

CILT Level 6 Advanced Professional Diploma

Strategic supply chain management

CASE STUDY

INSTRUCTIONS FOR CANDIDATES

You will be expected to demonstrate your knowledge and understanding of relevant theoretical principles, concepts and techniques; to apply these appropriately to the particular situation described in the case study; and above all, to make sound decisions. You will not gain marks by writing a general essay on the topic.

Please note that all work should be your own. Copying or plagiarism will not be tolerated and could result in no marks being awarded. If quotes or short extracts are used they should be attributed or the source of the information identified.

You should acquaint yourself thoroughly with the case study.

BOEING CASE

This case has been produced for assessment purposes only. It has been sourced directly from the articles indicated within the bibliography, which are available in the public domain. It contains a number of direct extracts and quotations, which have been referenced within the text.

The views and opinions expressed within the case are those of the authors of the reference material and are not necessarily the views or opinions of NIRTC or the companies mentioned. The case may not reflect the actual situations of the specific companies mentioned.

The case was written in March 2016 and may not reflect the current situation.

Candidates are advised to base their analysis, evaluation and critical review on the situation depicted in the case.

A bibliography can be found at the end of the case study.

INTRODUCTION

Boeing is the world's largest aerospace company and leading manufacturer of commercial jetliners, defence, space and security systems. As America's biggest manufacturing exporter, the company supports airlines and US and allied government customers in more than 150 countries. Boeing products and services include commercial and military aircraft, satellites, weapons, electronic and defence systems, launch systems, advanced information and communication systems, and performance-based logistics and training.

Boeing has a long tradition of aerospace leadership and innovation. The company continues to expand its product line and services to meet emerging customer needs. Its broad range of capabilities includes creating new, more efficient members of its commercial airplane family; designing, building and integrating military platforms and defence systems; creating advanced technology solutions; and arranging innovative customer-financing options. With corporate offices in Chicago, Boeing employs approximately 160,000 people across the United States and in more than 65 countries.¹

As well as manufacturing airplanes, Boeing offers a number of related services to customers around the world, including:

- aviation support
- aircraft modifications
- spares
- training
- maintenance documents
- technical advice.

Boeing instructs maintenance and flight crews in the 100-seat and above airliner market through Boeing Training & Flight Services, the world's largest and most comprehensive provider of airline training.²

Boeing has performed well over the last few years, as the airline industry sees improved demand across the globe. In 2014, Boeing reached an annual record for orders and deliveries of its commercial jetliners. Along with a drop in deal cancellations, this helped the company retain its title of the world's largest airplane manufacturer for the third consecutive year. Boeing delivered 723 jets in 2014, surpassing its rival Airbus's 629 during the same year.³

Boeing delivered a strong performance during the third quarter of 2014 (3Q14) with a 7% year-on-year rise in its revenues to \$23.8 billion and a 19% increase in earnings per share to \$2.14. Operating earnings

¹ www.boeing.com, accessed March 2016.

² 'Boeing's Global Competitors', marketrealist.com, December 2014.

³ 'Boeing Company Beginnings', marketrealist.com, April 2015.

also increased by 13% year-on-year to \$2.4 billion. This growth resulted from solid operating performance across the company's production programmes and service businesses. This was Boeing's fourth successive successful quarter. It ended with a record backlog of \$490 billion, including net orders of \$73 billion for the quarter and cash and investments totalling \$10.2 billion.⁴

COMPETITIVE ADVANTAGE

Boeing's competitive advantages are cited as follows:

- Both its sales and production facilities are global. This gives it a strong international presence, spread across more than 140 countries.
- The company enjoys strong relations with many companies, even its competitors. It successfully deploys a number of joint programmes. For example, Boeing partners with Lockheed Martin (LMT) in the United Space Alliance and with Northrop Grumman (NOC) in a joint common missile programme.
- Boeing has a broad product range that includes the Boeing Business Jet and the 717, 737, 747, 757, 767, and 777 families of jetliners. Also, the company's newly launched Dreamliner caters to major markets and niche segments.
- More than 12,000 Boeing-built commercial jetliners are in service around the globe. This is roughly 75% of the world fleet.
- The company has a strong, strategically positioned global distribution network that is linked by advanced digital systems to ensure prompt spare parts delivery. Up-to-the-minute inventory information is available on demand to keep Boeing fleets operating at optimum productivity.
- Boeing teams up with suppliers from different countries to develop technologies and design concepts. This in turn helps it gain market in these countries since companies that have a stake in Boeing are more likely to buy from Boeing than from its competitors. For example, Boeing has maintained longstanding relationships with Japanese suppliers, including Mitsubishi Heavy Industries and Kawasaki Heavy Industries. These companies have been increasingly involved in successive Boeing jet programmes in a process that has helped Boeing achieve almost total dominance of the Japanese commercial jet market.
- Boeing works with top firms such as General Electric (GE) and Rolls-Royce to develop more efficient engines; this gives Boeing a technological edge over its competitors.
- Boeing offers dedicated support for out-of-production airplanes and parts.⁵

Another competitive advantage is Boeing's established position as one of the two largest aircraft manufacturers in the world, along with Airbus. Aircraft manufacturing requires significant upfront capital, research and development expenditure, and Boeing has made these investments over the years.

A large number of airlines in the world operate Boeing airplanes and have a long, established relationship with Boeing. Companies such as Embraer, Bombardier, Comac, Russian Irkut or Mitsubishi that are looking to play a larger role as a commercial airplane manufacturer are not able to replicate this. Boeing's track record and existing relationships provide the company with a significant competitive advantage over smaller and relatively new airplane makers.⁶

⁴ 'Boeing's Global Competitors', marketrealist.com, December 2014.

⁵ 'Boeing's Global Competitors', marketrealist.com, December 2014.

⁶ 'Boeing Stock Update', trefis.com, 20 August 2015.

