Leading Business by Design: Aerospace sector

Design Council

70 years
Designing our future

About Design Council

Design Council is an enterprising charity which improves people's lives through the use of design. Our work places design at the heart of stimulating business growth, helps to transform our public services and enhances places and cities to ensure a sustainable future for everyone. We advance new design thinking, encourage debate and inform government policy. Our vision is to create a better world by design.

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Executive summary

“We can’t not invest, design is so engrained. We can’t separate design from the business. It is not a function. It is a way of being and doing.”

Head of Customer Experience, Airline

Civil aerospace poses unique challenges to designers working within it. Rightly one of the most heavily regulated and scrutinised of all industries, its design vision is relentlessly impacted by legislation, certification, environment, safety and security. Yet it is an industry where rewards for successful design are high and new technologies and materials are pushing the art of the possible.

To understand the current and future role of design in civil aerospace, RS Consulting has conducted research on behalf of Design Council, interviewing those in leading positions across the UK industry. A broad understanding of design was adopted as this is how it is understood in aerospace.

It covers a continuum from design that is focused directly on the experience of passengers – from in-flight service to seats in cabins – to design in a more technical sense – for example, sensors and fundamental components of the aircraft structure itself.

However, even passenger-facing product and service design must operate in an environment defined by technical design-engineering aspects. This can lead to tension, for instance between airframe manufacturers keen to spread costs over long, standardised production runs and airlines seeking to differentiate through regular refreshes of cabin interiors every few years.

The aerospace industry is highly fragmented so organisations' visions of design tend to fall on the more directly passenger-facing or more technical side of the design continuum. However, it is important to highlight the interconnection between these two. If design is viewed centrally and strategically, it can serve to provide sustainable competitive advantage for both airlines and the manufacturing supply chain.

Five themes emerged in this study, building on evidence in Design Council's 2014 *Leading Business by Design* report:

1 Where design succeeds most it is driven and informed by passenger and customer requirements and creates a positively differentiated result

2 For sustained corporate success, design needs to be embedded strategically and take place in a corporate environment with a strong design vision

3 Design-led innovation is challenged by the complexities of the supply chain and conflicts between different actors. To achieve best results, designers must collaborate with customers and companies across the supply chain

4 Design in aerospace requires many technical skills, but a common theme is the need for trade-offs to successfully execute briefs. Therefore, strong collaboration with disciplines covering technology, manufacturing, sales and marketing are vital

5 Evolving industry trends pose a whole new series of challenges for designers in aerospace. In the cabin, the increasing sophistication of in-flight entertainment (IFE) and passenger-driven requirements for connectivity will transform the future passenger experience. Elsewhere, new materials, innovative manufacturing techniques such as 3D printing and new tools for modelling and non-destructive testing require aerospace designers and companies to acquire new, more rounded skill sets as new applications and benefits are explored and developed.

Main themes

Innovation and growth
In an industry with hugely lucrative B2B customer-supplier relationships, the customer, ie, the passenger is still the end-user. Supply-chain partners may view the customer as the airframe manufacturer or the airline, but the most successful organisations in the industry retain a focus on design as a tool to directly or indirectly meet passenger needs.

There are several successful routes for design-led innovation and growth:

- The best design and engineering teams understand passenger's needs and desires. For best effect they are often embedded with insights teams or liaise frequently with sales and commercial functions to stay close to marketplace trends
- By monitoring wider technological developments and trends, designers can anticipate passenger requirements and offer useful, useable, desirable and innovative solutions that create new value in an increasingly commoditised market
- Designers looking at parallel and unconnected fields confer competitive edge. For example, inspiration for the earliest flat-bed premium seating configurations came from yacht design
- For sustained competitive advantage, a strong design vision must suffuse the organisation, cascading from the top, with an appropriate corporate structure in place to facilitate this.

> *"In some airlines, CEOs are like gods. If they have the right design vision that works really well, it trickles down the chain."*
>
> **Director, Design Agency**

Collaboration
Aerospace is characterised by extremely complex supply chains not just between different organisations, but also within larger manufacturers such as Airbus and Bombardier. This poses challenges for designers, especially where there is conflict or poor communication between different players. The greatest successes are often achieved where:

- The design requirement is specified as broadly and non-prescriptively as possible, focusing on solution and benefit, not just inputs
- The brief is shared by the company and its relevant supply chain companies as early as possible so all partners appreciate their role
- The customer encourages unconstrained thinking within industry safety/regulatory constraints
- Arrangements are in place for intellectual property ownership, incentivising the entire supply chain to innovate
- Within organisations, cross-disciplinary collaboration is encouraged between design, manufacturing and sales teams.

Some airframe and Tier One manufacturers are investing in supply chain innovation capability and improvement. For example, Rolls-Royce has partnered with Design Council to use design to drive innovation and better engineering design capability to deliver consistent service levels, foster greater collaboration, build customer understanding and achieve a unified approach across their strategic supply chain.

Designers' skills and competencies
Almost regardless of where designers are employed and the briefs they work on, design in civil aerospace is characterised by trade-off and compromise, imposed by regulation, certification constraints and technical, safety and environmental considerations. Therefore, while designers must have certain technical skills, they are increasingly the bridge between commercial, technical and passenger driven demands.

Successful designers are:

- Strategically creative yet grounded in the lore (and laws) of the sector
- Prepared to work in multi-disciplinary teams to ensure design reflects commercial, manufacturing and regulatory realities
- Able to involve and engage all partners, influencers and suppliers as early as possible in the development process
- Champions for dissemination and advocacy of the design vision throughout the supply chain
- Integrators of varying viewpoints, inputs, partners, interests and considerations in the quest for design-led innovation to create differentiation
- Design engineers that have strong strategic and human-centred design skills
- Strategic designers with a firm grasp of the technical requirements of the sector.

