

General Electric CF34/TF34

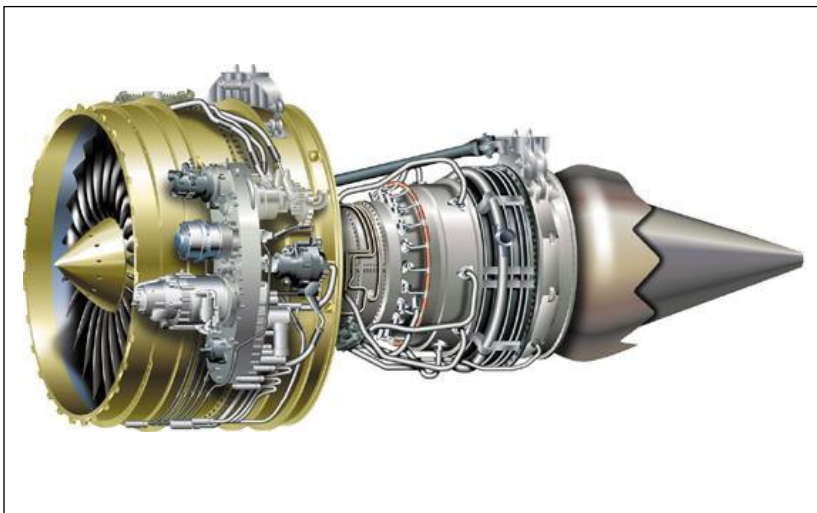
Turbofans
May 2020

Program Briefing

The wildly successful General Electric CF34 turbine is a mid-range, high-bypass-ratio fan targeting the large business jet and regional jet markets. The CF34 has been scaled from 8,500- to 18,500-lbst, competing with the Rolls-Royce AE3007 and RB282, and P&WC PW300 at its lower end and the Rolls-Royce BR700 and PowerJet SaM146 at the upper end. A civil version of the TF34 found on the Fairchild A-10 attack aircraft, the engine's first commercial application was the Challenger 601 in 1980.

The proven reliability and low cost of ownership of the CF34 family has won over the regional jet manufacturers whose clients generally live on razor-thin profit margins and can't afford any surprises. We see no immediate competition for the engine until GE's own Passport (see report) hits the market.

The latest variant in the family, the CF34-10E, is an 18,500-lbst fan, which received its FAA type certification in March 2005 and entered service aboard the Embraer 190 in early 2005.



Quick Specs:

Power Class:	8,650 – 18,750 lbst (38.5 – 83.4 kN)
Bypass & Pressure Ratios:	4.9:1 – 6.2:1 & 21:1 – 29:1
Airflow:	320 – 446 lb/sec (145 – 202 kg/sec)
SFC:	0.345 – 0.390 lb/lbst-hr (10 – 11 mg/Ns)
Configuration:	1 F; 8A – 10A HPC; Annular; 2A HPT; 4A LPT

The CF34 won the coveted competition to power the COMAC ARJ21 "People's RJ" (Snecma, Rolls-Royce and P&WC were the losers), but we think the development schedule is exceedingly optimistic and the chance that the aircraft never goes beyond the low-rate series production phase is not insignificant.

We are not ready to include significant orders for the Chinese ARJ21, but the CF34 does nicely without those applications for the first half of the forecast period. We project deliveries of 1,443 CF34s over the next 10 years, with an estimated retail value of \$5.3 billion.

Manufacturers

General Electric Co.
GE Aviation
1 Neumann Way
Cincinnati, OH 45215-6301
tel: (513) 243-2000
website: www.geae.com

Summary Forecast

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
Units Produced	234	197	155	132	106	98	122	128	138	133	1,443
Value (then-yr \$millions)	910.5	774.8	613.1	524.2	415.0	362.5	416.5	398.0	427.5	418.2	5,260.3

Risk-Sharing Partners

- Ishikawajima-Harima Heavy Industries: 30% share in CF34-8C on the CRJ700.

Subcontractors

- Aero Decals, Palm Bay, FL, USA—placards, ID plated markings.
- Allen Aircraft Products, Inc., Ravenna, OH, USA—chip detectors.
- Allfast: rivets on engine nacelles
- Ametek Aerospace: engine sensor suite for CF34-10E on the Embraer 195
- Beldam Crossley Ltd., Bolton, England—seals and gaskets.
- CSE, Brea, CA, USA—clamping devices.
- Derlan Aerospace Canada: accessory gearboxes; power takeoff assemblies.
- DuPont Vespel Parts & Shapes, Valley View, OH, USA—VSV bushings.
- Engine Components, Turbine Fuel Technologies, West Des Moines, IA, USA—fuel nozzles.
- Goodrich Aerostructures: nacelle systems for CF34-10 on Embraer 190/195.
- Haskon Aerospace, Taunton, MA, USA—seals.
- Heroux-Devtek: various components.
- Hispano-Suiza: nacelles, transmissions.
- Honeywell: main engine start system, thrust reverser actuation system.
- Kawasaki Heavy Industries: engine pylon.
- Kirkhill Elastomers, Brea, CA, USA—clamping devices.
- Laserdyne Systems, Champlin, MN, USA—laser material processing systems.
- Lee Products Ltd., Gerrards Cross, England—valves.
- Middle River Aircraft Systems (GE): thrust reversers on Embraer 190.
- Neomet Ltd., Stockport, England—honeycomb seals.
- Omega Technologies Inc., Westlake Village, CA, USA—universal wrenches, sockets and adapters.
- PSI Bearings, Simi Valley, CA, USA—bearings.
- PTI Technologies Inc., Oxnard, CA, USA—filters.
- Precision Castparts Corp., Portland, OR, USA—castings.
- Reform Maschinenfabrik, Fulda, Germany—high-speed blade tip grinds.
- Schenck Trebel Corp., Deer Park, NY, USA—dynamic balancing machines.
- Sealtron Inc., Cincinnati, OH, USA—hermetic connectors.
- Short Brothers: engine nacelles (replacing Vought in early 1994).
- Simrit-Aerospace, Santa Ana, CA, USA—sealing products.
- Smiths Aerospace: thrust reverser actuators.
- Spincraft Inc., New Berlin, WI, USA—plugs, nozzles, anti-icing system.
- Sumitomo Precision: engine heat management system on Challenger.
- TA Aerospace, Valencia, CA, USA—clamping devices.
- Techspace Aero: combustor for CF34-10.
- Vibro-Meter: engine vibration monitoring system and engine interface unit.
- Vitta Corp., Bethel, CT, USA—brazing materials.
- Vought Aircraft: nacelle acoustic panels (for Aermacchi).
- Woodward: fuel nozzles.

Technical Description

Components

Layout

The CF34 is a two-shaft, medium sized, civil and military (TF34) turbofan.

Fan

Single-stage design of between 44 and 53 inches. Bypass ratio is between 4.9:1 and 6.2:1. The -8C and -10 turbines have wide-chord blades.

Compressor

Fourteen stages for the TF34 and early models of the CF34 and 10 stages (including blisks) for the -8 models and newer.

Combustor

Single annular combustor with 18 burners.

HP Turbine

Two stage turbine driving the compressor assembly.

LP Turbine

Four stage turbine driving the fan.

Other Components

Models -8 and newer are equipped with a Lockheed Martin FADEC.

Engine Variants

CF34-3/3A/3A1/3B—The initial production version of the civil CF34, it is very close in design to the TF34. The turbines generate 9,220 lbst and are used on the Canadair Challenger 600 and CRJ 100/200 aircraft.

CF34-8C/8E—Building on the success of the -3, GE extended the power range of the turbine by around 50% by introducing a new compressor, modified HP and LP turbines and a FADEC. The 12,500 to 14,500 lbst variant has been selected to power the Canadair CFJ700 and -900 and

the Embraer ERJ-170. The CF34-8D was also selected to power the now defunct Fairchild Dornier 728 regional jet.

CF34-10A/10E—A further upgrade of the turbine to the 17,500-20,000 lbst range, the -10 touches on the power range of the larger CFMI CFM56 and IAE V2500 turbines. The variant has been selected to power the Embraer ERJ-190 and the COMAC ARJ21. As with the -8, the -10D was also selected by Fairchild

Dornier for installation on the now cancelled 928 jet.

TF34-GE-100/100A/101—The -100 and -100A power the Fairchild A-10 Thunderbolt. The unaugmented, 9,065-lbst engine also was used on several experimental aircraft. The -100, based on the CF34-8, is rated at 11,000 lbst and has been proposed for A-10 re-engine program.

TF34-GE-400—The 9,300 lbst, unaugmented turbine is used aboard the Lockheed Martin S-3 Viking.

