

ARCHIVED REPORT

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Boeing 747 Series

Outlook

- Retrofit market kept alive by new 747-8 orders
- Worldwide fleets shrinking
- ADS-B Out deadline approaching

Note: Icons indicate area(s) of current and potential retrofit/modernization activity



Orientation

Description. Intercontinental-range, four-engine, commercial jet transport aircraft.

Current Status. 747-400 production ended in 2009. 747-8 in production.

Total Produced. Through 2017, Boeing delivered 124 747-8s. Boeing delivered 1,418 747s of earlier types, including 694 747-400s.

Application. Very long-range, high-density scheduled passenger and cargo transportation. Military applications include airborne strategic communications and VIP.

Price Range. 747-8 Intercontinental, \$402.9 million; 747-8 Freighter, \$403.6 million.



Boeing 747-400F Freighter in Artist Rendering

Source: Air Traders

Boeing 747 Series

Contractors

Prime

Boeing Commercial Airplanes	http://www.boeing.com/commercial/ , 3003 W Casino Rd, Everett, WA 98203 United States, Tel: + 1 (425) 294-2300, Fax: + 1 (425) 294-6200, Prime
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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

(747-400)

	Metric	U.S.
Dimensions		
Length overall	76.3 m	250.2 ft
Height overall	19.4 m	63.5 ft
Wingspan	68.5 m	224.7 ft
Weight		
Max takeoff weight	447,696 kg	987,000 lb
Max payload (passenger)	82,100 kg	181,000 lb
(747-8 Freighter)	134,000 kg	295,200 lb
Performance		
Max range (Intercontinental)	14,815 km	8,000 nm
(747-8 Freighter)	8,130 km	4,390 nm
Typical cruise speed (passenger)	Mach 0.855	Mach 0.855
Propulsion		
Four GE GENx-2B67 turbofans		
296 kN (66,500 lbst)	252.4 kN	56,750 lbst

Program Review

Background. In November 2005, Boeing officially launched the new Boeing 747-8 program, which includes the 747-8 Intercontinental passenger airplane and the 747-8 Freighter models (see **Variants / Upgrades** for details).

The original plans called for the Intercontinental to be about 7 feet shorter than the freighter and have a passenger capacity of 450 in a three-class configuration. However, Boeing decided during 2006 to sacrifice some of the expected range of the prior design to build the Intercontinental at the same length as the freighter after consulting with potential customers of the passenger variant. Both variants were stretched 5.6 meters (18.3 ft) in comparison to the 747-400 model then in production.

Boeing originally scheduled the rollout of the first 747-8 for November 2008. This deadline was later pushed back three months after Boeing decided to wrap up production of all remaining orders for the existing -400F before transitioning the production lines to the new, longer variant. The delay was also partly caused by the need to divert engineering teams from the 747 program to the 787 and 777 Freighter programs. A months-long strike by the machinists union at Boeing's commercial aircraft division in 2008 further aggravated the situation. More delays were announced in the fall of 2009 and in 2010. The freighter flight test fleet included five aircraft that were later delivered to customers (RC521 and RC522 to Nippon Cargo Airlines, and RC501, RC502, and RC503 to Cargolux).

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The -8 Intercontinental test fleet included three aircraft: RC001, RC003, and RC021.

The 747-8F Freighter achieved U.S. Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) certification on August 19, 2011. Launch customer Cargolux received its first aircraft on October 11, 2011.

Certification of the -8 Intercontinental followed in mid-December. Certification was granted after Boeing locked out the 3,300-gallon (12,500-liter) fuel tank in the aircraft's horizontal stabilizer after the flight test program revealed that a flutter condition could occur if the aircraft wing-to-strut joint fitting failed. The measure reduced the Intercontinental's range, but the freighter version was not affected by the issue.

The delivery of the first Cargolux aircraft was marred by a last-minute dispute over compensation for a fuel burn performance shortfall of 2.7 percent that was discovered during flight testing.

The GENx-2B Performance Improvement Package (PIP) has since improved fuel burn by 2 percent. Upgrades to

the flight management computer (FMC) software allowed the reactivation of the aircraft's fuel tank in the horizontal stabilizer, adding range and allowing changes to the trim of the aircraft for reduced drag while cruising. Boeing said in July 2014 that these and other changes made since the aircraft entered service in 2011 increased fuel efficiency by 3.5 percent.

