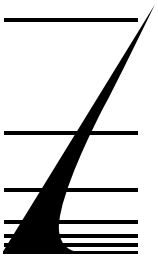
# The Market for Aviation Turboshaft Engines

Product Code #F642



A Special Focused Market Segment Analysis by:



FORECAST INTERNATIONAL

# Analysis 4
# The Market for
# Aviation Turboshaft Engines
# 2011-2020

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# PROGRAMS

The following reports are included in this section: (**Note:** a single report may cover several programs.)

General Electric T700/CT7
Honeywell T55 (Turboshaft)
LHTEC T800
MTR GmbH MTR390
Pratt & Whitney Canada PT6B/C
Pratt & Whitney Canada PT6T/T400
Pratt & Whitney Canada PW200
Rolls-Royce AE 1107
Rolls-Royce Model 250/RR300 (Turboshaft)
Rolls-Royce Turbomeca RTM322
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Turbomeca Arrius
Turbomeca Makila
Turbomeca TM333/Ardiden

# Introduction

This analysis discusses those trends influencing turboshaft engine design and production. The current and future competitive environment is also explored, in order to gain an understanding of the relationship between the market environment and engine production.

The aerospace industry tends to be cyclical, and production peaks and valleys are usually tied to world economic conditions. The current global economic slowdown has interrupted the normal cycle, creating a lower low that has pushed the recovery timeline to the right. Military engine programs are typically an exception to this up-and-down cycle; procurement normally happens over a period of several years. At the present time, military spending is accounting for a large percentage of current and future engine production.

Looking at the broader market, past performance is no guarantee of future production. However, it does show that the aircraft and engine ordering process tends to be cyclical, a fact that makes the task of predicting future events a bit less problematic.

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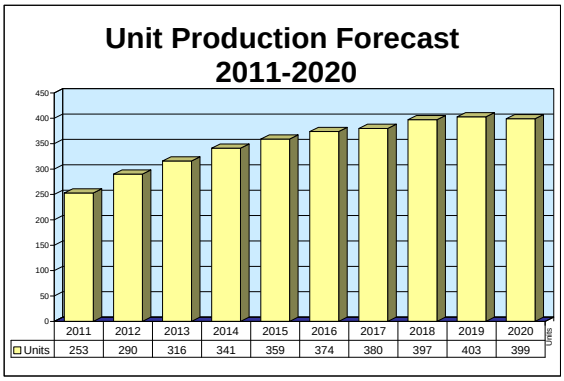
# Rolls-Royce Model 250/RR300 (Turboshaft)

## Outlook

- Bell Helicopter ends 430, 206B III production
- Robinson R66 will challenge Schweizer's 333/434 and Enstrom 480




## Orientation

**Description.** The Model 250 is a twin-shaft, axial-centrifugal and centrifugal-flow, free turbine turboshaft engine in the 200-shp (149-kW) to 700-shp (522-kW) class.

**Note:** *This report covers the Model 250 turboshaft version only. The Model 250 is covered in the "Rolls-Royce Model 250 (Turboprop)" report located in Tab C.*

**Sponsor.** Initial design work on the Model 250 was sponsored by the U.S. Department of Defense through the U.S. Army, Aviation Systems Command, St. Louis, Missouri, USA.

**Power Class.** 317-735 shp (236-548 kW).

**Status.** In production for several models of light civil and military helicopters.

**Total Produced.** As of December 2010, an estimated 38,067 Model 250/T63/T703 turboshaft engines were built by Rolls-Royce and its licensees, including engines produced by MTU in Germany and Mitsubishi in Japan.

**Application.** The Model 250 aviation turboshaft engine is used on civil and military helicopters. Previous applications have also included light fixed-wing aircraft.

| Model Variant | T-O Power Rating | Application | Units per Airframe |
|---|---|---|---|
| 250-C18/18A | 270 shp (201 kW) | MD Helicopters 500 | 1 |
| 250-C18B | 270 shp (201 kW) | Bell Helicopter Textron 206A JetRanger | 1 |
| 250-C18C | 270 shp (201 kW) | MD Helicopters 500 | 1 |
| 250-C20 | 385 shp (278 kW) | Agusta A109, A109A | 2 |
| | | Bell Helicopter Textron/Soloy 47/47G | 1 |
| | | Bell Helicopter Textron 206 JetRanger | 1 |
| | | Eurocopter BO 105C | 2 |
| 250-C20B | 420 shp (313 kW) | Agusta A109 II | 2 |
| | | Agusta NH500D/MD; NH500E | 2 |
| | | Bell Helicopter Textron 206B; 206B-III JetRanger | 1 |
| | | Bell Helicopter Textron 206L Long Ranger | 1 |
| | | Eurocopter BO 105C | 2 |
| | | Hiller/Rogerson Hiller UH12E/E4 | 1 |

## Rolls-Royce Model 250/RR300 (Turboshaft)

| Model Variant | T-O Power Rating | Application | Units per Airframe |
|---|---|---|---|
| | | Indonesian Aerospace NBO-105 | 2 |
| | | KAL 500D/MD | 1 |
| | | MBB BO 105 | 1 |
| | | MD Helicopters 500D/E | 1 |
| | | MBB BO 105 VBH; PAH-1 | 1 |
| 250-C20F | 420 shp (313 kW) | Eurocopter AS 355 | 2 |
| 250-C20J | 420 shp (313 kW) | Bell Helicopter Textron 206B-III JetRanger | 1 |
| | | Bell Helicopter Textron TH-57 Sea Ranger | 1 |
| | | Bell Helicopter Textron TH-67A Creek | 1 |
| 250-C20R | 450 shp (335 kW) | Agusta NH520N | 2 |
| | | Bell Helicopter Textron 206 LT Twin Ranger | 2 |
| | | Bell Helicopter Textron Eagle Eye | 2 |
| | | Eurocopter AS 355 | 2 |
| 250-C20R/1 | 450 shp (335 kW) | Agusta A109C; A109 C Max | 2 |
| 250-C20R/2 | 450 shp (335 kW) | Bell Helicopter Textron 206B-III JetRanger | 1 |
| | | Bell Helicopter Textron 206L Long Ranger | 1 |
| | | Kamov Ka-226 | 2 |
| | | MD Helicopters 500D/E | 1 |
| | | MD Helicopters 520NOTAR | 1 |
| 250-C20R/4 | 450 shp (335 kW) | Bell Helicopter Textron 206B III JetRanger | 1 |
| 250-C20W | 420 shp (313 kW) | Enstrom 480 | 1 |
| | | Schweizer 330/330SP; 333; RQ-8A | 1 |
| 250-C28B | 500 shp (372 kW) | Bell Helicopter Textron 206L-1 Long Ranger | 1 |
| 250-C28C | 500 shp (372 kW) | Eurocopter BO 105LS | 2 |
| | | MD Helicopters 530F | 1 |
| 250-C30G/2 | 557 shp (415 kW) | Bell 230 | 2 |
| 250-C30P | 600 shp (447 kW) | Bell Helicopter Textron 206L-III, IV | 1 |
| 250-C40B | 613 shp (457 kW) | Bell Helicopter Textron 430 | 2 |
| 250-C47B | 600 shp (447 kW) | Bell Helicopter Textron 407 | 1 |
| 250-C47M | 600 shp (447 kW) | MD Helicopters 600NOTAR | 1 |
| RR300 | 300 shp (223 kW) | Robinson R66 | 1 |