Specifications

(Imperial Units)

Model	Thrust (lbst)	Pressure Ratio	Bypass Ratio	Airflow (lb/sec)	SFC (lb/lbst-hr)	Fan Dia. (in)	Length (in)	Weight (lb)
CF34-1A	8,650	n/a	6.2:1	n/a	0.360	44	103	1,625
CF34-3A	9,220	21:1	6.2:1	319.7	0.357	44	103	1,625
CF34-3A1	9,220	21:1	6.2:1	319.7	0.357	44	103	1,625
CF34-3B	9,220	21:1	6.2:1	321.9	0.346	44	103	1,669
CF34-3B1	9,220	21:1	6.2:1	324.1	0.346	44	103	1,669
CF34-8C1	13,790	28:1	4.9:1	441.0	0.370	46	128	2,351
CF34-8C5	14,510	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8C5A2	14,500	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8C5B1	13,790	28:1	4.9:1	n/a	n/a	46	128	n/a
CF34-8D	14,500	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8D1	12,500	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8D3	12,875	27:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8D6	13,050	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8E	14,500	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8E2	14,000	28:1	4.9:1	445.4	0.390	46	128	2,470
CF34-8E5	14,510	28:1	4.9:1	445.4	0.392	46	121.2	2,470
CF34-8E5A1	14,000	28:1	4.9:1	445.4	0.393	46	128	2,470
CF34-10A	18,285	29:1	5:1	n/a	n/a	53	90	n/a
CF34-10D	18,500	26.7:1	5:1	n/a	0.380	53	90	3,799



Embraer 190 powered by two CF34-10E5s

CF34-10D5	17,355	29:1	5:1	n/a	0.380	53	90	3,799
CF34-10D6	18,750	29:1	5:1	n/a	0.380	53	90	3,799
CF34-10E	20,000	29:1	5:1	n/a	0.380	53	145.5	3,799
CF34-10E5A1	16,500	26:1	5:1	n/a	0.380	53	90	3,799
TF34-GE-100	9,065	21:1	n/a	n/a	0.371	n/a	100	1,440
TF34-GE-400A	9,275	21:1	n/a	n/a	0.363	n/a	100	1,478

(Metric Units)

Model	Thrust (kN)	Pressure Ratio	Bypass Ratio	Airflow (kg/sec)	SFC (mg/Ns)	Fan Dia. (m)	Length (m)	Weight (kg)
CF34-1A	38.5	n/a	6.2:1	n/a	10	1.1	2.6	737
CF34-3A	41.0	21:1	6.2:1	145.0	10	1.1	2.6	737
CF34-3A1	41.0	21:1	6.2:1	145.0	10	1.1	2.6	737
CF34-3B	41.0	21:1	6.2:1	146.0	10	1.1	2.6	757
CF34-3B1	41.0	21:1	6.2:1	147.0	10	1.1	3.3	757
CF34-8C1	61.3	28:1	4.9:1	200.0	10	1.2	3.3	1,066
CF34-8C5	64.5	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8C5A2	64.5	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8C5B1	61.3	28:1	4.9:1	n/a	n/a	1.2	3.3	n/a
CF34-8D	64.5	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8D1	55.6	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8D3	57.3	27:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8D6	58.0	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8E	64.5	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8E2	62.3	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-8E5	64.5	28:1	4.9:1	202.0	11	1.2	3.1	1,120
CF34-8E5A1	62.3	28:1	4.9:1	202.0	11	1.2	3.3	1,120
CF34-10A	81.3	29:1	5:1	n/a	n/a	1.4	2.3	n/a
CF34-10D	82.3	26.7:1	5:1	n/a	11	1.4	2.3	1,723
CF34-10D5	77.2	29:1	5:1	n/a	11	1.4	2.3	1,723
CF34-10D6	83.4	29:1	5:1	n/a	11	1.4	2.3	1,723
CF34-10E	89.0	29:1	5:1	n/a	n/a	1.4	3.7	n/a
CF34-10E5A1	82.3	26.7:1	5:1	n/a	11	1.4	2.3	1,723
TF34-GE-100	40.3	21:1	n/a	n/a	11	n/a	2.5	653
TF34-GE-400A	41.3	21:1	n/a	n/a	10	n/a	2.5	670

Applications

Engine	Aircraft	Engines per A/C	
CF34-1A	American Aviation FanStar (prototype aircraft; JetStar conversion)	2	
	Bombardier Challenger 601-1A	2	
	CF34-3A	Bombardier Challenger 601-3A	2
		CF34-3A1	2
	CF34-3A1	Bombardier Challenger 601-3R	2
Bombardier Challenger 604		2	
Bombardier Challenger 800 (initial version)		2	
Bombardier CRJ100		2	
CF34-3A2		Bombardier Challenger 601 (engine upgrade)	2
CF34-3B		Bombardier Challenger 604	2
CF34-3B1		Bombardier Challenger 604	2
		Bombardier Challenger 605	2
		Bombardier Challenger 800	2
		Bombardier Challenger 850	2
	Bombardier CRJ200	2	
	Bombardier CRJ200B (optional hot-and-high -3B1 variant)	2	
	Bombardier CRJ200B ER (optional hot-and-high -3B1 variant)	2	
Bombardier CRJ200B LR (optional hot-and-high -3B1 variant)	2		
Bombardier CRJ200ER	2		
Bombardier CRJ200LR	2		

	Bombardier CRJ440	2
CF34-3B MTO	Bombardier Challenger 650	2
CF34-8C1	Bombardier Challenger 870	2
	Bombardier CRJ700	2
	Bombardier CRJ701	2
CF34-8C5A1	Bombardier CRJ1000	2
CF34-8C5A2	Bombardier CRJ1000	2
CF34-8C5B1	Bombardier Challenger 890	2
	Bombardier CRJ705	2
	Bombardier CRJ900	2
CF34-8E5A1	Embraer E-170	2
	Embraer E-170 LR	2
	Embraer E-170 STD	2
	Embraer E-175 AR	2
	Embraer E-175 LR	2
	Embraer E-175 STD	2
CF34-10	Boeing B-52H (proposed re-engining)	8
CF34-10A	COMAC ARJ21-700	2
CF34-10D	Fairchild Dornier 928 (canceled)	2
CF34-10E5	Embraer E-195 AR	2
	Embraer E-195 LR	2
	Embraer E-195 STD	2
CF34-10E5A1	Embraer E-190 AR	2
	Embraer E-190 LR	2
	Embraer E-190 STD	2
TF34-GE-100	Fairchild A-10A	2
TF34-GE-101	Fairchild A-10C (engine upgrade kits were scheduled for 2009)	2
TF34-GE-400A	Lockheed Martin S-3	2
TF34-GE-400B	Lockheed Martin S-3	2

Marketing Data

Costs

Approximate pricing for current models of the series ranges from less than \$3 million (-3 series) to \$5.5 million for the -10E variant. We peg the retail price of the -8 at \$3.8 million.

The Competition

The CF34 has competed with the Rolls-Royce AE3007 and P&WC PW300 family at its lower end and the Rolls BR700 series at the upper end of its power class. New entries into the field are the Pratt & Whitney Canada PurePower PW800, PowerJet SaM146, Snecma Silvercrest, and possibly the Honeywell HTF10000. GE's new Passport (see report) and NG34 ultimately will replace the CF34.

Delivery History (production engines; estimated)

	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
TF34	1	9	17	28	130	254	258	258	235	173
	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>
TF34	173	173	173	171	124	—	—	—	—	—
CF34-1	—	—	8	34	34	26	45	43	54	50
Total	173	173	181	205	158	26	45	43	54	50

	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>	<u>1999</u>
TF34	—	15	15	—	—	—	—	—	—	—
CF34-1	60	48	43	15	—	—	—	—	—	—
CF34-3	—	2	24	87	121	155	191	222	259	286
Total	60	65	82	102	121	155	191	222	259	286
	<u>2000</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>
TF34	—	—	—	—	—	—	—	—	—	—
CF34-1	—	—	—	—	—	—	—	—	—	—
CF34-3	313	344	379	377	279	176	111	100	93	81
CF34-8	13	65	111	174	267	302	260	229	265	197
CF34-10	—	—	—	—	7	45	119	186	206	196
Total	326	409	490	551	553	523	490	515	564	474
	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>Total</u>
TF34	—	—	—	—	—	—	—	—	—	2,207
CF34-1	—	—	—	—	—	—	—	—	—	460
CF34-3	87	90	74	73	74	57	57	52	52	4,216
CF34-8	145	116	89	160	278	293	286	221	188	3,659
CF34-10	194	202	180	129	66	46	46	55	48	1,725
Total	426	408	343	362	418	396	389	328	288	12,267

Order Book

CF34-3A Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Air Canada	CRJ100	24/24	CF34-3A1
Air Littoral	CRJ100	19/19	CF34-3A1
Brit Air	CRJ100	20/20	CF34-3A1
Comair	CRJ100	110/110	CF34-3A1
Lauda Air	CRJ100	8/8	CF34-3A1
Lufthansa CityLine	CRJ100	35/35	CF34-3A1
SkyWest	CRJ100	10/10	CF34-3A1
The Fair	CRJ100	1/1	CF34-3A1