DEMAND FACTORS

Aircraft demand is strongly linked to global economic growth. A decline in passenger and cargo traffic because of the global recession in 2009 adversely impacted revenues and margins for commercial airlines throughout the world. This in turn affected aircraft demand. In recent years, as the global economy has steadily grown, airlines have seen their profits rise. Higher profits in turn have enabled airlines to place orders for new airplanes. If the global economy continues to grow, demand for air travel and new airplanes will also rise.⁷

The outlook for the global commercial aerospace sector is good, with significant expected revenue and earnings growth. This is driven primarily by the accelerated replacement cycle of obsolete aircraft with next-generation fuel-efficient alternatives, as well as the continued increases in passenger travel demand. On the other hand, the outlook for the global defence sector is not so good, with continuing declines expected. This is because of the cessation of prolonged armed conflict in Iraq and Afghanistan.⁸

Low-cost airlines or carriers (LCCs) are fast expanding around the world. They provide an alternative to other modes of transportation, such as railways, and typically use single-aisle aircraft, such as Boeing's 737 and Airbus's A320. Growth of LCCs is primarily a consequence of increased liberalisation in the commercial aviation industry, which has reduced entry barriers for private players. This is especially true in the emerging countries of the Asia-Pacific region where liberalisation driven by the Association of Southeast Asian Nations (ASEAN) has boosted growth of many LCCs. As regulatory hurdles continue to decline, the demand for single-aisle airplanes will increase.⁹

Boeing forecasts that 48% of global traffic in the future will come from the Asia-Pacific region. This could lead to the demand for about 9,540 narrow-body and 3,570 wide-body planes in the next 20 years. The company predicts that the majority of the requirement would be for single-aisle jets, so Boeing's 737 and 737 MAX families would be the company's leading products. Boeing claims that its re-engineered 737 MAX (scheduled to enter service in 2017) is 14% more fuel-efficient than competing jets. This would enable airlines to offer lower fares to passengers.¹⁰

Boeing generates about 80% of its Defence, Space and Security division revenues from the US government through its various agencies, such as the US Department of Defense and NASA. Owing to this high degree of dependence on the US government, Boeing is vulnerable to any cuts in the government's military spending.¹¹

In 2014 Chris Chadwick, chief executive of Boeing Defence, Space and Security, stated that the US budget had fallen by about 24% due to automatic spending cuts and that he expected the budget to continue to decline. However, he also said that the company has an advantage over competitors by using successful commercial airplane models to produce military products. Among the opportunities in the US defence sector, where spending is equal to the ten next-largest national defence budgets combined, are military customers still using equipment based on the Boeing 707 jetliner that are old and will need to be replaced. Boeing is investing in research and development to meet those needs.¹²

In February 2016 Boeing announced that it had received a licence from the US government to begin commercial discussions with Iranian airlines, opening the door to what could be the first US jet deliveries to the Islamic Republic since the 1970s. The next month, Iran invited Boeing to Tehran to negotiate an aircraft

⁷ 'Boeing Stock Update', trefis.com, 20 August 2015.

⁸ 2014 Global Aerospace and Defence Industry Outlook Report, Deloitte.

⁹ 'Boeing Stock Update', trefis.com, 20 August 2015.

¹⁰ 'Boeing's Global Competitors', marketrealist.com, December 2014.

¹¹ 'Boeing Stock Update', trefis.com, 20 August 2015.

¹² 'Two Thirds of Boeing's \$6bn Cost Cutting Will Come from Its Supply Chain', www.supplychain247.com, 12 August 2014.

purchase. 'Following the signals of the US administration to Boeing on removing the aviation industry sanctions, we invited the company to Tehran for negotiations,' said Abbas Akhoundi, Iran's Minister of Transport. It is estimated that Iranian airlines currently have a total of 150 aircraft, which are up to 20 years old. Ali Abedzadeh, the head of the Iran Civil Aviation Organisation (ICAO), said the country needs to buy up to 500 passenger planes in the next ten years to renovate its ageing fleet.¹³

MARKET SEGMENTATION

Boeing is organised into two business units: (i) Commercial Airplanes and (ii) Defence, Space and Security. Supporting these units are Boeing Capital Corporation, a global provider of financing solutions; Shared Services Group, which provides a broad range of services to Boeing worldwide; and Boeing Engineering, Operations & Technology, which helps develop, acquire, apply and protect innovative technologies and processes.¹⁴

Commercial Airplanes is Boeing's most successful business segment, contributing 66.83% of the company's revenue in 3Q14. Boeing designs, develops, produces and markets the company's commercial jetliners, which meet the passenger and cargo requirements of airlines worldwide. Roughly 75% of the world's total airline fleet is made by Boeing and about 90% of the world's cargo is carried on the company's airplanes.¹⁵

The market for aircraft can be classified according to a variety of factors, including:

- number of engines
- speed range
- distance range
- usage
- power and propulsion type
- lift type.

However, the most common way of classifying commercial aircraft is primarily as 'wide-body' and 'narrow-body', and secondarily as 'single-aisle' and 'dual-aisle'.¹⁶

Boeing's narrow-body airliners have cabin diameters typically ranging from 10 to 13 feet wide, with seating configurations that vary from two to six across. These are smaller planes with a single aisle separating the seats, with sufficient room for passengers to move about the cabin comfortably. They also contain passenger amenities such as lavatories, in-flight entertainment and baggage compartments. These aircraft primarily serve short- or medium-haul domestic routes. They typically accommodate up to 150 passengers and about five to ten crew members. The three- and four-across cabin types are generally used for short hauls or by private charters for groups such as professional sports teams. The rest are used by domestic airlines to transport passengers along their routes.

Boeing's single-aisle, narrow-body planes include the 727, 737 and 757 variants. The 737 is the best-selling commercial airliner in history and dominates the short- and medium-haul markets. The twin-engine plane is popular for its reliability, simplicity and economical operation.

In contrast to its narrow-body planes, Boeing's wide-body aircraft are larger planes with a cabin width of 16–23 feet across and seats configured from seven to ten across. These planes typically have two aisles separating the seats and have several travel classes. These aircraft also include galleys, lavatories, in-flight entertainment and baggage compartments. Some carriers also include on-board wi-fi service. Boeing's wide-body aircraft, also known as jumbo or super jumbo jets, are the 747, 767, 777 and 787 Dreamliner. These aircraft are capable of flying trans-continental routes, can accommodate 200–500 passengers, and also transport commercial cargo across the globe. They also serve scientific, research and military uses.

¹³ 'Iran Invites Boeing to Negotiate Airplane Purchase', www.aviationpros.com, 3 March 2016.

¹⁴ www.boeing.com, accessed March 2016.

¹⁵ 'Boeing's Global Competitors', marketrealist.com, December 2014.

¹⁶ 'Boeing Company Beginnings', marketrealist.com, April 2015.

The 747 series of aircraft feature four engines and double-deck configurations, with a twin-aisle main deck and a single-aisle upper deck. It is available in passenger, freighter, military and business jet versions. The 767 series are twin-engine, twin-aisle aircraft which can accommodate 181–375 passengers. It is used by major airlines such as Delta Airlines, American Airlines and United Airlines. The 777 family features long-range, wide-body, twin-engine jet aircraft with a seating capacity of 314–451 passengers. Its current production models comprise passenger and freight variants, while new models will include a lengthened version and another with extra-long range.