Future trends
Although the industry is apparently entering a consolidation phase following the billions of dollars spent developing the Boeing 787 and Airbus A350/A380, aerospace companies face a whole series of new design challenges. At the same time, emergent materials, techniques and technologies may help resolve some historic dilemmas. Emerging future trends are:

- In the cabin, the race to devise highly specified and frequently refreshed premium offers is balanced by the need to innovate in Economy. For the latter, with space always a constraint, there is an increasing focus of differentiating via improved ambience using lighting
- In all classes, passengers are demanding improved customer experiences, particularly around in-flight entertainment (IFE) and connectivity opportunities consistent with experience on the ground
- Composites, magnesium alloys and other new materials are increasingly important in aircraft components. Together with 3D printing's adoption in manufacturing, these will allow significant weight savings.

Also, it is possible that even more radical designs will be needed in future as limits to current technologies such as gas-turbines are reached. Academia and industry will need to work hand in hand to explore these issues in order to bridge the gap between research and commercialisation.

Computer modelling and non-destructive testing techniques will increasingly change the way aerospace components are designed. For example, design prototyping as early as possible will help organisations avoid what was referred to as "innovation trauma and sunk cost thinking" - the fear of expensive failure, driving safer, less innovative, solutions.

The future of aerospace design will be increasingly about designing novel passenger experiences with new materials and advanced manufacturing methods.

Recomendations

1. Embed design strategically
Design (in the broadest sense) can provide sustained competitive advantage at almost every level of the civil aerospace industry. However, for an organisation to benefit fully, design thinking must be embedded in its ethos and structure. This means the company leadership championing a clear design vision, understood throughout the company, so that design thinking and initiatives are encouraged and design becomes part of the way the company does business. Strategic design can bridge design's more passenger-focused elements with the more technical understanding of design, which currently are rarely connected in the sector.

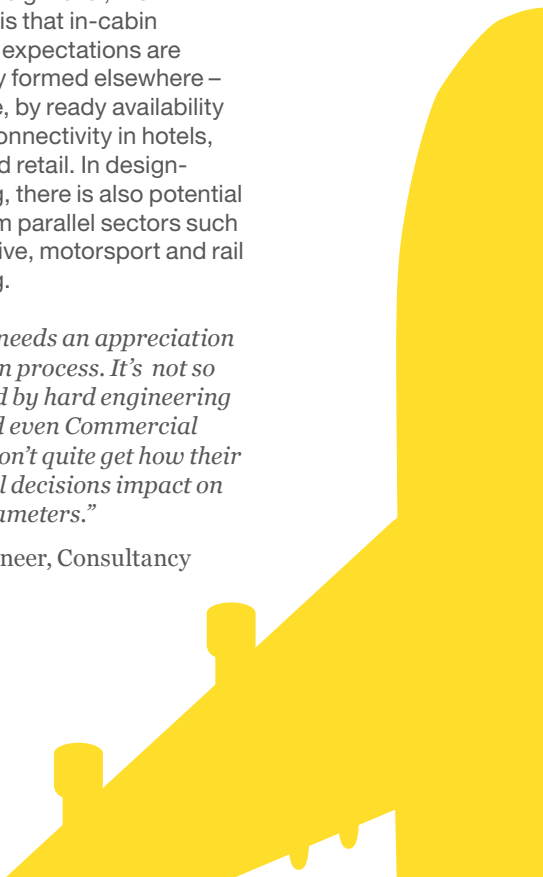
2. Design with the passenger in mind
In an industry with a complex supply chain and strong business-to-business relationships, organisations across the supply chain must understand passenger needs and desires. In passenger-facing organisations such as airlines this can be achieved through the co-location of design with customer insight departments. Further down the supply chain, collection of competitor and market intelligence by sales staff working with design engineers can be a proxy.

3. Encourage intra-company collaboration
In addition to a clear understanding of passenger and customer needs, companies should facilitate close design collaborations with the factory floor at the earliest stage possible. This is so designed elements can be prototyped and manufactured with the greatest possible efficiency (especially where new materials such as composites are used).

4. Incorporate best practice from parallel industries
At a pure design level, the consensus is that in-cabin experience expectations are increasingly formed elsewhere – for instance, by ready availability of mobile connectivity in hotels, catering and retail. In design-engineering, there is also potential to learn from parallel sectors such as automotive, motorsport and rail engineering.

"Everyone needs an appreciation of the design process. It's not so appreciated by hard engineering [teams] and even Commercial Directors don't quite get how their commercial decisions impact on design parameters."

Safety Engineer, Consultancy



5. Encourage design-led innovation through the supply chain
The industry has highly complex supply chains. There is an imbalance between a small number of airframe and major component manufacturers and a huge number of Tier Two suppliers, many of whom are under-resourced or capitalised. Larger industry players must lead in better supporting supply chains to drive up innovation through design in the end consumer's interests. Where possible, they must depart from a prescriptive model of 'managing' suppliers as a cost base, moving towards broader, solution-oriented briefs and specifications more likely to result in innovative design.

6. Support new approaches to design that can ease historic challenges
The combination of new techniques such as non-destructive testing, rapid advances in the introduction of new materials and a deeper collaboration between industry and academia have the potential to make introduction of radical new designs easier.

7. Government: embed explicit initiatives to support design in the sector
The government has numerous relevant initiatives, most notably the Aerospace Growth Partnership, with support programmes spread across technology, manufacturing, supply chain and skills. These should be complemented by embedding explicit initiatives to support the design of customer-centric passenger experiences and of aircraft components using new manufacturing techniques and materials, especially for smaller Tier Two suppliers.

8. Foster the next generation of industry designers
Designers in the aerospace sector need a skill set that incorporates technical knowledge, business acumen and people-centred design. Passenger facing designers need to be technically proficient. Conversely, design engineers need to be familiar with people-centred design. Individual firms and trade associations must support outreach programmes, not just to higher education but schools to ensure a healthy supply of recruits with a rounded design skill set. The government needs to value subjects that bring together arts and science such as Design and Technology.