**Price Range.** The following are cost estimates of 250 series engines (in 2011 U.S. dollars): 250-C20/28 series, $225,000-$255,000; C30/C40 series, $285,000-$335,000; and T703 series, $300,000-$325,000.

**Competition.** The chief competition to the Model 250 is Turbomeca's Arrius and Pratt & Whitney Canada's PW206 and PW207.

# Contractors

## Prime

| | |
|---|---|
| **Rolls-Royce Corp** | http://www.rolls-royce.com/northamerica, PO Box 420, 2001 S Tibbs Ave, Indianapolis, IN 46206-0420 United States, Tel: + 1 (317) 230-2000, Fax: + 1 (317) 230-4020, Prime |
| **MTU Aero Engines GmbH** | http://www.mtu.de, Dachauer Strasse 665, Munich, 80995 Germany, Tel: + 49 89 1489 0, Fax: + 49 89 1489 5500, Email: info@muc.mtu.de, Licensee |

## Subcontractor

| | |
|---|---|
| **Argo-Tech Corp** | http://www.argo-tech.com, 23555 Euclid Ave, Cleveland, OH 44117-0798 United States, Tel: + 1 (216) 692-5803, Fax: + 1 (216) 692-5293 (Fuel Pump) |
| **Cabot Corp** | http://www.cabot-corp.com, Two Seaport Ln, Boston, MA 46904-9013 United States, Tel: + 1 (617) 345-0100, Fax: + 1 (617) 342-6103 (Investment Casting) |
| **Chromalloy Gas Turbine Corp** | http://www.chromalloys.com, 4430 Director Dr, San Antonio, TX 78219-3299 United States, Tel: + 1 (210) 333-6010, Fax: + 1 (210) 359-5570 (Compressor Wheel) |

| | |
|---|---|
| **Goodrich Engine Control Systems** | http://www.goodrich.com, Charter Oak Blvd, PO Box 330651, West Hartford, CT 06133 United States, Tel: + 1 (860) 236-0651, Fax: + 1 (860) 236-1062 (Main Fuel Pump MFP-262-64) |
| **Honeywell Aerospace** | http://www.honeywell.com/sites/aero/, 717 N Bendix Dr, South Bend, IN 46620 United States, Tel: + 1 (574) 231-2000, Fax: + 1 (574) 231-3335 (Power Turbine Governor) |
| **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 (Integral Turbine Components) |
| **Timken Super Precision (MPB)** | http://www.timken.com, 7 Optical Ave, PO Box 547, Keene, NH 03431-0547 United States, Tel: + 1 (602) 352-0310, Fax: + 1 (602) 355-4554 (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

Intake. Front annular steel intake with five struts.

Compressor. All models prior to the 250-C28 had one centrifugal and six axial compressor stages. Beginning with the 250-C28, a single titanium centrifugal compressor was employed. The 250-C30 has an improved centrifugal unit, allowing for a greater mass flow and higher pressure ratio. The 250-C28 pressure ratio is 8.4:1; 250-C30 is 8.5:1. Air mass flow is 4.5 lb/sec (2.04 kg/sec) and 5.6 lb/sec (2.54 kg/sec), respectively.

Combustor. Single aft-mounted cannular combustor of short length, with a single duplex fuel nozzle mounted on the aft face. It is ignited by a capacitor discharge with a low-tension exciter, utilizing a single plug. The ignition units are produced by Unison Industries. Series II engines have twin igniters.

Turbine. Both the gas generator and power turbines are composed of two-stage units. The power turbine drives the forward-mounted gearbox via the inner coaxial shaft. The cooled first-stage turbine was introduced with the 250-C28 and subsequent models, resulting in higher turbine inlet temperatures. Nickel-base alloy blades are employed.

**Dimensions.** The approximate dimensions and weights of the Model 250 turboshaft series are as follows:

| | Metric Units | English Units |
|---|---|---|
| **Series II** | | |
| Length | 1,035-1,037 mm | 40.756-40.81 in |
| Width | 477-527 mm | 18.784-20.76 in |
| Height | 574-589 mm | 22.596-23.20 in |
| Weight, dry | 71.6-73.5 kg | 158-162 lb |
| **Series IV** | | |
| Length | 1,097 mm | 43.198 in |
| Width | 559 mm | 21.996 in |
| Height | 632-660 mm | 24.88-25.99 in |
| Weight, dry | 111.1-114.7 kg | 245-280 lb |

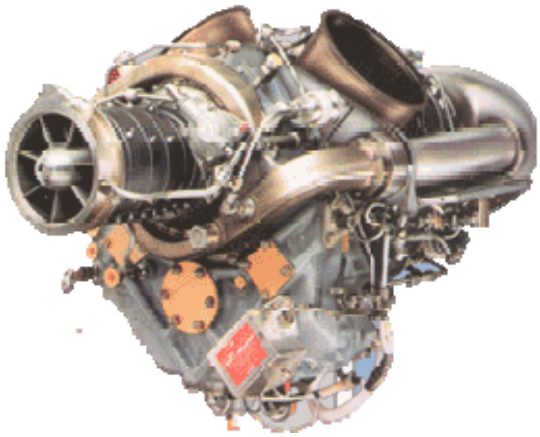
**Performance.** According to data in U.S. FAA Type Certificate Data Sheet E4CE, Revision 39, June 11, 2001, and Type Certificate Data Sheet E1GL, Revision 21, June 9, 2003, the Model 250 aviation turboshaft series of engines have the following performance parameters (first figure is shp, second figure is kW):

| | Max. Cont. at S/L | T-O 5-Min. at S/L | 30-Min. OEI at S/L | 2.5-Min. OEI at S/L | 30-Min. Intermediate at S/L |
|---|---|---|---|---|---|
| 250-C28 | 478 (356) | 500 (372) | 500 (372) | n/a | n/a |
| 250-C28B/C | 500 (372) | 500 (372) | 500 (372) | 550 (410) | n/a |