The Boeing 787 Dreamliner is the company's biggest jetliner, with a capacity of 242–335 passengers. It is a long-range, mid-size, wide-body, twin-engine jet airliner and features fly-by-wire flight systems, a four-panel windshield and a smoother nose contour. The 787 features serrated chevrons on its engine nacelles, which reduces the noise from the engines' jet blast.¹⁷

BUSINESS STRATEGY

Since the 1990s the global market for full-sized commercial airliners has been a duopoly between Boeing, an American firm, and Airbus, its European competitor.

In recent years the two companies' business strategies for long-haul aircraft have differed markedly. Airbus has based its strategy on the assumption that airlines will continue to operate hub-and-spoke networks, in which passengers fly in smaller planes on shorter routes (spokes) which feed into hubs, where they transfer to much larger aircraft for onward travel. The Airbus A380 super-jumbo has been developed to service the hub-to-hub elements of this model. It is considered the biggest airliner around, and Airbus claims that it can offer airlines lower seat-mile costs (through economies of scale) than any other aircraft, leading to 25% lower ticket prices.

Boeing's business strategy is based on a fundamentally different vision, and it is radically different by design. Boeing does not take the hub-and-spoke model as a given, having discovered that customers prefer point-to-point flights, flown more frequently, on smaller airplanes. The Boeing 787 Dreamliner aircraft is the outcome from this market insight.¹⁸

'Our strategy has been to design and build an airplane that will take passengers where they want to go, when they want to go, without intermediate stops; do it efficiently while providing the utmost comfort to passengers; and make it simple and cost-effective for airlines to operate. Rather than seek economies through scale, the 787 will deliver economy through technological innovation, making the most of newly designed, fuel-efficient twin engines and lightweight composite materials. The 787 offers a very different take on the flying experience, focusing on comfort rather than perks that could be eliminated by airlines: more standing headroom, larger windows and bathrooms, and higher humidity; all features that will benefit passengers regardless of seat configuration.'¹⁹

SUPPLY CHAIN STRATEGY

The aerospace industry is characterised by high material costs (about 65–80%). Manufacturing systems and regulatory compliance are considered to be very complex, coupled with a limited number of suppliers, owing to the high barriers to entry. Moreover, the aircraft manufacturers have to do whatever it takes to win orders long before the commencement of production. There are two things Boeing and Airbus have in common: the utilisation of lean manufacturing systems and the adoption of strategic sourcing. However, the overall implementation of strategic sourcing differs between the two companies (see **Fig 1** on next page).

¹⁷ 'Boeing Company Beginnings', marketrealist.com, April 2015.

¹⁸ 'Japan's Role in Making Batteries for Boeing', www.nytimes.com, 25 January 2013.

¹⁹ www.boeing.com, accessed March 2016.

	BOEING	AIRBUS
Product strategy	Smaller aircraft for more frequent flights and direct routes	Larger aircraft to drive down operating costs
Lean manufacturing system	Yes	Yes
Strategic sourcing	Outsource design, testing and production of key components	Keep design and production of key components in-house
Manufacturing strategy	Finish assembly within three days	Finish assembly as soon as possible

Fig 1: Comparison of Boeing and Airbus Supply Chain Strategies.²⁰

Boeing wants to encourage more flight frequency and direct routes using a smaller capacity aircraft. It decided to outsource many things such as the design, testing and production of key components to key industrial partners, and tried to reduce the number of components that go to assembly. The ultimate goal is to finish the final production process within three days. Airbus takes a different approach. It wants to utilise high-capacity airplanes to help airlines drive down operating costs. It decided to outsource selectively the production of parts and keep the design and production of key components in-house.²¹

The aerospace industry has applied manufacturing strategies from the automotive sector. Aerospace original equipment manufacturers (OEMs), such as Boeing and Airbus, employ lean principles and just-in-time deliveries to their assembly lines, kanban systems for managing inventory, and point-of-use delivery of supplies. Although currently 80–90% of raw material inventory is pulled by OEMs, the trend is growing towards vendor managed inventory (VMI), where suppliers own the inventory and are responsible for managing it.²²

Boeing uses a supplier portal to manage the 23,000 suppliers who provide parts for a typical aircraft. The key aspects of the supplier portal are:

- Order requirements are posted online, allowing suppliers to tender for supply, reducing the time and effort required to manage the procurement process.
- Both supplier and customer are kept up to date with order progress at all times through the portal.
- All information relating to the project is stored centrally so parties can answer their own queries, reducing both overheads and delays for both parties.
- Increased overall production efficiency by keeping all parties fully informed of progress and allowing for better planning of each stage of the just-in-time manufacturing process.

Despite being named a ‘supplier’ portal, this platform benefits both parties and acts as a powerful tool for just-in-time manufacturing success.²³

THE 787 DREAMLINER SUPPLY CHAIN

Boeing’s 787 Dreamliner is the first long-range, mid-sized, wide-body passenger jetliner made using light-weight carbon composites. Substantially lighter than aluminium, the carbon composite construction allows the 787 to be quieter, more fuel efficient, and more durable than its predecessors. The aircraft also features state-of-the-art avionics and engines, as well as many passenger amenities.

²⁰ Adapted from ‘Supply Chain Case Study’, www.supplychainopz.com, June 2014.

²¹ ‘Supply Chain Case Study’, www.supplychainopz.com, June 2014.

²² ‘Supply Chain Research Insights: Aerospace Industry Trends’, www.aviationweek.com, 23 December 2015.

²³ ‘Seize Control: Improve Your Supplier Relationships in 3 Steps’, www.business2community.com, 14 April 2015.

