Row 23 provides the $1.65 average fuel cost used in the Final Rule.

Row 25 provides the percentage increase in average fuel costs using the $2.01 fuel cost forecast over the $1.65 fuel cost in the Final rule of 121.57 percent.

Row 27 provides the present value of the fuel costs (using a 7% discount rate) of $199 million using the final rule fuel cost.

Row 29 provides the re-calculated present value of the fuel costs of $242 million using the 121.57 percent increase in fuel costs over the final rule fuel cost.

TABLE 1

WEIGHTED AVERAGE FUEL COST CALCULATIONS

	C	D	E	F	G	H
4		NUMBER OF HCWT FRM SCHEDULED PASSENGER AIRPLANES AFFECTED IN EACH YEAR			FUEL PRICE FORECAST PER GALLON	TOTAL FUEL COST
5	YEAR	PRODUCTION	RETROFITTE	TOTAL		

			D			
6						
7	**2009**	**244**	**0**	**244**	**$2.4392**	**$595.16**
8	**2010**	**443**	**283**	**726**	**$2.2278**	**$1,617.26**
9	**2011**	**635**	**566**	**1,201**	**$2.1859**	**$2,625.02**
10	**2012**	**840**	**849**	**1,689**	**$2.1208**	**$3,581.67**
11	**2013**	**1,065**	**1,132**	**2,197**	**$2.0641**	**$4,534.36**
12	**2014**	**1,356**	**1,415**	**2,771**	**$2.0120**	**$5,574.69**
13	**2015**	**1,689**	**1,698**	**3,387**	**$1.9670**	**$6,661.57**
14	**2016**	**1,978**	**2,180**	**4,158**	**$1.9355**	**$8,048.45**
15	**2017**	**2,290**	**2,663**	**4,953**	**$1.9258**	**$9,538.49**
16						
17	**TOTAL**	**2,290**	**2,663**	**4,953**		
18						
19	**CUMULATIVE**			**21,325**		**$42,776.67**
20						
21	**WEIGHTED AVERAGE PRICE PER GALLON**					**$2.01**
22						
23	**AVERAGE PRICE PER GALLON IN FINAL RULE**					**$1.65**
24						
25	**PERCENTAGE INCREASE IN FUEL COST**					**121.57%**
26						
27	**PV TOTAL FUEL COST IN FINAL RULE**					**$199**
28						
29	**PV TOTAL FUEL COST @ $2.01 A GAL**					**$242**

APPENDIX II-1

ESG FLEET FORECAST (2006-2018)

APPENDIX II-2

AIR CARRIER FLEET FORECAST (2007-2018)

APPENDIX II-3

AIR CARRIER PRODUCTION FLEET FORECAST (2009-2017)

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AIR CARRIER RETROFITTING FLEET FORECAST (2008-2017)

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LIST OF PART 91 OPERATORS (2006)

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TRANSPORTATION RESEARCH BOARD LIGHT COMMERCIAL AND GENERAL AVIATION COMMITTEE – SUBCOMMITTEE ON BUSINESS AVIATION

FORECAST OF GENERAL BUSINESS JET AVIATION PRODUCTION (2007-2016)

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AIR CARRIER FLIGHT HOURS FORECAST (2008-2043)

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OPERATING REVENUES AND COSTS FROM FORM 41 (CALENDER YEAR 2006)

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LOSSES FROM AN IN-FLIGHT AIR CARRIER PASSENGER AIRPLANE EXPLOSION

APPENDIX IV-3

LOSSES FROM AN ON-THE-GROUND AIR CARRIER PASSENGER AIRPLANE EXPLOSION

APPENDIX IV-4

LOSSES FROM AN AIR CARRIER CARGO AIRPLANE EXPLOSION

APPENDIX IV-5

AVERAGE BENEFITS FROM PREVENTING A LARGE, MEDIUM-SIZED, AND SMALL PASSENGER AIRPLANE HCWT EXPLOSION

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PROBABILITY DISTRIBUTION OF THE FINAL RULE BENEFITS

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TOTAL NUMBER OF ENGINEERING ASSESSMENTS AND TOTAL ENGINEERING ASSESSMENT COSTS

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COST PER ENGINEERING ASSESSMENT

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COST PER RETROFIT IN THE INITIAL REGULATORY EVALUATION

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COST PER RETROFIT IN THE FINAL REGULATORY EVALUATION

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TOTAL NUMBERS AND COSTS OF RETROFITTED AIR CARRIER PASSENGER AIRPLANES

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COST PER PRODUCTION AIRPLANE IN INITIAL REGULATORY EVALUATION

APPENDIX V-7

COST PER PRODUCTION AIRPLANE IN FINAL REGULATORY EVALUATION

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TOTAL COST FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES

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TOTAL NUMBERS AND COSTS FOR WATER SEPARATION/FILTER

ASSEMBLIES FOR AIR CARRIER RETROFITTED PASSENGER AIRPLANES

APPENDIX V-10

TOTAL NUMBERS AND COSTS FOR WATER SEPARATION/FILTER

ASSEMBLIES FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES

APPENDIX V-11

TOTAL FUEL COSTS FOR RETROFITTED AIR CARRIER PASSENGER AIRPLANES

APPENDIX V-12

TOTAL FUEL COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES

APPENDIX V-13

TOTAL OPERATIONAL COSTS FOR AIR CARRIER PASSENGER AIRPLANES

APPENDIX V-14

ASM REPLACEMENT COSTS FOR RETROFITTED AIR CARRIER PASSENGER AIRPLANES

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ASM REPLACEMENT COSTS FOR AIR CARRIER PRODUCTION PASSENGER AIRPLANES

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TOTAL INSTALLATION COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

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TOTAL FUEL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

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TOTAL OPERATIONAL COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

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TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER PRODUCTION CARGO AIRPLANES

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TOTAL RETROFITTING COSTS FOR PART 91 AIRPLANES

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TOTAL RETROFITTING COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES

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INVENTORY COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES

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TOTAL FUEL COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES

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TOTAL OPERATIONAL COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES

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ASM REPLACEMENT COSTS FOR AIR CARRIER CONVERSION CARGO AIRPLANES

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TOTAL RETROFITTING COSTS FOR AIR CARRIER CARGO AIRPLANES

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INVENTORY COSTS FOR AIR CARRIER RETROFITTED CARGO AIRPLANES

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TOTAL FUEL COSTS FOR AIR CARRIER RETROFITTED CARGO AIRPLANES

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TOTAL OPERATIONAL COSTS FOR AIR CARRIER RETROFITTED CARGO AIRPLANES

APPENDIX B-6

TOTAL ASM REPLACEMENT COSTS FOR AIR CARRIER RETROFITTED

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