OWNER'S & OPERATOR'S GUIDE: ATR FAMILY

ATR 42 & 72 specifications

There are six prominent variants of the ATR 42 & 72. There specifications are examined.

The ATR 42 & 72 comprise one of the few families of turboprop aircraft. They share the same basic design, flightdeck, wing, fuselage, tail and empennage and have a high degree of commonality between their rotable components and engines. Both have a range of up to 900nm with their respective full passenger loads. The ATR 42 seats 46-50 passengers, depending on interior layout, while the ATR 72 seats 60-72. They have cruise speeds of 265 to 280 knots, and so can operate routes of up to 350nm in a flight time of 90 minutes. They also have extensive pilot commonality.

The initial ATR 42 and 72 models were launched in the mid-1980s, when regional carriers in the US were forming alliances with major airlines. US carriers were also undergoing consolidation. Regional affiliates served as feeders of major hubs on routes to spoke cities that had the lowest traffic volumes. In the early 1980s US regionals developed their networks, and increased aircraft size as traffic volumes grew. The main regional workhorses changed from 19-seaters to 30-seaters and became 40- to 50-seaters as the ATR 42 and 72 were launched.

Regional carriers were also changing from commuter-type operators, using 20- and 30-seat aircraft, to larger airlines operating wider route networks with larger aircraft. The ATR 42 was popular with US airlines, while regional carriers in Europe, with their higher inherent costs, preferred the larger ATR 72. The US and Europe have been their most important markets, but they have also sold well in India and the Asia Pacific.

There are two main variants of the ATR 42, the -300 and -500, and two main variants of the ATR 72, the -200 and -500. There are, however, three ATR 42 passenger variants and three ATR 72 passenger variants *(see table, page 5)*.

ATR 42

The ATR 42 and 72 are based on a four-abreast fuselage with a high-mounted wing, and are powered by two turboprop engines. Their basic take-off thrust rating is 1,800-2,475 shaft horse power (SHP), depending on aircraft variant *(see table, page 5)*.

All ATR 42 variants have a cargo door and compartment at the forward section of the fuselage as standard, with the passenger cabin behind and door with integral stairs at the rear. The forward cargo compartment has a central passage to allow access to the flightdeck. The compartment can be one or two seat rows deep, so it affects the floor area available for seating, and can vary between two halves each of 63.5 cubic feet up to two halves of 106 cubic feet.

The aircraft also has several interior configurations, depending on the size and type of galley and toilet installed. These all affect seat numbers, which can vary between 42 and 50. These are all with the same galley at the rear of the fuselage and stowage compartment.

Given the ATR 42's prime use as a hub feeder on routes of up to 250nm, the baggage volume available is not of major importance for most operators. This implies that high seat-density variants of 48 and 50 seats are more likely.

The first ATR 42 variant was the -300, with a maximum take-off weight (MTOW) of 36,815lbs, maximum zero fuel weight (MZFW) of 33,510lbs and operating empty weight (OEW) of 22,675lbs *(see table, page 5)*, providing a structural payload of 10,835lbs. The aircraft has a usable fuel capacity of 1,481 US Gallons (USG), which is standard for all ATR 42 variants.

The aircraft is powered by two Pratt & Whitney Canada PW120 engines, rated at 1,800shp, and equipped with a four-blade 14SF-5 propeller with a 13-foot diameter. The ATR 42-200 has a cruise speed of 265 knots *(see table, page 5)*, and a take-off field length of 3,575 feet when operating at sea level and a standard temperature of 15 degrees centigrade (ISA). This rises to 4,265 feet in hot and high conditions of ISA plus 10 degrees and an elevation of 3,000 feet. This is relatively short compared to most commercial airfields. The -200 has a landing distance of 3,392 feet at sea level and maximum landing weight (MLW) *(see table, page 5)*.

The ATR 42-210 with a PW121 engine rated at 1,900shp was launched two years after the ATR42-200. The -210 shares the same basic specifications and performance characteristics as the -200, although it has marginally shorter take-off and landing distances.

The third main civilian version of the ATR 42 is the -500 series, launched in 1993. It included several improvements over the -200/-210, one of the most

The ATR 42-500 and 72-500 are powered by the PW127E/F, utilising a six-bladed propeller. The ATR 42-500 has a 34-38 knot faster cruising speed than its -300/-320 counterpart variants. The six-bladed propeller lowers specific fuel consumption and noise emissions.

important being the use of a PW127E engine rated at 2,160shp and equipped with a six-blade 568F propeller. This gives the -500 a higher MTOW of 41,005lbs and a faster cruising speed of 303 knots, enabling routes of up to 410nm to be operated in 90 minutes. The six-blade prop reduces interior vibration. The -500 has a Stage III noise margin of 31.3EPNdB, and a Stage IV margin of 21.3EPNdB *(see table, this page)*.

The -500 series has the same fuel capacity as the -200/-210 series, but its higher MTOW increases its range capability. The ATR 42-500 has take-off and landing distances of 3,710 feet and 3,592 feet *(see table, this page)*.

The -500 series also differs from the -200/-210 series in that the PW127E engines produce lower gaseous emissions, have a lower specific fuel consumption, and give the aircraft a faster climb and cruise speed. The 500's higher gross weight gives it a longer range capability.

The main commonality features are common maintenance architecture, pilot ratings, engines and rotable components.

The ATR 42-500 has a common type rating with the ATR 72-500, so a pilot certified to operate one is automatically certified to operate the other. Pilots, however, still have to attend a differences course, and also have to remain current on both types.

The ATR 42-500 also has cross-crew qualification (CCQ) with the ATR 42-300/-320 and the ATR 72-200/-210.

ATR 42 & 72 FAMILY SPECIFICATIONS

Aircraft variant	ATR 42 -300	ATR 42 -320	ATR 42 -500
MTOW lbs	36,815	36,815	41,005
MZFW lbs	33,510	33,510	36,817
OEW lbs	22,675	22,685	24,802
Structural payload lbs	10,835	10,825	12,015
Usable fuel USG	1,481	1,481	1,481
Engine	2 X PW120	2 X PW121	2 X PW127E
Cruise speed knots	265	269	303
Seats	46-50	46-50	46-50
Aircraft variant	**ATR 72 -200**	**ATR 72 -210**	**ATR 72 -500**
MTOW lbs	47,400	47,400	48,501
MZFW lbs	43,430	43,430	44,092
OEW lbs	27,337	27,447	28,549
Structural payload lbs	16,093	15,983	15,543
Usable fuel USG	1,646	1,646	1,646
Engine	2 X PW124B	2 X PW127	2 X PW127F
Cruise speed knots	277	278	276
Seats	64-72	64-72	64-72

ATR 72

The ATR 72 is a stretch development of the ATR 42. The ATR 72-200 was launched in 1985 and entered service in 1989. It offers a passenger or cargo door at the front of the fuselage. As with the ATR 42, there is a central passage through the cargo compartment for access to the flightdeck. The ATR 72-200/-210, however, have the option of a front passenger door and rear cargo compartment. The ATR 72-500 has the front cargo compartment as standard.

The front cargo compartment varies in size, so the floor space available for seating varies. With a front passenger door, most configurations allow 66 seats with a seat pitch of 31 inches, and 74 seats with a 30-inch seat pitch. With a front cargo door the number of seats will be as low as 60 with a high seat pitch, although 66 are still possible. With a lower pitch seat numbers can rise to 72.

The ATR 72-200 has an MTOW of 47,400lbs, MZFW of 43,430lbs, OEW of 27,337lbs and a structural payload of 16,093lbs. The aircraft has a standard fuel capacity of 1,646USG, giving it a range of 900nm with 66 passengers.

The -200 is powered by the PW124B engine, equipped with a four-blade Hamilton Standard 14SF-5 propeller, and has a cruise speed of 277 knots.

The ATR 72-200 has a take-off field length of 4,626 feet at sea level and ISA conditions, and a landing distance of 3,963 feet. Take-off field length is 5,735 feet at hot and high conditions of 3,000 feet and ISA plus 10 degrees.

The ATR 72-210 entered service in 1992. It has the same weight and fuel capacity specifications as the -200 series, but the -210 uses the more powerful PW127 engine. This is a higher rated variant of the engine used to power the ATR 42-500, which entered service in 1995. The PW127 on the ATR 72-210 is rated at 2,475shp, and has the same propeller as the PW124B powering the -200 series. It gives the -210 more power, so it has a shorter take-off run, and the same cruise speed as the -200 series.

A main benefit of the -210's higher engine power is that its take-off field length is reduced by 700 feet, and its landing distance by 500 feet compared to the -200 series *(see table, this page)*.

The ATR 72-500 was launched shortly after the ATR 42-500. Like the ATR 42-500, the ATR 72-500 provided many improvements over earlier models.

The ATR 72-500 entered service in 1997. It has a high MTOW of 48,501lbs, an MZFW of 44,092lbs, an OEW of 28,549lbs and a structural payload of 15,543lbs *(see table, this page)*.