The 787 is Boeing’s biggest bet in the wide-body segment and was expected to lead the company ahead of its rival Airbus. However, the Dreamliner project experienced multiple issues, including:

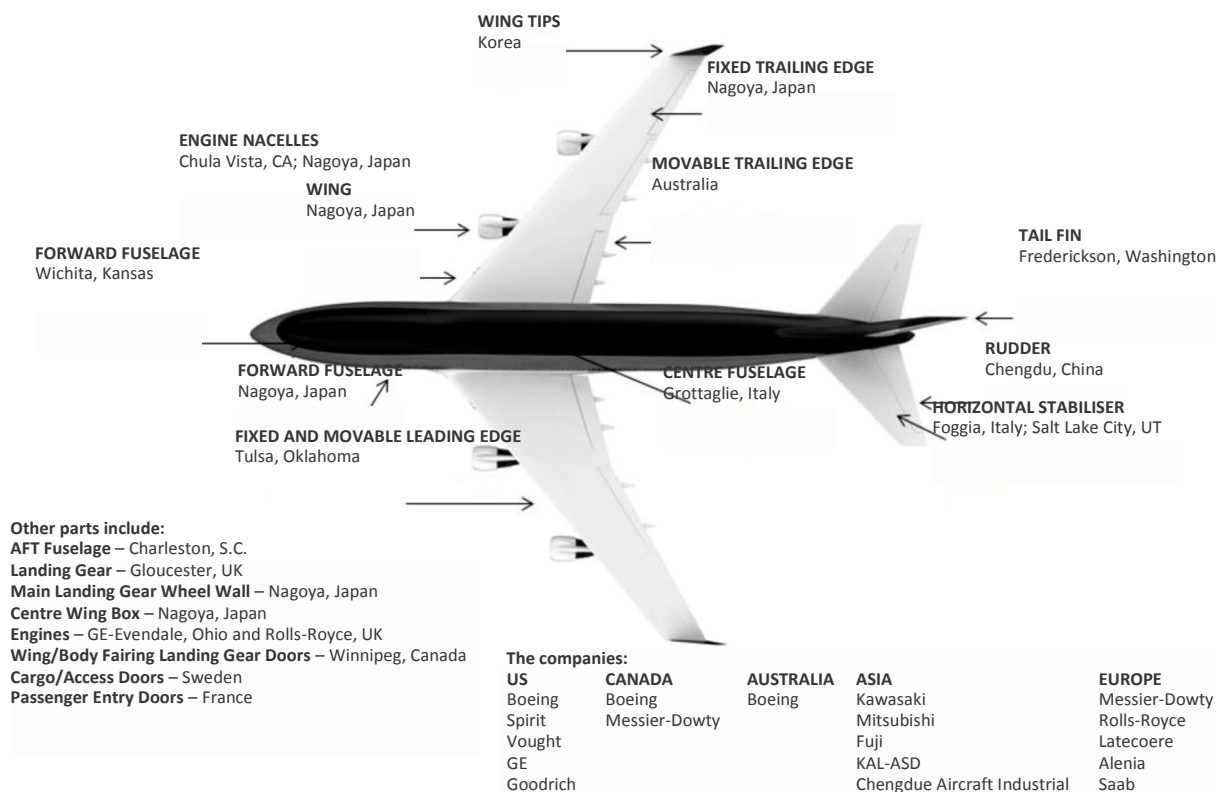
- production delays
- cost overruns
- labour strikes
- supply chain interruptions
- technical glitches
- engine failures
- design-induced battery fire
- fuel leakages
- fire on an empty jet
- high-altitude ice-crystal formation when flying near thunderstorms.

These issues contributed to the Dreamliner’s status as the company’s most expensive project, with costs exceeding estimates by more than \$1 billion.²⁴

Like many companies worldwide, Boeing embraced outsourcing to reduce its costs. It raised outsourcing to 70% for the 787 in order to reduce the production time from six years to four years, as well as its costs from \$10 billion to \$6 billion.²⁵

Unlike Boeing’s earlier aircraft, in which it played the traditional role of integrating and assembling different parts and subsystems produced by its suppliers, the Dreamliner’s supply chain is based on a tiered structure that would allow Boeing to foster partnerships with around 50 tier-1 strategic partners. These strategic partners were to serve as integrators who assemble different parts and subsystems produced by tier-2 and tier-3 suppliers.²⁶

The disaggregated supply chain for the 787 Dreamliner is shown in **Fig 2** below.²⁷



²⁴ ‘Boeing Company Beginnings’, marketrealist.com, April 2015.

²⁵ ‘Boeing Company Beginnings’, marketrealist.com, April 2015.

²⁶ ‘What Went Wrong at Boeing?’, www.forbes.com, 21 January 2013.

²⁷ Adapted from ‘Lessons from Boeing’s Dreamliner Supply Chain Missteps’, www.ebnonline.com, 28 February 2013.

Initially, the arrangement was lauded as visionary and brilliant. Investment costs in tooling and inventories were shifted upstream, seemingly reducing risk to Boeing. Vought Aircraft Industries, for example, invested in equipment needed to produce one-piece composite fuselages. The risk was huge, and the risk lay with Vought.²⁸

However, the supply chain was complex. Boeing outsourced the design and development of many critical sections to tier-1 suppliers: the fuselage to Spirit (USA) and Alenia (Italy); electrical systems to Thales (France); and wings to Mitsubishi (Japan) and Kal-ASD (Korea). These tier-1 suppliers regularly subcontract various modules to tier-2 suppliers, who in turn outsource certain components to tier-3 suppliers. For example, Thales was the tier-1 supplier for the electrical system, but it outsourced some of its tasks to tier-2 suppliers: lithium-ion batteries to Yuasa (Japan), battery chargers to Securaplane (USA), and voltage monitors to Kanto (Japan).²⁹

Logistics was a major undertaking. For example, the airliner's wings were travelling from Nagoya, Japan, to Everett, USA. Fuselage section 43 was travelling from Nagoya to Charleston, USA, and then to Everett. Fuselage section 46 went from Grottagli, Italy, to Charleston, to Everett and so on.³⁰

This multi-tier supply chain with at least 500 suppliers located in over ten countries has created major problems for Boeing. Cultural and language differences between Boeing, its suppliers, and their subcontractors created recurrent major delays and cost overruns.³¹

Supply and logistics information needed to be synchronised across multiple partner tiers so key components arrived at the company's Everett facility at just the right time for final assembly over a three-day period. However, design engineers at tier-1 suppliers such as Vought did not traditionally collaborate across multiple supply tiers to develop coordinated designs. There were delays at various plants around the world. 'In addition to oversight, you need insight into what's actually going on in those factories,' said Scott Carson, who heads Boeing's Commercial Airplanes unit. 'Had we had adequate insight, we could have helped our suppliers understand the challenges.'³²

Boeing aerospace engineer L. J. Hart-Smith addressed this issue in a white paper that he presented during a 2001 Boeing conference. He noted, 'In order to minimize these potential problems, it is necessary for the prime contractor to provide on-site quality, supplier management, and sometimes technical support. If this is not done, the performance of the prime manufacturer can never exceed the capabilities of the least proficient of the suppliers. These costs do not vanish merely because the work itself is out-of-sight.'