Introduction

Research shows that design can positively affect financial performance, but such impact is not unconditional. It depends on factors such as innovativeness, the regulatory requirements of this industrial sector, the mix of design and engineering skills and, in particular, whether design is used strategically or driven purely by technical requirement. Organisations benefit most from design – as a function, a set of skills, and a perspective – if it is embedded in organisational processes and informs strategic choices.

The Danish Design Ladder maps the different levels of design use within organisations.

At steps 3 and 4 design is used not as an add-on but to structure development and strategy. Organisations benefit most from it here.[1] Danish companies adopting a "comprehensive and systematic approach to design" saw "a clear difference in their bottom line."[2] Design Council provides support programmes focusing on steps 3 and 4 and has delivered compelling evidence of the impact it can make.

Source: Danish Design Centre 2003

1 Chiva and Alegre, 2009; Design Council, 2007; Micheli et al., 2012; Perks et al., 2005.
2 Danish Design Centre,2003

Nevertheless, more research in this area is still needed. Therefore, in 2013 Warwick Business School and Design Council undertook a joint research project – *Leading Business by Design* – to address the following three questions:

- What triggers the strategic use of design?
- How is design used and integrated into organisational processes?
- How does design contribute to the success of an organisation?

A total of 53 interviews in 12 companies (large and SMEs, manufacturing and service-based) operating in different sectors were undertaken. These involved relevant personnel in design, marketing and finance, as well as CEOs and Chairmen. The final report highlighted design's role and impact in a variety of organisations.

However, the research also found that particular dynamics in certain sectors can strongly affect design's use and impact. As a result, Design Council has commissioned a series of research studies examining the role of design in addressing competitiveness issues identified in the government's Industrial Strategy sectors.

What we mean by design in civil aerospace

Design's role in aerospace is highly complex. It operates on a continuum from service experience and branding elements visible directly to the passenger, through to highly technical engineering requirements for the manufacturing of aircraft components.

Compared to other aircraft components, cabin-related environments are seen to have less engineering-oriented design. However, it can be difficult in this industry to draw a clear line between product/service design (for example interior aesthetics and usability/ergonomics) and engineering design. First, there is a high level of engineering design even in cabin fittings such as seats and in-flight entertainment, but also engineering design provides a strict envelope within which much product and service design has to operate.

Nevertheless, we have sought to concentrate on design aspects that affect customer experience directly, excluding pure engineering design such as fly-by-wire. We have also excluded DFMA (Design for Manufacture and Assembly) and aspects of airline branding or design outside the aircraft, such as airport lounges. However, these aspects of design are also of great importance to many organisations in the industry.

The common thread that runs through the designer's role in the aerospace industry is the challenge of preserving the aesthetic, engineering and commercial rationale for the design from the constraints assailing it.

Therefore, we consider three primary roles of design and designers:

- Understanding customer desires and needs and converting them into product/ service offerings
- Providing competitive advantage to clients
- Successfully translating insights into innovation within commercial, technical, physical or regulatory constraints.

"Good design translates in many ways. It is efficient to manufacture, lasts and the customer is happy with it, which attracts other customers ."

Head of Projects, Tier Two Manufacturer

"It is inevitable in this sector that certification requirements, timelines or weight and balance considerations will impact upon delivery to some extent. The important thing is to retain the ambition and the vision in view."

Design Manager, Airline

Aerospace in the United Kingdom

Aerospace is one of the UK's manufacturing success stories, with the largest industry in Europe, second only to the US worldwide, and with a global market share of around 20% of industry revenues.

Many global industry players are either UK-based or multi-nationals with key operations here. The UK industry is approximately equally divided between civil and military aerospace and both are significant contributors to the UK economy.[3,4]

The sector employs around 110,000 people directly, generates 5% of all UK manufacturing turnover and accounts for over 12% of circa £12bn per annum spent on manufacturing R&D.[5] The industry's value to the UK is increased further still by its current positive trade balance of over £5bn per annum.

Future prospects appear very healthy, with both Airbus and Boeing projecting significant fleet increases over the next two decades. This projection is driven by growth in emerging markets, which will represent almost two thirds of world air traffic in 2033. To satisfy this demand, Airbus estimates that over 31,000 new aircraft will be required between 2014 and 2033, while only slightly over 12,000 of the existing fleet will retire.[6,7]

3 The Future of Civil Aerospace, KPMG and ADS, 2013,
4 David Hough and Matthew Ward, The Aerospace Industry, House of Commons Library, 2014
5 What does the UK aerospace industry look like today? Office for National Statistics, 2014
6 Flying on demand; Global Market Forecast, Airbus, 2014
7 Randy Tinseth, Current Market Outlook, Boeing, 2014

In the UK, aerospace manufacturing ...

£28bn

has reached £28bn
annual turnover

110k

directly employs around
110,000 people

£10.5bn

accounts for around
£10.5bn in UK exports


Rolls-Royce

Theme 1: Innovation and growth

Innovation is the basis of differentiation, which is what airlines desire above all else. In order to grow in what has become a highly commoditised market, they must convince passengers that their products and services are better than those of competitors, often flying the same aircraft over the same routes. Some Airlines – and their manufacturers – turn to design as the driver of innovation and differentiation which allows design to be of strategic importance to the industry.

"Airlines are very aware of design's ability to make one experience different and better to another."

Director, Design Agency

Passengers also indirectly place pressure on designers to increase innovation, for example, by expecting comfort levels (both emotional and physical), network connectivity and privacy not available in older cabins. Innovative design ideas coupled with new materials and manufacturing techniques have been instrumental here. Demographic changes also present the industry with immediate and long-term challenges. Longer life expectancies mean a need for greater mobility and accessibility, not to mention a 'growing' population due to a rise in obesity. These are human-led challenges which present major commercial opportunities that design can unlock.

