



THE LOADSTAR

LongRead

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AEROSPACE



The huge growth in commercial aviation is providing opportunities for logistics providers. But do industry consolidation, new technologies, downsized military budgets and complex politics threaten traditional supply chains?

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In fewer than 20 years, an astonishing seven billion passengers will be flying every year – double the number that flew in 2015. That growth will require (depending on who you ask) between 33,000 and 39,000 additional aircraft. IATA forecasts a 3.8% average annual growth rate of seats booked until then.

That growth rate will require some complex supply chain management. The Boeing 737 is made up of 367,000 parts, while a widebody aircraft is composed of up to six million parts. It is forecast that the commercial aerospace industry as a whole will need to move some 35 billion components – for new aircraft alone – by 2034.

Better still for logistics providers and carriers, aerospace – which includes defence – is a truly global world. Airbus, for example, sources parts from 7,700 suppliers around the world

and sells to about 400 customers. It has fully owned subsidiaries in the US, China, Japan, India and the Middle East; spare parts centres in Hamburg, Frankfurt, Washington, Beijing, Dubai and Singapore; and engineering and training centres in Toulouse, Miami, Mexico, Wichita, Hamburg, Bangalore, Beijing, Russia and Singapore.

Of course, there is far more to aerospace manufacturing than Boeing and Airbus. For airframes alone, there is Embraer, Bombardier and new entrants such as Mitsubishi, Sukhoi and Comac. Then there are component makers, engine companies and, of course, some 400 active airlines, while new carriers take off and old ones go to ground with regularity.

“Overall, logistics within the aerospace sector has been quite dynamic based on the globalisation of the vendors and supply chains,” says

Advances in technology could change flows and plans

Advances in technology have the potential to disrupt trade flows across many sectors – and aerospace is no exception.

There are some aspects which can help trade flows and communications – relevant across all verticals. PEMCO's Mr Johnson notes: "It is my belief we will see continued improvements in RFID technology as it relates to tracking the life of parts as well as movements."

But it is the advent of smart technology, the internet of things (IoT) and 3D printing that could have the greatest ramifications. A recent Oliver Wyman survey on aerospace technology noted: "The advent of big data technologies will bring airlines unprecedented transparency into the condition of their aircraft. As the global fleet transitions from previous-generation to next-generation aircraft, the volume and predictive power of this big data will enable operators and providers of maintenance to better forecast, plan, and deploy aircraft assets. Players of all stripes have piled into the aftermarket, seeking to define a profitable niche, even as

airlines themselves take a measured, modest approach to adoption."

It notes two applications in particular – aircraft health monitoring (AHM) and predictive maintenance. Its survey shows that 63% of respondents found that AHM increased reliability, while 30% noted better reliability from predictive maintenance. Costs – for maintenance, inventory and ownership also fell with both technologies (see chart below).

"The aerospace industry has and will continue to change through technology," believes B&H Worldwide's Mr Allen.

"The IoT will continue to change how companies look at the data from various devices and systems moving forward. It will provide increased volumes of data that will be used to streamline processes, increase efficiencies and ultimately reduce costs in sections of their supply chains.

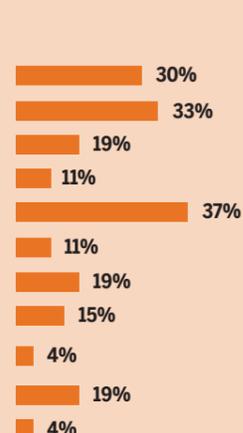
"Handling and processing that data to meaningful business planning will also be a challenge."

Tangible benefits due to the adoption of

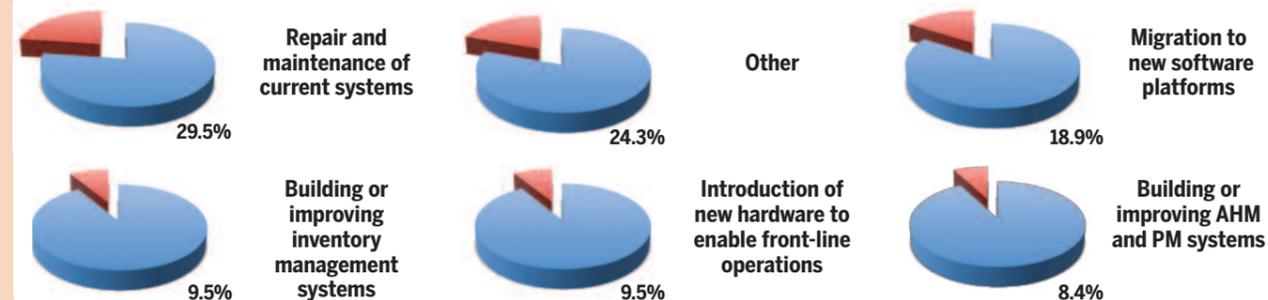
AIRCRAFT HEALTH MONITORING



PREDICTIVE MAINTENANCE



Airline spending by type of technology (airline respondents only)