747-8 Selected for Air Force 1 Recapitalization

The U.S. Air Force announced in January 2015 that it had selected the 747-8 for its Presidential Airlift Recapitalization program. The program ordered two new aircraft to serve as Air Force One aircraft in a sole-source acquisition deal announced in September 2017. Boeing delivered the two aircraft – white tails the manufacturer had already built for Russia's bankrupt Transaero airline – in late 2017. They will undergo a substantial conversion under the PAR program prior to entry into service.

Variants

747-100. First production model, delivered in 1969 with Pratt & Whitney JT9D-3 turbofans.

747-200B. Flew in 1970. Longer range passenger version with increased fuel capacity, more power options, and increased max TOW – to 377,847 kilograms (833,000 lb), extending range with 442 passengers to 11,378 kilometers (6,140 nm). Original engine was the JT9D; later, GE and Rolls-Royce engines were added as options.

747-200M Combi. Features 3.12 x 3.40 meter (10.25 x 11.66 ft) cargo door in port side of fuselage. Entered service in 1975.

747-200C Convertible. Can be converted from all-passenger to all-cargo, or five combinations of both. Has powered freight-handling system, reinforced deck, and hinged nose. Power options, gross weights, and performance basically the same as the 747-200B's.

747-200F Freighter. All-cargo version carries from 112,400 kilograms (247,800 lb) up to 8,300 kilometers (4,480 nm), or lesser loads over greater distances.

747-300. Upper forward fuselage extended aft by 7.11 meters (23.333 ft) to increase upper deck seating to 96. Max TOW originally 371,950 kilograms (820,000 lb), increased to 377,846 kilograms (833,000 lb). First delivery in 1983.

747-300 Combi. Usual configuration is 278 passengers, 12 pallets. Max payload 80,695 kilograms (177,900 lb), 20 percent more than the -300's. GE CF6-50E2 and Pratt & Whitney JT9D-7R4G turbofans.

747-100SR. Specially configured for short-haul, high-capacity, single-class passenger transport. Initial versions based on 747-100B with strengthened fuselage and undercarriage. Total of 29 delivered to JAL and All Nippon.

747-400. Same fuselage dimensions as -300, but increased range, a 9 percent reduction in fuel burn, more interior configuration flexibility, reduced operating costs, and 6-foot wingtip extensions with 6-foot-high winglets. First flight in 1988. Deliveries ran from 1989-2009.

747-400F. Uses standard hinged-nose section; has capacity of 131,543+ kilograms (290,000 lb).

747-400D (Domestic). Short-range version for JAL, All Nippon, and Japan Air System. Seats 625+ in a single economy class.

747-400M. Combi variant.

747-400ER/ERF. Formerly 747-400X, with strengthened wing of -400F freighter and stronger

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landing gear and fuselage structure. Max TOW increased to 910,000 pounds (35,000 lb more than the -400); additional fuel tank in forward cargo hold. The -400ERF is a freighter that can use the higher maximum takeoff weight to either extend the range of the aircraft or carry more cargo.

E-4. Militarized airborne command post version of the 747-200.

VC-25. Designation for two 747-200s in service with U.S. Air Force. Known as Air Force One and Air Force Two.

747 Advanced. Announced in 2003, with projected in-service date of 2009-2010. Passenger version would have been powered by the same engines as the 787 and been stretched 140 inches. Superseded by 747-8.

747-8I/F. Stretch of the 747-400. Includes both the Intercontinental passenger model and 747-8 Freighter model. Both versions feature GENx engines, meet Stage 4 and QC2 noise requirements, have reduced emissions, offer lower trip costs, and have an upgraded flight deck and improved wing.

Milestones

Month	Year	Major Development
Apr	1966	Program announced
Feb	1969	First flight of a 747
Dec	1969	747 receives certification
Mar	1983	Initial deliveries of 747-300 variant
May	1985	747-400 announced
Jan	1989	Certification of 747-400
Nov	2005	Launch of 747-8
	2009	Close of 747-400 line
Feb	2010	First flight of 747-8
Aug	2011	747-8F Freighter wins FAA and European certification
Sep	2017	Pentagon orders two 747-8s for Air Force One replacement program