However, the sector impacts design significantly. Aerospace is necessarily highly regulated, safety-conscious and risk-averse, which means design and innovation are subject to airworthiness certification. The entire industry operates within a tight framework of external constraints; including regulatory, environmental, political, economic and social (eg oil prices and changing travel patterns). Those imposed by other parts of the industry – for example, modification work at terminals required by the Airbus A380 – can also significantly impact potential design decisions.

"The creative element is compromised by the status quo of what's been certified, what's safe and what can be achieved in the production line."

Founder, Design Agency

> *“We need to understand how the particular airline treats their customers and design accordingly. We design around the service that brand offers.”*
>
> **Founder, Design Agency**

All of these constraints act as barriers, potentially preventing the individual firms from using design as strategically as they might. Interestingly however, constraints also push designers to find creative solutions, precisely to overcome these barriers. For example, keeping fuel emissions, noise and weight down has spurred development and use of composites in the engine, wing and tail design and fabrication.

“We’re constrained in that once an aircraft is in operation it’s been certified. You then need to work out how to make changes without having to recertify the aircraft because the cost can be quite significant.”

Engineering Director, Airframe Manufacturer

Innovation in the cabin

The cabin is where passengers judge airlines, so airlines, bent on competition, turn to design to impress. It is the industry’s hotbed of innovative design. The most successful airlines do not just look at the cabin design as a stand-alone aesthetic exercise; it has to be considered alongside their service offering and more widely in the context of the airline’s brand and values. For this reason, design is often co-located with brand or customer experience departments and in many cases represented at c-suite level by the heads of those functions.

"Our design is the leading edge that we seek to deliver. We have a relentless eye for detail. Design is fundamental in supporting the brand and what it represents. We want design-led inspiration that takes customer input as its start point."

Head of Customer Experience, Airline

British design agencies are reaping the benefits of this focus, regularly commissioned by international airlines and airframe manufacturers to design innovative cabin interiors. Several agencies also work in hospitality and larger transport sectors, so there is some cross-fertilisation. For instance, design work in luxury hotels inspires cabin seats, beds, lavatories, and indeed general ambience.

At the front of the cabin, designers have more space to manipulate and passengers (or their expense accounts) have deeper pockets. It is here that airline in-house design teams and design agencies have the greatest flexibility in design. This is most evident in the premium cabins of Middle Eastern based 'super-connectors' such as Etihad and Emirates, which have invested heavily in 'Super First Class' concepts offering hotel room levels of comfort. In this case, cabin design is part of a wider strategic vision including the opening of new routes, large-scale fleet purchases and massive investment in hub airports which has fundamentally changed long-haul travel between Europe and Asia, and is starting to impact North America.

In Economy there is less customisation and a catalogue approach is common, maintaining some creativity, but manageably so: airframe manufacturers allow airlines to choose from existing configurations, themes and seating options. Even here, though, new techniques and materials can feature highly; composites have allowed for stronger, lighter seats with more space and legroom. The key question is how design can improve the passenger experience and still maintain revenue yields. An example of design changing the wider product offer has been the introduction of a new class (Premium Economy) by some airlines, which is proving attractive to business travellers trading down due to company restrictions and leisure travellers trading up.

Driven by ground-based expectations, airborne network connectivity is now commonplace. Designing new in-flight entertainment systems is crucial in improving passenger experiences. It allows passengers to access hundreds of audio and video entertainment channels and again provides a significant point of differentiation from competitors.

"We look for good uses of technology in parallel markets, especially consumer electronics. Today's mobile phones are so far in advance of what's on most planes these days!"

Senior Engineer, Tier One Manufacturer

Innovation in design engineering
Whilst designing innovative cabins makes headlines, the same level of design-led innovation in sections such as engines and wings might not create the same impact but is still critical.

Design-led innovation further down the supply chain happens more slowly for several reasons. For one, companies generally work to prescriptive design specifications provided by airframe manufacturers. Also, the significant cost and time involved to design innovative components can be a deterrent, especially given the onerous certification process.

Nevertheless, pressures to improve performance, reduce weight, lessen noise and lower fuel emissions force companies to try to improve the design of components, mechanisms and processes. Again, design in this field can be important strategically. Airframe manufacturers are being forced to increase their production rates to meet demand and this is impacting many aspects of the design process.

"The airframe manufacturers have made it clear that they see their biggest challenge with their new products as developing the supply chain to meet the required levels."

Commercial Director, Engineering Consultancy

Development in this sector has lately been driven by the availability of composite materials and manufacturing techniques such as 3D printing. The Boeing 787 is viewed as a game-changer here for using composites in the airframe while the Airbus A350 will also make significant use of composites in its airframe and components.

The Boeing 787 illustrates the importance of these improvements as part of a bigger picture rather than just design for its own sake; its longer range and greater fuel economy are designed to serve flights between secondary airports rather than the long-haul airlines' traditional hub-to-hub networks.

“I think materials like carbon fibre have, over the years, made significant leaps from where you initially were using them on things like race cars. Those types of technologies have been adopted into aircraft, but it’s wise to remember that aviation is ultra-cautious because of what it does. So, you are not likely to get someone having a eureka moment and then being allowed to stick it on an aeroplane.”

Sales Director, Tier Two Manufacturer

Theme 2: Collaboration

The civil aerospace sector is characterised by uniquely complex supply chains. For example, Airbus has more than 2,000 suppliers in over 20 countries,[8] and Bombardier's Belfast plant alone has a European supply chain of 900 companies.[9] For design to be used strategically there needs to be extensive collaboration across the supply chain, which means it is important to understand why tension occurs between different players. Besides the product's obvious complexity, there are several key reasons for this tension, including the high market share held by global players, the need to support maintenance and repair operations globally and off-set agreements increasingly being seen as a major source of competitive advantage.

