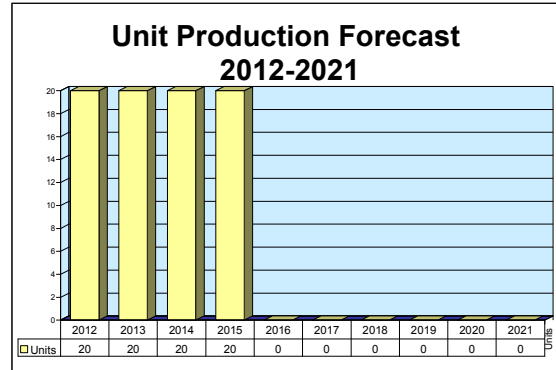


Pratt & Whitney Canada JT15D

Outlook

- Hawker 400XP program suspended
- Current engine production supports older Citation I and II models



Orientation

Description. Two-shaft, axial-centrifugal-flow, medium-bypass-ratio aviation turbofan engine in the 2,200-3,350-lbft range.

Sponsor. The JT15D was privately sponsored and developed by the prime contractor.

Power Class. 2,200-3,350 lbft (9.6-14.7 kN) at takeoff. Further growth to 3,500 lbft (15.4 kN) possible.

Status. In production for Hawker 400XP light business jet. Limited JT15-4 production continues for Cessna Citation II fleet.

Total Produced. As of July 2012, an estimated 6,772 JT15Ds of all variants were built.

Application. Small personal/business/commuter jets and light jet-powered military aircraft. Applications (current, out-of-production, or otherwise) include the following:

<u>Engine Variant</u>	<u>Thrust Rating</u>	<u>Application</u>	<u>Units per Airframe</u>
JT15D-1/1A/1B	2,200 lbft (9.7 kN)	Cessna Citation I (out of production)	2
		Aerospatiale SN600 Corvette (prototype)	2
		Honda/MSU MH-02 (research)	2
JT15D-4/4B/4C/4D	2,500 lbft (11.1 kN)	Cessna Citation II (production resumed)	2
		Cessna Citation S/II (out of production)	2
		Mitsubishi Diamond I (out of production)	2
		Mitsubishi Diamond IA (out of production)	2
		Agusta/SIAI-Marchetti S.211 (out of production)	1
		Aerospatiale SN601 Corvette (out of production)	2
		Beechjet 400A (out of production)	2
JT15D-5	2,900 lbft (12.9 kN)	Cessna Citation V (production completed)	2
		Cessna Citation V Ultra (production completed)	2
JT15D-5	2,965 lbft (13.04 kN)	Hawker 400XP	2

Pratt & Whitney Canada JT15D

Price Range. JT15D-5D, \$550,000 (estimated in 2012 U.S. dollars).

Competition. The engines that most directly compete with the JT15D are the Honeywell 3,500-lb (15.5-kN) TFE731-2 and the 1,900-2,200-lb (8.4-9.8-kN) Williams FJ44-1/-2. The JT15D is being partially superseded by one of P&WC's own engines, the

PW500, which covers the 3,000-4,000-lb (13.3-17.8-kN) range. Pratt's newest engine family under development, the PW600 series, has a thrust range from 900-3,000 (3.9-13.2 kN) and will power the Eclipse 500 and Cessna Mustang Very Light Jets. As of this writing, Pratt & Whitney reports no plans to replace the JT15D with the PW600.