The ATR 72-500 is powered by two PW127F engines, rated at 2,475shp, the same rating as the PW127 powering the -210. These have a six-blade Hamilton Standard 568F propeller, which results in lower cabin noise. The -500 has a Stage III margin of 26.6EPNdB, and a Stage IV margin of 16.6EPNdB, so it comfortably meets all future noise requirements.

The -500 series has the same standard fuel capacity of 1,646USG as all other ATR 72 variants, which gives it a range of 900nm with 68 passengers. The ATR 72-500 has marginally longer take-off and landing field lengths than the -210, but shorter than the -200 series *(see table, this page)*.

The other main benefits of the ATR 72-500 are a common type rating with the ATR 42-500 and the ATR 72-200/-210. The ATR 72-500 also has CCQ with the ATR 42-300/-320.

There is also a higher gross weight variant of the ATR 72-500, with an MTOW of 49,604lbs, a higher MZFW and structural payload of 16,203lbs.

Freight capacities

The ATR 42 and 72 can also be operated as freighters, and are available as quick change variants. The forward cargo door allows the removal of the aircraft's seats, partition and cargo net of the forward cargo compartment. A ball mat and floor locks are added, to provide space for freight containers.

The aircraft utilise a standard 43-inch deep, 50-inch tall and 83.5 inch wide freight container, giving total capacity of 99 cubic feet. The ATR 42 can hold nine containers, giving a total freight volume of 891 cubic feet. The ATR 72 holds 13 such containers, giving a total freight volume of 1,287 cubic feet *(see table, this page)*. Freight packed at a density of 7lbs per cubic foot gives the ATR42 a net structural payload of 6,237lbs, and the ATR 72 9,009lbs. AC

ATR 42 & 72 fleet analysis

The ATR fleet is divided almost equally between 42s and 72s. The majority of aircraft on order, however, are the ATR 72-500.

There have been 696 ATR 42s and 72s built, of which 647 are in active service or in storage. The ATR 42 and 72 each account for about half of these aircraft. Another 49 aircraft have been destroyed or retired, while a further 118, mostly ATR 72s, are on order and awaiting delivery.

The fleet of ATR 42s and 72s can be subdivided between their respective sub variants as outlined below.

ATR 42

There are 316 ATR 42s in active service, and another 21 aircraft that are temporarily inactive or in storage.

There were 112 PW120-powered ATR 42-200s built, between 1985 and 1995, 96 of which are still in operation. The ATR 42-200 was the first ATR variant in production. Most active aircraft have accumulated 20,000-35,000 flight hours (FH), and a higher number of flight cycles (FC). Most aircraft have been operated at average FC times of 0.75-0.90FH.

The ATR 42-200 is operated by a variety of airlines, including Aero Caribbean, Total Linhas Aereas, Danish Air Transport, First Air, Aer Arann and European Air Express.

There were 86 ATR 42-210s built, 82 of which remain in service. These aircraft were built between 1986 and 1996, and have accumulated similar FH and FC to the -200 aircraft, while operating at similar average cycle times. The aircraft that remain in service are operated by a large number of airlines, including Israir, Trip Linhas Aereas, Air Madagascar, Olympic Airlines, Alliance Air and Air Deccan.

There are a further 32 ATR 42-200Fs in service, which were built between 1986 and 1993. The majority of these aircraft are operated by FedEx and Air Contractors. There are another 11 ATR 42-210Fs in operation, eight of them with FedEx.

The ATR 42-500 is the only ATR 42 variant still in production. Since the first deliveries were made in 1994, a total of 95 have been delivered. The largest operators are Aeromar, Airlinair, Air Deccan, Eurolot, Tarom, and CSA Czech Airlines. Many of these aircraft have been operated on longer average cycle times than the -200 and -210 fleets, with some airlines operating their aircraft for up to 75 minutes. The highest-time aircraft have accumulated 21,000FH.

There are a further 15 ATR 42-500s on order. Most of these aircraft are with Precision Air Services, Pakistan International Airlines and Finnish Commuter Airlines.

ATR 72

There are 307 ATR 72s in service, three in storage and another 103 on order.

The fleet of active aircraft is split between three sub-variants. The -500 is the only variant still in production.

There are 91 ATR 72-200s in service, built between 1989 and 1998. Most of these aircraft have accumulated 15,000-27,000FH and have operated at cycle times of 0.70-0.95FH. The fleet is dispersed between a large number of operators, which include Euromanx, Aero Airlines, Airlinair, JAT Airways, Olympic Airlines, Eurolot, Cimber Air and Vietnam Airlines.

There were 73 ATR 72-210s built, 71 of which are still in service. These have been operated at similar rates of utilisation to the -200 and have accumulated a similar number of FH and FC. The largest operators are Executive Airlines (which flies for the American Eagle network), Atlantic Southeast Airlines (which flies for Delta Connection), Iran Aseman Airlines, Alitalia Express, and Yangon Airways.

The ATR 72-500 is the most successful ATR 72 variant to date, with a total of 234 orders. There are 130 aircraft in active service and a further 103 on order, with the ATR 72-500 accounting for most of the resurgence in sales. The first ATR 72-500s were built in 1996 and the highest-time aircraft has accumulated 17,000FH. Like the ATR 42-500, the aircraft have been operated at longer average cycle times than their older and lower gross weight counterparts.

The largest ATR 72-500 operators are Executive Airlines, China Southern, Transasia Airways, Air Dolomiti, Air Nostrum, Mount Cook Airline, Alitalia Express, Binter Canarias and Bangkok Airways.

A further 103 72-500s are on order, with turboprop sales having seen a resurgence over the past two years. Customers include Air Deccan, Tarom, Kingfisher and Aer Arann. AC

ATR 42 & 72 FLEET SUMMARY

	ATR 42 -300	ATR 42 -320	ATR 42 -500	ATR 42 -300F/ -320F	Total
In service	96	82	95	43	316
Temporarily inactive	1	2			3
In storage	15	2	1		18
On order				15	15
Total	**112**	**86**	**96**	**58**	**352**
	ATR 72 -200	**ATR 72 -210**	**ATR 72 -500**	**ATR 72F**	**Total**
In service	91	71	130	15	307
Temporarily inactive	1	1			2
In storage		1			1
On order				103	103
Total	**92**	**73**	**130**	**118**	**413**

ATR family modification programmes

Besides several avionic upgrade programmes which all aircraft must be compliant with, the only major modification programmes for the ATR 42 & 72 are a selection of Class C & E freighter modifications.

The two ATR models have led to a wide range of cargo modification programmes, including an original equipment manufacturer (OEM) large door freighter, several varieties of bulk freight carrier, a modular series of combis, and a rapidly installed cargo loading system that leaves much of the passenger interior in place.

Engine and airframe

There are no major issues with the ATRs' engines. Pratt & Whitney Canada's fleet enhancement programme (FEP) gives operators the opportunity to trade in old engines, typically in conjunction with a shop visit. Under the FEP the value assigned to the old engine depends on its condition and utilisation status. An engine exchange also offers an opportunity for operators to join PWC's Eagle Service Plan (ESP) programme, under which they make a monthly payment based on a fixed rate per flight hour (FH) to cover most maintenance and overhaul eventualities.

A service bulletin (SB) requires the replacement of corrosion-prone ribs in the flaps with ribs of a more corrosion-resistant material. This is a manpower-intensive task costing EUR 40,000-65,000 ($52,000-85,000), depending on the extent of the corrosion. Sabena Technics has been the only maintenance provider approved to undertake the work, but Air New Zealand, Cimber Air Maintenance Center in Denmark and M7 Aerospace in San Antonio, Texas, have been, or are about to be, added to the list of shops approved to incorporate the SB.

Cargo conversions

The ATR 42's cabin has a maximum width of 101.2 inches and is 89 inches wide at floor height. It includes a 219 cubic foot (cu ft) baggage/cargo compartment immediately aft of the cockpit, accessed by a door 50.2 inches wide and 60.2 inches high, at a sill height of 47.2 inches. The compartment is shortened in aircraft configured for more than 46 passengers.

There is a second cargo/baggage compartment in the tapered section of the rear fuselage, along with an airstairs passenger door measuring 29.5 inches by 60.2 inches. The aft cargo compartment has a volume of 85 cu ft in all but two of the aircraft below MSN 115. In later aircraft the baggage area is extended aft to provide 169.5 cu ft. The length aft of the flight deck to the rear of the aft baggage compartment is 45 feet, 5 inches in the aircraft with the shorter compartment, and 48 feet, 4.5 inches in the later examples.

The ATR 72's cabin has the same widths but is 17 feet, 7 inches longer, extending 63 feet from the rear of the flight deck to the rear of the aft compartment. Baggage compartment volumes are similar to those of the later 42s, and most ATR 72s also have a cargo door forward and a passenger door aft. However, 22 have a forward airstairs passenger door instead of a cargo door.

Both models are offered in quick change (QC) configuration (option 03-011 container transport capability), with the floor strengthened to support 66lbs per square inch and class E fire protection, which involves extending the existing smoke detection system and installing isolating valves in the air conditioning system.