Worldwide Distribution/Inventories

Country	Operator	Designation	Quantity	Average Age
ANGOLA	TAAG Angola Airlines	747-300	1	31.00
ARGENTINA	Aerotransportes Wollkopf	747-400F	1	23.00
ARMENIA	Vertir Airlines	747SP	1	36.00
AUSTRALIA	Qantas Airways Ltd	747-200B	1	39.00
AUSTRALIA	Qantas Airways Ltd	747-400	5	22.00
AUSTRALIA	Qantas Airways Ltd	747-400ER	6	15.50
AUSTRALIA	Qantas Airways Ltd	747-400F	1	18.00
AZERBAIJAN	Silk Way Airlines Ltd	747-400F	5	17.40
AZERBAIJAN	Silk Way Airlines Ltd	747-8F	5	3.00
BAHRAIN	Bahrain Royal Flight	747-400	1	15.00
BAHRAIN	Bahrain Royal Flight	747SP	1	31.00
BANGLADESH	Biman Bangladesh Airlines	747-400	1	25.00
BELGIUM	TNT Airways	747-400ERF	3	12.67
BELGIUM	TNT Airways	747-400F	1	16.00
BRUNEI	Brunei Government	747-400	1	26.00
CANADA	Cargair	747-200B	1	39.00
CANADA	Pratt & Whitney Canada	747SP	1	38.00

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Country	Operator	Designation	Quantity	Average Age
CHINA, PEOPLE'S REPUBLIC OF	Air China	747-400	3	21.67
CHINA, PEOPLE'S REPUBLIC OF	Air China	747-400M	1	21.00
CHINA, PEOPLE'S REPUBLIC OF	Air China	747-8	7	3.57
CHINA, PEOPLE'S REPUBLIC OF	Air China Cargo	747-400F	5	19.80
CHINA, PEOPLE'S REPUBLIC OF	Air China Cargo	747-400M	2	28.50
CHINA, PEOPLE'S REPUBLIC OF	China Cargo Airlines	747-400	1	25.00
CHINA, PEOPLE'S REPUBLIC OF	China Cargo Airlines	747-400ERF	2	11.50
CHINA, PEOPLE'S REPUBLIC OF	China Cargo Airlines	747-400F	2	20.00
CHINA, PEOPLE'S REPUBLIC OF	China Southern Airlines	747-400F	3	17.33
CHINA, PEOPLE'S REPUBLIC OF	Suparna Airlines (Yangtze River AL)	747-400	2	24.00
CHINA, PEOPLE'S REPUBLIC OF	Suparna Airlines (Yangtze River AL)	747-400F	1	20.00
CHINA, PEOPLE'S REPUBLIC OF	Uni-Top Airlines	747-200F	2	32.00
FRANCE	Air France	747-400	3	21.67
FRANCE	Air France	747-400ERF	2	15.50
FRANCE	Corsairfly	747-400	3	26.00
GABON	Gabon Government	747-200B	1	40.00
GEORGIA	Air Georgia	747-200F	1	37.00
GEORGIA	The Cargo Arline	747-200F	1	31.00
GERMANY	Lufthansa	747-400	16	21.38
GERMANY	Lufthansa	747-8	21	4.33
GREECE	Hellenic Imperial Airways	747-200B	1	32.00
HONG KONG	Air Hong Kong	747-400F	2	24.00
HONG KONG	Cathay Pacific Airways	747-400	6	25.50
HONG KONG	Cathay Pacific Airways	747-400ERF	6	9.33
HONG KONG	Cathay Pacific Airways	747-8F	14	5.64
HONG KONG	Hong Kong Aviation Capital (HKAC)	747-400F	1	20.00
ICELAND	Air Atlanta Icelandic	747-400	1	28.00
ICELAND	Atlanta Icelandic Air Transport	747-400F	1	19.00
INDIA	Air India Ltd	747-400	2	22.00
IRAN	Atlas Air	747-400ERF	1	14.00
IRAN	Atlas Air	747-400F	1	26.00
IRAN	Caspian Airlines	747-200F	1	40.00
IRAN	Fars Air	747-200F	1	27.00
IRAN	Iran Air	747-100	1	48.00
IRAN	Iran Air	747-100F	1	48.00