## Rolls-Royce Model 250/RR300 (Turboshaft)

| | Max. Cont. at S/L | T-O 5-Min. at S/L | 30-Min. OEI at S/L | 2.5-Min. OEI at S/L | 30-Min. Intermediate at S/L |
|---|---|---|---|---|---|
| 250-C30 | 650 (484) | 650 (484) | 650 (484) | 700 (522) | n/a |
| 250-C30G | 650 (484) | 650 (484) | n/a | n/a | n/a |
| 250-C30G/2 | 557 (415) | 650 (484) | n/a | 650 | n/a |
| 250-C30M | 600 (447) | 650 (484) | n/a | n/a | n/a |
| 250-C30P | 600 (447) | 650 (484) | n/a | n/a | n/a |
| 250-C30R/1 | 600 (447) | n/a | n/a | n/a | 650 (484) |
| 250-C30R/3 | 600 (447) | 650 (484) | n/a | n/a | 650 (484) |
| 250-C30R/3M | 600 (447) | 650 (484) | n/a | n/a | 650 (484) |
| 250-C30S | 650 (484) | 650 (484) | 650 (484) | 700 (522) | n/a |
| 250-C40B | 613 (457) | 715 (533) | 715 (533) | 770 (574) | n/a |
| 250-C47B/M | 600 (447) | 650 (484) | n/a | n/a | n/a |

n/a = not applicable



Rolls-Royce 250

Rolls-Royce

# Variants/Upgrades

The following are major variants of the Model 250 turboshaft engine (military variant designations immediately follow the commercial or civil designation):

**Series I Engines**

250-C10 (T63-A-5). The 250-C10 is an early version of the Model 250, rated at 250 shp (186 kW) at T-O and 212 shp (158 kW) at maximum continuous. Engine variant was certificated in 1962. Variant powered first few Hughes (now McDonnell Douglas Helicopter Systems) OH-6A aircraft.

250-C10B. The 250-C10B is the first engine in Series I to develop 317 shp (236 kW) at T-O and 270 shp (201 kW) at maximum continuous. It powered the OH-6A under the designation T63-A-5A. The 250-C10B was certificated in 1965.

250-C10D. The 250-C10D is similar to the 250-C10B, but was designed for the Bell Helicopter Company Model 206A-1 (OH-58A) series of light observation helicopters. Engine variant was certificated in 1968.

250-C18 Series. The 250-C18 is a 270-shp (at T-O) model used in the Fairchild FH-1100 and Bell Model 206A aircraft. The 250-C18B and 250-C18C are similar to the 250-C18 and 250-C18A, respectively, but provisions have been added for water-alcohol injection. The 250-C18 and 250-C18A variants weigh 141 pounds (63.96 kg); the 250-C18B and 250-C18C weigh 141.2 pounds (64.05 kg). The 250-C18 was license-built in Japan by Mitsubishi Heavy Industries under the designation CT63-M-5A.

250-C19. The 250-C19 is similar to the 250-C18, but the engine exhaust is directed downward. Engine weight is 144 pounds (65.3 kg).

CT63-M-5A. See 250-C18 Series, above.

T63-A-5A. See 250-C10B, above.

### Series II Engines

250-C20. The 250-C20 is similar to 250-C18, but has a larger diameter Stage 1 compressor and turbine wheels. It is rated at 385 shp (278 kW) at T-O. Shaft ratio for all 250-C20 variants is 5.53:1. It was certificated in 1970.

250-C20B. The 250-C20B is similar to the 250-C20 but its performance has been uprated to 420 shp (313 kW) at T-O and maximum continuous. Provision has been added for water-alcohol injection. It was certificated in 1974. This engine model is license-built in Germany by MTU under the designation 250-MTU-C20B.

250-C20F. The 250-C20F is similar to the 250-C20B, but incorporates a forward gearbox mounting point for use in the Eurocopter (Aerospatiale) AS 355/AS 555 TwinStar helicopters. Engine variant develops 420 shp T-O. It was certificated in 1979.

250-C20-R/1, R/2, R/4. The 250-C20R series is the highest rated of the Series II engines. Output ratings are 450 shp (335.5 kW) at T-O and at maximum continuous. Gas producer speed is 50,537 rpm at T-O and max continuous. The R/1 was certificated in 1986, the R/2 in 1987. The R/1 is similar to the 250-C20B engine variant but offers better performance. In addition, it features a new compressor that has two fewer stages than the 250-C20B and incorporates thicker airfoils, an optional-use rear mount, an increased-capacity No. 2 bearing, an abradable tip and seal coatings, and an electronic power turbine overspeed ($N_2$) system. The 250-C20R's compressor case is hard-coated with aluminum graphite, thereby increasing the variant's resistance to erosion.

The R/2 is similar to the R/1, but it does not have the R/1's electronic power turbine overspeed ($N_2$) system.

The R/4 is similar to the R/2, but the gear meshing frequency between the torquemeter gear and the PTO gear was changed from 5,000 Hz to 6,000 Hz; there was no change in output speed.

The 250-C20R was ordered by the Italian Army for 24 new Agusta A109 Mk IIs, and Germany is expected to convert its fleet of PAH-1 aircraft to the new engine standard. Eventually, almost all operators of Model 250-C20B-powered aircraft will eye a kit conversion program.

250-C20W. The 250-C20W variant develops a T-O power of 420 shp, but is derated to 285 shp (212 kW) at T-O and 250 shp (186 kW) at maximum continuous. The 250-C20W is similar to the 250-C10A, with the exception that the accessory gearbox spare pad has been deleted. The engine variant's rating is the same as that of the 250-C20F.

250-MTU-C20B. See 250-C20B, above.

T63-A-730. See 250-C20B, above.

### Series III Engines

250-C20R/S. A refined version of the C20R, the C20R/S, or "Super R," series entered the market in 2000. The C20R is improved with a larger centrifugal diffuser throat area, which helps boost the compressor air flow by 9 percent. Also featured are new first- and second-stage gas generator nozzles and new third- and fourth-stage power turbine nozzles and discs, raising maximum power by 20 percent. Finally, it is equipped with the Full Authority Digital Engine Control (FADEC) system of the C20R/9.