Tension in the supply chain

The structure of the civil aerospace industry can make using design strategically a challenge, since at the top of the supply chain sit two different groups of buyers, the airframe manufacturers and the airlines. The supply chain is also subject to an inherent tension between complex and often highly detailed design requirements from the airframe manufacturers (which get passed down through Tier One manufacturers) and the desire of Tier Two manufactures to innovate.

> *"A Tier One [manufacturer] has that connection with an OEM (Original Equipment Manufacturer), but smaller companies aren't able to make those links and end up frustrated. When you become frustrated you disengage."*
>
> **Managing Director, Tier Two Manufacturer**

8 http://www.airbus.com/tools/airbusfor/suppliers/
9 http://uk.bombardier.com/en/aerospace/presence-in-country.html

Much complexity comes from the lack of alignment between passenger needs and those of airframe manufacturers. This creates unique challenges for organisations seeking to use design strategically:

- Airframe manufacturers are selling a common product to multiple airlines, all seeking to differentiate themselves from competitors using design while offering consistent a customer experience across often mixed aircraft fleets
- Designers have to balance airframe manufacturers' and the supply chains' need for highly standardised products subject to long production runs with airlines that may specify small bespoke fit-outs (such as First Class pods)
- Designs must accommodate both installations into new planes and retrofits of existing fleets, sometimes decades old, working around airframes' different lifespans and interior fittings. In extreme cases, this may include creation of completely new product categories such as Economy Plus within existing fleets.

"We are the meat in the sandwich on big customisation programmes."

Head of Design, Consultancy

This is exacerbated by a ripple effect in which a change in the design or manufacture of one component can require subsequent changes in hundreds of others. This naturally acts as a barrier to design-led innovation among individual Tier Two firms.

Some Tier One manufacturers are trying to work collaboratively with their supply chain, up to and including jointly designing products, but acknowledge the problem:

"One of the biggest challenges we face is to allow and encourage creativity within the context of a heavily prescribed process; the trade-off between capability and process compliance."

Head of Supplier Engineering, Tier One Manufacturer

However, despite industry efforts, a significant minority of Tier Two manufacturers continue to find that design collaboration remains a challenge:

"Within Tier One, Tier Two and the SME community there is a big frustration that we can't seem to reach the design-engineers to discuss the manufacturing capability before it is signed, sealed and nobody can touch it."

General Manager, Consultancy

Limited budgets for capital investment or research are a further problem cited by managers of smaller Tier Two suppliers.

In addition to individual firms' efforts, the government is also investing to boost UK Tier Two suppliers' competitiveness and sales with higher tier companies globally. An example includes the National Aerospace Technology Exploitation Programme (NATEP). It is a £40m initiative that builds consortia of at least two suppliers and one prime manufacturer (often an aircraft manufacturer or Tier One supplier) with expert mentoring. Although such programmes address collaboration in general, embedding government initiatives to foster design collaboration in the supply chain could drive innovation up the supply chain, particularly from smaller companies.

A holistic view of design collaboration

In cabin interiors, diverging directions limit the potential of collaboration. Cabin design is often broken into distinct sections and not viewed holistically. The mix of an aircraft's supplier-furnished equipment (SFE) and buyer-furnished equipment (BFE) poses design challenges to those seeking to create a single design ethos for the product. Many organisations find it is difficult to give SFE components high aesthetic design values, either because they are

> *"Within the industry there is pressure to innovate because of the rivalry between Boeing and Airbus. But for smaller companies there's a limit to what you can sensibly invest with such a limited customer pool."*
>
> **Senior Engineer, Tier Two Manufacturer**

contract-manufactured to price and specification or because the equipment (e.g. galleys) has less direct contact with passengers.

Integrating BFE equipment in the cabin can also undermine overall design values. Additionally, airlines often undertake cabin fit-outs in different classes as separate projects. Besides clashing design values across the cabin, the result can also be inefficiency in the use of cabin space.

Some Middle-Eastern airlines are often cited as the exception here, having explored collaborations to improve overall cabin design. An example is the recently completed cabin configuration for Etihad by a single consortium to design the entire cabin rather than the traditional piecemeal approach. This re-emphasises the need to consider design strategically.

Internal collaboration

A significant trend among global manufacturing companies (not just in aerospace, but also similar industries such as rail and automotive) has been the migration from individual sites with a broad capability-range to centres of excellence responsible for one part of the business regionally or globally.

In larger organisations collaboration between different teams or sites is as important as between

companies. This is particularly evident where manufacturing organisations are relatively deep in the supply chain and so can lack direct contact with passengers to understand their requirements.

The most common themes here are the advantages of using feedback from sales executives to formulate design initiatives and closer liaison about design changes with the factory floor, leading to greater machining efficiency, lower raw materials costs and reduced failure.

"Feedback from our sales guys on the competitors shows that we need to do things differently to competitors, like Wi-Fi on board, bigger cabin windows, more attractive cabin configuration. We then work out how we can engineer this change in a way that we can maintain the safety and reliability and the certification of the product while still being in cost and weight."

Engineering Director, Airframe Manufacturer

“The main driver from the business point of view is that design is a genuine value-add. Contract manufacturing is a commodity … By adding in factors such as the design capability … we can begin to differentiate ourselves from our competitors.”

Sales Director, Tier Two Manufacturer

Theme 3: Designers' skills and competencies

"Designers respond to creative briefs formulated on the basis of customer insight. The best of these understand the constraints and considerations of the aviation business so they do not make naïve recommendations or waste time."

Customer Experience Team, Airline

As previously stated, design within aerospace covers a broad continuum. This means the pool of designers needs to embrace a large range of skills and competencies collectively (and individual designers also need a broad skill set).

Design for the passenger is driven by airlines and realised by the airlines' in-house design teams, designers employed by the manufacturers and design agencies commissioned by these parties. Regardless of where they sit, designers must have a firm grasp of the technology they are working with.