Contractors

Prime

Pratt & Whitney Canada	http://www.pwc.ca , 1000 Marie-Victorin Blvd, Longueuil, J4G 1A1 Quebec, Canada, Tel: + 1 (450) 677-9411, Fax: + 1 (450) 647-3620, Prime
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Subcontractor

Champion Aviation Products Division	Bldg B, Suite 200, 330 Pelham Rd, Greenville, SC 29615 United States, Tel: + 1 (803) 370-9655, Fax: + 1 (803) 232-7050 (Igniter Plug)
Eaton Aerospace - Hydraulic Systems Division	http://www.aerospace.eaton.com , 5353 Highland Dr, Jackson, MS 39206-3449 United States, Tel: + 1 (601) 981-2811, Fax: + 1 (601) 987-5255 (Vane-Type Fuel Pump)
Goodrich Aerostructures	http://www.goodrich.com , 850 Lagoon Dr, Chula Vista, CA 91912-0878 United States, Tel: + 1 (619) 691-4111, Fax: + 1 (619) 691-3030 (Clamshell-Type Thrust Reverser)
Howmet Castings, Corporate Machining	http://www.alcoa.com , 145 Price Rd, Winsted Industrial Park, Winsted, CT 06098 United States, Tel: + 1 (860) 379-3314, Fax: + 1 (860) 379-4239 (Investment Cast Airfoil)
Nordam Manufacturing Div	510 South Lansing, Tulsa, OK 74120 United States, Tel: + 1 (918) 587-4105, Fax: + 1 (918) 583-2604 (Thrust Reverser)
PCC AETC Ltd	http://www.pccairfoils.com , Victoria Ave, Yeadon, Leeds, LS19 7AY United Kingdom, Tel: + 44 113 2505151, Fax: + 44 2113 2103006 (Machined Fan Blade)
Timken Aerospace (Fafnir Bearings)	http://www.timken.com/aerospace , 336 Mechanic St, Lebanon, NH 03766 United States, Tel: + 1 (603) 448-3000, Fax: + 1 (603) 443-5202 (Main Shaft & Accessory Ball & Roller Bearings)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call + 1 (203) 426-0800.

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

Design Features. Pratt & Whitney Canada JT15D series engines have the following design features:

Intake. Direct annular one-piece stainless steel intake with no inlet guide vanes. Bulletdome spinner. Hot compressor bleed air for anti-icing.

Fan. The JT15D-1 has a single-stage midspan-supported fan consisting of 28 titanium blades dovetailed to a forged titanium disc. Bypass ratio is 2.0:1 to 3.3:1. The JT15D-4 has an additional booster stage behind the fan to augment the airflow through the core. The JT15D-5 employs a shroudless fan with a bypass ratio of about 2.8:1. The JT15D-5A has an

improved fan with a stainless steel case. Mass air flow is 69.4-83.3 lb/sec (31.47-37.78 kg/sec).

Compressor. Single-stage titanium radial flow compressor with 16 full vanes and 16 splitter vanes. Overall pressure ratio is 7.4:1 to 12.6:1, and core flow is 17.5 lb/sec (7.93 kg/sec). JT15D-4/5 has axial boosters.

Combustor. Fully annular reverse-flow combustion system with outer casing of heat-resistant steel and flame tubes of nickel-based alloy.

Turbine. The single-stage HP turbine has 71 uncoiled directionally solidified blades held in place by fir-tree

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roots, and drives the centrifugal HP compressor. The LP turbine, which drives the fan (and booster stage in the JT15D-4), is a two-stage axial unit with nickel alloy

discs. Stage 1 is an integrally cast wheel with 61 blades, while Stage 2 has 55 blades set with fir-tree roots.

The dimensions of the Pratt & Whitney Canada JT15D-4 and JT15D-5 engines are as follows:

	<u>Metric Units</u>	<u>U.S. Units</u>
Dimensions		
Length	1,534-1,608 mm	60.4-63.3 in
Diameter, fan	686-693 mm	27.0-27.3 in
Weight, dry	261.7-286.7 kg	557-632 lb
Weight, JT15D-5C	301.6 kg	665 lb

Variants/Upgrades

JT15D-1/1A/1B. The JT15D-1 is the first production series. N1 speed is 15,480 rpm for the JT15D-1 and 16,540 rpm for the JT15D-1A/1B; N2 speed is 31,120 rpm. This subseries powered the first Citation business jet, the Model 500, and subsequently, the Citation I. The current Citation is from Serial No. 0665, used on the improved JT15D-1B, and has 3.3 percent more thrust at cruise altitude. The engine has a 1.4 percent increase in fan speed and a TBO of 3,000 hours.