250-C28. The 250-C28 incorporates an advanced single-stage centrifugal compressor in place of the axial-centrifugal units on earlier models. The pressure ratio is increased to 8.4:1, and air mass flow to 4.33 lb/sec (1.964 kg/sec). It was certificated in 1976 at 500 shp (372 kW) at T-O. Maximum continuous power rating is 478 shp (356 kW).

250-C28B/C. The 250-C28B/C is similar to the basic 250-C28, but has a redesigned compressor, turbine, and combustor, which produce better SFC and 500 shp at T-O and maximum continuous. The 250-C28B has an integral particle separator, while the 250-C28C does not. The Model 250-C28B has SFC of 0.606 lb/shp-hr; 250-C28C, 0.602 lb/shp-hr. Both were certificated in 1978.

### Series IV Engines

The Series IV, the largest of the Model 250 engines, is virtually identical to the Series II layout configuration but has a one-stage centrifugal compressor rather than an axial/centrifugal compressor. These engines are FADEC-equipped.

250-C30. The Model 250-C30 is similar to the 250-C28C except for compressor and turbine changes, which result in an increased power rating of 650 shp (484.7 kW) at T-O. The basic 250-C30 was certificated in 1978; 250-C30P, 1981; 250-C30S, 1982; 250-C30M, 1983; 250-C30L and 250-C30R (with FADEC), 1983; 250-C30G, 1989. All models in the Model 250-C30 family provide 650 shp (484 kW) at T-O and (except for the 250-C30, 250-C30S, and 250-C30G) 600 shp (447 kW) at maximum continuous. Maximum power (2.5-minute power) for the 250-C30 series is 700 shp (522 kW) at gas producer speed of 51,550 rpm.

## Rolls-Royce Model 250/RR300 (Turboshaft)

The 250-C30G is similar to the 250-C30S but offers a 9,518-rpm PTO shaft speed and incorporates an overspeed No. 1 wheel internal energy-absorbing ring.

In 1989, a new Model 250 turboshaft designation was revealed: the 250-C30G/2. This engine variant has a T-O rating of 557 shp (415 kW) for use in the twin-engine Bell Model 230 helicopter (see **Program Review,** below). The 250-C30G/2 has a power output shaft speed (at 100 percent rpm) of 9,545 rpm, and a power turbine rotor speed of 30,737 rpm.

The 250-C30M is similar to the 250-C30 but has no 2.5- or 30-minute ratings. It is adapted for torque tube mounting and incorporates an overspeed No. 1 wheel internal energy-absorbing ring.

The 250-C30P is similar to the 250-C30 but has no 2.5- or 30-minute ratings. The 250-C30S is similar to the 250-C30 except for compressor changes, which result in a 5 percent new or overhaul performance margin.

The 250C-30R is similar to the 250-C30L but has an inducer fuel pump and filter.

The 250-C30U is similar to the 250-C30R, but has a 5-minute T-O rating, and certain critical parts have lower life expectancies.

Models 250-C30, 250-C30S, and 250-C30G are equipped with dual ignition and can be installed in all category rotorcraft. Engine models 250-C30P, 250-C30M, 250-C30L, and 250-C30R have a single ignition system.

The 250-C30 series powers the McDonnell Douglas Helicopter Systems Models 530F and 530MG/TOW and the Fantrainer 600, and the 250-C30P model variant powers the Bell 206L-3 LongRanger III. The Model 250-C30R carries the designation T703-A-700 for the U.S. Army's Bell OH-58A/D AHIP effort (see **Program Review**); the T703 can burn the following fuels: JP-4, JP-5, JP-8, ASTM-1655, and Types A, A1, and B.

250-C30R/3. The 250-C30R/3 engine was FAA certificated in 1997. This engine was specifically designed to increase the performance and safety of and reduce pilot workload on the OH-58D Kiowa Warrior scout helicopter. Improvements include a larger centrifugal diffuser throat area, which helps boost compressor air flow by 9 percent. Also featured are new first- and second-stage gas generator nozzles and new third- and fourth-stage power turbine nozzles and discs, which bring maximum power up by 20 percent.

250-C40B. The 250-C40B is similar to the 250-C30G/2, but the air flow path changes of the 250-C30R/1 have been incorporated. The engine has a 9,598-rpm power takeoff shaft speed at the 100 percent power turbine speed of 30,908 rpm. It has no 2.5-minute one-engine inoperative rating, but does have a 30-second one-engine inoperative rating; 2-minute inoperative ratings are added. It is equipped with a single-channel FADEC system, with manual backup. It has a T-O rating of 613 shp (457 kW).

250-C47B. The 250-C47B is similar to the 250-C30P, but the airflow path changes of the 250-C30R/1 have been incorporated, and it offers 6,317-rpm output shaft speed. It is equipped with a single-channel FADEC system, with manual backup. It has a T-O rating of 600 shp (447 kW).

250-C47M. The 250-C47M is similar to the 250-47B, but offers a 6,317-rpm output shaft speed at the 100 percent power turbine speed of 30,650 rpm. It has a T-O rating of 600 shp (447 kW).

T703 Series. See 250-C30, above.

# Program Review

**Background.** The Model 250/T63 turboshaft engine made by the General Motors Corporation, Rolls-Royce Gas Turbine Division, is the most widely used small main propulsion turbine in the world. Turboshaft versions are lightweight, ranging from 158 pounds (71.6 kg) for the 250-C20 to 252 pounds (114.3 kg) for the 250-C30R. Development began in the early 1960s when the Army sought a powerplant for a Light Observation Helicopter (LOH). The first version to be qualified was the T63-A-5, rated at 250 shp (186.4 kW), but this was soon superseded by the T63-A-5A variant with a rating of 317 shp (236 kW).

The Model 250 engine series is of modular construction, with the major units being the compressor module, gearbox module, turbine module, and combustion section. Maintenance or overhaul of a single module can be accomplished independently of the remainder of the engine.

In 1965, (then) Hughes Aircraft was awarded a contract for the OH-6A LOH, which was powered by the T63-A-5A engine. Spinoffs from this program were the Hughes 500 civil model and export versions of the OH-6A. A second LOH contract was awarded to Bell for an uprated version of the OH-58A, also using the T63. Some 2,200 OH-58As were built using the T63-A-700 engine, and again, the civil Bell 206 JetRanger and military export variants were spun off the original design.