Class E certification, applicable to freighters, requires that the smoke detection system alert the flight crew within 60 seconds of smoke first appearing in the cargo compartment. Aircraft carrying passengers must have class C systems, which add fire suppression systems able to suppress combustion to controllable levels and prevent reignition or spreading of the combustion for at at least 60 minutes.

The 99 cu ft containers have a tare weight of 168lbs and maximum gross weight of 1,102lbs. The ATR 42 can carry nine for a total containerised volume of 891 cu ft, while the ATR 72 can carry 13, providing 1,287 cu ft. Both can also carry bulk freight in the aft cargo compartment, but use of the standard flight attendant seat is not permitted during cargo operations.

Modification programmes to class E freighters for the ATR 42 & 72 are provided by Aeronavali, ATS International and M7 Aerospace.

Once converted to freighter, the fuselage interior is strengthened and lined to provide protection during container loading and off-loading.

The maximum payload of the basic ATR 42 is 10,1412lbs, rising to 10,891lbs for aircraft that have incorporated SB ATR42-08-0003. In QC configuration, maximum zero fuel limited gross payload is 11,993lbs, but the cabin nets allow a maximum bulk payload of 10,582lbs and the aft cargo hold is limited to 1,693lbs, giving a maximum net bulk payload of 11,894lbs. This is reduced by 847lbs in the early aircraft with the shorter aft compartment. The maximum net containerised payload is 8,413lbs.

The ATR 72's maximum payload is 15,432lbs basic, with an optional increase to 16,094lbs. The longer model offers maximum payloads in containers of 17,527lbs gross, 17,377lbs net bulk and 12,152lbs in QC configuration.

The OEM also offers cargo conversions. Alenia, which manufactures the ATR fuselage, holds the supplemental type certificates (STCs), and the conversions are carried out by its fellow Finmeccanica subsidiary, Officine Aeronavali. In 2003 FedEx chose the ATR 42/72 to replace its Fokker F.27 freighters, highlighting their payload, Stage 3 noise certification and cabin width as factors in the choice. FedEx's aircraft have been converted to cargo configuration by M7 Aerospace. There are several other certified conversions, including various designs from ATS International and a C class combi version by Canada's First Air. Indraéro Siren offers a ball mat loading system designed for rapid installation.

Aeronavali

ATR launched its cargo conversion programme in 2000, offering either a large cargo door, or a tube conversion that uses the existing doors. The tube conversion involves: the removal of galleys, toilets, partitions, attendant seat and overhead bins; the installation of protective linings to the sidewalls and ceiling; reinforcement of the floor to 82lbs per square foot; window plugs; and modification of the cabin to meet E class cargo compartment requirements. Two additional floor rails are installed in the aft door area, and the cargo door is modified for opening from the inside.

The lining can be either a light or a structural tube. The light tube is supported by longitudinal elements attached to the frames with clips and is suitable for use with containers or with spider nets attached to the floor tracks. Screws and velcro fastenings are used for rapid installation and replacement of the lining panels. In this configuration the ATR 42 has a gross useable volume of 1,660 cu ft and a net payload of 12,683lbs. Comparable figures for the ATR 72 are 22,600 cu ft and 18,968lbs.

The structural tube is designed for rough loading operations. It uses thicker panels reinforced by a substructure supported by longitudinal tracks attached to the frames to protect the fuselage and systems, and to provide resistance to in-flight loads. It includes attachment points for 9G vertical nets and six additional longitudinal tracks for flexibility of net attachment positions. The nets can be secured in three minutes by one person and can withstand loads of 3,527lbs, reducing to 2,866lbs in the forward compartment. The resulting gross useable fuselage volume is 1,978 cu ft for the ATR 42 and 2,666 cu ft for the ATR 72. Respective maximum payloads are 12,374lbs and 18,569lbs.

The large cargo door is 116 inches wide and 71 inches high, enabling the ATR 42 and 72 fuselage to accommodate LD3 containers and 88 x 108-inch pallets. With an 88- by 108-inch cargo loading system the ATR 42-300/310 can carry three pallets for a maximum gross payload of 11,684lbs. The ATR 72-200 can take five pallets with a maximum gross payload of 17,842lbs. An 88- by 62-inch cargo loading system enables the ATR 42 and 72 to hold six and nine pallets respectively, giving them respective maximum gross payloads of 11,629lbs and 17,784lbs. With an LD3 loading system, the ATR 42 can take five containers and a maximum payload of 11,755lbs gross, while the ATR 72 can take seven and a maximum gross payload of 17,941lbs.

ATS International

Part of France's Group Aeroconseil, ATS International has developed four separate configurations for ATR 42 and 72 cargo conversions, all complying with the E class fire detection and suppression standard.

The first uses the wires for the passenger seats to secure horizontal nets on the ATR 42-300, while the second has vertical nets to separate the cargo zones in both the 42 and the 72. Ireland's Air Contractors uses several of the latter on services for FedEx. The ATR 42 has six cargo zones, with a total volume of 1,870 cu ft and accommodating a payload of 12,566lbs, while the ATR 72 provides 3,002 cu ft and a payload of 19,000lbs.

The conversions are carried out by manufacturer-selected shops, including Denmark's Cimber Air Maintenance Center and Toulouse-based Latécoère. The quoted prices of EUR 275,000 ($360,000) for the ATR 42 and Eur 325,000 ($422,000) for the ATR 72 include the STC, engineering services such as job cards, drawings and wire lists, plus design and provisioning of the installation kit, working party follow-up and certification. Ground time for the work is three to four weeks.

A third conversion, developed for the Swedish postal service, accommodates 29 mail trolleys that are used in the operation's rail and road networks.

ATS is working on a fourth, quick-change configuration in early 2007, with orders anticipated from South American operators.

FedEx selected M7 Aerospace in California won a contract from FedEx to convert 33 ATR 42s and 72s.

First Air

Ottawa-based First Air claims to be the world's foremost Arctic air carrier. Its fleet of eight ATR 42-300s have been converted to combi configuration, and given STCs by Air Canada. The conversion is approved for cold weather operations down to minus 54 Centigrade and remote runways.

The First Air combi conversion can provide one, two, three, four, five or six bulk cargo zones combined with seats at 33-inch pitch for 42, 34, 30, 22, 18 or 10 passengers respectively. In the ATR 42 passenger version the single cargo zone occupies the standard forward cargo compartment. Associated cargo volumes are 325, 471, 617, 763, 909 or 1,055 cu ft, while in full cargo configuration it offers 1,275 cu ft.

The existing forward cargo door is used, and new floor panels are installed to give 82 lbs per square foot. The cargo zones are separated by 9G barrier nets.

The removable sidewall and ceiling liner provides 1.5G lateral load protection and acts as a fire and smoke barrier. The cargo compartment complies with Federal Aviation Administration (FAA) class C requirements.

The reconfiguration procedure involves removing the cabin side wall and ceiling panels and overhead bins, and installing the cargo side wall panel system, partition, posts and aisle nets. The cargo positions match those of the overhead bins: each section is 49.5 inches long with a limit of 1,400lbs, but 99-inch long double bays, able to carry 2,800lbs, are an option. In each case the maximum loading is 6.6lbs per cubic foot.

Indraéro Siren

France's Indraéro Siren has sold 20 of the quick-change cargo loading kits it has designed for the ATR 42 and 72. They are in service with operators in Europe, Africa, South America and the Asia Pacific region, and are offered by Erie Aviation in the United States.

Weighing 353lbs and 463lbs respectively for the two types, the Indraéro Siren kit enables the ATR 42 to carry nine dedicated containers and the ATR 72 to take 13. The containers measure 83.5 by 43 inches and are 50 inches high, with a maximum gross weight of 1,102lbs. The respective maximum payloads for the two models are 8,413lbs and 12,152lbs, and both can carry 1,693lbs in the rear cargo hold.

The conversion requires E class smoke detection and fire suppression, along with strengthening of the floor to 82lbs per square foot and modification of the forward cargo door so that it can be opened from inside.

The conversion process involves removing the forward cargo masts and nets, the forward partition and the passenger seats. Other passenger amenities, including the galley, can be left in place. A passenger ATR 42 can be converted and fully loaded with nine containers in as little as 45 minutes.

M7 Aerospace

M7 Aerospace was formed at San Antonio International Airport in December 2002 with the acquisition of three Fairchild Aircraft support units, including aircraft manufacturing facilities. It subsequently added the assets of Dornier Aircraft North America and started operations supporting Dornier Do 328s and Fairchild Metros and Merlins under its own name in April 2003.

In July 2004 M7 acquired Springfield, Missouri-based Worldwide Aircraft Services, which had a contract to convert 33 ATR 42 and 72 aircraft for FedEx. It completed the ATR 42 STC and by June 2005 had converted 20 ATR 42s to freighter configuration. Three months later M7 was awarded an additional STC for the ATR 72.

The M7 conversion removes all passenger amenities, adds hardpoints for netting and reinforcement of the cabin floor, and modifies the smoke detection, lighting and air systems. Conolite cargo liners are installed, the passenger windows are removed and plugged with aluminium, the structure surrounding the forward and rear doors is protected with stainless steel, and the rear door is converted from airstair to top-hinge opening to improve accessibility for personnel and loading equipment.