JT15D-4/4B/4C/4D. The JT15D-4 is an uprated series with T-O thrust of 2,500 lbst (11.12 kN) and maximum continuous thrust of 2,375 lbst (10.56 kN). N1 speed is 16,540 rpm for the JT15D-4/4D and 16,860 rpm for the JT15D-4B/4C; N2 speed is 31,450 rpm for the JT15D-4 and 31,800 rpm for the JT15D-4B/4C/4D. The JT15D-4 has a reported 90 percent commonality with the earlier JT15D-1. This engine subseries powers the Cessna Citation II, the Mitsubishi Diamond I business jet, the Century Aircraft Century 5 modification, and production SIAI-Marchetti S.211s. The S.211 utilizes the JT15D-4 with electronic supervisory engine control and an inverted flight lubrication system. The JT15D-4B and the JT15D-4D were certificated in 1983.

JT15D-5/5A/5B/5C/5D/5F. The JT15D-5 is a further uprated series with T-O thrust of 2,900 lbst (12.89 kN) for the JT15D-5A/5B/5F, 2,965 lbst (13.18 kN) for the JT15D-5, and 3,190 lbst (14.18 kN) for the JT15D-5C. Maximum continuous thrust is 2,900 lbst (12.89 kN) for the JT15D-5/5A/5B/5F and 3,190 lbst for the JT15D-5C. N1 speed is 16,540; N2 speed is 31,450 rpm; maximum oil pressure is 83 psig for the JT15D-5/5A/5B/5F and 90 psig for the JT15D-5C.

The JT15D-5 is similar to the JT15D-4 except for its higher thrust ratings and the electronic fuel control. The JT15D-5A is similar to the JT15D-5 except for the

hydromechanical fuel-control unit and ignition system (two separate executors replace the single input/dual output of the JT15D-5 unit). The JT15D-5A was certificated in 1988.

The JT15D-5C is a fully rated aerobatic derivative of the JT15D-5, offering a 10 percent increase in thrust over the JT15D-5. Several factors contribute to this increase in power, including a new fan with a higher mass flow and efficiency, an improved boost compressor stage and HP compressor, and, in the hot section, improvements in design and materials for increased durability. The JT15D-5C was chosen to power the Agusta/SIAI-Marchetti S.211A trainer aircraft, which the Grumman/Agusta/SIAI-Marchetti partnership offered in the USAF/USN Joint Primary Aircraft Training System (JPATS) competition. The JT15D-5C was certificated in 1992.

The JT15D-5D is rated to a maximum 3,045 lbst (13.5 kN, takeoff and max continuous). Aerodynamically refined wide-chord fan blades have been introduced. The blades are slightly thicker than those of previous makes, for greater resistance to damage from foreign objects. The fan case is of abradable aluminum and Kevlar, and tip clearances are tighter than previously attained for a redline at 106 percent N1. The fan and low-pressure axial compressor are solid one-piece units. The engine's high-pressure turbine blades are made of a single-crystal alloy. The engine produces 737 lbst (3.28 kN) at 40,000 feet (the JT15D-5A produces 702 lbst [3.1 kN] at the same altitude). The JT15D-5D's thrust-specific fuel consumption is 0.868 pph/lbst, versus 0.876 pph/lbst for the JT15D-5A. The engine's TBO is 3,500 hours, with a hot section inspection interval of 1,750 hours. The engine received FAA certification in 1993.