CF34-3B Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Adria Airways	CRJ200	5/5	CF34-3B1
Air Canada	CRJ200	17/17	CF34-3B1
Air Dolomiti	CRJ200	5/5	CF34-3B1
Air Nostrum	CRJ200	35/35	CF34-3B1
Air Wisconsin	CRJ200	64/64	CF34-3B1
Ansett/Kendell	CRJ200	12/12	CF34-3B1
Atlantic Southeast Airlines	CRJ200	45/45	CF34-3B1
Austrian Arrows	CRJ200	13/13	CF34-3B1; engine launch
British European	CRJ200	4/4	CF34-3B1
China Eastern Yunnan	CRJ200	6/6	CF34-3B1
China Ocean Aviation	Challenger 800	1/1	CF34-3B1
Cimber Air	CRJ200	2/2	CF34-3B1
Compaq Computer	Challenger 800	1/1	CF34-3B1
DAC Air	CRJ200	2/2	CF34-3B1
Delta Connection	CRJ200	94/94	CF34-3B1
Eurowings	CRJ200	12/12	CF34-3B1
Execujet Air Charter	Challenger 800	1/1	CF34-3B1
Fruit of the Loom	Challenger 800	1/1	CF34-3B1

GECAS	CRJ200	5/5	CF34-3B1
Government of China	Challenger 800	5/5	CF34-3B1
Independence Air	CRJ200	87/87	CF34-3B1
J-Air	CRJ200	9/9	CF34-3B1
Lufthansa CityLine	CRJ200	10/10	CF34-3B1
Maersk Air	CRJ200	11/11	CF34-3B1
Malev	CRJ200	4/4	CF34-3B1
Mesa	CRJ200	32/32	CF34-3B1
Midway Airlines	CRJ200	24/24	CF34-3B1
Northwest Airlines	CRJ200	56/56	CF34-3B1
Northwest Airlines	CRJ440	86/86	CF34-3B1
Saeaga	CRJ200	1/1	CF34-3B1
Shandong Airlines	CRJ200	5/5	CF34-3B1
Shanghai Airlines	CRJ200	3/3	CF34-3B1
SkyWest	CRJ200	100/100	CF34-3B1
South African Express	CRJ200	6/6	CF34-3B1
Southern Winds	CRJ200	2/2	CF34-3B1
Styrian Spirit	CRJ200	1/1	CF34-3B1
The Fair	CRJ200	1/1	CF34-3B1
Unidentified Customer(s)	Challenger 800	23/23	CF34-3B1
US Airways	CRJ200	35/35	CF34-3B1
Xerox Corp.	Challenger 800	1/1	CF34-3B1; launch customer for Corporate RJ

CF34-8C Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Adria Airways	CRJ900	6/6	CF34-8C5B1
Air Canada	CRJ705	15/15	CF34-8C5
Air Nostrum	CRJ1000	35/25	CF34-8C5A1
Air Nostrum	CRJ900	11/11	CF34-8C5B1
Air One	CRJ900	10/10	CF34-8C5B1
American Airlines	CRJ900	69/54	CF34-8C5B1
American Eagle	CRJ701	47/47	CF34-8C1
Arik Air	CRJ900	7/5	CF34-8C5B1
Atlantic Southeast Airlines	CRJ701	12/12	CF34-8C1
Atlasjet	CRJ900	3/3	CF34-8C5B1
Brit Air	CRJ1000	14/14	CF34-8C5A1
Brit Air	CRJ700	15/15	CF34-8C1
China Express	CRJ900	38/26	CF34-8C5B1
Chorus Aviation	CRJ900	5/5	CF34-8C5B1
CIB Leasing	CRJ900	5/—	CF34-8C
CityJet	CRJ900	10/10	CF34-8C5B1
Comair	CRJ700	20/20	CF34-8C1; Delta connector
Delta Air Lines	CRJ900	60/45	CF34-8C5B1
Delta Connection	CRJ701	30/30	CF34-8C1
Delta Connection	CRJ900	44/44	CF34-8C5B1
Eurowings	CRJ900	15/15	CF34-8C5B1
Felix Airways	CRJ701	2/2	CF34-8C1
Garuda Indonesia	CRJ1000	6/6	CF34-8C5A1
Government of Iraq	CRJ900	6/6	CF34-8C5B1
Horizon Air	CRJ700	20/20	CF34-8C1
Libyan Airlines	CRJ900	5/5	CF34-8C5B1
Lufthansa CityLine	CRJ700	20/20	CF34-8C1
Lufthansa CityLine	CRJ900	12/12	CF34-8C5B1
Macedonian	CRJ900	1/1	CF34-8C5B1

Maersk Air	CRJ701	5/5	CF34-8C1
Mesa	CRJ701	20/20	CF34-8C1
Mesa	CRJ900	38/38	CF34-8C5B1
My Way	CRJ900	4/4	CF34-8C5B1
Nordic Aviation Capital	CRJ1000	12/12	CF34-8C5A1
Northwest Airlines	CRJ900	36/36	CF34-8C5B1
Pluna	CRJ900	13/13	CF34-8C5B1
RwandAir	CRJ900	2/2	CF34-8C5B1
SAS Scandinavian	CRJ900	12/12	CF34-8C5B1
Shandong Airlines	CRJ701	2/2	CF34-8C1
SkyWest	CRJ700	79/79	CF34-8C1
SkyWest	CRJ900	21/21	CF34-8C5B1
Styrian Spirit	CRJ701	1/1	CF34-8C5B1; first customer for engine variant
Tartarstan	CRJ900	2/2	CF34-8C5B1
Tuninter	CRJ900	1/1	CF34-8C5B1
Uganda Airlines	CRJ900	4/—	CF34-8C5B1
Unidentified Customer(s)	CRJ701	18/18	CF34-8C1
Unidentified Customer(s)	CRJ900	6/—	CF34-8C5B1
US Airways	CRJ705	8/8	CF34-8C1;

CF34-8E Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Air North	E170	1/1	CF34-8E5
Alitalia	E170	6/6	CF34-8E5
Cirrus	E170	1/1	CF34-8E5
ECC	E170	4/4	CF34-8E5
Egyptair	E170	12/12	CF34-8E5
Finnair	E170	10/10	CF34-8E5
GECAS	E170	9/9	CF34-8E5
Japan Air Lines	E170	18/18	CF34-8E5
LOT Polish Airlines	E170	6/6	CF34-8E5
Regional	E170	10/10	CF34-8E5
Republic Airways	E170	48/48	CF34-8E5
Satena	E170	1/1	CF34-8E5
Saudi Arabian Airlines	E170	15/15	CF34-8E5
Sirte Oil	E170	1/1	CF34-8E5
Suzuyo	E170	2/2	CF34-8E5
TAME	E170	2/2	CF34-8E5
US Airways	E170	28/28	CF34-8E5
Virgin Australia	E170	6/6	CF34-8E5
Air Canada	E175	15/15	CF34-8E5
Air Caraibes	E175	1/1	CF34-8E5
Alitalia	E175	2/2	CF34-8E5
ECC	E175	1/1	CF34-8E5
Flybe	E175	15/11	CF34-8E5
GECAS	E175	5/5	CF34-8E5
LOT Polish Airlines	E175	12/12	CF34-8E5
Northwest Airlines	E175	36/36	CF34-8E5
Oman Air	E175	5/5	CF34-8E5
Republic Airways	E175	117/117	CF34-8E5
Royal Jordanian	E175	2/2	CF34-8E5
Suzuyo	E175	8/6	CF34-8E5
TRIP	E175	5/5	CF34-8E5

Unidentified Customer(s)	E175	15/—	CF34-8E5
Air Lease	E175	8/8	CF34-8E5
American Airlines	E175	89/64	CF34-8E5
BA City Flyer	E170	6/6	CF34-8E5
Horizon Air	E175	33/15	CF34-8E5
Nordic Aviation Capital/Jetscape	E170	1/1	CF34-8E5
KLM Cityhopper	E175	17/17	CF34-8E5
Petro Air	E170	2/2	CF34-8E5
SkyWest	E175	149/126	CF34-8E5
United Airlines	E175	85/65	CF34-8E5
Nordic Aviation Capital/Aldus	E175	2/—	CF34-8E5
Nordic Aviation Capital/Jetscape	E175	9/9	CF34-8E5;

CF34-10A Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Chengdu Airlines	ARJ21-700	30/9	CF34-10A
GECAS	ARJ21-700	5/—	CF34-10A
Ghengis Khan Airlines	ARJ21-700	25/1	CF34-10A
Government of Congo	ARJ21-700	4/—	CF34-10A
Hebei Airlines	ARJ21-700	10/—	CF34-10A
Institute of Electronics/China Academy of Sciences	ARJ21-700	2/—	CF34-10A
Joy Air	ARJ21-700	50/—	CF34-10A
Shandong Airlines	ARJ21-700	10/—	CF34-10A
Shenzhen Financial Leasing	ARJ21-700	20/—	CF34-10A
United Eagle Airlines	ARJ21-700	30/—	CF34-10A
Urumqi Airlines	ARJ21-700	20/—	CF34-10A;