The other major change expected is 3D printing, which is already being used relatively extensively in aerospace.

"I think the further development and future of 3D printing will have an impact on how some aerospace parts and components are handled in the future. It may give the opportunity for a part to be made at the aircraft suffering a mechanical failure, rather than waiting for a part to arrive from another facility, for example," says Volga Dnepr's Mr Kaldschmidt.

"In production, it may improve the process and time required for

actual manufacturing, again at a local level. Logistics will also be necessary as far as movement and transportation of commodities are concerned. It is just a matter of how that process changes."

For contract logistics providers, this is likely to involve even greater regulation and certification of parts – and possibly higher insurance liabilities.

It is also likely that logistics service providers are well-placed to take on the new volumes of data that airlines and manufacturers will inevitably have to process.

Axel Kaldschmidt, global director – aerospace, Volga-Dnepr Group.

"If you take a look at overall fixed wing aircraft production, rarely is there a manufacturer which is maintaining a local or regional supply base. For the smaller companies, such as Pilatus or Beechcraft, the overall time and expenditure lends itself to keeping their supply bases local. However, if you look at the major manufacturers, such as Boeing, Airbus, Bombardier and Embraer, the main structures and components are being sourced on a global level. The larger the aircraft, the more complex the supplier base and tier structure."

At any one time, vast numbers of aircraft components are moving through what are some of the world's most complex supply chains. This is not a sector for the faint-hearted – but it's full of opportunity.

"One of the biggest challenges for our sector is managing growth," says Stuart Allen, chief executive of specialist forwarder B&H Worldwide. "The aerospace sector has seen phenomenal growth in recent years. It's a highly competitive industry and our most valuable assets are our people."

Steve Hunt, regional account director for aerospace and defence at CEVA Logistics, notes: "It's one industry which is in positive mode. There are new markets in Asia, and the Chinese are becoming a more global population. There is a huge potential for new fleets and bigger aircraft."

Asia is indeed a serious growth opportunity. It has become one of the biggest aviation markets in the world, with a billion passengers travelling to, from or within the continent each year, with another 100 million a year set to enter. Fleets have nearly doubled, while the number of airlines has risen to 225 from 150 a decade ago.

Asia is also attempting to boost its own, fledgling aerospace business. The state-owned Commercial Aircraft Corporation of China (Comac) was set up in 2008, and has produced its first aircraft type, the ARJ21, a 70-90 seater, which some experts claim is closely modelled on the MD-80. Only two are flying currently, but Comac has about 350 orders – the majority from Chinese airlines. And about 80 of China's Xian MA60, the 60-seater turboprop approved in 2000, are operating, with orders for another 200 or so.

The Mitsubishi Aircraft Corporation



formed in the same year, has plans to launch another regional jet. There are now some 240 orders for its MRJ90, the first of which is set to be delivered in 2018. As a major Boeing supplier, it has promised not to produce any jets larger than the MRJ.

Meanwhile Russia's Sukhoi Superjet enjoyed its first commercial flight in 2011. With up to 100 seats, it is thought to have about 200 orders.

Some of these developments may be a while off, but new aircraft types mean new suppliers, spare parts companies, maintenance providers and conversion companies or programmes. It is big business.

"We continue to move many parts from European countries as we grow our strength in Airbus capabilities," explains Justin Johnson, conversion specialist PEMCO's director of materials. "As we develop our partnership with Mitsubishi, we will increase our lanes with Japan. PEMCO will continue to see strong growth and movement in China with long standing partners in the region."

The consolidation effect

There may be more original equipment manufacturers (OEMs), but there has also been a trend towards consolidation further along the chain.

"We find a growing number of the major airframe manufacturers are reducing the overall vendors utilised in the supply chain process," says Mr Johnson. "This helps with the manufacturing aspects, but is leading to less diversification in the aftermarket."