The reinforced floor structure is supplemented by increased load-capacity floorboards from Teklam, enabling the floor to be certified to a limit load of 100 lbs per square foot. Options include a floor roller/conveyor system and a new tail stand, which protects the aircraft from the risk of improper loading and is stowed behind the co-pilot's seat. Additional services include structure and systems repair, maintenance up to C check level and avionics installations.

The M7 ATR 42 has seven or eight cargo zones separated by 9G vertical netting. The narrow forward zone can carry 400lbs, and each of the next five zones has a volume of 294.5 cu ft and a load capacity of 2,600lbs. Zone 7 in the tapered section of the aft fuselage has a volume of 273.3 cu ft, while later aircraft with the extended aft cargo compartment have an eighth zone of 138 cu ft that can take a further 800lbs. The converted ATR 72 has two additional zones.

By January 2007 M7 had converted a total of 45 ATR 42s and 72s, most for FedEx but also some for other customers. For more flexibility in the size of the zone the maintenance and repair operations (MRO) modified the design to include the option of a continuous cargo net rail. Farnair of Switzerland was the first customer. AC

ATR family fuel burn performance

There are six main variants of the ATR 42 and 72. Most operators have cycle times that average one hour. The fuel burn performance of these six main variants on a typical sector is analysed.

Analysis of the fuel burn performance of three variants of the ATR42, and three variants of the ATR72, reveals that for a given payload flown over a given distance, the fuel burn per seat is influenced by several factors that include operating empty weight (OEW) per seat, rated engine power, and cruise speed.

Aircraft overview

Six models of the ATR family of turboprops have been evaluated. These are subdivided between the baseline ATR42 and larger ATR72 variants.

Three ATR 42 models are examined: the -300, -320, and -500. The ATR42-300 has a maximum take-off weight (MTOW) of 37,200lbs and is powered by four-bladed PW120s rated at 1,800shp. The ATR42-320, as analysed here, is operated with a lighter MTOW of 37,000lbs and is powered by PW121s each delivering 1,900shp. Meanwhile, the ATR42-500 is operated with an increased MTOW of 41,100lbs, is powered by six-bladed PW127Es and is rated at 2,160shp. With a cruise speed of 303 knots, this aircraft cruises 34 knots faster than the older ATR42-300 series.

As very few examples of the ATR42-200 and -400 series are still in service, these types have not been included in the analysis.

As for the larger ATR-72 series, we have evaluated the -200, -210 and -500 models. The -210 is powered by a four-bladed PW127 with a take-off power rating of 2,475shp, while the -200 is powered by a four-bladed PW124B with 2,160shp. These two have a gross weight of 48,500lbs *(see ATR 42 & 72 specifications, page 4)*. The -500 model has the highest MTOW and is powered by a six-bladed PW127F engine rated at 2,475shp. All three variants have a cruise speed of 277 knots.

Route analysed

The three aircraft are analysed on a route that is typical to many ATR operations: Vienna (VIE) - Venice (VCE). Aircraft performance has been analysed in both directions to illustrate the effects of wind speed and direction on the actual distance flown, which is also referred to as equivalent still-air-distance (ESAD). This airport-pair is typical of many ATR regional turboprop operators, since it has a block time of 75-95 minutes, depending on aircraft type and the direction of travel.

The flight time for each aircraft depends on wind speed and direction, and 85% reliability winds and 50% reliability temperatures for the month of June have been used in the flight plans performed by Jeppesen. The flight plans have also been calculated using Prague as an alternate airport when operating to Vienna, and Milan Malpensa is the alternate when operating to Venice. The performance of the six aircraft has also been analysed using a taxi time of 10 minutes. This adds about 140lbs of fuel to the trip for the ATR 42-300/-320, and 180-190lbs of fuel for the other four models.

The aircraft have been analysed with full passenger payloads: 48 passengers in the case of the ATR42; and 68 passengers for the ATR72. The standard weight for each passenger plus baggage is taken as 220lbs.

The payload for each aircraft is therefore 10,560lbs for the three ATR42 models and 14,960lbs for the three ATR 72 variants.

Operating from Vienna to Venice, the aircraft encounter a headwind of 13 to 14 knots, which increases the 'distance' flown from a tracked (actual) distance of 307nm to an ESAD of up to 320nm *(see table, page 11)*.

This route has a block time of 88-96 minutes, depending on the cruise speed of the aircraft model. For example, the original ATR42-300 with four-bladed PW120s has the slowest cruise speed of 265 knots, while the ATR42-500, which is powered by a six-bladed PW127E, has an enhanced target cruise speed of 303 knots. The ATR 72 variants cruise at around 277 knots.

Meanwhile, for the VCE-VIE route, where there is only a 1-knot headwind, the 267nm tracked distance flown equates to an ESAD range of 267-271nm, depending on the aircraft type. This route has a block time of 74-83 minutes, depending on aircraft type and cruise speed.

The later generation ATR 42-500 and 72-500 were equipped with six-bladed propellers designed to lower specific fuel consumption. While the ATR 42-500 can take advantage of this and operate at a higher cruising speed than the -200 and -210, the -500 still has an overall higher fuel burn.

FUEL BURN PERFORMANCE OF CF6-80C2 SERIES

City-pair variant	Aircraft	Engine model	TOW lbs	Fuel capacity USG	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
Vienna-Venice	ATR 42-300	PW120	37,010	1,481	260	96	48	321	5.43	-13
Vienna-Venice	ATR 42-320	PW121	35,490	1,481	250	95	48	320	5.21	-13
Vienna-Venice	ATR 42-500	PW127E	39,670	1,481	305	85	48	318	6.36	-13
Vienna-Venice	ATR 72-200	PW124B	45,917	1,646	303	91	68	319	4.46	-14
Vienna-Venice	ATR 72-210	PW127	46,523	1,646	321	88	68	318	4.72	-14
Vienna-Venice	ATR 72-500	PW127F	48,552	1,646	362	88	68	318	5.33	-14
Venice-Vienna	ATR 42-300	PW120	37,200	1,481	227	83	48	271	4.72	1
Venice-Vienna	ATR 42-320	PW121	35,715	1,481	219	82	48	268	4.56	1
Venice-Vienna	ATR 42-500	PW127E	39,860	1,481	267	74	48	267	5.55	1
Venice-Vienna	ATR 72-200	PW124B	46,316	1,646	267	80	68	267	3.93	1
Venice-Vienna	ATR 72-210	PW127	46,910	1,646	281	76	68	267	4.13	1
Venice-Vienna	ATR 72-500	PW127F	48,248	1,646	317	78	68	267	4.66	1

Source: Jeppesen

ATR 42 fuel burns

The fuel burn for each aircraft and the consequent burn per passenger are shown *(see table, this page)*. To remain consistent when comparing the three aircraft models, the outward leg (VIE-VCE) is used as the basis for the fuel burn analysis.

At first glance, the data show that the fuel burn per passenger increases for higher gross weight aircraft models and actual take-off weights. There are several other factors at play here, however. Among these is OEW, which is the manufacturer's empty weight plus the operator's items, and does not include useable fuel and payload. In short, the higher the OEW, and all other things being equal (such as passenger counts), then the higher the actual take-off weight. To compound this, more fuel has to be burned to carry the additional structural weight over a given distance.

The ATR42-300 has an OEW which is 1,320lbs more than the ATR42-320's. In turn, the -300's actual take-off weight is 1,520lbs heavier on the same sector (and with virtually identical ESAD), and with the same number of passengers as its lighter sibling *(see table, this page)*.

The ATR 42-500 makes things more interesting, since the aircraft has higher performance. The -500's OEW is 2,200lbs and 3,520lbs higher than the -300 and -320 models. In turn, the -500 also has a take-off weight which is about 4,000lbs higher than the others. Part of this increase, however, is to provide greater payload-range performance.

The other important factor is the -500's 38-knot faster cruise speed, which is afforded by its more powerful 2,160shp rated six-bladed turboprop engines. This speed accounts for the 10-minute shorter block time compared to the older variants. By flying faster, however, there is an unavoidable aerodynamic drag penalty, since airframe-induced drag increases with the square of the speed, when all other variables are equal. The -500's engine has a lower specific fuel consumption than the engines powering the -300/-320, but this advantage is offset by the aircraft's faster speed. The overall difference is the -500's higher fuel burn per passenger.

This penalty of faster cruise speed performance (even though the -500 operates at a lighter all-up weight than its maximum) is that its fuel burn per passenger, at 6.36 US Gallons (USG), is 17-22% higher than the -300/-320 which have fuel burn rates of 5.43USG and 5.21USG per passenger. At a fuel price of $2 per USG, these fuel burn rates equate to a fuel cost per passenger of: $13 for the ATR42-500; $10.9 for the ATR42-300; and $10.4 for the ATR42-320.