In Germany, MTU Motoren- und Turbinen-Union provides about 33 percent of the components and assembles the Model 250 for the Eurocopter (MBB) BO 105/VBH/PAH-1 program. The VBH is a military liaison version of the BO 105, while the PAH-1 is the anti-armor variant.

**Model 250 Turboshaft Applications.** Among the current and proposed applications of the Model 250 turboshaft are the following:

Agusta A109. The A109 is a twin-engine, eight-seat, single-main-rotor design initially powered by two 250-C20Bs, aimed at the light executive and utility sector. In 1987, Agusta introduced an uprated Mk II model powered by 250-C20R/1 engines flat rated at 450 shp each, which, when combined with an uprated transmission, permits a gross TOW increase to 5,984 pounds from the earlier model's 5,720 pounds. The A109 Mk II Plus model also features the longer nose and fixed landing gear of the military A109K, and represents the first use of an electronic flight instrumentation system (EFIS) in the A109 line. The A109 is also offered with the Turbomeca Arriel 1K engine, the Turbomeca Arrius 2K, and the Pratt & Whitney Canada PW206C.

More than 540 commercial and military A109s powered by the Model 250 have been built and delivered.

Bell OH-58C Program. The protracted, and ultimately canceled, Advanced Scout Helicopter (ASH) project prompted the U.S. Army to initiate an interim measure to ensure adequate scout helicopter capability until more modern systems (e.g., AHIP) could be employed. A total of 275 OH-58As were converted to the OH-58C configuration, using the T63-A-720 powerplant and incorporating upgraded avionics and cockpit improvements.

Bell OH-58D AHIP. The cancellation of the Advanced Scout Helicopter in 1981 led to a decision to continue updating inventory helicopters to fill the ASH role. Under the Army Helicopter Improvement Program (AHIP), the Bell OH-58A/C was selected in 1981 to be upgraded to the OH-58D standard (approximately $3.5 million upgrade kit, including missiles and guns, or $6 million for newly armed OH-58D) with a McDonnell Douglas mast-mounted sight, a four-blade rotor system, and a "run dry" transmission. Under the AHIP program, the OH-58A/C helicopter airframe was extensively modified. The superstructure of the OH-58A/C remains the same, but its rotor system, engine, powertrain, and avionics components have been replaced either with equipment currently in use commercially or militarily, or with new technology components.

Powertrain modifications include a four-blade fiberglass composite main rotor and composite main rotorhub; an uprated drive system with a 435-horsepower (324-kW) main transmission; an uprated 110-horsepower (82-kW) tail-rotor drive system; a vibration isolation pylon mounting system; the Model 250-C30R 650-shp (484-kW) gas turbine; and provision for mounting a gun and rocket pods and/or anti-tank and air-to-air (FIM-92 Stinger) missiles (Stinger capability funded separately from AHIP).

The U.S. Army qualified an upgraded version of the T703 for the OH-58D under the Reliability and Maintainability Enhancement Program (RAMEP). The engine upgrade provided an 11 percent performance improvement for better operation in hot/high conditions. Phase One of the program focused on compressor improvements that resulted in lower turbine inlet temperatures. A new impeller was introduced to increase compressor air flow and improve surge margins. A second round of improvements begun in 1995 focused on turbine improvements. These included incorporation of an air-cooled first stage nozzle, some air cooling of the second stage nozzle, a redesigned power turbine wheel, a simplified shafting arrangement, brush seals, and an exhaust collection splitter. This second set of improvements produced an additional 8 percent performance increase. The addition of a FADEC unit has been considered. A Chandler Evans single-channel FADEC is on the civil 250/C40 (T703-AD-700C equivalent) engines on the Bell 430 equivalent to the OH-58D.

Original plans called for the conversion of 720 inventory aircraft, at a program cost of $1.1 billion. The Army subsequently opted for a $2.2 billion (FY86 dollars) outlay for only 578 units, with initial deliveries being made in 1985. In 1986, after the service noted that no AHIP funding would be included in its FY88 budget request, the Army announced that it planned to halt the OH-58D modifications upon completion of the 135th aircraft. In 1988, following an extensive study of its overall rotorcraft requirements, the service revised this figure upward to 477 units, with final deliveries planned for 1996. In FY89, the program was reduced once again, this time by the administration of George H.W. Bush, to 207 units. From FY90-FY93, however, Congress added 36 aircraft annually, followed by 24 in FY94, 18 in FY95, 33 in FY96, and 20 in FY97. The last of the 412 converted aircraft were delivered in the second half of 1999.

In 1997, an uprated Model 250 version, the 250-C30R/3, a T703 derivative, was FAA-certificated. The upgrades embody the developments from RAMEP, with some additional improvements. An initial order

## Rolls-Royce Model 250/RR300 (Turboshaft)

for 78 R/3 engines was placed in 1996. After certification, the U.S. Army placed an order for 604 C30R/3 engines. Re-engining was expected to be completed in 2005.

Bell 206 Series. This single-engine, five- to seven-seat, light commercial and utility helicopter was launched in 1965 as the Model 206A JetRanger. The highly popular series continues to be the Rolls-Royce Model 250's best-selling application; constant improvements have enabled the B206 to compete against some newer helicopters, while correcting earlier deficiencies. Licensees have had considerable success with the B206 series, and Agusta of Italy now produces the AB206B-III model using the 250-C20J.

Several Model 250-powered 206s have been offered. Introduced in 1976, the JetRanger II was the first Bell to be single powered by the Rolls-Royce Model 250-C20. The JetRanger III followed in 1977, powered by the improved 250-C20B engine. The current production JetRanger III is powered by the 313-kW 250-C20J and offers significantly improved hot/high performance. It is also faster, incorporates a larger tail rotor, and has an increased-capacity oil cooler blower and an improved transmission oil temperature gauge. Bell offers a retrofit kit for upgrading JetRanger II models to the current standard.

Announced in 1973 and certificated in 1975, the LongRanger variant featured a fuselage lengthened by 0.813 meters (2.667 ft), easily the most noticeable change over the JetRanger 206B. Power was provided by the Model 250-C20B rated at 420 shp. The 206L-1 LongRanger II was certificated in 1981, and used the uprated 250-C28B rated at 435 shp and a new transmission that absorbed 435 shp for takeoff, although the gearbox's max continuous power rating remained 370 shp. The water/alcohol system of the prior model was eliminated. This helicopter was phased out of production in 1983. The 206L-3 LongRanger III was introduced in 1982, powered by a Rolls-Royce Model 250-C30P rated at 650 shp. This model was superseded on the Bell line by the LongRanger IV in 1992. The 206L-4 LongRanger IV was fitted with a more powerful (366 kW/490 shp), long-life Rolls-Royce Model 250-C30P. The aircraft features an uprated transmission, permitting an increase in maximum takeoff weight to 4,450 pounds from the previous 4,150 pounds. The new LongRanger also offers better hot/high performance, greater payload capability, and lower overall maintenance costs. Bell delivered the first aircraft to a Malaysian customer in 1992.