Boeing discovered that some tier-1 strategic partners did not have the know-how to develop different sections of the aircraft or the experience to manage their tier-2 suppliers. To regain control of the development process, Boeing was forced to buy Vought Aircraft Industries and supply expertise to other suppliers. Boeing also had to pay strategic partners compensation for potential profit losses stemming from the delays in production.³³

In January 2013, a lithium-ion battery was involved in a fire on board a Japan Airlines 787 in Boston and an ANA flight made an emergency landing in Japan prompted by a battery alarm alert and presence of smoke. The Federal Aviation Authority (FAA) decided to ground indefinitely all fifty 787s around the world. It was discovered that Boeing's supplier, Yuasa, had no experience in developing or building lithium batteries for commercial aircraft before, thus casting doubt on Boeing's supplier selection process.³⁴

²⁸ 'What's Causing Huge Delays for the Boeing 787 Dreamliner?', www.designnews.com, 24 August 2009.

²⁹ Tang Christopher S & Zimmerman, Joshua D; Managing New Product Development and Supply Chain Risks: The Boeing 787 Case', *Supply Chain Forum: An International Journal*, vol. 10, no. 2, 2009.

³⁰ 'What's Causing Huge Delays for the Boeing 787 Dreamliner?', www.designnews.com, 24 August 2009

³¹ Tang, Christopher S & Zimmerman, Joshua D; Managing New Product Development and Supply Chain Risks: The Boeing 787 Case', *Supply Chain Forum: An International Journal*, vol. 10, no. 2, 2009.

³² 'What's Causing Huge Delays for the Boeing 787 Dreamliner?', www.designnews.com, 24 August 2009.

³³ 'What Went Wrong at Boeing?', www.forbes.com, 21 January 2013.

³⁴ 'Japan's Role in Making Batteries for Boeing', www.nytimes.com, 25 January 2013.

Boeing's approval process was also questionable. The FAA allowed Boeing to self-certify certain components. For example, the FAA relied on the data generated by Boeing itself to approve the safety of the lithium-ion battery. Regarding the battery approval process, there was another concern that Japanese authorities were under pressure from various Japanese airlines to relax safety standards to fast-track the Boeing 787 rollout.³⁵

The Dreamliner has suffered numerous electrical system flaws beyond the battery problems. Company engineers blame poor quality components from subcontractors that have operated largely out of Boeing's view. 'The risk to the company is not this battery, even though this is really bad right now,' said one 787 electrical engineer, who asked not to be identified. 'The real problem is the power panels.' Unlike earlier Boeing jets, he said, the innards of the 787 power distribution panels, which control the flow of electricity to the plane's many systems, consist of parts that are 'cheap, plastic and prone to failure'. Another engineer confirmed that there is a 'preponderance of electrical faults'.³⁶

A further problem was that the 787's composite technology was unproven. There was an ongoing concern about the safety of the epoxy tape used to connect the wings and the middle fuselage. Also, technical experts wondered how the maintenance crew would inspect for stress cracks and fatigue of the composite structure of the 787s when x-ray or ultrasound equipment may be required. The lack of a workable plan for inspection and maintenance caused major concerns.³⁷

The head of Boeing's commercial airliner division, Jim Albaugh, admits that with hindsight too much of the Dreamliner programme was contracted out to other firms. Some work has been brought back in-house so that it can be more closely supervised.³⁸ For example, Boeing announced in 2014 that it was moving the production of parts for the 777X aircraft to its St. Louis facility in the USA, beginning in 2017. Previously, parts for the 777 programme had been made by overseas suppliers. 'Placing this work in St. Louis optimises resources, skills and technology in St. Louis and creates high technology jobs in the region,' Bob Ciesla, Boeing's Military Aircraft Cross-Enterprise Design/Build vice-president, said in a news release.

Work on the 777X performed in St. Louis will support production at Boeing's new 1 million-square-foot composite wing centre that is under construction in Everett. Final assembly of the 777X will also take place in Everett. 'Boeing has outstanding capability, resources and experience across the company and the 777X programme will leverage that skill base,' said Bob Feldmann, vice-president and general manager of the 777X programme, Boeing Commercial Airplanes. 'A programme of this size requires that we bring together all of the talent that Boeing has to offer.'³⁹

SUPPLY CHAIN LOGISTICS

New Breed Logistics is a supply chain and distribution centre operations company, featuring world-class capabilities in warehousing and distribution, manufacturing support, service parts logistics, reverse logistics, refurbishment and repair, procurement services, transportation management, business process improvement, and supply chain consulting. Globally recognised for its superior service capabilities, New Breed is consistently named among leading third-party logistics providers. New Breed employs 7,500 people and operates more than 50 distribution centres.

New Breed was selected in 2006 as the lead logistics provider for the 787 Dreamliner final assembly and delivery programme at Boeing's manufacturing campus in Everett. In 2010, Boeing established a second 787 final assembly operation in North Charleston, and again selected New Breed to operate the

³⁵ Japan Relaxed Safety Standards to Fast Track Boeing 787 Rollout, Japan Daily News, 29 January 2013.

³⁶ 'Boeing 787's Problems Blamed on Outsourcing, Lack of Oversight', www.seattletimes.com, 2 February 2013.

³⁷ Tang, Christopher S & Zimmerman, Joshua D; Managing New Product Development and Supply Chain Risks: The Boeing 787 Case', *Supply Chain Forum: An International Journal*, vol. 10, no. 2, 2009.

³⁸ *The Economist*, Boeing: Faster, Faster, Faster, 28 January 2012.

³⁹ 'Boeing Moving More Manufacturing to the US', www.industryweek.com, 6 October 2014.

support facility. Additionally, New Breed supports several other Boeing commercial and defence aviation programmes. The company operates the Boeing Commercial Airplanes' spare parts programme for Eastern North America, South America and Central America, as well as one for military aircraft. It also provides parts-kitting and line-side delivery services for new-build military programmes at Boeing's Ridley Park manufacturing site.

New Breed received the prestigious Boeing Performance Excellence Award (BPEA) in 2007, 2008, 2009 and 2010. The BPEA is awarded annually in recognition of suppliers who have achieved superior performance.

In 2011 New Breed announced that it had been selected by Boeing to provide logistics and supply chain management of commercial aircraft fasteners in support of the Boeing Aggregated Standards Network (BASN) programme. This agreement represented continued growth of the relationship between New Breed and Boeing. The programme included planning, ordering, storage and distribution of fasteners for up to 300 Boeing suppliers and 20 Boeing fastener manufacturers. The services that New Breed provided included forecast aggregation for fasteners, capacity planning, supply base management, inbound transportation management, product storage, order processing and coordination of outbound transportation.