Airlines should, however, consider the positive economic benefit resulting from the -500's faster cruise speed, which includes additional frequencies. If managed well, the faster aircraft could conceivably squeeze in an extra frequency per day, thereby generating additional revenue and gross profit.

ATR 72 fuel burns

Turning now to the larger 68-seat configured ATR 72 models, it can be seen that (again using the VIE-VCE leg for the following study) the -200, -210 and -500 models used are operating with identical payloads of 14,280lbs and over virtually identical ESADs.

They also share the same design MTOW of 48,000lbs. The two variants, however, as operated here differ from each other in several key aspects. These are actual take-off weight (45,917lbs versus 46,523lbs), OEW (27,940lbs versus 28,380lbs), and engine power (2,160shp versus 2,475shp). It should be noted that the two have the same cruise speeds.

The heavier ATR 72-500 has the same cruise speed as the lighter -200 and -210 variants. The -500's OEW is about 1,000lbs higher than the lighter -200 and -210 models, which results in the -500 having a higher fuel burn.

In terms of fuel burn, the ATR72-200 and the -210 models have block fuel burns of 4.46USG and 4.72USG per passenger, equivalent to a difference of 5.8% between the two. At a fuel price of $2 per USG, this is equal to a fuel cost per passenger of $9.0 for the ATR72-200 and $9.4 for the ATR72-210.

The ATR 72-500 has a fuel burn of 5.33USG per passenger, equal to about $10.6 at current fuel prices. This is up to $1.6 more per passenger than the -200.

It is perhaps worth noting the differences between the ATR42 and its 'stretched' ATR72 sibling, which arise as a function of their respective size-related properties. The larger, 68-seat ATR72 has lower fuel burn compared to the smaller, 48-seat ATR42, equivalent typically to a 21% fuel saving per passenger. This is to be expected, however, since the ATR72 is a stretch, which gives it a minimal drag increase over the ATR42. The ATR72 also uses a similar fuselage and wingbox structure that leads to a lower fuel-burn per seat. AC

ATR 42 & 72 maintenance analysis & budget

The ATR 42 & 72 have a complex base maintenance programme, but engines and rotable components are the highest elements of maintenance costs.

There are 630 ATR 42s & 72s in operation, and another 120 aircraft on order. The aircraft continue to sell well, and both can be expected to continue in operation for another 20 years. The aircraft's main role is as a regional passenger carrier, but the number being converted to freighters will steadily increase. The maintenance costs of mature aircraft are analysed here.

ATR 42 & 72 in operation

The majority of ATR 42s & 72s are operated by airlines in the US and Europe, with large numbers in service in Africa and India. Most are operated as regional feeders, flying sectors of 35-50 minutes in most cases. Few airlines have operations where the average cycle time exceeds one flight hour (FH). Cimber Air in Denmark, for example, operates a fleet of three ATR 42s and four 72s on domestic services between Copenhagen and smaller Danish cities, with flight times averaging only 30 minutes.

Other carriers have similar styles of operation. Finnair's ATR fleet, for example, accumulates 2,000-2,400FH per year with an average FC time of 45-50 minutes. Most passenger operations have operations with similar average FC times and annual rates of utilisation, and so accumulate 2,600-2,900FC per year.

Freight operators generally use the aircraft on longer cycles of about one FH, but accumulate fewer FH per year as a result of the nature of their operations.

Maintenance costs

All elements of the ATR 42's & 72's maintenance costs are examined and analysed here, starting with the aircraft's maintenance planning document (MPD) and maintenance programme, line and ramp checks, A checks, C checks and related base check items, heavy components, rotable components and engine maintenance.

Many elements of the aircraft's maintenance are related to FCs, and the total maintenance cost per FH is influenced by the aircraft's pattern of operation, average FC time and rates of utilisation. This analysis assumes that an aircraft accumulates 170FH per month, or 2,000FH per year. The average FC time is 50 minutes, so the aircraft completes 200FC per month or six to seven flights per day. This is equal to 2,400FC per year.

Maintenance programme

The ATR 42's & 72's maintenance programme is based on A checks, C checks and other base check inspections (calendar) that operators usually combine with C checks. The programme is based on maintenance steering group 3 (MSG3) principles.

"The ATR 42 and 72 have almost identical numbers of inspections in their MPDs," explains Pascal Pastor, senior vice president of sales at Sabena technics. "The ATR 72 has 2-8% more MPD tasks (depending on the operator and the systems installed), which are mainly structural and system items that are related to the engines, and additional fire extinguishers and oxygen bottles."

The ATR's A check has a basic interval of 500FH, and there are tasks with multiple intervals that result in a cycle of four block checks. These are the A1, A2, A3 and A4 checks. The A4 check and the cycle therefore have an interval of 2,000FH. "The A checks only include system items," says Pastor. "The checks have a downtime of about two days to complete, including rectifications and supplemental tasks due at that time."

The base check programme comprises several groups of tasks. First there are the actual C check items. "There are the 1C, 2C and 4C tasks, with intervals of 4,000FH, 8,000FH and 16,000FH. These are just system tasks," explains Pastor. "When performed as block checks, the C1 and C3 checks have just 1C tasks, the C2 check has 1C and 2C tasks, and the C4 check has 1C, 2C and 4C tasks. The average downtime to complete one of these checks is one to two weeks, depending on the check combination."

The next group of base check tasks comprises the structural inspections. These are divided between fatigue damage items with FC intervals and environmental and corrosion-related items with calendar intervals.

The maintenance programme of FC fatigue tasks is complex. "Fatigue tasks

The ATR 42's & 72's base maintenance programme comprises three major portions of system, FC-fatigue and calendar-fatigue tasks. Despite the aircraft operating on average cycle times of less than one hour, inputs for base checks result in maintenance reserves of less than $100 per FH.

The PW120 series engines powering the ATR family are relatively simple, with just 10 LLPs. Engine removal intervals of 7,500EFC and 15,000EFC can be targeted, which conveniently match LLP lives of 15,000EFC and 30,000EFC.

have intervals that are multiples of 3,000FC. There are a small number of tasks with initial and repeat intervals of 3,000FC, 6,000FC and 12,000FC, and the FC-related fatigue tasks only get to be a significant amount when the aircraft has accumulated 24,000FC. This is because there is a large increase in the number of 3,000FC, 6,000FC and 12,000FC tasks at this point. Before this threshold is reached, fewer than 10 tasks have to be performed in a C check. These only generate 10-15 routine man-hours (MH)," explains Gareth Rees, managing director Cimber Air Maintenance.

If the C1, C2, C3, C4 and C5 checks were performed every 4,400FC, then the C5 check would be due after 21,700FC. The single 3,000FC tasks would be performed every check, the single 6,000FC task in the C1, C2 and C4 check, and the five 12,000FC tasks done in the C2 and again in the C4 checks.

The C5 check is therefore when there is a large increase in the number of FC-related tasks, since the C6 check would be at 26,000FC. Here a larger number of 3,000FC, 6,000FC and 12,000FC tasks must be performed.

The next large group would be at 36,000FC, in this case the C8 check at about 34,700FC, when all groups of tasks would come due. Given that most aircraft accumulate 2,000-3,000FC each year, the 36,000FC limit is reached after 12-18 years. It is therefore unlikely that these inspections will have to be performed twice in the aircraft's operational life. The next largest check would be the C11 check, after about 48,000FC, when the 3,000FC, 6,000FC and 12,000FC tasks come due.

The environmental and corrosion inspections have intervals of two, four, eight and 12 years. These are zonal checks. Fuel tanks, for example, are inspected at the 12-year check, either by a video inspection, which can only be done by ATR, or by a full opening of the tank, which uses more MH but can be done by the operator or an independent maintenance facility.

Check planning

The three categories of base check inspections have to be organised and planned to minimise downtime. "We try to plan base checks on the ATRs so that no base maintenance is required for up to two years," says Veijo Paakkonen, ATR & S340 project engineer at Finnair Technical Services. "The C check's 4,000FH interval is twice that achieved by most operators on an annual basis. Obviously aircraft that generate more than 2,000FH per year would require base maintenance more frequently than every 24 months. A 4,000FH interval in our case is close to about 6,000FC."

In the case of an ATR42 or 72 achieving a utilisation of 2,000FH and 2,400FC per year, the aircraft would accumulate 4,800FC after a 4,000FH interval.

First, C checks can be performed every two years for an aircraft accumulating 2,000FH per year. Actual planning and operational constraints at most airlines mean that this is more likely to be every 3,600FH, rather than using its full interval. This would be equal to 21-22 months. The aircraft will therefore accumulate 3,600FH and 4,400FC between C checks. The number of cycles will be higher for aircraft operating short average cycle times. Some operators accumulate up to 3,000FC per year with their aircraft, and so 5,250-5,500FC between C checks.

The cycle of C checks, finishing with the C4 check, will therefore be completed after 86 months, equal to seven years.

The FC-related fatigue tasks have various intervals, and how they fall into each of the C checks has been described.

