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Flying high

Civil aerospace is forecast to continue its good growth pattern in the long term, which is good news for the suppliers involved, reports Steve Karpel

In tough economic times, the aerospace market often seems to defy the pervading gloom and set its own agenda. Although not immune to economic cycles, this sector is one that has shown consistent growth in the past, and moreover, is forecast by its major players to continue an above-average growth over the long term.

The two dominant manufacturers of large passenger jets, Boeing based in the USA and Airbus in Europe, each publish a 20-year global market forecast, and reach similar conclusions. Boeing's *Current Market Outlook 2015-2034* looks at the probable global demand for new commercial planes (passenger and cargo) over this period. It forecasts that the number of planes in service will double from 21,600 in 2014 to 43,560 in 2034, with a total demand for 38,050 new planes over this period (*see tables*).

The company notes that aviation is becoming more geographically diverse, with about 40% of new planes – or over 14,000 – being delivered to the Asia-Pacific region up to 2034, and about 20% each delivered to North America and Europe. The total value of new deliveries in this period is put at nearly $5.6 trillion.

In its *Global Market Forecast 2015-2034*, Airbus estimates that new aircraft deliveries up to 2034 will total 32,585, including 22,927 single-aisle planes, with a total value of $4.9 trillion. Airbus notes that air travel has proven to be resilient to various external shocks over the past decades, showing a persistent growth trend in spite of the 1970s oil crises, two Gulf wars, the 1997 Asian economic crisis, the 9/11 terrorist attacks and the 2008-09 financial crash. The company points out that annual global air travel, as measured by revenue-passenger kilometres (RPK, or number of paying passengers multiplied by distance flown) has in fact increased by 85% to over 6 trillion since 2001.


NORSK TITANIUM

Stages in titanium component production via Rapid Plasma Deposition™

Airbus forecasts that global air travel will double in the 15-year period 2015-29, to over 12 trillion RPK, as a result of an average annual growth of 4.6%.

Bill Bihlman, president of aerospace consultancy Aerolytics, Indiana, USA, urges some caution, however, when projecting demand some 20 years ahead, especially as the world has seen "much more volatility since 2001". He believes that it is difficult to forecast much beyond 3-5 years.

Nevertheless, the long-term growth pattern in aerospace will be encouraging to suppliers, and to the metal industries that have an appreciable stake in the sector, such as aluminium, titanium, nickel and cobalt.

The commercial aeroplane market up to 2034

	In service 2014	In service 2034	New demand 2015–34
Large widebody	740	670	540
Medium widebody	1,620	3,800	3,520
Small widebody	2,520	5,800	4,770
Single aisle	14,140	30,630	26,730
Regional jets	2,580	2,660	2,490
Total	**21,600**	**43,560**	**38,050**

Source: Boeing

About 80% of a typical aircraft's unladen weight is aluminium, according to the International Aluminium Institute (IAI), and the alloys and finished components tend to be high-value. The low density of aluminium has made it essential in aviation, ever since the Wright brothers' first flight in 1903, which used a 12 hp engine modified with an aluminium block to reduce its weight.

Aluminium advances

Low density is combined with the essential qualities of strength, toughness and high corrosion resistance in the various specialist aluminium alloys that are established in aviation. But more importantly, it has proven possible to develop new alloys that have allowed aerospace technology to advance, a prominent example being aluminium-lithium.

Although known since the 1950s, aluminium-lithium alloys have recently become a vital component of modern aerospace, and Alcoa opened what it described as the world's largest plant for these alloys in late 2014 in Lafayette, Indiana, USA, with 20,000 tpy capacity. Alcoa points to its growing demand owing to "an outstanding combination of strength, toughness, stiffness, corrosion resistance and high-temperature performance, at a lower cost than titanium or composites."

The world's largest passenger jet, the Airbus A380, required seven years of joint research between Airbus and Alcan Aerospace (now Constellium) to develop the new set of aluminium alloys that make the project possible. One of several technological challenges was to cast advanced 7xxx alloys into massive 16.8-tonne ingots which are required to make the plane's very large wing spars, but this was achieved and the airliner made its first flight in 2005. In the A380, 61% of the structure is aluminium alloy, 22% is composite, and 10% is titanium and steel.

Myriad titanium uses

Another metal that makes a big contribution to aerospace is titanium, which is used for its low density and high strength-to-weight ratio, corrosion resistance, mechanical properties and all-round reliability.

In the airframe, it is used in wing structures, landing gear, critical fasteners, springs and hydraulic tubing. In engines, it is used for parts that operate up to 600°C, mainly in the compressor. This includes inlet blades, discs, hubs, inlet guide vanes and cases. Titanium-base alloys make up 20-30% of the weight of an engine. Aerospace makes up 40% of titanium's total market, which is the greatest market proportion for any aerospace material, according to Aerolytics.