Essentially, as OEMs increase volumes, they must also manage the risk of possible parts shortages from suppliers. However, aggressive pricing means the OEMs have pressured suppliers to reduce costs, such as

Boeing's controversial Partnering for Success programme, which demanded that suppliers shave between 15% and 25% off their rates.

"These competing pressures of significant volume increases and price reductions are benefiting suppliers of scale with significant competitive advantage," notes Michael Richter, managing director of Lazard, in *Aviation Week*.

"While consolidation offers the potential for lower prices and reduced going-concern risk associated with larger, more stable suppliers, the OEMs must contend with increased single-point-of-failure risk should a supplier stumble. This, in turn, raises enhanced opportunities for well-run, well-capitalised Tier 1, 2 and 3 suppliers."

"You need to deliver, and price accordingly. You can't cut corners and costs when a customer wants consistency"

But Mr Kaldschmidt notes that this consolidation has not impacted supply chain flows.

"There has not been too much of a change of supply chains based on consolidation of the components and parts manufacturing. If anything, we have seen the smaller suppliers being purchased and brought into the larger companies. The dynamics here change as the suppliers are now part of a larger buying power, which they then look to leverage to reduce costs for logistics and services due to volume and expenditure increases."

There may be reduced costs, but it can also lead to heightened risk from supply chain or logistics mistakes.

"Aircraft manufacturers are maintaining 'Lean' principles in regard

AEROSPACE IN NUMBERS



EXPORTS

Aerospace exports by country totaled **\$352.1 bn** in 2015, up by an overall **40.6%** for all aerospace shippers over the 5-year period starting in 2011. Year over year growth in the value of global aerospace exports was **9.3%** from 2014 to 2015. (World's top exports)

The fastest-growing aircraft and spacecraft exporters since 2011 were: Ireland (up 650.8%), China (up 113.7%), India (up 64.3%), Israel (up 58.4%) and Japan (up 52.5%).

TOP 15

1. United States: \$131.1 bn (37.2% of total aerospace exports)
2. France: \$76.8 bn (21.8%)
3. Germany: \$43.4 bn (12.3%)
4. United Kingdom: \$19 bn (5.4%)
5. Canada: \$12.3 bn (3.5%)
6. Singapore: \$6.4 bn (1.8%)
7. Italy: \$5.25 bn (1.49%)
8. Japan: \$5.17 bn (1.47%)
9. Ireland: \$4.74 bn (1.35%)
10. Spain: \$4.69 bn (1.33%)
11. Brazil: \$4.5 bn (1.28%)
12. India: \$3.78 bn (1.07%)
13. China: \$3.5 bn (1%)
14. Israel: \$2.9 bn (0.83%)
15. Switzerland: \$2.7 bn (0.78%)

7,000,000,000

By 2034 there will be **7 billion** passengers flying.

35,000

Some **35,000** additional aircraft will be needed by 2034.

- China will have an additional 758m pax
- US: 523m
- India: 275m
- Indonesia: 132m
- Brazil: 104m

(source IATA)

JOB

Aviation helps sustain **58 million** jobs and **\$2.4 trillion** in economic activity. In 20 years' time, aviation is expected to support around **105 million** jobs and **\$6 trillion** in GDP.

BOEING

The **737** is made up of **367,000** parts.
The **767** has **3.1m** parts
The **787** has **2.3m** parts
The **777** has **3m** parts
The **747-8** has **6m** parts

AIRBUS A380

An Airbus A380 has an approximate **4 million** parts, with **2.5 million** part numbers produced by **1,500** companies from **30** countries around the world, including **800** companies from the United States. There are **310** miles of electrical wiring on the A380.

to parts and production materials required in manufacturing processes,” explains Mr Kaldschmidt. “They place the responsibility of holding inventory on suppliers, and manage the components already moving within the supply chain. This does not leave much room for error, nor does it allow much flexibility when it comes to disruption or issues stemming from *force majeure*. In a way, it is also positive as it keeps the airlines and logistics providers working towards ensuring the schedules and production timelines are held in place.”

As a result, logistics providers in this business must be efficient, accurate and globally capable.

PEMCO’s Mr Johnson explains: “3PL providers have been very useful in establishing supply chain routes. This helps both domestically and internationally. We source parts from a broad spectrum of providers to include OEM partners, parts manufacturer approval (PMA) manufacturers, overhaul shops and third-party brokers. We grow our partnerships as the industry develops, but many have remained over long periods as they continue to provide exceptional support.”