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Country	Operator	Designation	Quantity	Average Age
IRAN	Iran Air	747-200B	3	40.00
IRAN	Iran Air	747-200C	1	30.00
IRAN	Iran Air	747SP	3	41.00
IRAN	Iran Air Force	747-100F	4	48.25
IRAN	Iran Air Force	747-200F	2	40.50
IRAN	Mahan Air	747-300	2	32.00
IRAN	Mahan Air	747-400	2	27.00
IRAN	Saha Airlines	747-100	1	49.00
IRAQ	Iraqi Airways	747-400	1	24.00
IRELAND	ASL Aviation Holdings DAC (Air Contractors)	747-400ERF	1	14.00
ISRAEL	CAL Cargo Air Lines Ltd	747-200F	1	29.00
ISRAEL	CAL Cargo Air Lines Ltd	747-400ERF	1	11.00
ISRAEL	CAL Cargo Air Lines Ltd	747-400F	1	28.00
ISRAEL	EI Al Israel Airlines Ltd	747-400	4	22.50
ISRAEL	EI Al Israel Airlines Ltd	747-400F	1	24.00
JAPAN	ANA - All Nippon Airways	747-400	1	25.00
JAPAN	Japan Air Force	747-400	2	27.50
JAPAN	Nippon Cargo Airlines	747-200F	1	28.00
JAPAN	Nippon Cargo Airlines	747-400F	4	10.75
JAPAN	Nippon Cargo Airlines	747-8F	8	4.88
KENYA	Astral Aviation Ltd	747-400F	1	20.00
KOREA, REPUBLIC OF (SOUTH)	Asiana Airlines	747-400	7	22.43
KOREA, REPUBLIC OF (SOUTH)	Asiana Airlines	747-400F	6	21.50
KOREA, REPUBLIC OF (SOUTH)	Korea Republic of (South) Air Force	747-400	1	17.00
KOREA, REPUBLIC OF (SOUTH)	Korean Air	747-400	7	22.43
KOREA, REPUBLIC OF (SOUTH)	Korean Air	747-400ERF	4	12.75
KOREA, REPUBLIC OF (SOUTH)	Korean Air	747-400F	2	18.00
KOREA, REPUBLIC OF (SOUTH)	Korean Air	747-8	11	2.09
KOREA, REPUBLIC OF (SOUTH)	Korean Air	747-8F	6	4.83
KUWAIT	Kuwait Airways Corp	747-400	1	24.00
LUXEMBOURG	Cargolux	747-400	1	28.00
LUXEMBOURG	Cargolux	747-400ERF	2	10.50
LUXEMBOURG	Cargolux	747-400F	11	16.18
LUXEMBOURG	Cargolux	747-8F	14	5.00
MALAYSIA	Malaysia Airlines (MAS)	747-400	2	18.00
MALAYSIA	Malaysia Airlines (MAS)	747-400F	1	12.00
MOLDOVA	Fly Pro	747-200F	1	31.00
MOROCCO	Morocco Government	747-400	1	19.00

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Country	Operator	Designation	Quantity	Average Age
MOROCCO	Royal Air Maroc	747-400	1	25.00
NETHERLANDS	AerCap	747-400F	1	27.00
NETHERLANDS	KLM - Royal Dutch Airlines	747-400	14	24.43
NETHERLANDS	KLM - Royal Dutch Airlines	747-400ERF	3	14.67
NETHERLANDS	KLM - Royal Dutch Airlines	747-400F	1	22.00
NETHERLANDS	Martinair Holland	747-400	1	28.00
NETHERLANDS	Transavia Airlines	747-400	1	27.00
NIGERIA	Kabo Air	747-100	3	46.67
NIGERIA	Kabo Air	747-200B	3	32.00
NIGERIA	Kabo Air	747-300 (SR)	1	30.00
NIGERIA	Kabo Air	747-400	1	25.00
NIGERIA	MaxAir (Nigeria)	747-300	3	31.00
NIGERIA	MaxAir (Nigeria)	747-400	2	21.00
OMAN	Oman Royal Flight	747-400	1	14.00
OMAN	Oman Royal Flight	747SP	1	39.00
PAKISTAN	Pakistan International Airlines Corp - PIA	747-300	2	32.00
PAKISTAN	Rayyan Air	747-200F	1	40.00
PHILIPPINES	Philippine Airlines	747-400	4	24.50
QATAR	Qatar Airways	747-8F	2	3.00
QATAR	Qatar Amiri Flight	747-8	1	6.00
RUSSIA	AirBridge Cargo	747-400ERF	5	10.80
RUSSIA	AirBridge Cargo	747-400F	2	9.50
RUSSIA	AirBridge Cargo	747-8F	12	3.92
RUSSIA	Globus	747-400F	1	18.00
RUSSIA	Polar Airlines	747-8F	1	5.00
RUSSIA	Rossiya-Russian Airlines	747-400	4	18.75
RUSSIA	Rossiya-Russian Airlines	747-400F	1	17.00
RUSSIA	Transaero Airlines	747-300	1	32.00
RUSSIA	Transaero Airlines	747-300 (SR)	1	31.00
RUSSIA	Transaero Airlines	747-400	9	19.44
SAUDI ARABIA	Flynas (Nas Air)	747-400	4	21.50
SAUDI ARABIA	Saudi Arabia Air Force	747SP	2	36.00
SAUDI ARABIA	Saudi Arabian Royal Flight	747-300	1	35.00
SAUDI ARABIA	Saudi Arabian Royal Flight	747SP	1	36.00
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747-300	1	32.00
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747-400	12	23.08
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747-400ERF	1	16.00
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747-400F	2	20.00
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747-8F	2	5.00
SAUDI ARABIA	Saudia (Saudi Arabian Airlines)	747SP	1	37.00
SINGAPORE	Singapore Airlines	747-400	1	17.00
SINGAPORE	Singapore Airlines	747-400F	1	19.00
SINGAPORE	Singapore Airlines Cargo	747-400F	6	14.00
SLOVAK REPUBLIC	Air Cargo Global (AC Global)	747-400F	1	27.00