Louis DeJoy, New Breed's Chairman and CEO commented: 'We focus every day on providing superior technology-driven solutions and precision execution that transform our clients' supply chains. This expansion of our relationship with Boeing demonstrates that our efforts have truly made a difference for them and provides further incentive for us to keep raising the bar.'⁴⁰

SUPPLY CHAIN PERFORMANCE MANAGEMENT

When Boeing began rapidly increasing orders for its V-22 military aircraft programme, New Breed added a second shift at its Swedesboro distribution centre and authorised weekend overtime to fill the additional orders. Despite the increased labour, output was still not keeping pace with demand. Volumes exceeded projections for more than 24 months, and that negatively impacted the facility's performance metrics. Specifically, the on-time delivery rate decreased by 23%.

Several factors contributed to the decline in this critical metric. In addition to high levels of unplanned order activity, the company was also coping with orders that had higher priorities than were anticipated. On top of that, the order mix was skewed toward items with strict packaging guidelines, and revised packing plans required more time to complete owing to the need for high-end packaging configurations. Because bottlenecks in the packaging process interrupt total logistics flow, New Breed's packaging metrics greatly influence on-time delivery rates.

New Breed management called on Sherif Mahdi, the Director of Business Performance Excellence and a Lean Six Sigma Black Belt, to help the facility increase on-time packaging rates, throughput and packaging efficiency; reduce waste; and improve product flow to support increased throughput. Mahdi assembled an improvement team consisting of 11 employees representing New Breed and Boeing. As project manager for the improvement team, Mahdi set high standards for the operation. The goal was to increase throughput from 167 orders to 240 orders per day and modify warehouse layout to accommodate a volume increase of 40% to 45%. The warehouse would be redesigned to reduce waste in New Breed's overall distribution logistics process.

The team also planned to adjust the performance metrics used as customer requirements. The key measurement would change from 98% on-time delivery to 98% on-time packaging. Boeing had been using on-time delivery rates to measure 3PL performance, but those numbers were out of New Breed's control. 'Our on-time delivery is essentially looking at packaging,' explains Mahdi. 'On-time packaging is something that we can control as well as something value-added for both Boeing and the government.'

⁴⁰ 'New Breed Logistics to Provide End to End Supply Chain Management of Boeing Commercial Aircraft Fasteners', www.prnewswire.com, 21 November 2011.

The improvement team began by using cause-and-effect analysis to identify root causes of the reduction in on-time metrics. Current and future states of the process were documented by gathering all potential outcomes of process improvements and identifying customers with increasing volumes. Many other quality tools were employed, including trend analysis for key performance indicators (KPIs), '5 Whys' for root-cause analysis, run charts for data analysis and 7S as a baseline for the improvement process.

The '5 Whys' exercise began with a question: 'Why are we not keeping up with increased volumes?' The five answers were: not enough floor space; improper lighting levels; not enough product staging; resources not available to keep up with increased volumes; and equipment not available to support increased volumes. Based on this exercise, the team concluded that increasing order volumes could not be supported by New Breed's current processes or equipment because the warehouse layout could not support additional equipment.

Through value-stream mapping, a technique that analyses the flow of materials and information required to bring a product or service to a consumer, Mahdi discovered the most significant bottlenecks were occurring in packaging because of the different packaging requirements involved. Other root causes uncovered by quality tools included resource allocation and packaging method times. Training and audits were also exposed as unforeseen root causes. The team developed a PICK chart to categorise potential solutions into four quadrants: Possible, Implement, Challenge and Kill. The graphical tool helped the team brainstorm and ultimately select the solution with the biggest payoff.

The improvement team came to a final conclusion: additional space had to be created in the existing facility through a warehouse redesign that would maximise flow, improve lighting and help employees meet customer packaging requirements. The project took four months and involved adding new floor space, as well as moving racks and inventory and modifying electrical wiring. A variety of new equipment was added, including mobile security workstations and computers, packaging carts, scales, heat sealers, scanners and printers.

Behind the scenes, KPIs were modified to measure on-time packaging rather than on-time shipping. New ergonomic equipment, such as mobile workstations and anti-fatigue matting, reduced the risk of employee injuries, and efficiency increased dramatically. New Breed lowered its overtime requirements by at least 30% while boosting employee morale. Employees felt more involved in the company's success since they had input into potential solutions. Overall, the project fostered better collaboration and communication and built a work environment based on honesty and trust.

The benefits of the performance improvement programme were numerous:

- Throughput increased from 167 to 240 orders per day.
- Ability to accommodate increasing customer volumes improved from 40% to 45%.
- Shipping accuracy steadily increased, reaching 100% after one year.
- Errors decreased from 9,903 parts per million (ppm) to 9.4 ppm after one month.

New Breed's warehouse redesign was so successful that the improvement team was named a 2008 finalist in the International Team Excellence awards presented by the American Society for Quality (ASQ). Looking back on the four-month project, Mahdi says he was impressed by how employees came together as a team to accomplish the end results.⁴¹

Boeing's production struggles with its 787 Dreamliner taught it to stress-test suppliers regularly, a skill that is coming to the forefront as it tackles a mountain of orders for its best-selling 737 jets. The company's comprehensive reviews are critical to its effort to mount one of its biggest production increases in years. At Vaupell Holdings, one of about 1,000 suppliers subject to exhaustive reviews of its production materials, schedules, finances and tools, Boeing's test regime prompted the 60-year-old vendor this year to make such changes as replacing shop-floor management software.

⁴¹ 'Lean for Distribution Logistics', www.mhlnews.com, 1 August 2009.

Boeing has bolstered its ranks of supplier examiners with about 200 engineers and other supply-chain specialists in the past 18 months. Its teams visit vendors more frequently and conduct evaluations that can take days to complete. 'Boeing has become much more proactive,' said Joe Jahn, chief executive of Seattle-based Vaupell Holdings. 'They've got someone here almost every day.' The intensified scrutiny is a key component of Boeing's strategy to speed up production of nearly all of its commercial jets without the kinds of costly bottlenecks and delays that hobbled it in previous major ramp-ups.

Boeing's intensified reviews are helping Vaupell Holdings stay on top of its game, Jahn said one morning, as he walked across the Seattle plant's shop floor, where workers wear dust masks as they polish luggage-bin trims, air nozzles and other airplane components. Boeing has been conducting roughly four-hour-long monthly and quarterly assessments of Vaupell Holdings' ability to speed up production, along with annual reviews that can take two to three days. A Boeing employee is at Vaupell Holdings' factory almost daily, compared with about once a week in the past, Jahn said.