CF34-10E Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
Aeromexico	E190	12/12	CF34-10E
AeroRepublica	E190	5/5	CF34-10E
Air Astania	E190	2/2	CF34-10E
Air Canada	E190	45/45	CF34-10E
Air Caraibes	E190	1/1	CF34-10E
Air Lease	E190	23/23	CF34-10E
Air Moldova	E190	1/1	CF34-10E
Aurigny	E195	1/1	CF34-10E
Austral Líneas Aéreas	E190	22/22	CF34-10E
AviancaTaca	E190	11/11	CF34-10E
AZAL	E190	4/4	CF34-10E
Azul	E195	59/59	CF34-10E
BA City Flyer	E190	8/8	CF34-10E
Belavia	E195	2/2	CF34-10E
BOC Aviation	E190	14/14	CF34-10E
BOC Aviation	E195	1/1	CF34-10E
China Southern Airlines	E190	20/20	CF34-10E
CIT Leasing	E190	7/7	CF34-10E
COPA Airlines	E190	15/15	CF34-10E
ECC (JetBlue)	E190	1/1	CF34-10E
Finnair	E190	12/12	CF34-10E
Flybe	E195	14/14	CF34-10E
GECAS	E190	27/27	CF34-10E
GECAS	E195	7/7	CF34-10E

Globalia	E195	12/12	CF34-10E
Guizhou Airlines	E190	9/9	CF34-10E
Hainan Airlines	E190	50/50	CF34-10E
Hainan Airlines	E195	20/17	CF34-10E
Hebei Airlines	E190	7/6	CF34-10E
Japan Air Lines	E190	14/13	CF34-10E
JetBlue Airways	E190LR	88/64	CF34-10E
Kenya Airways	E190	10/10	CF34-10E
KLM Cityhopper	E190	32/32	CF34-10E
Kunpeng Airlines	E190	5/5	CF34-10E
LOT Polish Airlines	E195	4/4	CF34-10E
Lufthansa	E190	9/9	CF34-10E
Lufthansa	E195	34/34	CF34-10E
M1 Travel	E190	8/8	CF34-10E
Montenegro	E195	1/1	CF34-10E
NAS Air	E190	3/3	CF34-10E
Niki	E190	7/7	CF34-10E
Nordic Aviation Capital/Aldus	E190	18/8	CF34-10E
Nordic Aviation Capital/Aldus	E195	4/1	CF34-10E
Nordic Aviation Capital/Jetscape	E190	16/16	CF34-10E
Nordic Aviation Capital/Jetscape	E195	2/2	CF34-10E
Regional	E190	10/10	CF34-10E
Republic Airways	E190	2/2	CF34-10E
Royal Jordanian	E195	2/2	CF34-10E
TAME	E190	3/3	CF34-10E
TRIP	E190	3/3	CF34-10E
TRIP	E195	1/1	CF34-10E
US Airways	E190	25/25	CF34-10E
Virgin Australia	E190	18/18	CF34-10E
Virgin Nigeria	E190	2/2	CF34-10E

TF34 Family

Customer	A/C Model	Ord./Del.	Engine Model/Notes
US Air Force	S-3A	196/196	TF34-GE-400A/B
US Air Force	A-10A/C	724/724	TF34-GE-100/101

Contract Briefs

Below is a listing of US military prime contracting actions involving the TF34 program that have been announced by the Pentagon since the beginning of FY88 (10/1/87) and through the date at the end of this report. These actions include the award of, or modification to, all unclassified DoD prime contracts with a base value of \$7 million or more.

Date	Contract Number	Obligation	Details
<u>AlliedSignal, Controls & Accessories</u>			
09/20/1994	F41608-91-C-1276	\$14,621,259	FVI to an FFP contract action issued by the SAALC for the Advanced Fuel Accessories Test System (AFATS) subsystem, which includes two test stations, one high pressure pump module, and test program sets. The contract is scheduled to be completed by 8/31/1996. Program involvement: F-100, T56, TF34, TF39, F-15, F-16, C-130.
<u>General Electric, GE Aviation</u>			
07/—1/1988	F41608-87-C-A606	\$12,754,000	CPFF contract action issued by the SAALC for engineering services and supplies necessary to conduct a component improvement program (CIP) on the TF34 and J85 engines used on various aircraft. The contract is

			scheduled to be completed by 12/31/1988. Program involvement: TF34, J85. RDT&E involvement: 0604268F.
07/21/1988	F34601-88-G-6605	\$6,072,000	order under a BOA contract action issued by the OCALC to provide 253 fan rotor disks for TF34 aircraft engines. The contract is scheduled to be completed by 8/31/1990. Program involvement: TF34, S-3.
08/12/1988	F34601-88-G-6605	\$4,875,000	ceiling-priced order under a BOA contract action issued by the OCALC for a high-pressure turbine module to support the TF34 engine. The contract is scheduled to be completed by 2/28/1991. Program involvement: TF34, S-3.
09—1/1988	F41608-87-D-A108	\$50,266,727	FVI to an FFP contract action issued by the SAALC for various spare parts in various quantities applicable to the J85 and TF34 engines. The contract is scheduled to be completed by 12/31/1990. Program involvement: J85, TF34.
09/13/1988	F41608-87-D-A108	\$26,958,615	FVI to an FFP contract action issued by the SAALC for various spare parts in various quantities to the J85 and TF34 engines. The contract is scheduled to be completed by 12/31/1991. Program involvement: J85, TF34.
09/27/1988	F41608-87-D-A108	\$5,792,017	FVI to an FFP contract action issued by the SAALC for various spare parts in various quantities applicable to the J85 and TF34 engines. Work will be performed in Binghamton, NY. The contract is scheduled to be completed by 12/31/1991. Program involvement: J85, TF34.
09/28/1988	F34601-88-G-6605	\$9,486,600	ceiling price contract action issued by the OCALC for 978 turbine disks for TF34 engines. The contract is scheduled to be completed by 12/31/1991. Program involvement: TF34, A-10.
08/16/1990	N00019-89-C-0189	\$35,914,837	letter contract action issued by the Naval Air Systems Command for 20 spare TF34-GE-400B engines for S-3 aircraft. The contract is scheduled to be completed by 6/30/1993. Program involvement: TF34, S-3.
12/18/1990	N00019-89-C-0189	\$27,516,210	increment to an FFP contract action issued by the Naval Air Systems Command exercising an option for 15 spare FY91 model TF34-GE-400B engines for S-3 aircraft. The contract is scheduled to be completed by 11/30/1993. Program involvement: TF34, S-3.
01—8/1991	F41608-90-D-2079	\$0	increment as part of a \$60,517,696 FFP requirements contract action issued by the SAALC for spare parts for engines used on F-5, T-38, and A-10 aircraft. The contract is scheduled to be completed by 12/31/1993. Program involvement: F-5, J85, T-38, A-10, TF34.
02/28/1991	F34601-91-G-7713	\$5,944,405	ceiling price order contract action issued by the ASO to provide 1,189 fan blade sets to support the S-3 aircraft. The contract is scheduled to be completed by 7/31/1992. Program involvement: S-3, TF34.
01/29/1992	N00019-89-C-0189	\$29,937,750	modification to an FFP contract action issued by the Naval Air Systems Command to exercise an option for 15 FY92 TF34-GE-400B engines and spare parts for the S-3 aircraft. Work will be performed in Lynn, MA (75%); and Cincinnati, OH (25%). The contract is scheduled to be completed by 7/31/1994. Program involvement: S-3, TF34.
07/21/1992	N00383-92-D-4211	\$13,810,364	FFP indefinite quantity contract action issued by the Naval Supply Systems Command - Weapon Systems Support to provide spare blades and vanes for the T64, J85, T58, and TF34 engines. Work will be performed in Rutland, VT (80%); Hookset, VT (15%); and Lynn, MA (5%). The contract is scheduled to be completed by 6/30/1995. Program involvement: T64, J85, T58, TF34.
03/13/1996	N00383-96-D-019M	\$148,402,342	FFP contract action issued by the Naval Supply Systems Command - Weapon Systems Support for 241 line items of various quantities of spare compressor blades and vanes used on the T64, J85, T56, and TF34 engines. Work will be performed in Rutland, VT (90%); and Hooksett, NH (10%). The contract is scheduled to be completed by 1/31/1991. Program involvement: T64, J85, T58, TF34.
06—8/1998	F34601-97-G-0002	\$7,156,289	ceiling-price, basic ordering agreement contract action issued by the OCALC for 74 combustion liners used on the TF34 engine of the S-3 aircraft. The contract is scheduled to be completed by 12/31/1999. Program involvement: TF34, S-3.
07/31/1998	F34601-97-G-0001	\$12,269,799	FFP contract action issued by the SAALC to provide for 36,450 Stage One Rotor Turbine Blades in support of the TF34 engine on the A-10 aircraft.