The compatibility of titanium with carbon-fibre composites, especially with respect to thermal coefficient of expansion, means that its use in aerospace is growing alongside the application of composites.

A disadvantage of titanium is its relatively high cost compared with steel or aluminium, which is a result of the energy required to produce the primary metal and the processing needed to convert it to a finished product. The extensive machining needed to produce a component from an ingot may result in up to 90% of the metal being turned into scrap – a wasteful process. However, it now appears that the evolving technology of additive manufacturing (or '3D printing') may boost titanium further by making component production quicker and less wasteful. With this technology, the component is built up layer by layer into a finished or near-net shape product.

Demand by region, 2015-2034

Region	New planes	Value*
Asia Pacific	14,330	2,200
Europe	7,310	1,050
North America	7,890	940
Middle East	3,180	730
Latin America	3,020	350
Africa	1,170	160
CIS	1,150	140
Total	**38,050**	**5,570**

**Catalogue prices, $ billions. Source: Boeing*

Many companies are turning their attention to 3D printing – suppliers of raw materials and component manufacturers. Alcoa, for example, has entered into an agreement with Airbus to supply 3D-printed titanium parts for fuselage and engine pylon components. It expects to deliver the first parts in the middle of this year (*see End user, page 59*).

More powder capacity

Suppliers of metal powders for additive manufacturing are anticipating increasing demand from aerospace and other industries, and are preparing greater capacity. Praxair Surface Technologies in the USA started production of aerospace-grade, fine, spherical titanium powder last August, using a proprietary high-pressure gas atomisation process specifically designed for this metal.

In the UK, Metalysis is developing its innovative metal powder production technology that has the potential to reduce the cost of production, and environmental impact, even further compared with current technologies. Currently focusing on titanium, the process is able to produce the powdered metal directly from titanium ore, rutile, in one step, and the resulting material has been successfully tested in 3D printing applications.

Aerospace components can be the subject of competition between different materials, such as aluminium vying with carbon fibre composites for wing or fuselage structures. In another example, engine front intake blades are often titanium, but General Electric has been using fibre-reinforced composite blades on some engines for over 20 years. Now Alcoa has developed an aluminium-lithium fan intake blade forging for Pratt & Whitney's PurePower® engine – the first such use of aluminium alloy in a jet engine, says Alcoa. In a 10-year $1.1 billion contract, the company will supply Pratt & Whitney with aluminium fan-blade forgings plus a range of other advanced components.

The new aluminium fan blade has found a place where others use alternative materials. General Electric and Rolls-Royce have made the investment in composite blades, notes Bihlman.

Nickel-base superalloys are another vital aerospace material, and typically make up 40-50% of the total weight of an engine, according to the International Nickel Study Group. Aerospace accounts for about 20% of the total superalloys market, estimates Aerolytics. These materials are also important for various other elements that may form part of the alloy, such as cobalt, rhenium, molybdenum, ruthenium, tantalum and tungsten. About 16% of cobalt demand is accounted for by superalloys, reports the Cobalt Development Institute.

Rolls-Royce has forecast that the global civil aircraft market will require 149,000 engines to be delivered in the period 2012-2031, with passenger traffic increasing by a compound 4.5% RPK over this period. This ties in with other forecasts for a steadily growing demand for commercial aviation in the years ahead.

3D printing developments

Additive manufacturing technology is undergoing various developments that could increase its efficiency and utility, especially in aerospace. Norway-based Norsk Titanium has developed a Rapid Plasma Deposition™ (RPD™) process. This starts from commercially-available titanium wire rather than powder, which is melted in an argon atmosphere and then built up in layers according to CAD data to a near-net shape component, up to 80% complete, that requires very little finish machining. The company claims that production costs and times are 50-75% less than traditional routes via billet production and forging, owing to the significantly less waste generated and machining energy used.

Norsk Titanium notes that the new Airbus A350 (which incorporates a significant amount of composites) contains 14% titanium. It estimates that such an aircraft could generate as much as 154,000 lb (69.9 tonnes) of titanium scrap during its production. Using the RPD process could save about $2.3 million per plane, the company claims.

Another composite-intensive aeroplane, the Boeing 787 Dreamliner, contains about 15% titanium. Norsk Titanium observes that military aircraft can incorporate much higher proportions of titanium: the Lockheed Martin F-35 comprises 30% of this metal, for example. The military sector accounts for 12% of aerospace material demand, says Bihlman.

The size of components made by RPD is limited only by the machine size, says Chip Yates, vp marketing, of Norsk Titanium, and parts up to one metre long can be made at present. The company is now building a factory in the USA that will contain 40 RPD machines for supplying the aerospace and defence markets, and it has signed contracts with major aircraft makers.