Airplanes are one of the biggest and most complex industrial products. Jets like the Boeing 777 contain several million parts. Problems far down in the supply chain, such as shortages of machines used to mould certain components, can cause delays that ripple across the industry. Boeing is trying to heed lessons from its past that some executives commonly refer to as 'scars on their backs'. In the late 1990s, Boeing temporarily had to shut some of its assembly lines, and took billions of dollars in charges, when bottlenecks and quality issues arose after it tried to expand production too quickly. More recently, in 2008, inadequate training of new mechanics and supply-chain glitches led to quality problems at its 737 plant.

Boeing says it has also increased its scrutiny of how its suppliers are evaluating their own vendors. That is a big shift for Exacta Aerospace, a firm that makes metal brackets and other components for Boeing jets, said Casey Voegeli, Exacta's director of business operations. 'It's a culture change,' he said. 'They want us to prove to them that our suppliers have the capacity to keep up.'⁴²

SUPPLIER RELATIONSHIPS

In the late 1990s, Boeing tried to increase its production only to find that its supply chain was unable to keep up with its requirements. Boeing spent billions of dollars dealing with production bottlenecks and quality issues over faulty parts. The reality was that a missing tiny fastener that holds pieces of the plane together could delay the entire assembly process.

In 2012 Boeing faced a similar challenge: it needed to fulfil a huge and growing backlog of orders. Boeing is at the mercy of thousands of vendor partners to meet its parts requirements in order to meet delivery promises made to its customers. With the next six years of production already sold, Boeing's main challenge is getting its 1,200 direct suppliers to ramp up production and ensure the quality of the parts ordered. In order to solve this problem, Boeing has become more open, sharing information and communicating more efficiently with its suppliers.

Boeing needed to renegotiate its relationship with its suppliers and create partnerships: seamless relationships based on informed cooperation intended to create added value for both parties. Formation of a partnership would allow Boeing to meet the customer demand for its airplanes and for the suppliers to get a bigger and more consistent stream of revenue. To get the process started, Boeing and the suppliers needed to ask themselves the right questions and look for opportunities to create added value through mutual gain solutions:

- Why do we have interruptions in the supply of parts and why is the quality not consistent?
- How can we cooperate with our suppliers so we get what we want? How can we help them give us what we need?
- What are the risks if we make these changes? What are the risks if we don't make these changes and continue to do business the same way we have in the past?

⁴² 'Boeing Examines Supply Chain for Weak Links', www.wsj.com, 30 December 2011.

According to Beverly Wyse, who oversees production of the 737, Boeing's attitude toward suppliers in the past was 'We'll set the requirements and you have to go do your job'. But, in the face of missed production deadlines, faulty parts and billions of dollars in fees, Boeing needed a partnership strategy to leverage opportunities for mutual benefits by working closely with its suppliers.

Boeing is communicating more often with suppliers and sharing more information about its own forecasts and production plans, according to executives at the company and several of its suppliers. Boeing has shifted its business culture by increasing its communication, becoming more transparent in the flow of information, and increasing the levels of trust.

One of the ways Boeing has increased communication is by hiring hundreds of engineers to work with the suppliers. These engineers have increased the exchange of information by visiting supplier sites and making sure the vendors are meeting technical specifications. The parties have become more proactive in their communication and this has helped them catch supply problems much earlier in the process.⁴³

Boeing's mission has been to increase levels of trust. Wyse revealed how challenging it has been to get the suppliers to meet the demand: 'Boeing has had to learn to be more open with them about its production plans, and a bit less paranoid about whether such information might reach the ears of its competitors.' Bringing the suppliers into the process allowed them to expand their own production capacity without fear that orders from Boeing would suddenly dry up.⁴⁴

It appears the benefits of this new approach are paying off. Parts shortages at Boeing's 737 plant are the lowest they have been in five years. Boeing has increased its output of planes to a higher rate than ever before. And, on 25 January 2012, Boeing announced a 21% increase in annual net profits, to \$4 billion. By shifting its business culture towards increased trust and communication, Boeing has been able to ramp up its production and make a dent in the soaring demand from customers.⁴⁵

An example of Boeing working more collaboratively with its supply chain partners is the case of Japanese chemical company Toray Industries for a new version of the 777 jetliner. Toray, the world's largest maker of carbon fibre, was already supplying Boeing with the building material for its 787 airliner, under a long-term supply arrangement worth ¥700 billion (\$6 billion), through to 2021. The new agreement brings the total value to more than ¥1 trillion over the next ten years, Toray said.

Boeing and Toray also agreed to work together to increase the aerospace applications of carbon fibre, a material that has replaced metals in some parts of aircraft construction, reducing weight, fuel consumption and operating costs. In the 787, for example, carbon fibre accounts for roughly 50% of the primary structure of the aircraft, including the fuselage and the wings.

The broadening of the partnership shows how relatively obscure Japanese suppliers of industrial parts and materials have become increasingly important contributors to the success of products from better-known companies, especially in the aerospace industry. Toray's president, Akihiro Nikkaku, said at a news conference that the company planned to invest ¥100 billion in a new carbon fibre factory in the USA by 2020 as it responds to an increase in demand.

Japanese companies, including Toray, dominate global production of carbon fibre. 'Though overseas manufacturers, including those in the US and Europe, are trying to catch up with us, we aren't so concerned since the research and development involved will take a lot of time,' Mr. Nikkaku said. 'We will try to keep ahead of our competitors by developing more highly efficient products through the joint project with Boeing,' he added. The new version of the 777, based on an older airliner design than the 787, uses less carbon fibre than the Dreamliner. But Toray said it expected aerospace applications of the material to expand 'exponentially' under the development deal with Boeing.⁴⁶

⁴³ 'Boeing Flying High With Supplier SMARTnerships', www.forbes.com, 9 February 2012.

⁴⁴ *The Economist*, 'Boeing: Faster, Faster, Faster', 28 January 2012.

⁴⁵ 'Boeing Flying High With Supplier SMARTnerships', www.forbes.com, 9 February 2012.

⁴⁶ 'Boeing Deepens Supply Relationship With Toray', www.wsj.com, 17 November 2014.

Another example of collaborative relationships is the case of Solvay, which is the second largest maker of composite materials for the aerospace industry. In 2016, Solvay and the Boeing Company announced that they have extended their contract through to 2020 for the supply of high-performance, structural composite and adhesive materials used to light-weight Boeing's large passenger aircraft for legacy programmes, such as the 737, 747 and 777, as well as for current and future platforms, including B787, 737MAX and the 777X.

Solvay's newly created Composite Materials Global Business Unit provides technologically advanced light-weighting materials which address the requirements of aerospace manufacturers to reduce fuel consumption, CO₂ emissions and maintenance time. 'Our composite technologies provide the right balance of sustainable performance and competitiveness to meet the industry's evolving needs,' said Jean-Pierre Clamadieu, chief executive of Solvay. 'We look forward to a continued and mutually beneficial relationship with Boeing.'

