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Managing the supply chain across the aerospace lifecycle

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'Supply chain' or a 'complex network'?

Whereas a chain suggests a serial entity, the reality of the aerospace industry is an increasingly complex network of relationships. With the structure of modern aerospace industry moving away from traditional vertical programmes to highly distributed, multinational and multi-stage operations (including production and the rapidly expanding aftermarket Maintenance, Repair and Overhaul(MRO)), there inevitably comes greater challenges. But with tier 1 and tier 2 suppliers taking on more responsibility and Original Equipment Manufacturers (OEMs) having less visibility and control over the supply chain than ever, how can the difficulties and the intricacies of the aerospace supply chain be adequately managed?

One possible solution may be stakeholders' improved collaboration, which can be facilitated through the usage of automated technologies such as Product Lifecycle Management (PLM).

Fig. 1.Challenges facing the aerospace Supply Chain

Facing up to realities

In recent times, both Boeing and Airbus have been victims of their supply chains' complexity. The delivery of Boeing's 787 has famously been hit by numerous delays, the majority of these as a result of failures in the supply chain. Likewise, the arrival of Airbus' A380 – the world's biggest commercial aircraft to date – has been clouded by a series of problems, shunting back its delivery schedule dramatically. Once again, the flaw in the A380 program lay within the production process, in what Christian Streiff, Airbus CEO and President called the *'one weak link in the chain'*, namely the airplane's electronic harnesses.[1] Both examples go to show the challenge of managing complex programmes in the Aerospace and Defence industry, with immense difficulties inherent in aircraft production, as well as the need for OEM's active top-down supply chain management to ensure timely and cost effective output.

Boeing's problems with the 787 in particular highlight the need for OEMs and increasingly top tier 1 and 2 suppliers to manage risk across the supply chain. Initially assigning its subcontractors to do more assembly themselves and deliver completed subsystems, Boeing intended to perform the final assembly of these component parts. However, some subcontractors encountered difficulty completing the extra work, because they could not procure the required parts; perform the sub-assembly on schedule, or both. As a result, Boeing was hit with serious delays. With hundreds of thousands of components coming together from hundreds of multinational suppliers all for one single aircraft, the prevention of late delivery will be a central concern for supply chain managers.

[1] Christian Streiff, Reported in 'Airbus A380 delay', *Aerospace News,* http://blog.seattlepi.nwsource.com/aerospace/archives/107302 (03/10/2006)

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Today's Supply Chain

To limit the very real risk and very costly issue of late delivery, relationships throughout the supply network aspire towards greater operational transparency and visibility. Yet the reality, according to a recent CSCO study of nearly 400 supply chain executives worldwide, shows that less than 20% are implementing practices to increase visibility and greater collaboration.[2] As you cannot manage what you cannot see, companies face the risk of inefficient operations and conflicting demand for materials resulting in cost-creating excess inventory. Exacerbating the situation further is the industry's sluggishness to move away from a mass-manufacturing model , as goods are 'pushed' through manufacture to a production schedule that may or may not align with customers requirements at the time of delivery. The advent of a demand-led pull model promises to streamline the process and reduce the non-value adding margins, but its implementation calls for astute management in an industry governed by long lead times in the production of low volume but highly engineered deliverables.

> 'Risks are not issues. Risk management entails forward thinking and the avoidance of issues.'
>
> *Supply Chain Director*
>
> *Large multinational aerospace company*

The marked trend towards customers' enforcing performance based contracts within the aerospace industry increases the pressure on stakeholders throughout the chain. With large scale programs characterised by multi-year contracts, multifaceted compliance regulations as well as intricate supply networks, meeting the customer's demands can often prove difficult. For the supply chain to operate at its optimum efficiency there must be an alignment of objectives realised through intimate relationships between the different tiers. In reality of course, this remains a rather lofty ideal. On the other hand, the disaggregated nature of the complex aerospace supply chain can often be improved by the careful balancing of the interests of each individual stakeholder with those that are overarching and shared. Sharing risk information across the chain would be one such method of collaboration, combining the OEM's greater wealth of resources with the potential for an earlier response in the tier 1 and tier 2 stages of manufacture. Such integration would alleviate last minute pressure on the OEMS to struggling to produce deliverables to deadline, allowing problems to be identified and worked through at an earlier stage.