The calendar-related fatigue tasks similarly have to be combined into the base checks. The eight-year tasks will come due every fourth check, at the C4, C8 and C12 checks. The 12-year tasks will come due at the C6 check, and can be done again at the C13 check. The four-year items will come due at the C2 and C10 checks, and the two-year tasks at all other checks.

The overall effect of base check organisation is a varying amount of routine base check tasks that have to be performed in each check. The first of the largest base checks is the C4 check, performed at eight years, with all C tasks, three groups of FC-related, and the eight-year calendar-related fatigue tasks. The C8 check is the largest, with all C tasks, most FC fatigue tasks and three groups of calendar-related fatigue tasks to perform.

The C2, C6, C10 and C11 checks are relatively large, with 1C and 2C items, and several groups of FC and calendar tasks to complete.

The approximate number of MH to complete these routine inspections is about 350 for the 1C items, while the 1C and 2C together use 700MH. The 1C, 2C and 4C tasks require 900MH, which is the largest MH requirement for the system-related tasks.

The number of MH required for the FC-related tasks is only 10-15MH for the C1, C2, C3 and C4 checks. The labour requirement rises to 150MH, however, at the C5 and C7 checks. The threshold of 36,000FC results in a requirement of 1,600MH for the routine FC inspections. The C11 and C12 checks both use 850MH for these tasks.

The calendar-based tasks vary in their labour requirement from 226MH for two-year check items, to 1,221MH for eight-year check items.

Overall, the variation in labour requirement for system tasks, FC inspections and calendar-based inspections results in the routine MH requirement for C checks varying from 590MH for a C1 check to 3,685MH for the C8 check. The C4 check will use 2,121MH, and the C12 check 2,956MH. The other checks have smaller MH requirements.

Line check inputs

The ATR's line check programme includes transit checks prior to each flight, a daily check performed every 24 hours, and a weekly check. Transit checks use an average of one MH, but as these can be performed by the flightcrew, they rarely require input from line maintenance. They also use a minimal amount of consumables.

About 350 daily checks will be performed each year. The checks may only use one or two MH of labour, and three MH can be used as a conservative budget, and $40 of materials. A labour rate of $70 per MH for line maintenance takes the total cost for the check to about $250.

A weekly check will use five to 10MH and about $200 in materials and consumables. A theoretical labour rate of $70 per MH will take the check's cost to $350-700. About 50 of these checks will be performed each year.

The total cost for daily and weekly checks for the year will be $120,000-140,000, equal to $60-70 per FH *(see table, page 20).*

A check inputs

While the A checks have an MPD interval of 500FH, the actual interval achieved by airlines is more likely to be 350-400FH. This means that the aircraft will require four to six A checks each year, depending on how each operator utilises the 500FH interval. "The total labour cost for the A check package averages about 150MH for a mature aircraft," says Pastor. "Use of materials and consumables is about $2,000-2,500."

A theoretical labour rate of $70 per MH would take the cost of the labour portion of the A check to $10,500, and the cost for the entire check to $12,500-13,000. If five of these checks are performed each year, it will take the total cost to $62,500. This will be equal to $32 per FH when amortised over the annual utilisation of 2,000FH (see table, page 20).

Base check contents

In addition to these routine tasks, non-routine rectifications will increase the workscope of the check. Other items will include service bulletins (SBs), airworthiness directives (ADs) and engineering orders (EOs). The aircraft will also require interior work. This will mainly consist of cleaning, but it will also include some refurbishment work. Because of their role as regional aircraft, ATRs will not require the same level of interior refurbishment as jetliners. Base checks will also include the removal and installation of hard-timed rotable components.

"The base check workpackages will also include work for ADs, SBs and EOs," continues Rees. "This portion of the check varies widely between 50 and 800MH, depending on what work is due. There have been several large SBs and ADs due on the ATR 42 and 72. One of the largest of these is the insulation blanket modification, which also affected the MD-11. This required about 500MH to complete on the ATR 42 and about 800MH on the ATR 72." Not all ATRs are affected by the AD, however, since this only applies to aircraft that have certain types of insulation blanket material installed.

"There have also been several major

ATR FAMILY HEAVY COMPONENT MAINTENANCE COSTS

FH & FC per year Average FC time of FH	ATR 42	ATR 72
Number of main & nose wheels	4 + 2	4 + 2
Tyre replacement interval-FC	800	800
Tyre shipset replacement cost-$	4,650	5,250
$/FC retread & replace tyres	**6.0**	**7.0**
Wheel inspection interval-FC	2,400	2,400
Main & nose wheel inspection cost-$	7,400	7,400
$/FC wheel inspection	**3.0**	**3.0**
Number of brakes	4	4
Brake repair/overhaul interval-FC	2,000	6,000
Brake repair cost-$	14,000	72,000
$/FC brake repair cost	**7.0**	**12.0**
Landing gear interval-FC	18,000	18,000
Landing gear exchange & repair fee-$	220,000-240,00	280,000
$/FC landing gear overhaul	**12.0-13.0**	**16.0**
Total-$/FC	**28.0-29.0**	**38.0**
Total-$/FH @ 0.8FH per FC	**25.0**	**32.0**

avionic upgrades required on the ATR, which include installation of a 8.33MHz VHF radio, enhanced ground proximity warning system (EGPWS) and emergency location transmitter (ELT). The compliance date for all of these upgrades has now passed. There is also SB 57-0038, which is a wing modification that requires the fasteners holding the skin to be changed. This requires about 385 MH for just the routine portion.

There are also examples of small ADs and SBs that have to be incorporated on the ATR. "One AD, which affects all older aircraft, is the fuel safety programme, which followed after the TWA 747 crash," explains Pastor. "A computer has to be installed, and the aircraft has to comply with the AD by December 2009. The modification uses about 200MH.

"There was also the Mode S transponder, but this had to be complied with in Europe by September 2006," continues Pastor. "Installation of EGPWS uses about 450MH plus the cost of the computer. Besides these, there are no major ADs affecting the aircraft."

Interior cleaning and refurbishment can be another major item. Some operators refurbish the interior work as necessary, on an on-condition basis, since the interior is not as important as it is in larger aircraft. "The interior is often refurbished when the aircraft changes operators," says Pastor. "The eight-year checks have a requirement for floor panels to be removed for an inspection, so this is a chance for the interior to be refurbished. The range of labour used in a base check can be 300-1,2300MH."

Stripping and painting is also treated as an on-condition maintenance task, and may only be performed when the aircraft changes operators. "We outsource the task to a specialist, as do many other operators, because of environmental limitations," says Rees.

"We have to dry strip and paint the aircraft at our facilities in Dinard," says Pastor. "The process takes about one week and uses about 800MH. It is often combined with an eight-year check, because a non-destructive test that requires the paint to be stripped has to be done at this check."

As is the case with other modern aircraft types, the majority of rotable components on the ATR are maintained on an on-condition basis. "The aircraft has about 700 different rotable components, and about 550 of these are maintained on an on-condition basis and the other 150 on a hard-time basis," says Paakkonen. "Hard-time components include emergency items such as oxygen generators, oxygen bottles, some electrical items, engine starters, engine fire extinguishers, and the propeller hub and propeller blades. The propeller hub and blades have a fixed overhaul interval of 10,000FH."

Base check inputs

The actual tasks performed in each check will vary between operators according to rates of utilisation and FH:FC ratio. "The heaviest check we have performed on an ATR was on a 13-year-old ATR 42, and included an A check, all C check system tasks, the two-, four- and eight-year tasks, 24,000FC fatigue items and 36,000FC fatigue items," says Pastor. "This whole package used about 7,000MH to complete, which is the largest base check package required for an ATR."

The routine MH used for each of the first 12 base checks in an aircraft's life have been described. Rectifications from routine inspections will add the largest portion of MH to a check. "The non-routine ratio will vary between 30% and 70% of routine MH for an aircraft during its first six or seven base checks," says Paakkonen.

Rees at Cimber Air adds that a non-routine ratio of 30-50% is typical of an aircraft in its first 12 years of life, but that the ratio will continue to increase as the aircraft gets older. "The ratio will reach 1:1 from about the C8 check, and so start to increase the number of MH used in the check."

In the case of the base checks described, a non-routine ratio of 30% in the C1 check will add about another 180MH, and up to another 1,500MH to the C4 check with a non-routine ratio of 70%. The aircraft could be expected to experience a non-routine ratio of 100% by the C8 check, which would therefore add another 3,700MH, while it would also add another 1,500MH to the C10 check, and another 3,000MH to the C12 check.

While the number of MH required for ADs, SBs and EOs varies, as they are issued by the airworthiness authorities and can require a large number of MH in individual cases, a budget of 250MH can be used as an approximate guide for base checks.

Interior refurbishment can be assumed to be performed every fourth base check, and use about 800MH. An additional 100MH can be included for interior work and cleaning for all other base checks. Another 50MH can be added to each base check for rotable removals and installations.

Stripping and repainting can be assumed to take place every fourth base check, and 800MH are used for this element.

Overall, the C4, C8 and C12 checks have the largest MH requirement, with the C4 using about 5,500MH, the C8 up to 9,000MH and the C12 about 7,800MH.