Tradelanes

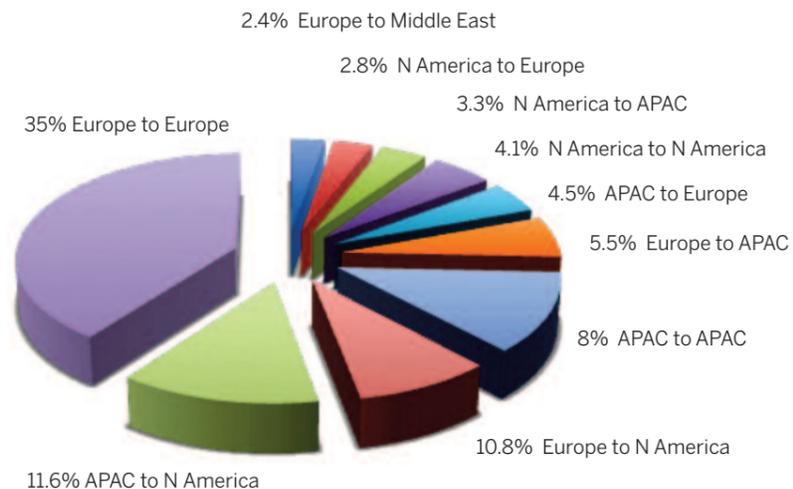
Despite the majority of top aerospace companies being based in the US, it is intra-Europe, home of Airbus, which accounts for the most significant regional trade flow for aerospace parts, according to Transport Intelligence’s Global Freight Forwarding 2016 research.

Intra-Europe makes up 35% of the total and is larger than the next three biggest put together (see chart above right) Next largest is Asia Pacific to North America, followed by Europe to North America. The greatest growth, however, reflecting the rise in passenger numbers, is intra-Asia and Asia Pacific to Europe – which grew 11.7% and 9% respectively in 2015.

The single largest tradelane must also be one of the shortest and reflects the multinational nature of Airbus: Germany to France (see chart right). And while France, Germany and the US make up all the import destinations of the top 10 tradelanes, the origin points are more diverse, and include the UK, Japan, Singapore, Italy and Canada.

Singapore is significant. It houses more than 100 aerospace companies, and is the regional hub in South-east Asia. It puts huge effort into aerospace – the Singapore Economic Development Board, for example, is

Top 10 regional trade flows of aerospace parts 2015



Top 50 tradelanes – aerospace parts

1	Germany to	France	5,816	26	Germany to	US	480
2	UK	Germany	5,290	27	US	S Korea	471
3	Japan	US	4,407	28	Singapore	France	457
4	UK	France	3,173	29	UK	Italy	442
5	Canada	US	2,511	30	France	UK	389
6	UK	US	2,122	31	Germany	UK	388
7	France	Germany	1,860	32	India	US	374
8	France	US	1,147	33	US	Taiwan	336
9	Singapore	US	1,015	34	Singapore	Hong Kong	323
10	Italy	France	966	35	Singapore	Japan	317
11	Spain	France	962	36	Japan	Canada	307
12	Italy	US	957	37	US	Italy	293
13	Netherlands	US	910	38	Austria	US	284
14	Singapore	China	880	39	France	China	283
15	S Korea	US	813	40	China	Hong Kong	281
16	US	Saudi Arabia	792	41	Germany	Italy	279
17	UK	Canada	767	42	Italy	UK	275
18	Spain	Germany	744	43	Turkey	US	274
19	Australia	US	707	44	US	Turkey	272
20	Germany	China	647	45	US	UK	270
21	Singapore	Taiwan	628	46	Singapore	S Korea	257
22	US	Japan	625	47	Spain	Saudi Arabia	252
23	Mexico	US	614	48	Singapore	Malaysia	249
24	US	Australia	614	49	S Korea	Japan	248
25	China	US	586	50	Austria	Germany	242

collaborating with Airbus on maintenance technology.

With regional clusters around the world, airlines are never far from a needed spare part.

“With the development of local and regional aerospace clusters which support a global production requirement, there are very few places where aerospace parts and

components are not being manufactured or utilised,” says Mr Kaldschmidt.

“Europe and North America are the main points for aircraft production. Asia is a growing market with its own ambitions of becoming a contributor to the global aircraft market. Almost all aircraft have some sort or type of component which either originated, or

was assembled, in Asia prior to dispatch.

