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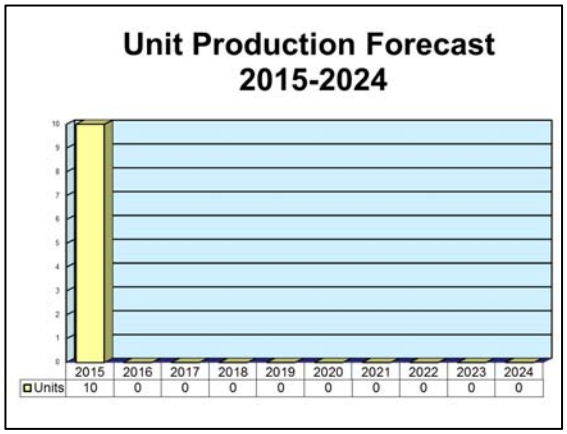
Williams International WR2/WR24

Outlook

- WR24-8 powers the BQM-74 aerial target drone
- Production of the BQM-74 forecast to end in 2015, leaving the WR24 without an application



Orientation

Description. The WR2/WR24 engines are single-shaft centrifugal- and axial-centrifugal-flow turbojet engines. The U.S. military designation of the engine series has the military prefix YJ400.

Power Class. 125-240 lbst (0.55-1.067 kN).

Status. In production for MQM/BQM-74 Chukar drone series.

Application. Applications include drones, remotely piloted vehicles (RPVs), reconnaissance/surveillance air vehicles, and other unmanned air vehicles (UAVs).

Price Range. WR24-8 estimated at $40,000.

Williams International WR2/WR24

BQM-74E

Source: U.S. Navy

Contractors

Prime

Williams International	http://www.williams-int.com, 2280 E West Maple Rd, PO Box 200, Walled Lake, MI 48390 United States, Tel: + 1 (248) 624-5200, Fax: + 1 (248) 669-0040, Prime
Federal-Mogul Corp	http://www.federal-mogul.com, 26555 Northwestern Hwy, Southfield, MI 48034 United States, Tel: + 1 (248) 354-7700, Fax: + 1 (248) 354-8950, Packager
Puroflow Corp	http://www.donaldson.com/en/gasturbine/index.html, 26235 Technology Dr, Valencia, CA 91359 United States, Tel: + 1 (661) 295-0800, Fax: + 1 (661) 295-8443, Packager

Subcontractor

Alcoa Howmet	http://www.alcoa.com/howmet/, 145 Price Rd, Winsted Industrial Park, Winsted, CT 06098 United States, Tel: + 1 (860) 379-3314, Fax: + 1 (860) 379-4239 (Integral Investment Cast Airfoil)
Triumph Engine Control Systems	http://www.triumphgroup.com, Charter Oak Blvd, West Hartford, CT 06133 United States, Tel: + 1 (860) 236-0651, Fax: + 1 (860) 232-1873 (Fuel Control System)
Unison Industries	http://www.unisonindustries.com, 7575 Baymeadows Way, Jacksonville, FL 32256 United States, Tel: + 1 (904) 739-4000, Fax: + 1 (904) 739-4093 (Filter Cable)

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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

Design Features

Intake. Annular pitot-type air intake. Aluminum alloy casing.

Compressor. The WR2 version has a single centrifugal compressor with a pressure ratio of 4:2 at an air mass flow of 2.2 lb/sec (1.0 kg/s). The WR24 series incorporates an additional axial-flow stage that raises the pressure ratio to 5.3:1 with a mass flow of 3.0 lb/sec (1.36 kg/s). Maximum speed is 60,000 rpm for the WR2-6 and 62,000 rpm for the WR24-7.

Combustor. An annular reverse-flow combustor has secondary air cooling holes to provide boundary layer air for cooling the aft wall. Fuel is supplied via a centrifugal fuel injection system incorporated in the compressor shaft. A single spark igniter, using igniter plugs from Federal-Mogul Corp (nee Champion Spark Plug), is also used.

Turbine. A single-stage axial turbine of IN713 drives the compressor at 60,000 rpm in the WR2 and 60,900 rpm in the WR24. Turbine inlet temperature (TIT) is 1,780°F (971°C). Turbine blades are uncooled.

Accessories. Self-contained oil mist lubrication system and integral alternator aft of the WR24's axial compressor stage. Main fuel control a product of Goodrich Pump & Engine Control Systems (nee Coltec Chandler Evans).