Production began in 1988 of a multirole, single-engine Model 206 derivative, intended for anti-armor, ground support, air assault support, and scout missions. The aircraft, the Model 406CS, uses the Model 206 airframe, the OH-58D four-bladed rotor, an all-composite tail rotor, a new main transmission, and a single Rolls-Royce 250-C30 engine. Saudi Arabia ordered 15 Model 406CS aircraft, with deliveries in the 1990-91 timeframe. A second order came from Singapore for 20 aircraft for counterinsurgency (COIN) and light attack roles.

In 1993, the U.S. Army selected the Bell TH-206, a modified 206B-III JetRanger with a Model 250-C20J engine, to fill its New Training Helicopter (NTH) requirement. Designated TH-67 Creek, these aircraft replaced aging Bell TH-1 (Huey) trainers. All aircraft are powered by Rolls' Model 250-C20JN engine. Deliveries to the U.S. Army began in 1993.

The U.S. Army ordered 17 more TH-67 trainer helicopters in 2002, augmenting its existing fleet of 149 helicopters.

At least 775 Bell 206s have been built and delivered.

Bell 407/407T. Bell flew a Model 407 concept demonstrator, comprising components and subsystems of a 206L and an OH-58, in 1994, with the design launched that year. The manufacturer contained costs by making maximum use of the 206L-4 airframe, wedded to the main rotor and transmission of the Kiowa Warrior. The first true prototype 407 flew in 1995. The model was certificated and deliveries were begun in 1996. The planned twin 407T (which would likely have been powered by two 250-C22 engines) was superseded by the Bell Pratt & Whitney Canada PW206-powered Bell 427 variant.

At least 650 Bell 407s have been built and delivered.

Bell 230/430. From 1987 through 1989, Bell considered several upgrade options for its Model 222, including the use of Turbomeca TM333B and Pratt & Whitney Canada PW200 series turboshafts. The former was much more powerful and heavier than the original Lycoming LTS101 engine, while the latter would have needed to grow from the existing 500-600 shp to well over 700 shp to meet the improved 222 performance requirements. The other engine options included the Turbomeca Arriel rated at 734 shp and the Rolls-Royce Model 250-C30G, selected by Heli-Air, Broussard, Louisiana, USA, for its Model 222 retrofit program.

Bell officials did not want to give up the entire market to MBB and Aerospatiale (now Eurocopter), so they launched the Model 230 with the 250 engines equipping the Heli-Air 222. The production line is located at the Bell Textron facilities in Mirabel, Quebec, Canada. Orders for the 230 came quickly, with Mitsui of Japan ordering 20. The Model 230 made its first flight in 1991; the aircraft was modified from the No. 6

Model 222A. A second prototype was converted from the No. 3 Model 222UT.

Bell discontinued the two-bladed Model 230 in 1996 in favor of the four-bladed Model 430, which offers better hot/high performance, a larger cabin, and uprated Model 250-C40 engines mated to a more powerful transmission. The 430 was discontinued in early 2010.

Enstrom 480/TH-28. The Enstrom Helicopter Corporation (Menominee, Michigan, USA) 480 is a four-place, single-engine, single-main-rotor light helicopter powered by a Rolls-Royce 250-C20W engine (derated to 289 shp at T-O and 250 shp at maximum continuous). The aircraft, which made its initial flight in 1989, is intended for military training, commercial and personal transport, and law enforcement. The military trainer TH-28 variant was entered in the U.S. Army's NTH competition, but lost to Bell's 206 (TH-57). Enstrom continues to offer the TH-28 for military markets worldwide. Enstrom was granted FAA certification of the TH-28 in 1992. The 480B was certificated in early 2001 and is also powered by the Model 250-C20W, but uprated from 289 shp to 305 shp. In July 2003, Rolls-Royce received a firm order from Enstrom for engines to power 18 480Bs.

More than 90 480/TH-28s have been built and delivered.

Kamov Ka-226. Kamov's Ka-226 is a six-passenger helicopter with Kamov's standard counter-rotating twin main rotors and twin tail boom. It was developed from the Ka-26, but is equipped with French- and U.S.-manufactured avionics, as well as two Model 250-C20 turboshafts, rated at 450 shp (335 kW) each. Owing to several years of development delays, the Turbomeca Arrius 2G seems to have eclipsed the Model 250 as Kamov's engine of choice for this aircraft, though dual sourcing remains a possibility.

Russia's Ministry of Emergency Situations has ordered 25 aircraft, and gas producer Gazprom, 22 aircraft.

The Rolls-powered Ka-226 made its first flight in 1997. A batch of Model 250s (quantity unspecified) was ordered for the aircraft in 2000. In addition, in 2002, Kamov announced a deal with French engine-maker Turbomeca for the use of its Arrius 2G aboard the helicopter. The Arrius could be license-produced at the NPO Saturn engine bureau in Ukraine. This seems increasingly likely, as NPO Saturn/Kamov and Turbomeca have signed an agreement calling for the installation of Arrius 2G engines aboard Ka-226s. Discussions centering on coproduction of the Arrius at NPO Saturn's Rybinsk factory are ongoing. The indigenous Progress (ZMKB) AI-450 and Klimov VK-800 are also considered possible engines for the Ka-226, as are the Pratt & Whitney PW127 and a Pratt & Whitney/Klimov Ltd (P&WK) derivative of the PW200.

MD Helicopters Model 500/520N. The MD Helicopters Model 500/OH-6 is a four- to seven-seat, single-engine, single-rotor, commercial and military helicopter that has undergone significant change and improvement since its inception in the U.S. Army's Light Observation Helicopter competition in 1961. With nearly a dozen variants of the popular aircraft having been produced or announced, U.S. production of this Model 250-powered helicopter currently centers on the 500E/MD/MG, the 530F/MG Defender, and the 520N (NOTAR®). During the early days of the program, the OH-6A used the Model 250-C10B rated at 317 shp (236 kW); the current hot/high version of the 500 series uses larger main and tail rotors and the 250-C30 engine, rated at 650 shp at T-O but derated to 375 shp (279 kW).