At the other end of the continuum we find design-engineers working for the airframe manufacturers and their supply chain, where a high degree of technical and, increasingly, specialist IT knowledge is an absolute prerequisite.

"They need to know engineering science, material science, all the aspects of design – using the tools like CAD/CAM and analytical tools."

Engineering Director, Airframe Manufacturer

"The route into the design office is traditionally through technician apprenticeship, then post-apprentice training like a degree."

Head of Design, Tier One Manufacturer

> *“There are two slightly different mind-sets, two different sets of training which can combine to provide what the airline is looking for – a beautifully-styled, aesthetic version of something that functions better than it did before.”*

Director, Design Agency

A common theme is that design is characterised by trade-offs and the ideal designer recognises this. The biggest trade-off is between original design conception and the sector’s constraints. For this reason we believe collaboration and interdisciplinary skills can rival technical competency in making an effective aerospace designer.

“However we dress it up at the end of the day, it is actually about people dealing with people. You have got to get on with the people you are working with. If they are speaking in this high-tech language all the time and baffle you, it’s hell to work with.”

Sales Director, Tier Two Manufacturer

The skills shortage

There is a skills shortage among designers at all manufacturing supply chain levels, mostly seen in the context of the UK’s wider shortage of engineers.[10] A distinct cohort effect can also be seen in many firms, which may mean that it will take a long time for the skills gap to be closed. There is a notable shortage of design engineers that have strong strategic and human-centred design skills. Similarly, there is an increasing requirement for strategic designers with a firm grasp of the technical requirements of the sector.

10 http://www.imeche.org/docs/default-source/press-office-2015/manifesto.pdf?sfvrsn=12

"There is a clear skills gap age-wise. Most of my team are 35 and up. Very few employees are under 25. Engineering-wise there is a huge skills gap and a mental block. Younger people don't want to get their hands dirty."

Head of Projects, Tier One Manufacturer

The sector imposes a steep learning curve, making it imperative that the industry proactively secures a steady stream of recruitment.

"Aircraft design is very challenging, especially the physical product. Those who arrive from other industries find it very frustrating. The certification process is cumbersome and lengthy for even the most minor of changes."

Customer Experience Team, Airline

Deepening relationships with academia

While the industry continues to support more traditional approaches to academia, for example by sponsoring university research chairs, the skills shortage is driving many organisations such as GKN[11] and Bombardier[12] to better train their staff by deepening their relationships with academia.

For example, in Northern Ireland, Bombardier is a key member of an ambitious scheme developing a cluster of companies that share interests in advanced manufacturing across different industrial sectors, of which aerospace is one (other partners include BAE Systems, Airbus, Rolls-Royce and QinetiQ).

"This is mostly about R&D, but it's within the R&D arena that our people get valuable, on the job, training and techniques like creativity and innovation. How do you take the business drivers (safety, cost reduction, product enhancement) and collect ideas and analyse and converge on a solution, then design into the product?"

Engineering Director, Airframe Manufacturer

Finally, although the initial reference point when discussing skills is always supply of apprentices and graduates, the consensus is that industry must also reach out to secondary schools, encouraging students to see aerospace as a potential career.

11 http://www.bristol.ac.uk/news/2012/8690.html
12 https://www.qub.ac.uk/schools/media/Media,165690,en.pdf

"This job is a vocation. We're reinvigorating connections with schools on the Isle of Wight, where the supply of designers is low. We need people to keep the company going. It's quite a thing on my mind that we need it to be there in 10 years."

Head of Design, Tier One Manufacturer

This is especially important in locations where aerospace is the major (or sole) manufacturing employer.

Future skills

Within the manufacturing supply chain the designer's role will become more complex and technical. In the future designers will be required to have a greater understanding of systems integration (for in-flight entertainment), materials science and CAD/CAM design. As specialist software (eg for stress analysis and non-destructive testing) is becoming more user friendly, designers will be required to use a wider suite of IT tools.

"As analysis packages get more sophisticated and user-friendly, you'll see designers using the packages more to do their own stress analysis and stuff. The machines we have here now can do analysis in a viable timespan we didn't have five years ago."

General Manager, Consultancy

A further common theme in both in-house design teams and design agencies is a need for multi-disciplinary designers: strong problem solvers, able to communicate with non-designers and present their proposals clearly to customers.

"It's important that they understand the certification requirements that they have to meet, so that they can talk to our stress analysts and vice versa."

General Manager, Consultancy

Theme 4: Future trends

While the pace of design, testing and certification of new airframes can seem glacial, advances in manufacturing technology, materials, computing and digital media are faster and are impacting the industry continuously.

Changing legislation and environmental regulations can also necessitate re-engineering airframe designs mid-life and, in extreme cases, complete changes of materials. So the industry is in continual tension between the need and desire to introduce new products and the drag caused by the risk of new technology.

Many observers take a view that aerospace design is of a cyclical nature (with sea-change products such as the Boeing 787 and Airbus A380 alternating with more incremental change such as NEO versions of the 777 and A330). It is a more complex picture where new design is incorporated within existing products almost continually. The result is that superficially similar aircraft such as the 737 have altered fundamentally throughout their production runs. This has implications that ripple across the industry, since every design-change the manufacturer makes needs to be known by the airlines and their MROs[13].

> *"If you give them a screen that you can't pinch and swipe like your smartphone they'll look at you aghast and say, 'What is this rubbish?'"*
>
> **Head of Design, Tier One Manufacturer**

13 MROs are companies that are involved in the maintenance, repair and overhaul of aeroplanes.

"As a result the design product can be changing right through its lifetime in production. So the aircraft we build in three years' time might be quite different to the detail that we built this year ... we need to know at exactly what design standard every part on that aircraft was designed to."