> 'A key driver is to deliver standardised processes and approaches to suppliers across the globe.'
>
> *Supply Chain Director*
>
> *Large multinational aerospace company*

Globalisation; outsourcing opportunities and competition

[2] 'The Smarter Supply Chain of the Future', *Global Chief Supply Chain Officer Study,* IBM United Kingdom Limited (2009)

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However, the ideal of a truly collaborative supply chain has undoubtedly been complicated through the outsourcing strategies of OEMs. With different geopolitical situations comes variation in both quality and technical expectations, not to mention differences in the personalities of those managing the processes. All of which can lead to a fractured and potentially fractious production chain, increasing the lower cost structures the OEMs went overseas to seek. Moreover, the national aspirations of China, Russia and India for example, to produce prime airframe manufacturers to challenge the duopoly of Boeing and Airbus poses a real risk to established players such as the UK and the US. Backed by heavily funded government programs, the technology and knowledge of nations such as China have made unprecedented progress in the last 20 years. Perhaps in a bid to hedge this risk, there has been a series of joint ventures between the established primes and Chinese manufacturers, including Boeing's Shanghai Aviation Services, an MRO which opened in November 2009. Aiming to combine MRO industry best practice with the Chinese cost structure, CEO Bernard Hensey says *'We take the best of both worlds, which allow us to do things others can't'*[3]. Whether ventures such as this one will lead to greater global collaboration in the long term however, remains to be seen.

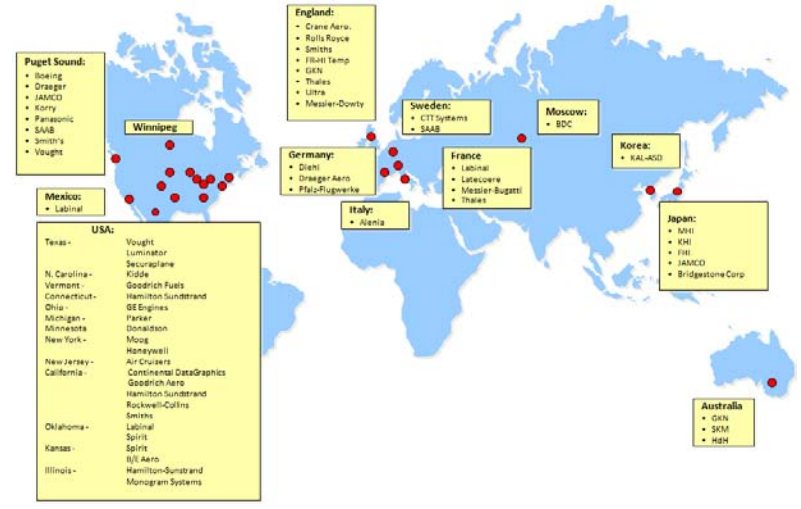

Fig. 2. Boeing 787 Supply Chain Network (Source Boeing)

Certainly the changing world order is forcing a response from the OEMs, but *'when it comes to the latest technology'*, says Morris A Cohen, professor of operations and information management at Wharton Business School in the US, *'Boeing and Airbus are very careful to outsource only certain parts of the manufacturing'*.[4] To retain their competitive advantage, Boeing, for example, keep their avionics and wing design in house, whilst benefiting from the clusters of competency in low cost locations such as Czech Republic, Mexico Indonesia, Malaysia, Tunisia and Morocco for manufacture and lower value-added services. Protecting their high value knowledge and Intellectual Property (IP), the OEMs are securing their interests against reproduction, but many critics including labour organisations, are concerned that nations such as China (with its clear ambition to build a domestic industry) are absorbing aerospace technologies and production knowledge gleaned from such joint ventures. Such anxiety and the opportunity to capitalise on aftermarket part profit can engender a

[3] Bernard Hensey, reported in 'Aviation Aftermarket Companies Bundle Services, *Aviation Week,* http://www.aviationweek.com (17/12/2009)
[4] 'New Investments Are Flowing Into the Aerospace Industry', *Wharton Aerospace & Defence Report,* The Wharton School, University of Pennsylvania (2009)

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culture of IP hoarding in elements of the supply chain, creating an adverse effect on the chain's network of relationships.