The Model 520N, featuring the NOTAR (i.e., no tail rotor) forced-air torque-counteraction tailboom, was certificated in 1991. It is powered by the Model 250-C20R derated to 425 shp (317 kW) at takeoff and 350 shp (261 kW) maximum continuous. The Model 530N is another NOTAR design, but it is powered by the Model 250-C30.

Model 520N NOTAR customers have complained about too much power being required (about 30 percent) to be diverted at takeoff. At takeoff, power is diverted from the main rotor drivetrain to the fan, which pressurizes the tailboom. In response, Rolls-Royce is offering the improved Model 250-C20R/S, or "Super R," to replace the Model 250-C20R Series II on the MD520N. Improvements include a larger centrifugal diffuser throat area, which helps boost the compressor air flow by 9 percent. Also featured are new first- and second-stage gas generator nozzles and new third- and fourth-stage power turbine nozzles and discs, which bring maximum power up by 20 percent, to approximately 510 shp.

In early 1999, the entire Boeing line of commercial helicopters had been acquired by MD Helicopters, an indirect subsidiary of RDM Holdings of the Netherlands. MD Helicopters produces all the dynamic components and ships them to four licensees for assembly. Kawasaki builds the 500D/OH-6D for both the Ground and Maritime Self-Defense Forces, in addition to building a few for domestic civil use. The Japanese company delivered 270 to the Japanese armed forces up to 1993. Agusta's Monteprandone facility, formerly known as BredaNardi, has produced the 500 series for several years, in both military and civil versions, for domestic and export markets, and recently

## Rolls-Royce Model 250/RR300 (Turboshaft)

added the 520N to its license. This firm was also designated the 500E/530F distributor for Central Europe. Argentina's RACA assembled 60+ Model 500C and D helicopters from McDonnell Douglas Helicopter-supplied kits, and recently began distributing United States-built Model 500E helicopters in Argentina. Korean Air Lines assembled 307 500D and MD models through 1988.

At least 3,775 aircraft in this model series have been built and delivered, including aircraft by Agusta, KAL, KHI, and RACA.

MD Helicopters MD600N. McDonnell Douglas Helicopter Systems launched the MD630N in early 1995. Later in 1995, the designation was changed to MD600N when the engine used was switched from the 650-shp (485-kW) Model 250-C30 to the 791-shp (590-kW) Model 250-C47. For the MD600N (now MD Helicopters), the Model 250-C47 is derated to 600 shp (447 kW) for takeoff and 575 shp (429 kW) for cruise. In the helicopter's powertrain, a sixth blade has been added to the main rotor, along with a 600-shp (447-kW) transmission.

The MD600N is a larger, eight-seat version of the MD520N NOTAR helicopter. A 30-inch (76-cm) center plug is added to the MD520N fuselage. McDonnell Douglas claimed direct operating costs of $220-$230 an hour, the lowest direct operating costs in the helicopter's class. Prototype testing enabled McDD to eliminate the yaw stability augmentation system used in the MD520N, reducing the complexity and cost of the aircraft.

The MD600 competes with the Eurocopter AS 350 AStar and the Bell 206L LongRanger.

More than 70 MD600Ns have been built and delivered.

Northrop Grumman VTUAV. Northrop Grumman's prototype VTUAV (vertical takeoff and landing tactical UAV) was designed and manufactured by Schweizer Aircraft Corporation. The air vehicle is a derivative of the company's Model 333 manned helicopter.

In 2000, the Northrop Grumman team was selected as the winner of the U.S. Navy's VTUAV competition. Under the contract, Northrop Grumman is building one complete Model 379 VTUAV system. This system includes three air vehicles, two ground stations, and remote data terminals, as well as three multimission payloads, including electro-optical and infrared systems with laser designation capability.

Together, the U.S. Navy and Marine Corps have considered procuring 23 systems, but changing Navy requirements threatened the program in 2002. The Navy has become interested in a more capable, longer-range system, but the Marine Corps and a few nations continue to consider the UAV.

Schweizer Model 330/333. The Schweizer Aircraft Corporation (Elmira, New York) Models 330 and 333 are three- to four-seat, single-engine, commercial and military utility helicopters. The Model 300C aircraft design was purchased by Schweizer several years ago from the company then known as Hughes, and the turbine-powered Model 330 was announced in 1987. The 330's first prototype flight was made in 1988. The aircraft received its FAA certification in 1992, with first customer deliveries in 1993. Schweizer announced a flyaway cost of $520,000 for the new aircraft, "$200,000 less than a Bell 206 or MD500," with direct operating costs of $130 per flight hour. The first military TH-330 sale was made in 1994, when the Venezuelan Army ordered three aircraft for pilot training.

At the beginning of 2000, Schweizer announced the uprated Model 333, offering a 100-pound increase in useful load and featuring a redesigned rotor system and larger diameter blades. Certification was granted in September 2000, followed by initial deliveries. Two aircraft were ordered by the Houston (Texas) Police Department in the spring of 2000.

At least 50 Model 330/333s have been built and delivered.

Robinson R66 Raven. Robinson's R66 is a larger, turbine-powered evolution of the piston-powered R44 model. The new helicopter uses the new 300-shp (225-kW) RR300 engine developed by Rolls-Royce rather than a piston engine. This RR300 is much lighter than the six-cylinder piston engine found in the R44, but it also consumes a little more than 50 percent more fuel. The additional power provided by the RR300 will offer substantially improved performance in operations in hot temperatures and/or high altitudes over the R44.

# Funding

No military funding for the Model 250 turboshaft series has been identified.

# Timetable

| Month | Year | Major Development |
|---|---|---|
| | 1958 | U.S. Army development contract awarded |
| | 1959 | Engine first run |
| Dec | 1962 | 250-C10 certificated by U.S. FAA |
| | 1963 | Engine tested on board Hughes (MDHC) Model 369 |
| Sep | 1963 | T63-A-5 certificated |
| Nov | 1968 | Hughes (MDHC) Civil Model 500 aircraft enters production |
| Aug | 1974 | 250-C28 certificated |
| May | 1976 | 250-C28B and 250-C28C certificated |
| Jun | 1983 | 250-C30S certificated |
| Jul | 1983 | 250-C30L, 250-C30R certificated |
| Mar | 1984 | Flight tests of 250-C34-powered Sikorsky S-76 |
| Dec | 1989 | First flight of Allison-powered Enstrom TH-28 |
| Feb | 1993 | Bell Model 430 program launched |
| Mar | 1995 | MD630N (now MD600N) program formally launched |
| Feb | 1996 | Bell 407 certificated, deliveries begin |
| Aug | 1996 | Bell Model 430 certificated |
| | 2000 | Schweizer 333 announced |
| Oct | 2010 | R66 receives FAA type certification |

# Worldwide Distribution/Inventories

As of December 2010, an estimated 38,067 Model 250/T63/T703 turboshaft engines were built by Rolls-Royce and the former Allison and their licensees. Model 250 turboshaft engines are in the inventory of over 90 nations worldwide, including many nations' military services.