Director Engineering, Airframe Manufacturer

Future trends in the cabin

Airline in-house design teams, Tier One manufacturers and design agencies have been working in concert to develop cabin interiors that mirror ground-based interiors development as closely as possible. This objective is relatively easier to achieve in premium cabins, where space is available and revenue equations allow for innovative configurations.

It is in back of the cabin – in Economy, and particularly single-aisle aircraft – where designers have had to work hardest to establish cabin design that differentiates – and to do so for an appreciable period of time. Here new materials will help designers create thinner and lighter seat frames, maximise stowage capacity and improve lighting and ventilation.

Across all cabin-classes a common design trend is the drive to improve in-flight entertainment and connectivity to match passengers' expectations:

"The next generation of in-flight entertainment equipment that we have been designing is effectively an iPad. So, I would say the next stage after that is the airline offering the option of having a screen on the plane, but, if you have your own screen, it's a bit bigger or your own laptop you want to watch it on, you just log in to this system and there's the movie library and you can screen what you want."

Sales Director, Tier Two Manufacturer

Positive differentiation in this field drives competitive advantage and delivers rewards. For example, Virgin Atlantic has always enjoyed a reputation for innovation and a distinct operating style. Over the years this has been seen in the launch of a Business Class equal to many First Class cabins, sector-leading airport lounges and an unparalleled reputation for being ahead of the game. In order to secure this, Virgin Atlantic is constantly on the lookout for ground-based innovations it can capitalise upon to design better passenger experiences.

Its approach is discussed further in the case studies from page 44.

Identifying evolving trends
Effective aerospace designers must not only work to generate creativity from resources that they have to hand and from blue-sky thinking, they must also keep a very close eye on developments in parallel and sometimes unrelated fields for developments that can be used in aerospace. This includes sharing information and ideas with motorsport, rail, hospitality and yacht design. For instance, Sheffield University's Advanced Manufacturing Research Centre (AMRC) has drawn on Formula 1 aerodynamics developing an integral ducktail feature that helps to harness the air leaving the engines of its composite-built flying wing model for aerodynamic effect.

Design-engineers in manufacturers are also increasingly looking into parallel fields to find inspiration, for example exploiting technology crossover from automotive and military aerospace.

"We like to look at gaps in the market – for example, stuff that is used in the US military that we can bring into a civil context. Bringing the technology across if it is feasible and economical."

Head of Design, Consultancy

Tier Two suppliers are especially likely to see the automotive industry as a broader source of innovative practice including component modularisation, efficient production techniques and supply chain management.

New methods, new materials
Design within civil aerospace is in flux as futuristic technologies, materials and manufacturing techniques integrate. Designers must be familiar with these options to best exploit them. At a more strategic level, government funding via NATEP (National Aerospace Technology Exploitation Programme) is supporting smaller firms in making new materials commercially viable.

"Design of the materials is very important for our customers. Typically we compete against other materials, notably aluminium and, increasingly, carbon fibre composites. Magnesium is more expensive, so we have to really pitch the relative strength of magnesium and that sweet spot of space-saving to strength."

Sales Director, Tier Two Manufacturer

One marked trend is a move away from traditional testing 'to destruction' to greater reliance on increasingly sophisticated computer modelling and non-destructive testing techniques.

Designers now enjoy new freedoms in early-stage design, unconstrained by expensive testing costs. In parallel, the research suggests prototyping at earliest possible stages is becoming more common, helping designers overcome so-called 'innovation trauma and sunk cost thinking' – fear of expensive failure, driving safer, less innovative, solutions.

As discussed in the Designer Skills and Competencies theme, these changes require new levels of training and familiarisation for designers in the industry wanting to realise the potential they offer.

One thing is certain: with market forces pushing both Boeing and Airbus to increase aircraft production levels, designers will have to absorb the intricacies and possibilities of new materials, technologies and techniques more quickly.

"The biggest changes will be in production rates and the number of aircraft operating. There's a new wave of fuel-efficient aircraft about to be launched – everybody wants them and we can't build them quick enough."

General Manager, Consultancy

“Robots are the big thing now, so the industry is getting more like the automotive industry. About ten years ago they realised that they had to bring in the technology and change. It enables them to cut down manpower while keeping the product quality high. Several automotive companies, notably German ones, are getting into aircraft.”

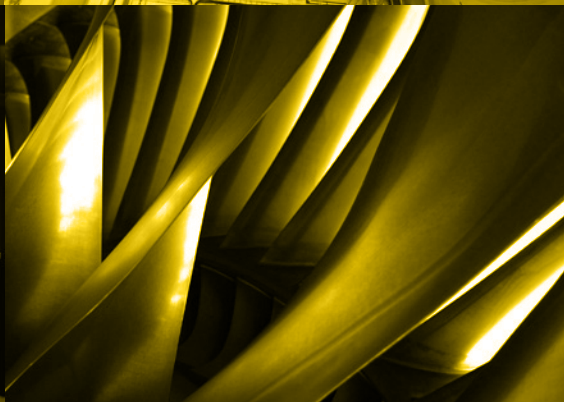
Operations Director, Tier Two Manufacturer

Case studies
Section 1: Innovation and growth






NOVA-TECH

Section 1: Innovation and growth
Case study: Factorydesign

London-based Factorydesign is responsible for work underpinning some of the past two decades' most notable flight experiences. Since its 1997 inception, it has focused on redefining the passenger cabin experience, starting with ambience and layout and moving to specific features: seats, galleys, bars, storage areas and bathrooms. Their work's driving force has always been attention to detail aimed at optimising passenger experience.

With a client roster including British Airways, SAS, Etihad Airways and other high-profile carriers, Factorydesign's philosophy and working practices have come to be viewed as routes to innovation and growth in the aerospace industry.

Design embodying cultural and brand values

Today's airlines vie to offer the special experience passengers increasingly seek. Brand values are key to this, which often, by extension, means an airline's country's values. Design that successfully conveys culture and personality is at the heart of innovation in the sector. This requires concerted effort.