“The Middle East is also looking to enhance its participation on the global stage, in terms of supporting the manufacturing of aircraft for local utilisation or components for shipment to Europe or the US.”

All of this amounts to a lot of logistics. And, understandably, it’s a very competitive arena.

“Aerospace logistics involves a constant fine-tuning,” explains CEVA’s Mr Hunt. “Our aim is to help manufacturers improve flows. We work with component suppliers and speed inventories through the process, which gives them a better cost base. We enable maintenance providers to minimise any time needed for maintenance.”

Market conditions

Spare parts are particularly important at the moment, say industry specialists. Low fuel prices have triggered new trends among shippers, and airlines have been happy to use older equipment – which means higher demand for spare parts.

“This demand creates a greater requirement for critical delivery of parts, which creates additional business for OEMs and stockists,” adds Mr Allen.

“As a result, logistics providers are seeing increased opportunities to grow their businesses. In addition, demand for e-commerce platforms has increased in line with this growth.”

Lower demand for new equipment, both to operate and to use for oil and gas projects that are highly dependent on aerospace solutions, has also shifted supply chains.

“With fuel levels at the current point, airlines can still afford to operate older aircraft which have been amortised and paid for at a much lower cost,” says Mr Kaldschmidt.

“In these circumstances, there is currently a lower demand for newer, more fuel-efficient aircraft and new orders emerging onto the market, slowing production and deliveries.

“This is also true in the helicopter market segment. Since there is a slowdown in the oil and gas sector, there is no longer as much support for helicopter operations for offshore installations. As a result, operators have a surplus of assets and equipment and no need for new purchases. It does also make it difficult for the operators in the market to find

work for existing fleets in such economic conditions.”

Cost control

Manufacturers and airlines, of course, are keenly aware of costs and rely on their logistics partners to ensure the best-priced service. And the most expensive problem is “aircraft on ground” (AOG). CEVA notes that it costs an airline about \$160,000 an hour for an immobilised widebody.

Mike Stephens, director aerospace for CEVA, who focuses on the military side, points out that forwarders – as they do in other verticals – need to ensure that costs are carefully controlled, and so shipping by air is not necessarily the first choice. However, spare parts sent by ocean freight spend a lot of time at sea and may still be en route when they are most needed.

“Customers have a supply chain budget they try to maintain. A lot does move by air, as traditionally ocean is the most desirable mode to drive cost savings. The most challenging aspect is to think you can move items via sea freight and then change your mind. Our job is to find the most cost-effective method, yet engage closely with customers to ensure their production or service needs are not impacted.”

But, he warns: “A common mistake would be to start changing the expectation of the customer. If a customer wants a part at a certain time, but as a service provider you feel you will save money by using a less-reliable carrier, you’ll fail. You need to deliver, and price accordingly. You can’t cut corners and costs when a customer wants consistency.

“There is some modal shift,” he adds. “As a customer’s supply chain

becomes more stable, there is a shift to ocean. For new aircraft, due to an immature supply base for parts, we use air freight more often to meet the customer’s requirements. When considering sea freight, you have to ask if the product is mature enough to send by water. Later, as the parts from suppliers will broaden out, you can have more confidence in moving items via sea freight.

“Rail could be a significant method of transport, depending on the country. In the US, the rail system is, in my opinion, not as mature as in Europe. But rail will be a definite player very soon. As the rail industry becomes more mature in the US, companies will shift to take advantage of this lower-cost option to move their product. One problem has been lack of visibility on rail, but technology today is improving in this area.”

Cheap capacity

One of the advantages of shipping by air, however, is that for many shippers – the airlines themselves – capacity is relatively cheap. But not as cheap as sourcing parts from regional spares hubs.

“When supporting airlines with their spare and support items, each works in a different way,” says CEVA’s Mr Stephens. “Some want you to place items on their aircraft, while some are comfortable to use other airlines so they can sell their own space to gain higher revenue.”

Volga-Dnepr Group has a mixed fleet of Boeing and Russian aircraft types.

“We use logistics providers in order to mobilise and circulate our parts and spares pool effectively and within the intervals required,” explains Mr Kaldschmidt. “As with any airline, we look to maintain all our aircraft in the



most effective way and return them to service as soon as possible. There are spares and facilities strategically located in Europe, the Far East and Russia, alongside our partnerships with other MRO service facilities around the globe."