			The contract is scheduled to be completed by 12/31/1998. Program involvement: A-10, TF34.
08/11/1999	F41608-99-D-0504	\$49,852,662	FFP contract action issued by the SAALC to provide for various quantities of 24 line items of spare parts applicable to the TF39 engine on the C-5 aircraft and the TF34 engine on the A-10 aircraft. The contract is scheduled to be completed by 12/31/2001. Program involvement: TF34, C-5, A-10, TF39.
12/—7/1999	F33657-99-D-2050	\$1,975,500,000	indefinite-delivery/indefinite-quantity contract action issued by the ASC for technical services from January 2000 through December 2014 for the Component Improvement Program supporting the F110, F101, F118, J79, TF34, TF39 and J85. The contract is scheduled to be completed by 12/31/2014. Program involvement: F110, F101, F118, J79, TF34, TF39, J85. RDT&E involvement: 0604268F—207268F.
09/12/2000	F41608-00-D-0323	\$123,174,235	requirements contract action issued by the SAALC to provide for various quantities of 258 line items of spare parts for the J85 on the T-38 aircraft, the TF34 on the A-10 aircraft, and the TF39 on the C-5. The contract is scheduled to be completed by 9/30/2003. Program involvement: J85, TF34, TF39, T-38, A-10, C-5.
12/—4/2000	N00383-01-D-999M	\$11,466,404	commercial requirements contract action issued by the Naval Supply Systems Command - Weapon Systems Support for 49 different types of items supporting the following engines/aircraft: F404 (F/A-18), J85 (T-38, T-2C, F-5), T58 (CH-46D/E, H-3), T64, T700 and TF34. The contract is scheduled to be completed by 6/30/2002. Program involvement: F404, J85, T58, TF34, T64, T700, TF34.
06/29/2001	F41608-00-D-0323	\$45,000,006	modification to an FFP, requirements-type contract action issued by the SAALC to provide for spare parts for the TF39, TF34 and J85 engine and 245 line items, various estimated quantities. The contract is scheduled to be completed by 6/20/2002. Program involvement: TF39, TF34, J85.
08/13/2003	N00383-01-D-004M	\$30,012,000	modification to a previously awarded requirements contract action issued by the Naval Supply Systems Command - Weapon Systems Support to exercise an option for the third- and fourth-year additional ordering periods for combustion liners for TF34 engines used on S-3 aircraft. The contract is scheduled to be completed by 8/31/2005. Program involvement: S-3, TF34.
06/—8/2004	F41608-00-D-0323	\$0	increment as part of a \$453,400,000 FFP contract action issued by the OCALC for Replenishment Spare Parts for the TF39, TF34 and J85 engines, 109 items priced per this modification, various estimated quantities. The contract is scheduled to be completed by 6/30/2005. Program involvement: TF39, TF34, J85.
10/—4/2004	SP0400-03-D-9404	\$18,419,479	FFP requirements type contract action issued by the DSCP for unique aircraft parts to support the F404, J85 and TF34 aircraft engines for the Navy. The contract is scheduled to be completed by 10/3/2006. Program involvement: F404, J85, TF34.
10/21/2004	SP0400-00-D-9403	\$444,884,060	FFP requirements type contract action issued by the DSCR for commercial parts for the following engine lines: T64, T58, TF39, TF34, F118, F404, T700, F110 and F101 with various quantities for the USN and USAF. The contract is scheduled to be completed by 7/30/2005. Program involvement: T64 T58 TF39 TF34 F118 F404 T700 F101.
06/8/2005	SP0400-00-D-9403	\$9,182,183	FFP contract action issued by the DSCR for Navy, and Air Force for adding 6 NSNs to existing contract for commercial items on engine lines T64, T58, TF39, TF34, F118, F118, F404, T700, F110, and F101. The contract is scheduled to be completed by 3/31/2007. Program involvement: T64 T58 TF39 TF34 F118 F101 F404.

Milestones

<u>Date</u>	<u>Milestone</u>
1965	development of TF34 commences
April 1968	TF34 chosen for S-3A
January 1973	TF34 chosen for A-10A
April 1976	CF34 program announced by GE

January 1980	CF34-1A chosen for Challenger 601
August 1982	CF34-1A certificated by FAA
March 1983	Challenger 601/CF34-1A certificated by FAA
September 1986	CF34-3A certificated by FAA
April 1987	Challenger 601-3A certificated by FAA/CAA
September 1986	first flight of Challenger 601-3A/CF34-3A
July 1991	CF34-3A1 certificated by FAA
1992	Bombardier CRJ100/CF34-3 enters regional service
May 1995	CF34-3B/-3B1 certificated by FAA
Summer 1995	CF34-3B certificated by FAA
April 1996	CF34-8C program launched
February 1998	first run of CF34-8C
June 1999	CF34-8E and CF34-10E programs officially launched
November 1999	CF34-8C1 certificated by FAA
2001	CRJ700/CF34-8 enters service
November 2000	First CF34-8E to test
February 2002	First flight of CF34-8E
April 2002	CF34-8E certificated by FAA
3Q 2002	First CF34-10E to test
November 2002	ACAC selects CF34-10A for ARJ21
February 2004	ERJ 170/CF34-8E certificated by FAA
March 2004	ERJ 170/CF34-8E enters service
2Q 2004	CF34-10E awarded FAA type certification
July 19, 2004	CF34-8C1 reaches one-million-flight-hour milestone
Mar 3, 2006	CF34-1A/3A/3A2 upgrade program announced
Oct. 17, 2007	CF34-10A First Engine to Test (FETT)
Dec. 21, 2007	ARJ21-700 rolled out
Sept. 3, 2008	First flight of CRJ1000 powered by CF34-8C5
Nov. 24, 2008	CF34 fleet reaches 50 million hours
Nov. 28, 2008	First flight of ARJ21
Aug. 12, 2010	CF34-3A2 upgrade offered
Dec. 30, 2014	ARJ21-700 receives Chinese type certification
Nov. 16, 2015	Aviall gets exclusive support of CF34-3

Program Overview

Background

Early History/TF34

The TF34 program began in the mid-1960s and flew for the first time in 1971. The turbine was selected to power the Fairchild A-10 and the Lockheed Martin S-3. Production for the military versions of the aircraft ended in 1984.

CF34 for Challenger/CRJ

Just before the termination of the military production run, GE's long-

time effort to launch a civilian version of the turbine met success aboard the Canadair Challenger 601 (and later 604). Reliability problems of the ALF502 led Canadair to seek other alternatives.

The success of the 601 led Canadair to design a stretch version, eventually named the CRJ. The CF34 was the natural selection for the aircraft, albeit a slightly underpowered one.

New Engine Variants & Applications

As with the original CRJ, the success of the initial RJ models led the Canadian company to develop further stretch versions, the 700 and 900. To provide power for the larger aircraft GE went about the business of upgrading the 25-year-old design and came up with the -8 model.

Somewhat fortuitously, the company hit the jackpot with the -8 and later -10 series which happened into

the market just when the 70 to 100 seat regional jet market was finally taking off.

The company was also able to win the competitions for the Embraer 170/190, the Fairchild Dornier 728/928 (later cancelled).

At 9,220 lbst at the lower end of its range, the CF34 turbine is currently the smallest active civil turbofan program offered by General Electric. GE unsuccessfully offered a de-rated version of the CF34 for installation on the Gulfstream V.

ACAC Selects CF34-10A

In 2002, AVIC 1 Commercial Aircraft Co. (ACAC) chose the CF34-10A to power its new 90-seat commuter liner, the ARJ21-700. The Chinese company sees the potential for at least 850 ARJ21s over the next 20 years.

CF34-3 Problems

In late 2002, the company urged operators of the CF34-3 to inspect the gearbox and stage-two HP turbine blades for early wear. The -3 was installed on the Canadair Challenger 600 and CRJ aircraft.

CF34-10E

The latest member of the CF34 family is the -10E variant. The engine program was launched in 1999 for the Embraer 190/195 aircraft series. First flight of the engine aboard the new Brazilian aircraft took place in March 2004. In March 2005, GE reported that the -10E had received its FAA type certificate.

A-10 Re-engining

In January 2005, it was reported that the Air Force had finally decided to pursue a \$160 million program to upgrade the A-10s TF35-GE-100 engines (presumably to -101 standard) as the final part of the general A-10C upgrade. The service plans to buy upgrade kits for 356 aircraft, as well as

65 additional spare kits. The upgrades will be performed as field installations and will commence in 2009. The modified aircraft are designated A-10C.

Upgrade Programs for Early CF34s

In May 2006, GE announced a modernization program for CF34-1A/3A/3A2 engines powering Challenger 601 aircraft. The modification primarily involves retrofitting the hot section of these engines with that of the airline-proven -3A1 engine version. This results in an "on-condition" engine maintenance plan rather than a "hard-time" schedule.