Although the outsourcing of manufacture is the most visible manifestation of globalisation, OEMs are increasingly seeking engineering and R&D talent pools outside the traditional hotspots of the US and Europe. In the last twenty years the maturation of digital design tools and innovations in the broadband infrastructure has both amplified the potential for outsourcing and offshore engineering. Boeing was one of the first OEMs to leverage these possibilities when, in 1993 it established a small technical centre in Moscow employing 10 engineers. Today Boeing employs nearly 2,000 engineers in its Engineering Design Centre there, a facility that produced approximately one-third of the structural drawings for the 747 model. Similar trajectories have been followed by Honeywell and GE, who both have set up large engineering centres in Bangalore, India. In the aftermarket MRO supply chain, only last year TIMCO, North America's largest third party heavy maintenance supplier, formed a partnership with COOPESA in Costa Rica. What is particularly significant about the partnership however is that the American company will establish the contracts and provide management oversight, using onsite TIMCO employees. Although engineering knowledge and manufacturing capabilities are successfully being mined from offshore hotspots, interestingly high level management and leadership skills are still perceived to be the domain of the historic Western aerospace power bases.

> 'Although we have to share information with our overseas suppliers, security management is crucial to mitigate the risks of regulatory non-compliance as well as to safeguard our IP rights.'
>
> *Supply Chain Manager*
>
> *Large multinational aerospace company*

Collaboration, Visibility, Integration and relationships

The network's complexity requires new thinking coupled with strategically applied technology to adapt and manage, driving improved efficiency into the supply chain. Many companies are already implementing supply chain improvement programmes, Airbus with their Power8 program is one such example. With many trying to shave costs in the current downturn, the financial crisis makes stark the complications and flaws within their supply chains. But current dynamics also provide an opportunity to get things right, cutting costs and improving business practice with focus on areas including supply chain and Lean initiatives. Enabling the three industry buzzwords of collaboration, visibility and integration, supply chain stakeholders can work together to try to ensure that there is no single point of failure.

> 'Close collaboration and streamlined communication across the supply chain is a desirable future ... as yet unrealised.'
>
> *Supply Chain Director*
>
> *Large multinational aerospace company*

With added complexity there is an ever greater need to synchronise activities across a vast number of players. What the industry is coming to terms with however is the fact that it simply doesn't have the systems in place to do this. Whereas the OEMs and the majority of Tier 1 suppliers have enough liquidity to absorb the costs of implementing technologies such PLM and Supply Chain Management systems, a leading aerospace supply chain manager noted the reluctance of smaller sub-contractors within the chain to adopt new systems which add extra overheads. However, our investigations have

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shown that value can be added across the supply chain. There are of course a number of reasons why the market is characterised by so little collaboration in its present state. The CSCO study of supply chain executives is particularly illuminating here, with many citing IP concerns, silos and lack of effective tools as reasons, whilst others blamed cost and time constraints.[5] Another limiting factor is of course the industry's reluctance to change; adopting seemingly expensive and time consuming 'manual' collaboration strategies for little immediately apparent value-add. If the ideal is to reduce costs through inventory rationalisation, change is needed and improving the efficiency of the supply chain would seem a good place to start.

Managing relationships

As a web of inextricably linked yet changing relationships, real time supply chain management can be seen as a corporate asset. As more responsibility has been delegated away from the OEMs, a direct result has been the increase of risk harboured in the lower tiers. The OEMs' rationalisation of their supply chains (e.g. Airbus Power8 program), provides an ideal opportunity for the OEMs and their top tier suppliers to build on their existing relationships, consolidate ties and create more standardised processes. When asked, one supply chain manager noted how, in his experience, there was at present very little synchronisation between the individual supply chain managers of the top-end stakeholders. One of the ways this can be improved upon is through mutual alignment of information, goals and shared risk mitigation using information technologies such as PLM as the enabler. In fact many, if not most modern contracts typically impose liquidated damages or financial penalties for late delivery of goods, there is more often than not no 'carrot', no incentive schemes, in place to reward timely output. Inevitably an OEM may not (and perhaps would not want to) adopt such an approach to all members of its supply base, but streamlining, prioritising and nurturing of relationships has been shown to deliver a strong, sustainable and profitable network of partners to the benefit of the end customer.

> 'Delivering our customers the same high standard operating procedures across a multinational network of offices remains a challenge.'
>
> *Supply Chain Manager*
>
> *Large multinational aerospace company*

Geopolitical concerns

The evolving nature of relationships in the aerospace industry increasingly calls for sensitive management of regional needs. This is exacerbated by a multitude of differences in international business practice, language and culture. Irrespective of the fact that the component parts are manufactured in various countries all over the world, the finished aircraft must meet the standards of any given customer's jurisdiction's complex regulatory requirements and quality control checks. In order for a newly designed model aircraft to fly over US airspace for example, it must first gain certification from the U.S Federal Aviation Administration, a lengthy process that requires a thousand hours of flight time and can take many years. The European Aviation Safety Agency performs a similar regulatory role in the Eurozone. In their attempts to cut costs the prime airframe