Dimensions.

	Metric Units	U.S. Units
Length, overall (WR2-6)	561 mm	22.1 in
Length, overall (WR24-8)	495 mm	19.5 in
Diameter (WR24-8)	274 mm	10.8 in
Weight:		
WR2-6	12.70 kg	28 lb
WR24-7	19.96 kg	44 lb
WR24-8	22.68 kg	50 lb

Applications.

Model Variant	Thrust Rating	Recent Applications	Airframe
WR2-6	125 lbst (0.55 kN)	Canadair(b) CL-89	1
		Northrop Grumman MQM-74A	1
WR24-7	190 lbst (0.8 kN)	Fuji Heavy Industries MQM-74C	1
		Northrop Grumman BQM-74 RECCE	1
		Northrop Grumman MQM-74C	1
WR24-8(a)	240 lbst (1.0 kN)	Northrop Grumman BQM-74 RECCE	1
		Northrop Grumman BQM-74C	1

(a) U.S. Navy designation is YJ400-WR-404.
(b) Bombardier Inc acquired Canadair in 1986.

Variants/Upgrades

WR2-6. The WR2-6 was the first large-scale production WR2/WR24 series engine. It was used to power the Canadair CL-89 (USD-501) target drone. It incorporates a variable exhaust nozzle; it is rated at 125 lbst (0.55 kN).

WR24-6 (J400-WR-400). The WR24-6 is similar to the WR2-6 but lacks the variable nozzle. Rated at 121 lbst, it powers the Northrop MQM-74A Chukar I target drone and the Meteor Gufone.

WR24-7 (J400-WR-402). The WR24-7 is an engine variant rated at 170 to 200 lbst. It powers the uprated MQM-74C Chukar II. This variant incorporates an axial-flow compressor stage in addition to the radial unit. A further improved WR24-7A incorporates an advanced electronic fuel control system that reduces SFC to 1.20 lb/hr/lbst (33.99 mg/Ns). It weighs 44 pounds (19.96 kg).

WR24-8 (J400-WR-404). Representing the latest development of the WR2/WR24 engine series, the WR24-8 has the same diameter and component layout as the WR24-7, but develops 240 lbst (1.067 kN); it operates at altitudes up to 40,000 feet (12,192 m). Qualification requirements are -40°F cold starting with JP-5 fuel, and 25-hour mission cycles. In addition, the engine must be reusable after sea water immersion. This engine model has an integral high-speed alternator and a self-contained oil mist lubrication system. The WR24-8 powers the BQM-74C Chukar III and BQM-74E drones.

WR24-17. The WR24-17 is similar to the WR24-7 but is rated at 200 lbst (0.889 kN). Some prototypes were

Williams International WR2/WR24

used in Northrop's entry in the Variable Speed Training Target (VSTT) competition that was awarded to Beech Aircraft. No other applications have emerged.

Program Review

Background. The first of the Williams International (formerly Williams Research Corp) small turbojet engines, the WR1 dates back to 1957 and was the progenitor of the WR2 and WR24 engines. The WR1 was a regenerative free-turbine machine of 70 shp and was redesigned into a pure jet engine of 50 lbst in 1957. However, because of continued advances, and with funding from the U.S. Navy for improvements to the Northrop BQM-74C Chukar III, the maximum thrust of the small engine is now 240 lbst (1.067 kN).

Applications. In the early 1960s, Williams joined with Hiller Helicopter Co in an experimental program aimed at using jet thrust to power tip-jet rotor designs. The Hiller program did not mature beyond the early stages of testing, although the engine's potential caught the attention of Canadair Aircraft Ltd, which was a partner in a joint development program for the CL-89 (USD-501) target drone. Under U.K.-Canada-Germany auspices, the CL-89, powered by the WR2-6, became a major program, and approximately 600 CL-89 drones were built over the life of the program, including units by Meteor of Italy. Demands for improved performance, however, led to the improved CL-289. The CL-289 is powered by a single KHD (BMW Rolls-Royce) T117 turbojet, although a few early prototypes were powered by WR2s.

Current Applications. Among the current or proposed applications of the Williams WR2/WR24/J400 series are the following:

Northrop MQM/BQM-74 Chukar. The uprated performance of the WR24 series was noticed by Northrop, and the firm's Ventura Division incorporated the turbojet into the design of the MQM/BQM-74 Chukar series of drones. That drone series is one of the most popular produced to date.