The C1, C3, C5, C7 and C9 are the smallest checks, using 1,200-1,700MH.

The C2, C6 and C10 are medium-sized checks, using 2,200-3,400MH.

Materials and consumables also have to be considered. "These are about equal to 20% of the labour cost of the routine portion of the check, or about 40% of the total labour cost of the check," explains Rees. This would see the cost of materials and consumables being $25,000-40,000 for lighter C checks, but increasing to $45,000-70,000 for the medium-sized C2, C6 and C10 checks. The heaviest eight-year checks would use about $110,000 in the case of the C4 check, and $160,000-185,000 for the C8 and C12 checks.

Using a theoretical labour cost of $50 per MH for base maintenance, the overall cost of base checks would be about $700,000 for the four checks in the first base check cycle. There would be a reserve in the region of $50 per FH when amortised over the 14,500FH interval. This would increase to about $80 per FH for the next two cycles leading up to the C8 and C12 checks *(see table, page 20)*.

Rotables

As described, the ATR 42 and 72 have about 600 rotable component part numbers, of which 150-200 are maintained on a hard-time basis. The remaining 400-450 are maintained on an on-condition basis. A few of the hard-time components can be classed as heavy components, and their maintenance is described below.

About 700 rotable components are installed on the aircraft.

Support of rotables can be offered by the rotable support provider leasing the operator an inventory of home base stock, which would comprise only high failure rate items. The remaining rotables could then be provided to the operator through a pool system, whereby the rotable provider holds the inventory of rotables and operators pay a pool access fee on a power-by-the-hour basis. Operators also pay a power-by-the-hour fee for the repair and management of the components.

The alternative is for an operator to make a single payment for an all-inclusive service. Rees says this could be $25,000 per aircraft per month for a small fleet. This rate would cover all eventualities, such as failed components that require replacement, and emergency situations. Once the fleet exceeds seven aircraft it becomes economic for the operator to have their own rotable stock and manage repairs themselves. The monthly rate of $25,000 would be equal to $140 per FH. Packages can vary in pricing according to aircraft utilisation, pattern of operation, and the age and modification status of the fleet. The largest factor influencing contract rates is fleet size. Rotable package pricing can be up to $200 per FH *(see table, page 20)*.

Heavy components

The heavy rotable components on both the ATR 42 and 72 are similar for those on turboprops and jet aircraft, and include tyres, wheels, brakes and landing gears. Turboprops do not have thrust reversers, but they do have propeller hubs. The ATR does not have an auxiliary power unit (APU).

These three categories of heavy components are considered here. "The landing gear on the ATR has an overhaul interval of 18,000FC," says Rees. At the annual utilisation used in this analysis this is equal to an interval of about seven years. Most operators use an exchange programme for landing gears, and exchange fees for an ATR 42-300 landing gear set are $220,000, for an ATR 42-500 landing gear they are $240,000, and for an ATR 72-500 they are $280,000.

Amortised over the interval, this equals a reserve rate of $12 per FC for the ATR 42-300, $14 per FC for the ATR 42-500, and $16 per FC for the ATR 72-500 *(see table, page 16)*.

The ATR uses several types of tyres, and some do not have remoulds. Rees says that tyres can last 500-1,200FC before they need replacement. New nose tyres each cost $425, while main wheel tyres each cost $950 for the ATR 42 and $1,100 for the ATR 72. A complete new shipset will cost $4,650 for the ATR 42 and $5,250 for the ATR 72. Amortised over an average interval of 800FC, the reserve for tyre replacement will be $6 per FC for both aircraft types *(see table, page 16)*.

Wheels are inspected once every three tyre removals, so the interval between wheel inspections would be in the region of 2,400FC. The unit cost of nose wheel inspections would be $780, and the unit cost of main wheel inspections $1,450. The reserve for inspections for a shipset of wheels would be $3 per FC *(see table, page 16)*.

The ATR 42 utilises steel brakes. The discs in these brakes have a life limit of 2,000FC, while elements of the brake unit require non-destructive tests (NDT) at a limit of 2,700FC. It is therefore convenient to perform a brake overhaul at an interval of 2,000FC. The average overhaul cost for a brake unit is $3,500, and so $14,000 for a shipset. This is equal to a brake repair reserve of $7 per FC *(see table, page 16)*.

The ATR 72 utilises carbon brakes. The carbon fibre heatpacks can last between 800FC and 3,000FC before requiring a repair. Two worn discs can be ground and combined to make a new disc, which means that some of the heatpack material is recoverable, and the cost of a complete heatpack, about $10,000, will not be incurred in full each time a heatpack is repaired. The brake unit also requires an overhaul every 6,000FC, which includes some NDT inspections. The average cost for a single brake unit is $10,000.

This means that a brake requiring a heatpack overhaul every 2,000FC might therefore incur a total cost of $18,000 for two heatpack repairs and an overhaul. Amortised over an interval of 6,000FC, this would be equal to a reserve of $12 per FC *(see table, page 16)*.

Engine maintenance

The ATR 42's and 72's engine types and thrust ratings vary between 1,800 and 2,475 shaft horse power (shp). The four main engine variants are the PW120, PW121, PW124 and PW127 *(see ATR 42 & 72 specifications, page 4)*. The first three operate with a four-bladed propeller, while the PW127 uses a six-bladed propeller.

Besides the engine unit, the propeller hub and propeller blades require maintenance. While the engine is maintained on a on-condition basis, the propeller blades and hub are maintained on a hard-time basis.

Like jet engines, turboprop engines are flat-rated. "Engine power reduces with increased outside temperature above the outside air temperature limit (OATL)," explains Paakkonen. "The PW124, for example, powering the ATR 72-200, has a maximum rating of 2,400shp up to an OATL of 34.4 degrees centigrade. The PW127F, which powers the ATR 72-500, is rated at a maximum of 2,750shp up to an OATL of 34.4 degrees centigrade. The PW127E is a de-rated version of the 127F, and powers the ATR 42-500. It has a maximum rating of 2,400shp up to an OATL of 45 degrees."

While the performance of jet engines is analysed in terms of exhaust gas temperature (EGT) margin, inter-turbine temperature (ITT) margin is measured in turboprop engines. "The PW120 turboprop has a core engine engine with two shafts. One high pressure (HP) system has a compressor turned by its own turbine, known as the gas generator turbine. The low pressure (LP) system has a turbine, known as the power turbine, which is used to turn the propeller. A third shaft is used to turn the propeller unit via a gearbox from the LP shaft," explains Paakkonen. "The ITT is measured between the two turbine sections, which gives the best indication of how hot it is inside the engine. There is also the turbine inlet temperature (TIT), which is measured between the combustion chamber and the gas generator turbine.

"There are limits to how high the ITT can climb, and this temperature varies up to 840 degrees centigrade. The actual limit varies according to the phase of flight," continues Paakkonen. "The actual limits are specified in the aircraft flight manual, but each operator also has their own limits. The ITT increases as the

DIRECT MAINTENANCE COSTS FOR ATR 42 & 72 FAMILY AIRCRAFT

Maintenance Item	Cycle cost $	Cycle interval	Cost per FC-$	Cost per FH-$
Line & ramp checks	120,000-140,000	2,000FH		60-70
A check	62,500	2,000FH		32
Base checks-1st cycle	715,000	14,400		50
Base checks-2nd cycle		1,135,000	14,400	80
Heavy components:				25/30
LRU component support				140-200
Total airframe & component maintenance				
Engine maintenance:				
2 X PW120/121/124B: 2 X $125-130 per EFH				250-260
2 X PW127E/F: 2 X $140-145 per EFH				280-290
Total direct maintenance costs:				
With 2 X PW120/121/124B:				557-678
With 2X PW127E/F:				587-702

Annual utilisation:
2,000FH
2,400FC
FH:FC ratio of 0.8:1.0

engine's hardware deteriorates, and ATR has an automated engine health monitoring system on the aircraft which records engine performance data for each flight. This can then be downloaded from the aircraft after each flight."

Airlines have to monitor ITT margin in order to remove engines for maintenance and performance restoration. Paakkonen comments that the PW120 series engines on the ATR family generally have enough ITT margin for them not to be removed due to performance loss. "The engines usually have ITT margins of 20-30 degrees centigrade after a shop visit, which is sufficient to allow engines to remain on-wing long enough for them to be removed due to hardware deterioration and other technical reasons," continues Paakkonen. "Only about half the ITT margin is lost during the on-wing interval of 4,500-5,500 engine flight hours (EFH), which is equal to 7,500-8,000 engine flight cycles (EFC) with our operation. We actually plan for a removal at 8,100EFC, since we have to consider life limited parts (LLPs). There are 10 LLPs in the engine, and five have lives of 15,000EFC, and so the LLP's full life can be completely used and the parts replaced every second removal. The other five LLPs have lives of 30,000EFC. These can be replaced every fourth shop visit.