But, he suggests, there is little reason to carry parts onboard.

"If you are looking at the scheduled services sector, there are very minimal spares on hand with the aircraft, if any. For the most part, the aircraft is flying hub-to-hub or to major destinations with facilities and spares available locally. This negates the need for taking up both volume and weight on an aircraft which could use this capacity to bolster revenue potential."

For the Russian aircraft, however, it is a different story. They fly with maintenance crew and are self-serviced, he says.

"Since these aircraft operate on a global level with specific spares and parts requirements, they do operate with spares onboard. This is necessary as the aircraft often operate into more austere areas of the world and to airports which very often are not serviced by a large number of scheduled services.

"The aircraft crew are trained to maintain the highest level of operations at all times. You don't want



to be stuck in the middle of Africa or Asia with no possibility of getting your spares when you need them."

As a logistics provider, however, Volga-Dnepr Group – which this year confirmed an order for 20 747Fs – and Boeing negotiated a deal for the group's airlines to provide long-term logistics support for Boeing Commercial Airplanes and its partners using Boeing 747-8F and Antonov 124-100 freighters. Volga-Dnepr reaps 30% of its revenues from the aerospace business.

"It's unique, as the airline is looking to

support Boeing as well as Boeing-appointed forwarders in an even more effective way," says Mr Kaldschmidt. "There are several components and partners throughout the supply chain which are part of improving the logistics process."

Forwarders

While airlines have differing demands concerning their parts logistics, forwarders too are split, between specialist and global 3PLs. A larger 3PL will be able to offer a more globalised service – CEVA, for example, deploys the control tower concept.

"Communication is the essence of any logistics," says Mr Hunt. "The physical movement is not hard, but you need to communicate with customers so that they can plan upstream, and you need to be multilingual."

XPO Logistics chief executive Brad Jacobs adds: "There's a growing preference among large companies to winnow down their supply chain relationships. If a company is multinational, it can be even more valuable to deal with a single global supplier to achieve benefits of scale, best practices and expertise, as well as technology. Innovation is expensive."

He explains there can be economies of scale from using a multinational. "One aerospace customer realised \$250m in annual cost reductions when

we developed a supply chain solution that consolidated global distribution for standardised parts."

But B&H Worldwide's Mr Allen argues that specialist forwarders can be more agile. "The smaller LSPs are more flexible and nimble, they are able to change on demand. The larger logistics providers can often struggle with this. Each has its place in the sector, with the larger providers offering a more

Asia is a growing market with ambitions of contributing to the global aircraft market"

commoditised service, while the smaller LSPs tend to be more innovative and specialist."

But as aerospace companies consolidate, there is a shift towards global rather than local, believes CEVA's Alain Souto, vice-president global contract logistics for aerospace.

"Tier 1 is 10 companies, but that is coming down – there is big consolidation. They allocate a programme for part of a plane. In the past, manufacturers worked with locals, close to the plant. But now with the pushback in Tier 1 and 2 suppliers, it might not be in the same country or continent, so it's a new challenge. As is quality control. Smaller logistics companies can't always adapt to the change of flows. You need a good worldwide footprint, and then you are able to propose global solutions."

There is, clearly, a place for both, confirms Mr Kaldschmidt. "There are forwarders in the market which do specialise in providing niche services within the aerospace logistics market. They are normally in place to service a

specific lane or customer requirement which is geographic or country-specific. The roles are primary, as some of the requirements such as helicopter transport, satellite logistics or space component transport require a specific logistics knowledge base which is not readily available on the market."

Compliance

Aerospace logistics contracts tend to run for between five and 10 years – and much is dependent on the expertise offered on compliance and regulation.

"When you look at the safety regulations, lots of research and development goes into component parts," says Mr Hunt. "Which takes time and involvement. Aerospace companies have always looked for partners, and are now looking for more in-depth and long-term commitments."

He adds that even a modal choice may be directed by what packaging is needed – for example, how it may be affected by salt water.

Military and defence contracts – especially for munitions logistics – require even higher security standards. CEVA's Mr Stephens explains: "We work all over the world, moving parts for military aircraft, and munitions. We work with different governments, and government-to-government sales.

"One of the most challenging things is compliance and regulation. Regardless of the country, there are licences and we have a robust compliance team in place that is properly trained. If you are not compliant there are penalties. You need proper resources for that. Each country is a bit different but security goes across all aspects."