The upgrade includes adding high-pressure turbine (HPT) borescope capability, utilizing advanced steel shrouds and more a robust stator in the HPT, and incorporating advanced combustion and transition liners.

In October 2006, GE reported that the operator Herzog was the first customer for the mod effort.

In August 2010, GE announced the availability of an another on-wing engine upgrade program for certain configurations of the CF34-3A2 engine that will allow the engines to go from a hard-time maintenance schedule to an on-condition maintenance schedule. These upgraded engines will have longer time on wing and greatly reduced maintenance costs with no scheduled hot section inspections or overhauls.

ARJ21

On Dec. 21, 2007, GE announced that COMAC had rolled out the first ARJ21. At the same ceremony, COMAC announced that it had received orders for 50 firm and 50 options for the aircraft from Kunpeng Airlines. Previously, in October, the first CF34-10A for the aircraft was tested (First Engine to Test/FETT). The aircraft made its first flight in November 2008.

As of July 2010, there were four aircraft in the test program. In September 2010, however, it was reported that first delivery of the ARJ21 would be delayed at least until the third quarter of 2011 because of "design issues."

In December 2014, the ARJ21-700 aircraft received the Type Certificate from the Civil Aviation Administration of China (CAAC), paving the way for the aircraft's entry into service.

GE Aviation Unveils New Upgrade to CF34-3A2 Engines

As of August 2010, GE Aviation began offering an on-wing engine upgrade program for certain configurations of the CF34-3A2 engine that allow the engines to go from a hard-time maintenance schedule to an on-condition maintenance schedule. The upgraded engines have longer time on wing and greatly reduced maintenance costs with no scheduled hot section inspections or overhauls.

The new on-wing upgrade was available for 36 CF34-3A2 engines that were in service on Challenger 601 aircraft.

The original CF34 modernization program was available for all CF34-1A and -3A and all remaining CF34-3A2 engines. This upgrade must be performed during an overhaul at GE's Strother facility, a GE Branded Service facility, or other GE-authorized shop. For these CF34 engines, the upgrade involved the replacement of the engine's existing honeycomb shrouds in the high-pressure turbine with new advanced steel shrouds and the addition of a borescope port. The combustor liner also was replaced with a new more durable, robust liner.

With the upgrade, the engines are fully on-condition with next unscheduled shop visit typically driven by the cycle limited parts lives.

MRO

100th OnPoint Agreement

GE Aviation reported in January 2008 that it had signed its 100th agreement for its OnPoint solution for maintaining CF34-3-powered business aircraft. More than 200 aircraft are covered by the agreements worldwide. The total value of the 100 five- to 10-year contracts is given as \$180 million. OnPoint services include overhaul, on-wing support, new and used serviceable parts, component repair, technology upgrades, engine leasing and diagnostics.

GE/Aviall Distribution Agreement

In January 2009, GE signed an exclusive distributor agreement with Aviall Services that expanded its spare parts distribution for CF34-3 engines. Under the agreement, Aviall became responsible for forecasting, ordering, and delivering OEM replacement parts unique to CF34-3s, as well as documentation management, worldwide inventory deployment, warehousing, and product distribution.

Azul Linhas Aéreas OnPoint Agreement

In October 2009, Azul Linhas Aéreas Brasileiras signed a 15-year OnPoint solution agreement covering the maintenance, repair and overhaul of CF34-10Es powering its Embraer 190/195 aircraft. The agreement was valued at nearly \$1 billion. The work was specified to be performed at the GE Celma facility in Petropolis, Brazil.

MTU CF34 Repair Station

In September 2010, it was reported that MTU Aero Engines had received FAA approval for its Appleton, WI, division to operate as a certified repair station to offer on-wing services for CF34 engines. Previously, the unit had to fly spares and technicians from its Berlin-Brandenburg maintenance arm.

GE and Bombardier Announce Engine Service Agreements for Challenger and Global Aircraft

GE Aviation and Bombardier Aerospace in October 2011 announced two new engine service agreements that boosted services support for Bombardier business aircraft customers. GE's OnPoint solutions engine maintenance coverage is being offered on Challenger aircraft equipped with CF34 engines and Global 7000 and Global 8000 aircraft. What's more, Bombardier's five wholly owned business aircraft service centers in the US were named GE Authorized Service Centers for CF34 engines for business aircraft.

Under the new service center agreement, Bombardier's five wholly owned business aircraft service centers, located in Dallas, Texas; Fort Lauderdale, Florida; Hartford, Connecticut; Tucson, Arizona and Wichita, Kansas, expanded their offering to provide factory-quality line maintenance and mobile repair services on CF34 engines. GE Aviation would provide Bombardier facilities with comprehensive material and technical support.

Jet Aviation St. Louis to Service CF34-3s

Jet Aviation St. Louis was named in March 2012 an authorized service center for the CF34-3 engine. Jet Aviation St. Louis is FAA- and OEM-authorized to support Bombardier Challenger aircraft.

With the GE authorization, Jet Aviation St. Louis was approved to perform line maintenance inspections; routine installed engine maintenance including removal and replacement of engine components; removal and replacement of engines; and removal and reinstallation of external engine components. This designation also allowed Jet Aviation St. Louis to provide warranty support and facilitates access to both GE parts and technical support.

Duncan Aviation to Service CF34-3s

Duncan Aviation was named an authorized service center for CF34-3 engines in August 2012. Under this agreement, Duncan Aviation could now perform line maintenance and on-wing engine maintenance, as well as provide OnPoint solution agreement and warranty support and facilitate access to both GE parts and technical support.

MNG Jet Tagged for CF34-3 Service

December 2012 saw GE Aviation name MNG Jet as an authorized service center for CF34-3. With the agreement, MNG Jet could now perform line maintenance inspections and routine installed engine maintenance, including removal and replacement of engines and engine components. This authorization also allows MNG Jet to provide OnPoint solution and GE new engine warranty support.

MNG Jet specializes in business jet operations and maintenance. Base maintenance is performed at MNG Jet's Istanbul, Turkey location with line maintenance support available in Sabiha Gokcen Airport in Istanbul and other stations requested by customers.

RUAG Named an Authorized Service Center for CF34-3s

In February 2013, GE Aviation named RUAG Aviation as an authorized service center for CF34-3 engines. Under this agreement, RUAG Aviation could perform engine line maintenance, as well as provide OnPoint solution agreement and warranty support and facilitate access to both GE parts and technical support.

Air Canada Commits to OnPoint Agreement

In June 2013, it was announced that Air Canada had committed to a five-year OnPoint solution agreement for a firm-fixed-price on time-and-material to repair and overhaul

its CF34-8E engines that powered its Embraer 175 aircraft. The value of the OnPoint solution agreement was not disclosed.

TAG Farnborough Engineering Agreement

In July 2013, GE Aviation named TAG Farnborough Engineering in the UK as an authorized service center for CF34-3. Under this agreement, TAG Farnborough Engineering could perform engine line maintenance, as well as provide On-Point solution agreement and warranty support and facilitate access to both GE parts and technical support.

Aviall Signs Deal for CF34 Services

Aviall, Inc., a wholly owned subsidiary of Boeing, in October 2014, signed an agreement with GE Aviation to become a provider of GE CF34-3A and CF34-3A2 used material and lease engines powering the Bombardier Challenger 601.

The ownership transfer built on an exclusive distributor agreement launched in 2009, where Aviall was responsible for forecasting, ordering, and delivering all Original Equipment Manufacturer (OEM) replacement parts that are unique to CF34-3 engines. This agreement leveraged Aviall's worldwide part distribution capabilities.

GE Expands CF34-3 Services in Asia

GE Aviation named Metrojet and STAECO in October 2015 as authorized service centers for CF34-3.

With this agreement, STAECO in Jinan and Metrojet in Hong Kong could perform line maintenance inspections and routine installed engine maintenance, including removal and replacement of engines and engine components. The two centers could also be allowed to provide On-Point solution and GE's new engine warranty support.

Bombardier Singapore Service Centre is Authorized

In April 2015, GE Aviation named Bombardier Singapore Service Centre as an authorized service facility for CF34-3 engines. With this agreement, Bombardier's Singapore Service Centre could perform line maintenance inspections and routine installed engine maintenance, including removal and replacement of engines and engine components. With this agreement, Bombardier's Singapore facility was authorized like its six other wholly-owned service centers in Amsterdam, Hartford, Fort Lauderdale, Dallas, Wichita, and Tucson.

Aviall Buys Leased CF34-3s

Aviall signed an agreement with GE Aviation in November 2015 to become the sole provider of all CF34-3 parts for business jets. The agreement included used and new parts, used line-replaceable units (LRUs) and lease engines powering the Bombardier Challenger 601, 604, 605, 650 and 850 aircraft.