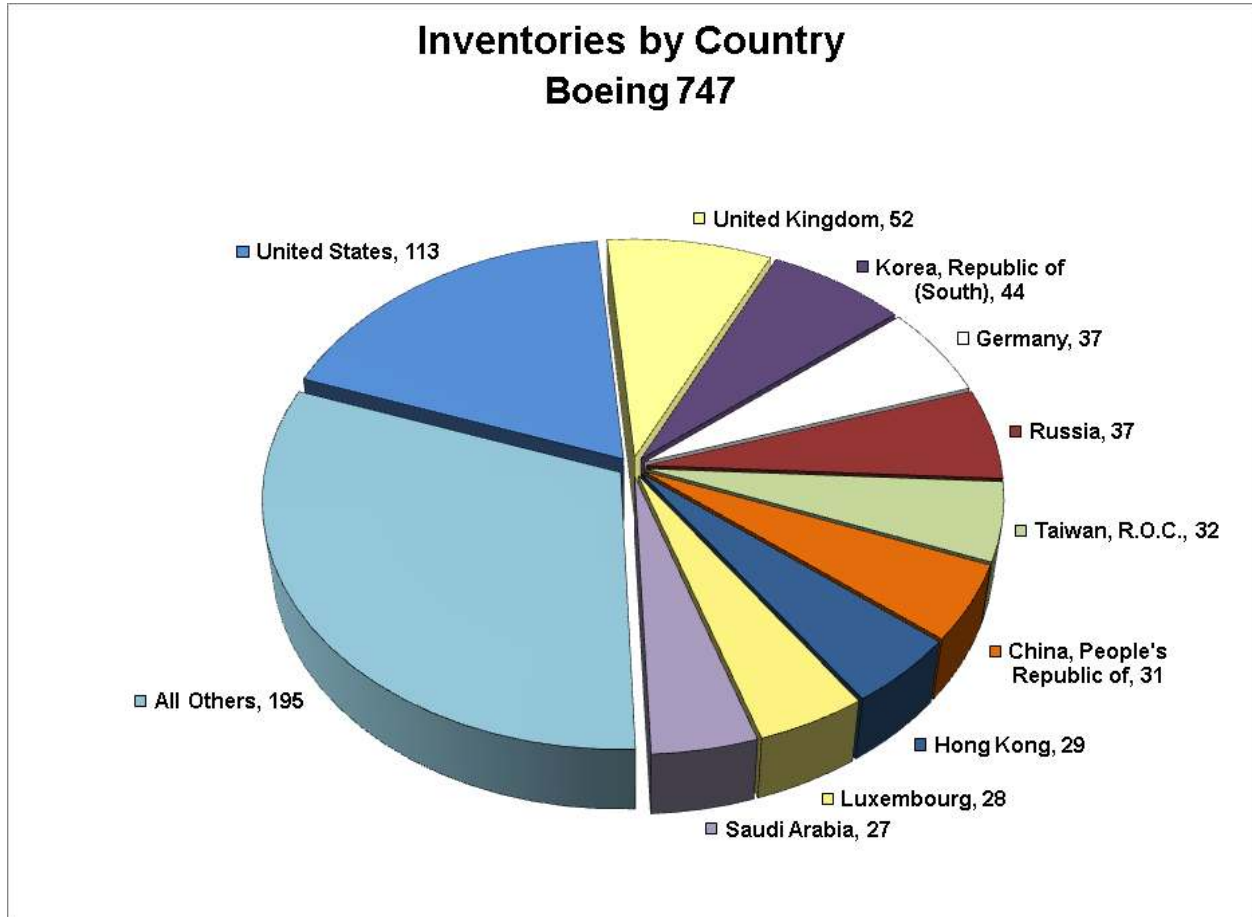
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Country	Operator	Designation	Quantity	Average Age
SPAIN	Air Pullmantur	747-400	1	24.00
SPAIN	Pronair Airlines	747-200F	1	44.00
TAIWAN, R.O.C.	China Airlines	747-400	9	17.33
TAIWAN, R.O.C.	China Airlines	747-400F	16	14.88
TAIWAN, R.O.C.	Eva Air	747-400	4	23.25
TAIWAN, R.O.C.	Eva Air	747-400F	3	19.33
THAILAND	Orient Thai Airlines	747-300	2	34.00
THAILAND	Orient Thai Airlines	747-400F	1	26.00
THAILAND	Phuket Airlines	747-200B	1	39.00
THAILAND	Phuket Airlines	747-400	2	26.00
THAILAND	Thai Airways International	747-400	13	21.31
UNITED ARAB EMIRATES	Aquiline International Corporation Ltd.	747-300SF	1	28.00
UNITED ARAB EMIRATES	Etihad Airways	747-400F	1	19.00
UNITED ARAB EMIRATES	MidEx Airlines Ltd	747-200F	3	27.67
UNITED ARAB EMIRATES	United Arab Emirates Amiri Flight	747-400	1	19.00
UNITED ARAB EMIRATES	United Arab Emirates Amiri Flight	747SP	1	29.00
UNITED ARAB EMIRATES	United Arab Emirates/ Dubai Air Wing	747-400	2	20.00
UNITED KINGDOM	British Airways	747-400	40	22.35
UNITED KINGDOM	CargoLogicAir	747-400ERF	1	14.00
UNITED KINGDOM	CargoLogicAir	747-400F	1	14.00
UNITED KINGDOM	CargoLogicAir	747-8F	1	2.00
UNITED KINGDOM	Virgin Atlantic Airways	747-400	9	18.78
UNITED STATES	Aero Controls Inc	747-200B	1	46.00
UNITED STATES	AerSale	747-400	2	20.00
UNITED STATES	Aircastle Advisor LLC	747-400ERF	1	10.00
UNITED STATES	Aircraft Guaranty Corp	747-200C	1	30.00
UNITED STATES	Aircraft Guaranty Corp	747-200F	1	33.00
UNITED STATES	Atlas Air (U.S.)	747-100B (SR)	1	39.00
UNITED STATES	Atlas Air (U.S.)	747-400	5	26.80
UNITED STATES	Atlas Air (U.S.)	747-400ERF	1	15.00
UNITED STATES	Atlas Air (U.S.)	747-400F	14	20.71
UNITED STATES	Atlas Air (U.S.)	747-8F	5	5.40
UNITED STATES	Baltia Air Lines	747-200B	1	39.00
UNITED STATES	Ernest Angley Ministries	747SP	1	38.00
UNITED STATES	Evergreen International Airlines	747-100F	1	48.00
UNITED STATES	Federal Aviation Administration - FAA	747SP	1	40.00
UNITED STATES	Kalitta Air	747-100F	1	47.00
UNITED STATES	Kalitta Air	747-200B	1	34.00
UNITED STATES	Kalitta Air	747-200F	6	37.00
UNITED STATES	Kalitta Air	747-400	6	27.33