# Forecast Rationale

Rolls-Royce's Model 250 turboshaft continues its lengthy production run powering a dozen different aircraft. The M250 is a popular engine on light singles, and competes with Pratt & Whitney Canada's PW206/PW207 and Turbomeca's Arrius in the 400-700-shp power range. The end of production of Bell's 430 means the M250 powers only one remaining twin, Kamov's Ka-226, an application it shares with the Arrius 2G1.

The Ka-226 is a contender for India's light utility helicopter competition, and will compete with Eurocopter's AS 550 and AgustaWestland's AW119 for the 197-aircraft contract.

MD Helicopters has been a good customer for Rolls-Royce; its entire line, save for the MD900, is powered by Rolls-Royce's M250. MD Helicopters may offer a variant of its MD500 to the U.S. Army Armed Aerial Scout program.

### *First RR300 Application*

Robinson Helicopter Company's latest design, the R66 Raven, earned its type certification from the U.S. FAA in October 2010, and will be the least expensive turbine helicopter available. Essentially an R44 with a turboshaft engine, the R66 is the first application of Rolls' new RR300 and will be a major force in the turbine training segment.

### *Bell's 206B Is History*

Bell Helicopters has built many variants of the original JetRanger helicopter powered by the M250. While the 206B III ended production in early 2010, the 206L III/L IV and 407 singles continue on. The 206B III had been losing ground to competing aircraft from Eurocopter, and the recent debut of Robinson's R66 would certainly have lead to more market losses for the LongRanger.

Edstrom’s 480 and Schweizer's 333/434 will benefit from Bell's decision to drop the 206 BIII, but they will also be challenged by Robinson's new R66.

Overall, we expect production of 3,512 Model 250 turboshaft engines during the forecast period.

Rolls-Royce Model 250/RR300 (Turboshaft)

# Ten-Year Outlook

| ESTIMATED CALENDAR YEAR UNIT PRODUCTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Designation or Program** | **High Confidence** | | | | | **Good Confidence** | | | **Speculative** | | | |
| | **Thru 2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **Total** |
| **Rolls-Royce Corp** | | | | | | | | | | | | |
| **250 -C -20B <> 500E** | | | | | | | | | | | | |
| | 629 | 5 | 4 | 4 | 4 | 6 | 7 | 7 | 8 | 8 | 8 | 61 |
| **250 -C 20R <> 520N** | | | | | | | | | | | | |
| | 118 | 7 | 7 | 7 | 7 | 9 | 9 | 10 | 11 | 12 | 11 | 90 |
| **250 -C 20R/2 <> Ka-226** | | | | | | | | | | | | |
| | 78 | 10 | 9 | 12 | 16 | 17 | 18 | 17 | 19 | 19 | 18 | 155 |
| **250 -C 20R/2 <> SW-4** | | | | | | | | | | | | |
| | 12 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 6 | 7 | 7 | 40 |
| **250 -C 20R/2 Military <> SW-4** | | | | | | | | | | | | |
| | 27 | 3 | 4 | 5 | 5 | 3 | 3 | 2 | 2 | 3 | 3 | 33 |
| **250 -C 20W <> 434** | | | | | | | | | | | | |
| | 13 | 6 | 6 | 4 | 6 | 7 | 7 | 6 | 5 | 4 | 5 | 56 |
| **250 -C 20W <> 480** | | | | | | | | | | | | |
| | 172 | 15 | 15 | 16 | 16 | 16 | 17 | 18 | 19 | 21 | 21 | 174 |
| **250 -C 20W <> S-333** | | | | | | | | | | | | |
| | 4 | 3 | 4 | 6 | 7 | 7 | 6 | 5 | 6 | 7 | 7 | 58 |
| **250 -C 20W <> S-434** | | | | | | | | | | | | |
| | 2 | 3 | 3 | 4 | 5 | 5 | 4 | 4 | 5 | 4 | 6 | 43 |
| **250 -C 20W Military <> MQ-8** | | | | | | | | | | | | |
| | 17 | 7 | 8 | 8 | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 37 |
| **250 -C 20W Military <> S-333** | | | | | | | | | | | | |
| | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 22 |
| **250 -C 20W Military <> S-434** | | | | | | | | | | | | |
| | 8 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 38 |
| **250 -C 30 <> 530F** | | | | | | | | | | | | |
| | 121 | 6 | 7 | 6 | 6 | 7 | 7 | 6 | 6 | 7 | 7 | 65 |
| **250 -C 30P Military <> 206 L III** | | | | | | | | | | | | |
| | 868 | 13 | 13 | 15 | 16 | 16 | 18 | 20 | 21 | 20 | 13 | 165 |
| **250 -C 47B <> 407** | | | | | | | | | | | | |
| | 1,701 | 72 | 71 | 80 | 84 | 88 | 89 | 91 | 92 | 93 | 93 | 853 |
| **250 -C 47B Military <> 407** | | | | | | | | | | | | |
| | 75 | 10 | 17 | 9 | 8 | 4 | 5 | 5 | 5 | 4 | 5 | 72 |
| **250 -C 47M <> 600N** | | | | | | | | | | | | |
| | 89 | 4 | 5 | 4 | 4 | 5 | 6 | 6 | 6 | 7 | 7 | 54 |
| **RR300 <> R66** | | | | | | | | | | | | |
| | 36 | 81 | 110 | 128 | 140 | 154 | 169 | 174 | 179 | 180 | 181 | 1,496 |
| **Subtotal** | 3,972 | 253 | 290 | 316 | 341 | 359 | 374 | 380 | 397 | 403 | 399 | 3,512 |
| | | | | | | | | | | | | |
| **Total** | 3,972 | 253 | 290 | 316 | 341 | 359 | 374 | 380 | 397 | 403 | 399 | 3,512 |

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