The announcement built on previous CF34-3 agreements between the two companies. In October 2014, Aviall became the sole provider of GE CF34-3A and CF34-3A2 used material and lease engines powering the Bombardier Challenger 601. The ownership transfer built on an exclusive distributor agreement launched in 2009, where Aviall became responsible for forecasting, ordering, and delivering all genuine Original Equipment Manufacturer (OEM) replacement parts that are unique to CF34-3 engines.

Lufthansa Technik Deal

GE Aviation signed Lufthansa Technik AERO Alzey GmbH (LTAA) in November 2015 to a maintenance support agreement where LTAA will be responsible for dispatching its mobile repair teams to Russia, Europe, the Middle East and Africa to service CF34-series engines powering the Bombardier

Challenger series and Embraer Lineage aircraft.

In October 2014, GE Aviation named LTAA an authorized service center for GE's CF34-series engines. With the expanded agreement announced today, LTAA's service center and mobile repair teams will perform line maintenance inspections, routine installed engine maintenance, including removal and replacement of engines and engine components as well as repair and overhaul services. The authorizations also allow LTAA to provide OnPoint solution and GE's new engine warranty support.

ExecuJet Named for Service

GE Aviation, in November 2015, announced that it had designated each of ExecuJet's global repair facilities as authorized service centers for CF34-3 engines powering the Bombardier Challenger series.

ExecuJet managed 160 business jets in six regions worldwide: Africa, Asia, Australasia, Europe, Latin America and the Middle East. In December 2012, GE Aviation had named ExecuJet Middle East as an authorized service center for CF34-series engines.

With the expanded agreement, ExecuJet's global service centers would perform line maintenance inspections, routine installed engine maintenance, including removal and replacement of engines and engine components as well as repair and overhaul services. The authorizations also allowed ExecuJet to provide On-Point solution and GE's new engine warranty support.

RUAG Named ASC for CF34-10E

In May 2016, GE named RUAG Aviation as an authorized service center (ASC) for CF34-10E engines. Expedited approval process had begun in February 2016, when GE approached RUAG Aviation with its requirements.

Prognostic Health**Management Plus for CF34-3**

In October 2016, GE Aviation introduced its Prognostic Health Management Plus for CF34-3 engines powering the Bombardier Challenger 600 series aircraft. Prognostic Health Management Plus would provide real-time enhanced engine prognostics plus C-FOQA Centerline.

The new service would collect data wirelessly after each flight using Avionica's miniature Quick Access Recorder (miniQAR) with 4G Cellular Module (avCM 4G) and utilizing Avionica's avSYNC global data transfer service. avSYNC service speeds data delivery directly to GE's Prognostic Health Management data centers. Once the engine data is transmitted to GE's expert analysts, customers would, in turn, receive operational insights, predictive maintenance reports, and safety event awareness for FOQA.

Aviall Named Sole Part Provider for CF34-8 and -10

In October 2016, Aviall, a wholly owned subsidiary of Boeing, signed an agreement with GE Aviation to become the sole provider of CF34-8 and CF34-10 new and used parts and line-replaceable units (LRUs) for corporate business jets.

ExecuJet Service Expands

In December 2016, GE Aviation named ExecuJet Middle East as an authorized service center (ASC) for GE's CF34-10E engines. With this further expanded agreement, ExecuJet Middle East was authorized to perform line maintenance inspections, routine installed engine maintenance, including removal and replacement of engines and engine components as well as repair and overhaul services for CF34-10E and CF34-3 engines. The authorizations also allow ExecuJet to provide OnPoint solutions and GE's new engine warranty support.

LTAA MRO

In April 2017, GE Aviation signed Lufthansa Technik AERO Alzey GmbH (LTAA) to a maintenance support agreement. LTAA would be responsible for dispatching its mobile repair teams to Asia Pacific, Australia and China to service CF34-series engines powering the Bombardier Challenger series and Embraer Lineage aircraft.

In October 2014, GE Aviation named LTAA an authorized service center for GE's CF34-series engines. With this current agreement, LTAA's service center and mobile repair teams would support Asia with line maintenance inspections and routine installed engine maintenance, including removal and replacement of engines and engine components. LTAA would also provide repair and overhaul services. The authorizations would allow LTAA to provide GE's OnPoint solution and GE's new engine warranty support.

HNA GBSA

In June 2017, HNA's subsidiaries Hainan Airlines and HNA Technic reached a 30-year GE Branded Service Agreement (GBSA) for GENx and CF34 engines with GE Aviation.

TrueChoice™ for Royal Air Maroc

In June 2017, Royal Air Maroc selected a five-year, TrueChoice™ overhaul agreement for the maintenance, repair and overhaul of the CF34-10E engines powering its four Embraer E190 aircraft.

SA Airlink MRO

In September 2017, SA Airlink signed a 10-year, TrueChoice™ Flight Hour agreement with GE Aviation for the maintenance, repair and overhaul of the CF34-8E and CF34-10E engines powering its three Embraer E170 and 10 Embraer E190 aircraft.

Biggin Hill ASC

In October 2017, GE added the Bombardier Service Centre at London Biggin Hill Airport in the United

Kingdom to its business jet Authorized Service Centre (ASC) network to support CF34 engines.

ACI Jet Deal

In October 2017, GE added ACI Jet in San Luis Obispo, California, as a business jet Authorized Service Center to support CF34-3 engines powering the Bombardier Challenger series.

West Star Aviation

In October 2017, GE announced the renewal of its Authorized Service Center agreement for CF34 engine service with West Star Aviation for its East Alton, Illinois and Grand Junction, Colorado locations.

AerFin Deal

In April 2018, Wales-based aftermarket supply specialist AerFin signed a three-year TrueChoice™ Material agreement with GE Aviation for serviceable OEM parts, advanced repairs and technology upgrades for the CFM56, CF34 and CF6-80C2 engines.

Lufthansa Bombardier Aviation Services

In May 2018, GE signed an agreement with Lufthansa Bombardier Aviation Services (LBAS) to become an authorized service center for CF34-3 engines powering the Bombardier Challenger series.

This agreement gave LBAS authorization to perform line maintenance inspections, routine installed engine maintenance—including removal and replacement of engines and engine components—as well as repair and overhaul services for the CF34-3.

Luxaviation Opts for OnPoint Business Jet Maintenance Solution

In May 2018, GE and Luxaviation signed a collaborative agreement, making GE's OnPoint Business Jet Maintenance Solution program available to Luxaviation's owners and operators worldwide.

The agreement made GE Aviation the preferred engine service provider for Luxaviation's owners and operators with CF34-powered aircraft. This included Bombardier's Challenger series, powered by CF34-3s, and the Embraer Lineage 1000 series, powered by the CF34-10E.

RUAG Aviation Agreement

In May 2018, GE and RUAG Aviation extended its authorized service center agreement for CF34-3 and CF34-10E engines.

Azorra Aviation Signs Agreement for CF34-10Es

Azorra Aviation and GE Aviation signed a Set Maintenance Offer (SMO) agreement for its CF34-10E engine fleet aimed at helping reduce

the engine's cost of ownership. GE notes that the SMO agreement is available to all CF34-10E customers, regardless of their maintenance, repair and overhaul provider.

Customers can purchase the SMO agreement for parts only or incorporate it into an overhaul agreement with GE. Under the SMO, customers receive the following parts: high pressure compressor blades, combustor dome, inner and outer combustor liners, high pressure turbine blades and nozzles, Stage 1 low pressure turbine nozzles and a brand-new stack of rotating LLPs.

GA Telesis Opens New Engine Hospital Shop

In July 2020, the engine division of GA Telesis reported it had opened

a new aircraft engine hospital shop in Helsinki to service demand in Europe from airlines and lessors for minor repairs, test cell runs, and end of lease inspections. Initially, the shop would offer these services on three engines types: CF6-80C2B, which powered the Boeing 747-400 and was one of two options for the 767-300, and the CFM56-5B and CFM56-7B, powering the Airbus A320 family and the 737, respectively.

The company confirmed that over the course of the next 18 months, it planned to expand the number of engines serviced and was specifically targeting the V2500-A5, Pratt & Whitney PW4000-94/100, GE CF6-80E1 and CF34-8/10 engine types.

Current Developments

CF34 for the B-52?

In October 2014, yet another re-engining proposal emerged for the USAF B-52 fleet. In this one, per the Global Strike Command, Boeing had presented a "concept brief" in which GE had examined fitting the bombers with eight CF34-10 engines. The scheme would increase the overall thrust rating of the plane and greatly increase fuel efficiency and maintainability.

But, at the time, due to budgetary constraints and other issues, this was not likely to happen. Two previous proposals were offered, one with four Pratt & Whitney PW2000s (in 1982) and another involving four Rolls-Royce RB211-535s (in 1996). Both engines, however, are now out of production and these eventualities became moot.

Bombardier Opts for Upgraded CF34-3 for G650

In October 2014, Bombardier selected an optimized version of the CF34-3 to power its new Challenger 650 aircraft.