Northrop developed the air-launched BQM-74C / Chukar III, which incorporates a fuselage stretch while retaining much of the MQM-74C Chukar II design. The BQM-74C eliminates the need for the booster motors and meets the needs of the U.S. Navy, a major customer of the drone. Successful flight tests were carried out aboard A-6E and A-4 aircraft in 1980, and the BQM-74C Chukar III drone soon became the production-standard model for the U.S. Navy.

First flight of the WR24-8 (J400-WR-404), which powers unmanned aircraft, took place on January 22, 1985, and seven flights were completed by June 1985. All versions of the BQM-74C simulate a variety of airborne threats, including aircraft, sea-skimming cruise missiles, and anti-ship missiles. They can be launched from aircraft, ships, or ground facilities. The air vehicles are used to train U.S. Navy pilots and missile and gunnery personnel, and for the evaluation of new weapons systems such as anti-aircraft missiles, ordnance, and aircraft.

In 1985, Northrop unveiled the BQM-74C/RECCE variant, featuring an electro-optic viewing system with a zoom lens. In June 1989, the USN awarded a $36 million contract to Northrop for the production of 129 BQM-74C aerial target drones. Work under that contract was completed in 1991.

BQM-74E Variant. At the 1988 Association of Unmanned Vehicle Systems convention in San Diego, California, Northrop unveiled its new BQM-74 target drone variant, designated the BQM-74E. The air vehicle features swept wings and an ogival, pointed nose that helps reduce its overall radar signature. Furthermore, the system is equipped with a 240-lbst engine (the same as on the Chukar III), which gives the vehicle a maximum speed of 530 knots (880 kmph). This aerial target has a maximum operating altitude of 40,000 feet (up from 35,000 ft).

The BQM-74E became the main production version in the summer of 1991. A contract was awarded for the manufacture of 200 air vehicles, with initial deliveries in 1993. Production of the BQM-74E was extended into 2009.

BQM-74F. In March 2002, Northrop Grumman Corp was awarded a contract to develop a new model of its BQM-74 aerial target. Known as the "F" model, that version can simulate anticipated anti-ship cruise missile threats. In comparison with the BQM-74E model, the BQM-74F features a higher speed of Mach 0.92, a greater maneuverability at 8*g*, and increased range and endurance.

The F model passed its Critical Design Review in 2003; the first BQM-74F was expected to fly in late 2004, but made its first flight in 2005.

Timetable

Month	Year	Major Development

Month	Year	Major Development
Early	1960s	Development of WR2 series begins
	1962	First run of WR2
Mid	1960s	Development of WR24 series begins
	1966	WR24 flight-tested aboard MQM-74A; WR2-powered CL-89 undergoes flight trials
	1967	Production of CL-89 begins
	1972	BQM/MQM-74 Chukar in design stage
	1973	Chukar receives RDT&E funding
Mid	1977	3,500th WR2/WR24 engine produced
Nov	1977	BQM-74C in design stage
Mar	1979	BQM-74C rolled out
	1984	First European deployment of the Chukar
	1988	BQM-74E variant introduced
	1989	Production of BQM-74E begins
Late	1991	End of production of BQM-74C by Northrop Grumman
	2005	Production of BQM-74F begins
	2015	Expected end of production of BQM-74 series drones

Forecast Rationale

Over the years, Northrop Grumman was able to adapt its Chukar series drones to the changing threat simulation requirements of U.S. and world militaries. Now, the Pentagon is no longer purchasing aerial target drones from Northrop Grumman, and Williams' WR24 engine has no other applications.

Northrop Grumman had hoped to hold on to its market share with a new version of the BQM-74. The Pentagon launched a competition to select a new Subsonic Subscale Aerial Target (SSAT) in which Northrop Grumman faced off against the Composite Engineering Inc (CEi) BQM-177. Northrop Grumman lost this competition to CEi, and so production of the BQM-74 for the U.S. military ended.

The BQM-74E will remain active within the U.S. training and weapons systems testing program until its numbers are exhausted. Meanwhile, Fuji Heavy Industries will continue production of the BQM-74 through 2015.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		**High Confidence**				**Good Confidence**			**Speculative**			
	Thru 2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Williams International												
WR24 -8 <> BQM-74 F												
	112	10	0	0	0	0	0	0	0	0	0	10
Total	112	10	0	0	0	0	0	0	0	0	0	10