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Country	Operator	Designation	Quantity	Average Age
UNITED STATES	Kalitta Air	747-400ERF	1	9.00
UNITED STATES	Kalitta Air	747-400F	10	19.60
UNITED STATES	Memphis Group, The	747-100	1	48.00
UNITED STATES	Mon Aviation	747-200B	1	43.00
UNITED STATES	National Airlines	747-400F	2	27.00
UNITED STATES	Northeast Airlines (Pty) Ltd	747-200B	2	44.00
UNITED STATES	Polar Air Cargo	747-400F	7	17.43
UNITED STATES	Polar Air Cargo	747-8F	4	6.50
UNITED STATES	Sky Lease Cargo	747-400ERF	1	13.00
UNITED STATES	Sky Lease Cargo	747-400F	1	21.00
UNITED STATES	Southern Air	747-400	1	25.00
UNITED STATES	United Airlines	747-400	3	26.00
UNITED STATES	United States Air Force	E-4B	4	44.00
UNITED STATES	United States Air Force	VC-25A	2	28.00
UNITED STATES	United States Government	747-100	1	49.00
UNITED STATES	UPS	747-400F	12	15.83
UNITED STATES	UPS	747-400M	1	25.00
UNITED STATES	UPS	747-8F	5	0.60
UNITED STATES	Wells Fargo	747-200B	1	40.00
UNITED STATES	Wells Fargo	747-400	2	24.50
UNITED STATES	Wilmington Trust	747-400F	1	13.00