For many military contracts, technical inspections can be performed by accredited staff only, and only they can access some parts or plants.

"Terrorism has increased the drive for safety," adds Mr Hunt. "Parts have to go through stringent safety checks, especially to get them airside. There is a continual safety process for people and parts."

Military and defence contracts, have, however, dwindled. "We do operations at top bases all over the world, such as Afghanistan and Iraq, and we work closely to position the goods in the UAE," explains Mr Stephens.

"But there has been a significant reduction due to less military demand.

"There's a growing preference among large companies to winnow down their supply chain relationships"

Some items move over to the commercial side, such as troop supplies and basic necessities. Munitions have to go on military transport."

Military moves may be decreasing, but as verticals go, aerospace is seeing good growth. But it is one of the more politicised industries (see box), which could lead to some crosswinds, and it remains highly regulated.

CEVA's Mr Hunt concludes: "When you roll it all up, it comes down to an investment in the future. With so many more planes flying, you need to ensure as a logistics provider you support the maintenance service and spare parts market worldwide."

Contract logistics grows

A large part of aerospace logistics is on the contract side – industrial and aerospace makes up 20% of CEVA's contract logistics clients, and it is seeing considerable growth in the sector.

"It's not just warehouses, but activity in customer facilities," explains CEVA's contract logistics specialist, Alain Souto (pictured). "Aerospace is booming and has gone up in each of the last five years.

"We have two different activities – one is focused on spare parts, for which you need smaller warehouses positioned strategically around the world. You need to be able to fulfil any type of spare part.

"For aircraft on the ground (AOG) the number of hours is critical. The requested KPI is four hours, so within around eight hours everything must be available.

"There are two formats: you can keep spare parts worldwide, or you might have another company who buys stock from a different brand.

"Before, there would be lots of small companies in each factory. In the last 10 years, they have tried to focus part of the production, so Tier 1 providers leave the responsibility to subcontract parts to Tier 2. Most factories now focus on assembly. Tier 1 and 2 tend to focus on ramping up production and risk, and push stock back to a provider. There is more in the pool. That creates a good opportunity for logistics companies for Tier 3 flows."

But contract logistics is also about getting the processes

right, says Mr Souto. "We ensure quality through technical inspections. You have to make sure spare parts match the requirements.

"Manufacturers will come in for sample inspections too, and to check documentation. You need specific documents for all elements, even the screws. It's not just a focus on the physical flow.

"There is too much paper though – some documents have to be on paper. But there has been a big trend in the past two to three years to digitise everything – before, everyone wanted the original documents. But it has to be in the correct format, and stored securely – you can't risk a digital copy getting into the wrong hands."

He adds that liability for managing "large chunks" of aircraft, such as having to handle a fuselage, is also critical, and global insurance management is also mandatory.

Another recent trend is 'workshare', by which an airline orders aircraft, but the government of its home country may insist the manufacturer opens a facility in the country as part of the deal.

"It is a trend. If you sell in a different country, the seller may offer a guarantee to move part of the production to the country that buys the plane.

"So you automatically have to set up new logistics flows. Or it could be the last mile – you could ask for a final assembly line in the buying country."



Politics and the Trump effect

Aircraft manufacturing is a political game. And the stakes just got higher, for Boeing in particular.

For one thing, president-elect Donald Trump has made known his feelings on the Iran deal negotiated by Barack Obama, which could halt Boeing's planned aircraft sales to Iranian airlines – although the American manufacturer and Iran Air have confirmed a \$16.6bn order for 80 aircraft.

Perhaps more important for Boeing's relationship with international customers is the future of the US Ex-Im Bank. Republicans have already shown their distaste for the "subsidies", in what is often called "financing of last resort". They have blocked nominations to the board of directors, meaning the bank has been unable to approve any loan greater than \$10m for more than a year.

Mr Trump has promised to get rid of the bank, which until 2015 used 30-40% of its loans for Boeing aircraft sales.

Mr Trump's presidency could also, if he sticks to policies

outlined on the campaign trail, put an end to "workshare" policies. He has already noted his disapproval of Boeing's completion and delivery centre in Zhoushan, China, which it has in partnership with Comac.

And if, as promised, he starts a trade war with the Chinese, Boeing's sales to Chinese airlines could come under threat – and, in turn, so could many US jobs.

On the plus side for the industry, Mr Trump has proposed lifting the budget caps imposed on defence.