"The high pressure turbine (HPT) blades also have a 15,000EFC replacement limit, and so the 7,500-8,000EFC removal interval is convenient in several respects. Erosion starts after about 4,000EFH, and they can be inspected at the first removal," continues Paakkonen. "Most blades and vanes get replaced at the second removal and shop visit, and so it is possible to have a shop visit workscope pattern of a hot section inspection followed by an overhaul. It is also possible to have a pattern of two hot section inspections followed by an overhaul at the third removal. This would be the case where the average removal interval is about 5,000EFC. The idea is to match the workscope with the life limits of installed LLPs."

Plans for removal intervals and shop visit workscope patterns do not always go according to plan, however, since unscheduled shop visits will cause interruptions. "Unscheduled shop visits can arise from hot section deterioration, which is discovered through engine borescopes," says Paakkonen. "Other examples are bearing failures, which are picked up through oil detection. Overall, the average interval, including unscheduled removals, is about 5,000EFC. On this basis most engines have two consecutive hot section inspections followed by an overhaul. A borescope is performed every 500 EFH to detect deterioration and anticipate unscheduled removals.

"A hot section inspection requires the engine to be opened from just the combustion chamber to the HPT, while an overhaul is a disassembly of the whole engine, including the gearbox," continues Paakkonen.

Shop visit costs comprise labour cost, materials and parts, and the cost of sub-contract repairs. The total for these three elements typically totals $220,000-250,000 for a hot section inspection, and $650,000-700,000 for an overhaul. The cost of two hot section inspections and an overhaul combined is $1.1-1.2 million. When amortised over the full interval of 15,000EFC, the engine shop visit costs have a maintenance reserve of $73-80 per EFC.

A full set of LLPs has a list price of $75,000-80,000. When the price of each LLP is amortised over its life, and allowing for about 500EFC of stub life at removal, the reserves for all 10 parts are about $15 per EFC. Total engine reserves are thus $90-95 per EFC. When corrected for the average FC time, this is equal to $77-80 per EFH. This is based on three shop visits every 15,000EFC. Reserves can be lower where the number of unscheduled visits is reduced, and only two shop visits per 15,000EFC interval are required.

Engine reserves have to be considered together with overhauls of propeller units. Propeller hubs and blades have overhaul intervals of 10,500EFH.

The cost of the hub overhaul can be about $7,500, but can be as much as $50,000 if a high level of corrosion is found. The repair and overhaul cost of each blade is $7,500, totalling $30,000 for engines with four blades and $45,000 for engines with six blades. Assuming an average hub repair cost of $20,000, and a utilised interval of 10,000EFH, the reserve for four-bladed propellers will be $50 per EFH, and for six-bladed propellers $65 per EFH.

This takes the total maintenance reserves for engines with four-bladed propellers to $125-130 per EFH, and the total for engines with six-bladed propellers to $140-145 per EFH *(see table, this page).*

Summary

Total maintenance costs for young aircraft in their first base maintenance cycle are $557 per FH for aircraft with PW120/121/124 engines, and $587 per FH for aircraft with PW127E/F engines *(see table, this page)*. Costs can be marginally higher, especially where higher rotable-related costs are incurred.

Older aircraft, in their second and third base maintenance cycles, with PW120/121/124 engines have higher costs of up to $678 per FH, while those with PW127 engines have costs of up to $702 per FH *(see table, this page)*. Again, rotable-related costs can vary according to contract terms and operational characteristics. AC

ATR 42 & 72 values & aftermarket activity

The increase in traffic experienced by airlines in 2006 led to the availability of ATR 42s & 72s declining through the year, and consequently led to an increase in lease rates and market values.

The bulk of ATR 42-300/320 trading activity that took place during 2006 involved the independent company Nordic Aircraft Contractors (NAC) of Denmark, rather than ATR Asset Management. During 2006 NAC purchased a total of 12 aircraft from: Alitalia (5), Boeing Capital (1), GPA-ATR (4) and Italy First (2). In turn several of these aircraft have been sold on to Coast Air of Norway (1), UT Air of Russia (5), Wiggins Airways of the USA (1) and Century Services, a Canadian investor (2). One aircraft has also been leased to Trigana Air of Indonesia.

By comparison, ATR Asset Management has been relatively inactive, with limited aircraft availability restricting transactions to leases for Aerocaribbean of Cuba (1), Aeromar of Mexico (1), Conviasa of Venezuela (2), First Air of Canada (1), Halcyon Air Bissau Airways of Guinea Bissau (1), Regional Air Lines of Morocco (1), TACV of the Cape Verde Islands (1), TRIP of Brazil (1), White Eagle Aviation of Poland (1) and the sale of one aircraft to Tiko Air of Madagascar.

Independent third-party transactions have included: the lease of one aircraft to Avanti Air of Germany by PLTC; the sale of one aircraft to Aero North International of Indonesia by BAC Leasing; two aircraft purchased by Fly540 of Kenya from Executive Turbine; one aircraft leased to Pelican Air Services of South Africa by the AA Partnership; one aircraft leased to White Eagle Aviation of Poland by Bravo Aviation; and the purchase by West Air Sweden of the sole large-door-equipped ATR 42 from Northern Air Cargo of the US.

Despite the use of more than 40 ATR 42-300/320 aircraft in the freighter role (29 of these owned by Fedex) the bulk of the transactions that took place in 2006 were for passenger operations. With the exception of the West Air Sweden freighter, the only other ATR 42 acquired during 2006 for freight operations is the aircraft purchased by Wiggins Airways from NAC. Interestingly on the advertised market, BAC Leasing is offering four freighter-configured aircraft for sale on behalf of its sister company Air Contractors of Ireland. Apart from these, only four other aircraft are on the market. These are all from separate sources and are all generally older, early-serial-number aircraft.

Sales outnumbered leases by nearly two to one (26 to 14) in 2006, and the geographic spread was worldwide, although with a bias away from the established European market. Lease rates have been in the region of $50,000-60,000 per month, with the higher figure for younger aircraft. Pricing, which appeared to peak at around $3.0 million before falling back to nearer $2.5 million, is on the rise again due to the limited availability of good aircraft. Asking prices around $3.5 million are now the norm.

ATR 42-500

Only four ATR 42-500 transactions took place in 2006. One aircraft was leased to Air Deccan of India by ATR Asset Management, while another aircraft was leased to Airlinair of France. Two aircraft were sold by Air Mauritius to Air Fiji. These transactions were exclusively for the passenger role.

Limited trading activity makes it difficult to estimate market lease rates with confidence, but somewhere in the region of $85,000-95,000 per month is probably a reasonable assumption. Pricing is equally difficult, but the only aircraft on the advertised market, a 1998-built Air Caraibes aircraft, is being offered for $7.9 million.

ATR 72-200/210

Despite their relatively high cost compared with other turboprops, there has been a substantial level of interest in the older model ATR 72s as freighters. During 2006 no fewer than nine aircraft were placed in this role. Farnair of Switzerland purchased one aircraft from ATR and three from Transasia Airlines of Taiwan. Fedex in the US purchased two aircraft from Nordic Aviation Contractor. Swiftair of Spain acquired two aircraft from West Air Sweden and one from Eurowings of Germany.

In comparison, passenger configured aircraft accounted for 12 transactions, including ATR Asset Management placing aircraft on lease with Aer Arann of Ireland (1), Aerocaribbean of Cuba (1), Airlinair of France (2), Hansung Airlines of Korea (1), Precision Air of Tanzania (1), TRIP of Brazil (1) and Vietnam Airlines (1). Independent owners leased three further aircraft: Bravo Aviation to Aer Arann (1), Phoenix Aircraft to Air Bagan (1) and Sabine Schroder Aircraft Leasing to Sun Air of Egypt (1). Bravo Aviation purchased one aircraft from Finnair.

Sales matched leases almost exactly (10 to 11) and again the geographic spread is worldwide. European lease rates at the beginning of 2006 were in the region of $72,500 per month, but rates were increasing throughout the year, with more recent deals reaching in excess of $75,000.

Aircraft placed outside of Europe command a premium, with a rate of $92,000 believed to have been achieved on one particular transaction. The high level of activity during 2006 is unlikely to be repeated in 2007, since aside from one Bravo Aviation passenger aircraft, the only other aircraft advertised with availability are the four freighters that are being offered by Europe Airpost. With few aircraft available, recent offers have exceeded $85,000 per month.

At the beginning of 2006 pricing for older aircraft was as low as $4.0 million, but the same aircraft today would not be offered for much below $6.0 million. Newer generation aircraft are being offered in excess of $7 million.

ATR 72-500

Discounting the transfer of aircraft between related companies, only four ATR 72-500 transactions took place during 2006. ATR leased one to Air Deccan of India, and sold one to Airlinair of France. Cimber Air Leasing of Denmark leased out two aircraft, one going to Air Mauritius and one to Binter Canarias of Spain.

Once again, limited trading activity makes it difficult to estimate market lease rates for the ATR 42 and 72 with confidence, but somewhere in the region of $100,000-120,000 per month is a reasonable rate. In the absence of any sales transactions, pricing is somewhat theoretical. Advertised availability is nil, but two aircraft have recently been offered, but not advertised, for about $9.5 million each. AC