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Identified Retrofit & Modernization Contractors

Airframe

IAI Bedek Aviation Group	http://www.iai.co.il , PO Box 323, Industrial Zone, Beer Sheva, Israel, Tel: + 972 8 627 2231, Fax: + 972 8 640 2252, Email: bendov@iai.co.il (747-400 Freighter Conversions)
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Electronics

CMC Electronics Inc	http://www.esterline.com , 600 Dr Frederik Philips Blvd, Saint-Laurent, Quebec, Canada, Tel: + 1 (514) 748-3148, Fax: + 1 (514) 748-3100 (ADS-B Out; CMA-2102 Antenna)
FreeFlight Systems	http://www.freeflightsystems.com , 3700 Interstate 35 S, Waco, TX 76706-3756 United States, Tel: + 1 (254) 662-0000, Fax: + 1 (254) 662-9450, Email: info@freeflightsystems.com (ADS-B SBAS/GNSS Sensor)
Rockwell Collins Inc	http://www.rockwellcollins.com , 400 Collins Rd NE, Cedar Rapids, IA 52498 United States, Tel: + 1 (319) 295-1000, Fax: + 1 (319) 295-5429 (ADS-B Out)

Boeing 747 Series**Opportunities****AIRFRAME****Cabin Refurbishment Activity**

Cabin retrofits encompass a number of options that may include new seats, cabin lighting, storage, air purification, air humidification, in-flight entertainment, power/USB connections, and lavatory modifications. They may include other low-cost modifications such as a new color scheme, carpeting, or window shades.

Cabin configurations are fluidly evolving, and what may be the talk of the town now may in a few years, as new offerings appear, lag behind in comfort, relevant IFE, and efficient seat design and space optimization.

In-flight entertainment systems are often included in cabin refurbishments. Such upgrades are detailed in the Electronics section of **Opportunities**.

Lighting

Airliner lighting is one of the fastest growing retrofit markets in the airline industry. Many of these modifications cut costs for an airline and enhance the customer's flight experience. Reduced costs result from lowered weight, less use of energy, and longer intervals between maintenance and replacement. Such improvements may be offered separately, but they are often part of a broad overhaul program for airline fleets, and are unpublicized. This report provides forecasts only for upgrades that have been specifically recognized by operators; therefore, the forecasts are highly speculative in nature.

Lufthansa plans to retrofit its 747-800s with an innovative lighting system designed to fit with passengers' day-and-night biorhythms. The LED technology will provide more than 20 different lighting settings in total.

Cargo Conversion

Although Boeing markets the 747-400BCF, its market is losing ground to other passenger-to-freighter (P2F) conversions such as the 737BCF and 767BCF. A total of 55 orders for the 737-800BCF have been received since its launch in February, including 43 from Chinese delivery companies. The last publicized 747-400BCF conversion was delivered in 2012, to Evergreen International Airlines.

Bedek Aviation Group, a subsidiary of Israel Aerospace Industries (IAI), appears to be the only company still receiving orders for 747 P2F conversions. Bedek offers the 747-400BDSF (Combi and PAX), and a 747-700

conversion. Bedek has performed 52 Boeing 747 conversions.



747-400BDSF Conversion

Source: Bedek Aviation

ELECTRONICS**CMA-2102 Antenna**

CMC Electronics supplies the CMA-2102 high-gain satellite communications antenna for 747 aircraft. CMC projects demand for 40 to 50 per year going down the far end of the slope. The upgrade is offered at \$60,000-\$100,000, depending on whether the airplane is pre-equipped or needs a brand new installation.

ADS-B

As part of an FAA initiative to fund avionics improvements to the U.S. civil air fleet, the Automatic Dependent Surveillance-Broadcast (ADS-B) system provides flight crews with high-precision, real-time representations of air traffic data, which are received from a satellite network. The system also allows access to weather services, terrain maps, and other navigational tools. The FAA hopes the system will allow aircraft to maintain safe distances from one another with less assistance from air traffic controllers.