[5] 'The Smarter Supply Chain of the Future', *Global Chief Supply Chain Officer Study,* IBM United Kingdom Limited (2009)

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manufacturers have often faced difficulties and delays as result of the differing standards of their outsourced suppliers, as was noticeably visible in the case of the manufacture of the Airbus A380. Supply chain managers therefore have to balance the need to cut costs in the production process with the need to deliver quality end-products to the airline carriers. At Airbus' China Plant, which is 49% owned by Airbus and 51% owned by a Chinese consortium, the production of its A320 model is subject to rigorous inspection programs to allay potential concerns on manufacturing quality to avoid issues that could taint Airbus's carefully cultivated reputation.

Indeed political concerns are increasingly becoming a key driver of complexity within the aerospace supply network. As this paper has already mentioned, the traditional aerospace competency clusters of the US and Europe have been facing increased competition from the aggressive aerospace development programs from emerging economies. Whilst the government-funded schemes in China, India amongst others are somewhat offset by stimulus packages in the US and France, successful management of supply chains could provide a sustainable way to maintain competitive advantage. Moreover, with evermore political rhetoric devoted to green issues, aircraft carriers have been under huge pressure to reduce their carbon footprint. As the end customer of the supply chain, these concerns subsequently filter down to the OEMs and their suppliers, who in turn face pressure to increase sustainability and 'green' their design and manufacturing processes. Of course implementation of these greening strategies means increased costs which are often factored in across the supply chain. To address this growing challenge, there is an increasing need for innovative technology solutions to satisfy existing and future environmental regulations and legislation.

Adding value to maintain competitive edge

Value engineering is another topical consideration in aerospace supply chain management. In the current economic climate, one challenge facing managers is to improve both real and perceived value of their products and services. Value, as defined, is the ratio of function to cost and it can therefore be increased by improving functionality or reducing the costs of goods and services. In terms of the aerospace supply chain in recent times, increased pressure has been placed on the companies to focus on the latter. Essential to understanding how to increase value is to fully understand the customer's needs and requirements, one of the many areas that can benefit from closer collaboration with involved supply chain members. Only then can a supply chain manager identify the opportunities for improvement in the supply chain's value stream and ultimately minimise waste and optimise value. To increase value added activity, significant focus is being made on schedules, processes and people. Together with efficient use of new technologies in the areas of project and supply chain management many companies are streamlining both workflows and assets to deliver added advantage. Whilst some believe that manual efforts may be simpler and more cost-effective with smaller contracts, managing larger partners with complex and high value deliverables can be a challenge that may be more efficiently managed with technologies such as Supplier Relationship or PLM solutions.

> 'Approaches to managing relationships are often tailored to the individual sub-contractor.....for example we don't treat the commodity companies as we do the large project based suppliers'
>
> *Supply Chain Director*
>
> *Large multinational aerospace company*

Delivering value to the disciplines

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As mentioned earlier in this paper, supply chain management touches many areas and encompasses a broad web of stakeholders. **Scheduling and the quality of deliverables** are just two examples of key areas with direct impact on successful project outcome. To this end the management and co-ordination of requirements through the supply chain and dynamic supervision and feedback of project information is fundamental to this process. One leading supply chain executive noted that he constantly asks *'Are these stakeholders focused on the same goals, using the latest information? Do we know where we're at in the project and are there any issues we can avoid '?* Any discrepancies and misunderstandings result in escalating costs and more often than not delay; but these issues can often be avoided through early identification and pro-active management.

Companies' central challenge of aligning expectation and deliverables is made all the more difficult by increasing industry anxiety over proprietary information sharing, particularly in today's global market. Regulations of note include ITAR (International Traffic in Arms Regulations), which restrict the import and export of Aerospace and Defence related articles and services. As the largest Aerospace and Defence market in the world, one could argue that the goal of such trade controls can be to advance US national strategic objectives as well as protect sensitive IP and knowledge from being shared with developing competitive markets. In response, companies have implemented secure systems and networks. More recently, with the advent of technologies such as PLM, companies are now able to enable and audit sophisticated access to sensitive or proprietary information with complex supplier networks. Indeed, Lockheed Martin's implementation of a Collaboration Network for the F-35 programme not only linked 5,000 users in over 30 counties, it had in place appropriate security safeguards to ensure ITAR compliance in a system that may well be regarded as best practice within the industry.