The new engine, called CF34-3B MTO, incorporated improved take-off thrust allowing the Challenger

650 aircraft to take flight from shorter runways while maintaining current CF34-3 durability and dispatch reliability. In addition, the CF34-3B MTO's offered a reduced take-off thrust mode for smoother departure and to further reduce maintenance operations.

B-52 Re-engining Gains Momentum

As of early 2018, the Air Force has reinvigorated its enthusiasm for re-engining some (we think) or all (they want to upgrade all) of the B-52H fleet. Current plans are for retiring all the B-1 and B-2 bombers and replacing them with the new B-21 Raider stealth bomber and upgraded B-52s (i.e., re-engining and other enhancements).

The CF34-10 would be one of the main candidates for any re-engining program (perhaps along with the Rolls-Royce BR700). It's a little too early, however, to make any solid predictions on which path the USAF will take.

COVID-19 Fallout

In June 2020, as the COVID-19 pandemic continued to keep global

fleets grounded, StandardAero reported a significant increase in its engine preservation business.

"We are seeing a higher than normal—possibly a record—number of customer requests for engine storage and preservation, particularly for the CFM56-7B and CF34-3 and -8 lines," said David Green, vice president & general manager for StandardAero CF34 and CFM56 MRO programs.

Preservation work and storage of those engines was being carried out by StandardAero at its Winnipeg, Canada, facility, a GE Designated Fulfillment Center for the CFM56-7B, and a GE Aviation Authorized Service Provider for the CF34-3 and -8.

Green said that his company saw sustained demand for its engine preservation services for the next couple of years—the timeline for a reasonable industry recovery estimated by analysts.

Program Status

GE reports that there are 1,643 CF34-10Es in operation with 98 operators. The powerplant has accumulated 32 million flight hours and 23

million cycles and has demonstrated a 99.98% reliability rate. Ninety-eight CF34-10As are in operation with four operators. This powerplant has accumulated 54,000 flight hours

and 38,000 cycles and has logged 100% reliability.

Further, the CF34-8 family includes 3,792 engines in operation with 92 operators. This fleet has accumulated 73 million flight hours

and 54 million cycles, and it has generated a 99.96% reliability rate..

Since its service entry, the CF34-10E fleet has accumulated 20 million flight hours and 28 million flight cycles.

Teal Group Evaluation

Bread and Butter

The CF34 has been one of the largest contributors to the GE Aviation top line revenue besides the 50% stake in CFM International, the GE90 and the GENx—all large turbofans. That is a huge accomplishment for a program that used to power something nicknamed the Warthog in the early 1970s.

Challenger Saves the Line

The reason for the engine's success following its modest military production run starts with its fortune in garnering the Challenger 601 bizjet application. The CF34 then rode the wave of expansion in this market segment which continues to this day with the Challenger 650.

Regionals Continue the Run

When Canadair came up with the Regional Jet (CRJ) variant of its successful bizjet, the CF34's fortunes blossomed even more. And then Embraer jumped in with its 170/190 series which has proven even more successful than the CRJ series. Between these two RJs, the CF34 has turned into a real money maker and the trend is likely to continue virtually unabated throughout our 10-year forecast period.

We're Bearish on the ARJ21

A wildcard in our projections is the Chinese ARJ21 program. This is a Chinese government-supported project that should at least show a modest level of yearly production in the near term.

The Future

Besides the latest variant of the CRJ, the CRJ1000, the business of winning new platforms is probably over for the CF34, a job that will be taken over by the successor to the CF34, the Passport (see report). Also, new engines from Pratt & Whitney Canada (PW800) and Rolls-Royce (Pearl) are waiting in the wings, so to speak, and will be tough competition for any new platform.

Now the GE team must get down to continuing delivery and upgrades of a good product, which we're confident they will. The successful testing and launch of the -10 series has been a continuing example of this.

The Bottom Line

Teal Group forecasts 1,443 units delivered and worth nearly \$5.3 billion for the CF34 program over the next 10 years.

Production Forecast

Units	Thru 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
TF34 series												
A-10A	1,738	—	—	—	—	—	—	—	—	—	—	1,738
S-3	469	—	—	—	—	—	—	—	—	—	—	469
Subtotal TF34 Series	2,207	—	—	—	—	—	—	—	—	—	—	2,207
CF34-1A												
Challenger 601-1A	152	—	—	—	—	—	—	—	—	—	—	152
Challenger 601-3A	305	—	—	—	—	—	—	—	—	—	—	305
FanStar (prototype aircraft)	3	—	—	—	—	—	—	—	—	—	—	3
Subtotal CF34-1 Series	460	—	—	—	—	—	—	—	—	—	—	460
CF34-3A1												
Challenger 601-3R	132	—	—	—	—	—	—	—	—	—	—	132
CRJ100	503	—	—	—	—	—	—	—	—	—	—	503
CF34-3A1/3B/3B1												
Challenger 604	809	—	—	—	—	—	—	—	—	—	—	809
CF34-3B1												
Challenger 605	739	—	—	—	—	—	—	—	—	—	—	739
CRJ200/440	1,857	—	—	—	—	—	—	—	—	—	—	1,857

CF34-3B MTO

Challenger 650	176	53	53	53	53	53	50	38	28	13	—	570
Challenger 6XX**	—	—	—	—	—	1	17	62	97	125	133	435
Subtotal CF34-3 Series	4,216	53	53	53	53	54	67	100	125	138	133	5,045

CF34-8C1

CRJ700/701	773	—	—	—	—	—	—	—	—	—	—	773
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CF34-8C5A2

CRJ1000	148	9	8	3	—	—	—	—	—	—	—	168
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CF34-8C5B1

CRJ900	981	37	41	41	40	34	26	18	3	—	—	1,221
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CF34-8E5A1

Embraer 170/175	1,757	100	70	44	30	13	—	—	—	—	—	2,014
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Subtotal CF34-8 Series	3,659	146	119	88	70	47	26	18	3	—	—	4,176
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CF34-10A

COMAC ARJ21	38	15	15	14	9	5	5	4	—	—	—	105
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CF34-10E5/E5A1

Embraer 190/195/Lineage	1,687	20	10	—	—	—	—	—	—	—	—	1,717
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Subtotal CF34-10 Series	1,725	35	25	14	9	5	5	4	—	—	—	1,822
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Total	12,267	234	197	155	132	106	98	122	128	138	133	13,710
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Value (\$ Millions)*	Thru 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
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TF34 series

A-10A	1,293	—	—	—	—	—	—	—	—	—	—	1,293
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S-3	277	—	—	—	—	—	—	—	—	—	—	277
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Subtotal TF34 Srs	1,570	—	—	—	—	—	—	—	—	—	—	1,570
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CF34-1A

Challenger 601-1A	175	—	—	—	—	—	—	—	—	—	—	175
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Challenger 601-3A	428	—	—	—	—	—	—	—	—	—	—	428
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FanStar (prototype aircraft)	4	—	—	—	—	—	—	—	—	—	—	4
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Subtotal CF34-1 Srs	607	—	—	—	—	—	—	—	—	—	—	607
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CF34-3A1

Challenger 601-3R	220	—	—	—	—	—	—	—	—	—	—	220
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CRJ100	871	—	—	—	—	—	—	—	—	—	—	871
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CF34-3A1/3B/3B1

Challenger 604	1,546	—	—	—	—	—	—	—	—	—	—	1,546
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CF34-3B1

Challenger 605	1,767	—	—	—	—	—	—	—	—	—	—	1,767
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CRJ200/440	3,627	—	—	—	—	—	—	—	—	—	—	3,627
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CF34-3B MTO

Challenger 650	468	146	148	150	152	155	148	114	85	40	—	1,607
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Challenger 6XX**	—	—	—	—	—	3	50	186	296	387	418	1,341
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Subtotal CF34-3 Srs	8,500	146	148	150	152	158	198	301	382	428	418	10,980
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CF34-8C1

CRJ700/701	2,249	—	—	—	—	—	—	—	—	—	—	—
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CF34-8C5A2

CRJ1000	516	34	30	11	—	—	—	—	—	—	—	76
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CF34-8C5B1

CRJ900	3,216	204	226	226	220	187	143	99	17	—	—	1,320
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CF34-8E5A1

Embraer 170/175	5,896	380	266	167	114	49	—	—	—	—	—	977
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Subtotal CF34-8 Srs	11,876	618	522	404	334	236	143	99	17	—	—	2,373
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CF34-10A												
COMAC ARJ21	194	63	63	59	38	21	21	17	—	—	—	281
CF34-10E5A1												
Embraer 190/195	8,039	84	42	—	—	—	—	—	—	—	—	126
Subtotal CF34-10 Srs	8,234	147	105	59	38	21	21	17	—	—	—	407
Total	30,786	910	775	613	524	415	362	416	398	428	418	15,937

**then-year dollars*

***provisional designation and engine application for a notional G650 follow-on*