The extended contract includes delivering on specific supplier initiatives, as well as long-term growth opportunities with current and future qualified Solvay products. Solvay supplies a range of products for primary and secondary structure applications, such as flaps, doors, fairings and ailerons. Products also include adhesives and surfacing materials that offer high toughness and strength, as well as tailor-made process materials solutions that lower manufacturing costs and save time by offering excellent process repeatability.⁴⁷

PARTNERING FOR SUCCESS PROGRAMME

Historically, within the aerospace and defence industry, operating margins for OEMs are very low when compared with those of their suppliers. Boeing has maintained margins of around 10%, while top-tier suppliers typically make 15% and lower-tier suppliers about 20%. This is despite the fact that the OEM carries the brunt of the risk with adherence to promised dates of delivery and promises of cost reductions to consumers. Seeing that Boeing carries a majority of the risk in the production of commercial aircraft, it has laid out a plan to increase its operating margins to be more in line with those of its suppliers.

To address the margin structure issue with suppliers and the pressure from customers to reduce costs, Boeing launched an initiative in 2013 called the Partnering for Success (PFS) programme in which it is targeting supplier margins that are historically higher than its own and pushing for cost savings. This programme was implemented with suppliers as Boeing redesigned the 737 and 777 jets, two of its largest programmes. Boeing indicated that discounts between 15% and 20% were to be the starting point for contract talks. By mid-February 2014, about one-third of contractors had locked-in volumes at the requested discounted prices, while the rest of the contractors were either still in talks or trying to wait for the programme to go away, according to Boeing CEO, Jim McNerney. The programme resulted in several billion dollars in committed savings across Boeing's supplier base.

Though programmes like this generate massive savings figures, there are some potential downsides in over-valuing cost efficiency and ending supplier relationships when they are not willing to meet aggressive cost requirements, such as awarding contracts to inexperienced suppliers. For example, Boeing awarded the landing gear contract for the 777X jetliner in 2013 to Heroux-Devtek, a Quebec-based manufacturer and repairer of aerospace and industrial products. This company had no prior experience in manufacturing the required landing gear systems for commercial planes and had sales of \$233 million in 2013. To put this into perspective, United Technologies, the company that makes the landing gear for the current 777 model, posted sales of \$63 billion and has extensive experience and knowledge working with Boeing in commercial aircraft production. Switching this work from United Technologies to a company such as Heroux-Devtek is a testament to Boeing's commitment in lowering its cost of production and ending relationships with suppliers that are not willing to get on board.

⁴⁷ 'Solvay and Boeing Extend Advanced Light Weighting Materials Supply Contract for Large Passenger Aircraft', www.aviationpros.com, 7 March 2016.

Boeing's PFS programme seems to be paying dividends with the savings locked in thus far and Boeing continues to ensure quality by enforcing its rigorous standards with new suppliers. However, companies who are long-time partners of Boeing continue to resist this unavoidable change in their operating margin structure and, as a result, Boeing has adopted a 'no fly list' of companies that are not willing to cooperate.⁴⁸ These undisclosed companies are no longer welcome to bid for work on new commercial aircraft.⁴⁹ With Boeing's massive operation and volume potential, as a supplier, you would want to avoid being put on this list.

In February 2014, Boeing officials reaffirmed the company's commitment to the PFS programme. CEO James McNerney spoke at a Cowen Co conference and in subsequent interviews, noting that some suppliers have greater margins than Boeing, which he termed 'out of kilter'. Stan Deal, Vice President and General Manager for Supply Chain Management and Operations for Boeing Commercial Airplanes, told the Pacific Northwest Aerospace Alliance conference in Seattle that PFS is proceeding well, with the cooperation of most suppliers.

Most of the suppliers attending the conference were not happy with Boeing's PFS programme. None of them consented to be identified, but all complained that Boeing is being unreasonable in its requirements for 15% to 25% cost reductions. Those suppliers who are on the 787 programme were especially unhappy. Under the original 787 contracts, suppliers were not paid until the airplane was certified. Given a delay of nearly four years, and many parts or systems redesigns necessary, suppliers faced severe cash-flow shortages and, in some cases, nearly went bankrupt. Even major, well-financed suppliers faced millions of dollars of cash-carrying costs, such as holding stock, yet were asked by Boeing to give up margins. 'Behind closed doors, they will tell you this is entirely about margin,' one supplier said.

In response to questions at the conference, Boeing's Deal said the company takes into account the pain inflicted by the 787 programme on those suppliers it asks for re-pricing. Later, suppliers in the audience disputed this view. Teal Group analyst, Richard Aboulafia, criticised Boeing's hard-line approach, which he characterised as one that can harm its supply chain relationships. There is also the prospect of Boeing's suppliers seeking to diversify with Airbus in order to reduce their exposure to Boeing.⁵⁰

Indeed, in March 2014, two top Airbus executives drew a sharp distinction with Boeing over supply chain strategy and mocked their rival's programme to squeeze cost savings from suppliers. 'They say, "We're partnering for success." I don't think it's been that successful,' said Airbus's US subsidiary chief executive, Alan McArtor, speaking to reporters at a press breakfast in Washington DC, also attended by Airbus Group CEO, Tom Enders. 'While we want to get best value with our supply chain we think it's better to work with our suppliers and their processes, as opposed to dictating suppliers to carve 15% out of their cost,' McArtor said.

Enders noted that Airbus had achieved similar cost savings by working with suppliers on the A320neo programme, but without a process of issuing public threats. 'The simple test is to ask our suppliers who are supplying both companies who they would rather work with,' Enders says. Airbus officials have been known to publicly spar with suppliers on specific performance issues, such as Rolls-Royce and Spirit AeroSystems, but Enders describes the overall relationship between Airbus and suppliers as less confrontational than Boeing's approach. 'We don't use temporary weaknesses of our suppliers to drive down cost,' Enders says.

Airbus's philosophy is a reflection of the long-term nature of industrial relationships in the aerospace industry, when a single production programme can span decades from launch to line closure, said Enders. 'Over the years, it's very rare that only the OEM has leverage over suppliers. Sometimes you need suppliers badly to do something and to do it immediately. You won't want to get bogged down in protracted negotiations before they sort the issues.'⁵¹

⁴⁸ 'Boeing Pushing for Major Supplier Discounts', www.strategicsourceror.com, 16 April 2014.

⁴⁹ 'Airbus Execs Criticise Boeing Approach to Suppliers', www.flightglobal.com, 7 March 2014.

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