Pratt & Whitney Canada JT15D



JT15D

Source: Pratt & Whitney Canada

Program Review

Background. The United Technologies Pratt & Whitney Canada (P&WC) JT15D program began in the early 1960s as a major study effort by the Canadian unit of (then) United Aircraft Corporation. Following a review of the small gas-turbine market, it was determined that a turboprop in the 2,000-2,300-lb (8.89-10.23-kN) class would be an ideally marketable product. Engine design began in 1966. The design objectives of the JT15D program included a minimum number of rotating components, low emissions, low noise generation, simplified maintenance, and long overhaul periods. The engine design was based in part on the Pratt & Whitney JT12/J60, PT6A, and JT9D.

The early JT15D-1 engine model had only a one-stage fan, and achieved a takeoff thrust of 2,200 lb. The more advanced JT15D-4, at 2,500 lb, featured the addition of an axial boost stage on the low spool to boost the compressor. As early as 1976, the JT15D engine was being further refined. A new, improved radial compressor and a new fan were successfully proven, and the components were mated together and run for the first time as the JT15D-5.

Pratt & Whitney Canada JT15D Applications. Among the current applications of the Pratt & Whitney Canada JT15D series are the following:

Cessna Citation Series. The JT15D's first major application was the Cessna Citation 500, the first of a highly popular series in the business/corporate market. Since then, the basic design has expanded to include the Citation I, II, S/II, V, and V Ultra versions powered by the JT15D.

The Citation V Ultra, an improved and further refined Citation V, replaced the Citation V in 1994. It uses the JT15D-5D and has a heavier payload, a 400-pound (1,814-kg) increase in maximum takeoff weight, and interior and flight system refinements. The U.S. Army began taking delivery of the first of 35 C-XX Ultra variants in 1996 to fulfill the VIP shuttle mission.

Production of the Cessna Citation V Ultra has been superseded by the P&W Canada PW535-powered Citation Encore. Compared with its JT15D-5D-powered Ultra predecessor, the new Encore offers a 10 percent increase in engine thrust and a 15 percent reduction in specific fuel consumption.

Raytheon/Beechjet 400/Mitsubishi Diamond. Having captured a notable share of the turboprop market with the MU-2 series, Mitsubishi developed a business jet design under the designation Diamond I, powered by two JT15D-4 engines. FAA certification was awarded in 1981. The subsequent Diamond IA with JT15D-4 engines greatly expanded the aircraft's airfield performance, range, and payload, especially in hot/high conditions.

Because of the poor market perception of the Diamond I, Mitsubishi launched the Diamond II, powered by the JT15D-5. The first Diamond II was delivered in 1985. The same year, Beech Aircraft Corporation acquired the Diamond II line, and renamed the aircraft Beechjet 400. The first Beechjet 400 assembled by Beech in the United States was delivered in 1986. Under the acquisition agreement, Mitsubishi shipped aircraft in kit form to Beech, where they were assembled.

Pratt & Whitney Canada JT15D

In 1989, Beech announced a further advanced aircraft model, the Beechjet 400A. That model is outwardly similar to the Beechjet 400, but has a top speed of 468 knots, compared with 461 knots for the Beech 400. Maximum certificated altitude is 45,000 feet (13,716 m) with a gross weight of 16,100 pounds, compared with the 400's 41,000 feet and 15,780 pounds. The 400A has a maximum passenger capacity of nine, compared with the earlier aircraft's eight.

The military version of the aircraft selected for the USAF's Tanker/Trainer Transport System program, the T-1A Jayhawk, is powered by the JT15D-5B engine. The first flight of the Jayhawk took place in 1991. Overall, the Air Force operates 180 of these aircraft.

In May 2003, the Beechjet was renamed the Hawker 400XP. The jet is 200 pounds (90 kg) heavier and offers several extra features (such as thrust reversers) as standard. There is no change to the engines.

Agusta/SIAI-Marchetti S.211. SIAI-Marchetti, part of Gruppo Agusta, developed the S.211 as a trainer/light strike design as a possible replacement for the hundreds of SF.260s in worldwide service. Powered by a single

JT15D-4C, the S.211 is designed for simplicity and low cost, features appealing to prospective customers, particularly those currently using the piston-powered SF.260.