Fig 3. An example of interconnected disciplines in the Aerospace Supply Chain

In general the Aerospace supply chain can be likened to a complex geared system. All of the parts must operate in tandem with as little resistance as possible to operate effectively. The sheer scope of the interaction between the 'cogs' - each individual supply chain member – is such that all process areas rely or influence others to a greater or lesser extent. From the very beginning of the supply chain in the **product design and development** stage, incremental value can be delivered through effective collaboration between the OEM and its supply chain. Engineers from both parties can add value and insight, especially true in the case of critical components and sub-assemblies where significant, often detailed expertise resides primarily in the supply chain. In turn, closer collaboration and

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transparency can help to reduce the development cycle and provide greater confidence and control over the quality of deliverables. In terms of the chain's management, it also signals a transparency and visibility from the earliest stages in the development process, allowing expectations and issues to be as aggregated and rationalised at the earliest possible opportunity.

When it comes to **sourcing and procurement;** communicating and collaborating with suppliers on sourcing processes and procedures can provide more effective workflows and insight in a number of key areas, including the enforcement of due diligence, the status of purchase orders as well as the significance of incoming shipments; these can form part of the information shared between the chain's members via digital 'dashboards' available with more advanced IT solutions. Managing schedules, subcontract deliverables and change can also be more efficiently co-ordinated. Having information instantly available enhances proactive management of the supply chain and their outputs and encourages successful delivery to agreed service levels.

Logistics and transportation is another area that can see benefit through effective use of information technology. Working in tandem with logistics service providers, supply chain managers can establish greater transparency into the status and location of goods in transit, enabling real-time and accurate forecasting of delivery schedules; essential to the production and assembly of sophisticated and complex deliverables. The same principle works vice versa, as providing suppliers with visibility into their customers' production schedules can help them plan to serve the OEMs (and so too MRO's) production and shipment targets more effectively, thereby avoiding the shortages that can bring assembly or production to a grinding halt.

Whilst component shortages can often plague the OEMs timely delivery of aircraft, stockpiling and excessive inventory are expensive overheads for the prime airframe manufacturers. Historically linked to the industry's previous adoption of 'push' mass manufacturing systems, this often resulted in output that may not be aligned with customer demand and needlessly eats up valuable capital. Effectively used in areas such as the automotive and high tech industries, shared or open **inventory management** delivers immediate value. Increased supply chain collaboration coupled with the adoption of Lean manufacturing techniques enables top tier stakeholders to formulate aligned view of supply and demand with the supply chain. Of course, such close integration may not always be applicable for many standard parts or build to print suppliers. These may more typically require low levels of interaction, but for higher tiered stakeholders, treating them as an extended part of your company can be mutually beneficial. Improved long and short term forecast accuracy, better demand planning, enhanced finished goods management and improved customer services can all form part of the value add in this case.

Maintenance, Repair and Overhaul (MRO) operations working with suppliers to manage critical parts and spares capacity can significantly improve their asset efficiency and utilisation. Whereas airlines once held 75% of the spare parts inventory, today they hold just 61% of the $48 billion parts inventory in the MRO supply chain. Indeed, inventory technical management could be a "massive growth opportunity" for MROs according to Christopher Gibbs, Cathay Pacific's engineering director. As these airlines move further from inventory ownership, MROs that offer this service could benefit significantly. Yet in order for these MROs to take advantage of these opportunities, they too must manage their own supply chains and aim for a collaborative environment across the supplier network. As in the production supply chain, emerging technologies from MRO and PLM vendors

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enhance management of the complex in-use lifecycle. Unscheduled maintenance, or a disruption in spares production schedules, for instance may result in an unexpected parts shortage. However, in an integrated, managed supply chain environment as spares or replacement information becomes available, companies can adjust maintenance, service and sourcing accordingly. Additionally, making this information visible to a broader stakeholder set leads to fewer expedited or emergency orders due to mistakes or opacity within the supply chain.

Moving forward

In today's aerospace industry the challenge of delivering to-time and to-cost while co-ordinating complex network deliverables requires more than just capability or technical competence. New, often lower cost competitors are forcing a change in how companies in the market deliver differentiation and tangible added value to their customers. Disjointed, often manual management of large multi-stage, multimillion dollar contracts is no longer an ideal platform for sustainable operations and can often have detrimental effects on product quality, asset utilisation and delivery performance. To this end, emerging IT solutions in areas such as PLM can help to manage the increasing product and supply chain convolution, providing a more dynamic and integrated environment to the benefit of both OEM and supply chain partners; supporting the business through improved management of risk while encouraging increased profitability, product and business performance.

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