ADS-B Out is already mandated in some regional airspace and will be mandated per DO-260B for retrofit in Europe and the U.S. by 2020.

Many airlines will wait until the last minute to upgrade their fleets. This is especially true for 747 operators, whose fleets could be retired before the 2020 deadline.

As the clock ticks closer to 2020, upgrade demand will surge, as will prices for the upgrade. To date, only about a quarter of U.S. airlines have been equipped with ADS-B Out.

Boeing 747 Series

Rockwell Collins provides the TOR-901-205 ADS-B Out system; other providers include Esterline CMC and FreeFlight Systems.

CMC provides a \$40,000 kit that is already certified and in production. It takes ~50 hours to install the kit versus a box swap, which is an automatic process. Operators will have to choose between a longer installation time versus problems associated with last-minute box swaps. Such difficulties may include high prices, queues, and a plethora of unknown obstacles that will accompany the rush to be ADS-B compliant.

In 2016, Kalitta Air selected FreeFlight Systems' 1203C satellite-based augmentation system/global navigation satellite system (SBAS/GNSS) sensor for retrofit on its Boeing 747 series of aircraft as part of its ADS-B compliance program. Kalitta Air paired the 1203C with the 747s' existing TPR-901 transponders.

In the future, ADS-B In capabilities will make the skies safer by allowing airline crews to see ADS-B Out signals. But with airlines struggling to make the ADS-B Out deadline by 2020, and in the face of continued 747 retirements, ADS-B In upgrades for the 747 are unlikely during the 10-year forecast period.

Company	Platform	Notes
CMC Electronics	747-200	
Delta Engineering	747-200	
FreeFlight Systems	747-200	
Honeywell	747-200/300/400	STC possible 6-12 months after receipt of order
UPS Airlines	747-400	



ADS-B In Traffic Symbol Set

Source: Boeing

Boeing 747 Series**Future Avionics Upgrade**

Unless there are additional avionics mandates, most 747 operators will attempt to hold out on further upgrades

until they know whether their respective fleets are being retired. Any upgrades will emphasize communication and navigation, both essential for operating in increasingly crowded airspace.

Forecast Rationale

The Boeing 747 provides very limited modernization opportunities, as Boeing is moving toward ceasing production and many operators are planning to retire the aircraft. The major obstacles are that the aircraft's four engines burn too much fuel and airlines struggle to fill flights. Because operators plan to retire their 747 aircraft, upgrades that are common throughout the industry, such as Wi-Fi and cabin improvements, are not in demand for 747 fleets.

Even with a handful of new orders of 747-8s, worldwide fleets are shrinking.

Cargo conversions may remain barely active for the next few years, but for the most part have ceased.

Future upgrades will be limited to the 747-8 market, most likely focusing on communications and navigation.

FI's Opportunity Outlook

AIRFRAME													
		High Confidence					Good Confidence			Less Confidence			
Status		Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total
Estimated Potential Candidates	500	Cargo Conversion <> 747											
Planned/In Progress		137	0	0	0	0	0	0	0	0	0	0	0
Speculative			1	0	1	0	1	0	0	0	0	0	3
Estimated Potential Candidates	500	LED Lighting <> 747											
Planned/In Progress		21	0	0	0	0	0	0	0	0	0	0	0
Speculative			10	10	5	2	0	0	0	0	0	0	27

ELECTRONICS													
		High Confidence					Good Confidence			Less Confidence			
Status		Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total
Estimated Potential Candidates	500	Future Avionics Upgrade Comms <> 747											
Planned/In Progress		0	0	0	0	0	0	0	0	0	0	0	0
Speculative			0	0	0	12	12	10	10	8	8	6	66
Estimated Potential Candidates	500	Future Avionics Upgrade Navigation <> 747											
Planned/In Progress		0	0	0	0	0	0	0	0	0	0	0	0
Speculative			0	0	0	12	12	10	10	8	8	6	66

Boeing 747 Series

ELECTRONICS													
		High Confidence				Good Confidence			Less Confidence				
Status		Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total
Estimated Potential Candidates	500	ADS-B Out <> 747											
Planned/In Progress		0	0	0	0	0	0	0	0	0	0	0	0
Speculative			80	100	0	0	0	0	0	0	0	0	180