VisionAire Vantage. VisionAire Corp, Chesterfield, Missouri, had developed a six-place, composite business jet powered by a single JT15D-5. A single prototype was built by Scaled Composites, Mojave, California (five were planned). The first aircraft flew in 1996. The JT15D was selected to power the Vantage because of its reliability. Studies by VisionAire determined that, based on engine shutdowns per 1,000 hours, the JT15D-5 is 70 times more reliable than a reciprocating engine, 10 times better than a turboprop, and three times better than a turbojet. VisionAire entered into a partnership in 2000 with Scaled Technology Works whereby the latter would build the conforming prototypes, ground test vehicles, and the first nine production-standard Vantages.

VisionAire concedes that the development program has been all but suspended since the 1999/2000 redesign to incorporate weight-reduction measures. VisionAire entered Chapter 11 bankruptcy in 2003.

Funding

No funding for the JT15D has been identified.

Contracts/Orders & Options

No major military or commercial contracts for the JT15D have recently been identified.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1965	Small turbofan market studies conducted
Jun	1966	Detail design initiated
Sep	1967	First run of JT15D
Aug	1968	First flight aboard Avro/P&WC CF-100 testbed
Aug	1969	First flight of JT15D-1-powered Cessna Citation
May	1971	U.S. FAA/Canada DoT certification of the JT15D-1
Oct	1971	First JT15D-powered Citation delivered
Jan	1972	First run of JT15D-4
Jan	1974	JT15D-4 certificated
Oct	1976	JT15D-1A certificated
Oct	1977	JT15D-5 development initiated
Apr	1978	First flight of JT15D-5
Sep	1982	JT15D-1B certificated
Dec	1983	JT15D-4B and JT15D-4D certificated
Apr	1984	Citation T-47A first flight
Jun	1984	JT15D-5 certificated
Late	1987	JT15D-5A program unveiled
Dec	1988	JT15D-5A certificated
Early	1990	JT15D-5C program announced
Nov	1990	JT15D-5B certificated

Pratt & Whitney Canada JT15D

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Aug	1992	JT15D-4C and JT15D-5C certificated
Oct	1993	JT15D-5F certificated
Dec	1993	JT15D-5D certificated
Nov	1996	VisionAire Vantage business jet first flown with a single JT15D-5
Mid-3Q	1999	VisionAire switches to JT15D-5D for Vantage
3Q	2005	JT15D-4 re-enters production
	2014	JT15D production expected to end

Worldwide Distribution/Inventories

As of July 2012, an estimated 6,772 JT15D engines had been produced, with the majority being installed on corporate and privately owned aircraft.

Forecast Rationale

With the suspension of Hawker's 450XP program, the JT15D has no production applications. Furthermore, the bankruptcy proceeding and the recent purchase of Hawker Beechcraft's assets by China's Superior Aviation have cast doubt on whether the program will be revived.

This latest development leaves the JT15D-4 in very low-rate production for fleet support of older Cessna Citation I and II aircraft. These aircraft have Supplemental Type Certificates (STCs) available for replacing the original engines with modern, updated turbofans. The most popular engine upgrade involves

repowering with Williams International's FJ44 series engines for a major boost in thrust and range, and an accompanying reduction in fuel burn.

It is unknown how much longer Pratt Canada will continue to produce the JT15D series. No production information has been made available from the company, so our figure is a best guess based on the dwindling size of the older Citation fleet. The JT15D is an old technology engine, and competes with newer engines such as Williams' FJ44 and even Pratt's own PW535D.

Overall, we estimate JT15D production at 80 engines during the 10-year forecast period.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	High Confidence					Good Confidence			Speculative			Total
	Thru 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
Pratt & Whitney Canada												
JT15D -4 <-> Citation II												
	140	20	20	20	20	0	0	0	0	0	0	80
Total	140	20	20	20	20	0	0	0	0	0	0	80