The Factorydesign team start by immersing themselves in their clients' culture. They also establish close relationships with their client's leadership team to redistribute build understanding of corporate culture and the priorities for their designs. They consult consumers too, often in collaboration with consumer research firms, running workshops to unearth passenger priorities and concerns. These exploratory initiatives provide the fundamental frame of reference for design innovation.

A broad challenge

Factorydesign believes that design's ability to drive innovation and growth is maximised by design briefs that are as broad as possible. The traditional element-by-element approach that might ask a design agency for a review of Business Class seating or Economy Class stowage can confine and constrain creativity, preventing an effective overarching brand design. Innovative design is born from looking at space holistically, revealing effective ways to redistribute components or redraw sections. Redesigning the entire cabin from nose to tail allows space optimisation and harmonious brand design throughout aircraft and fleet.

Etihad: Revolutionising cabin interiors

Factorydesign's approach to brand design is exemplified by work undertaken with design agencies Acumen Design and Honour Branding, all three working together as the Etihad Design Consortium on a 'cabin re-visioning' project for Etihad Airways in 2008-2014.

Etihad Airways wanted to create the most luxurious living space in the air and undertook the biggest single commitment to interiors made by any airline, introducing innovation across every cabin element. Unique configurations were prototyped, new seats installed and dedicated zones for passenger recreation and rest established. Galleys and bathrooms were designed to match the reworked cabin.

The project began with a month-long 'cultural immersion', comprising observation, networking and analysis, vital in framing subsequent design work. Importantly, Factorydesign put the passenger at the innovation process's heart, partnering with specialist agencies to conduct passenger workshops in various cities. These insights set the vision for reimagining the cabin interior and the service styles to be enacted within.

The Etihad brief had been as broad as the designers could have hoped, requesting complete redesign of the fleet's A380 and B787 interiors.

"We could optimise the entire footprint of the cabin. Where traditionally you might slice up a plane into First Class, Business Class, Economy, we were able, as a group, to look at the whole, which provoked all sorts of ideas for innovation in the layout and products..."

Commercial Director, Factorydesign

This freedom allowed development of an all-pervading brand style across every aircraft and cabin class. It was critical in driving creation of consistently designed, harmonious and highly innovative cabins that expressed the best of Etihad and met the needs identified in the cultural immersion.

Section 1: Innovation and growth
Case study: Bombardier

Bombardier is one of the world's largest aircraft manufacturers, supplying both business – the Learjet, Challenger and Global jet families – and commercial – the CRJ NextGen, Q-Series turboprop and C-Series aircraft families. With over 40 years' experience developing composite components as well, its current portfolio includes around 30 aircraft components, including wings, horizontal stabilisers, engine nacelles and landing-gear doors.

The company's Belfast operation is one of Northern Ireland's largest manufacturers, with a workforce of some 5,700 and revenues last year of approximately £616m. It plays a major role in all Bombardier's families of business and commercial aircraft, also producing aircraft structures and engine nacelles for other international manufacturers and providing aftermarket support: maintenance, repair and overhaul.

It specialises in design and development of complex advanced composite and metallic aero-structures. Its European supply chain of 900 approved suppliers includes around 800 in the UK and Ireland. UK and Ireland suppliers were awarded contracts worth over £260m in 2014.

Design within Bombardier
Bombardier Belfast has a 100-year legacy of design-led innovation and development. Design is closely integrated within manufacturing, with both research and technology development and product design and development.

Design input is generated by technical customer and regulatory requirements. The design process then establishes how to meet these and cost-effectively manufacture components to optimise lifecycle cost (or cost of ownership), production cost and product performance. Bombardier constantly monitors markets to understand customer needs. For example, the new CSeries commercial aircraft programme was launched in July 2008 based on clear, industry demand for 100 to 149 seat airliners. It offers unmatched operating economics with a significantly reduced environmental footprint, including a 20 per cent fuel burn advantage and radically reduced emissions. It is also four times quieter than other in-production aircraft in its class.

The programme is currently being flight tested and progressing steadily towards type certification. The airframe design will carry the aircraft programme into the 2030s and beyond, during which it may be subject to multiple interior, engineering and system reconfigurations.

“Seven-year product development is typical within the aerospace industry for a brand new aircraft, and this aircraft could be in service for 25 years or longer. The rigour of the design and development process means that this can be a lengthy procedure, but the end product will be long-lasting.”

Director of Design Engineering and Technology

The wings of change

Belfast's principal role in the CSeries aircraft programme has been development, design and production of a new composite wing. The £520m investment in this is the largest ever single inward investment in Northern Ireland. During peak production years, it will generate around 800 Bombardier jobs and thousands more in the wider supply chain.

The wing is developing Bombardier's capabilities and skills to a completely new level. It uses an advanced new Bombardier-designed and patented composite manufacturing process: Resin Transfer Infusion (RTI). The composite structure offers weight, resilience and strength advantages over conventional alloy structures.

RTI is different from composite technologies used in most other aircraft programmes, though with very similar materials. Most programmes use material supplied pre-impregnated with resin, binding fibres together to create hard, durable structures when cured under high temperature and pressure, usually in an autoclave.

RTI uses 'dry' carbon fibre fabrics for the structure, then injects resin in after placement in the autoclave.

This allows manufacture of large, one-piece, complex structures, reducing the need for many different parts and mechanical fasteners, resulting in significant material and cycle time reductions. Customer benefits include less inspection and maintenance, due to the corrosion-free material properties.

"We believe RTI is a major step forward in the evolution of advanced composites technology."

Director of Design Engineering and Technology

The wing is the largest aero-structure ever produced using RTI. Being lighter than conventional metal wings reduces fuel burn, contributing to environmental benefits.

Design assumptions were modelled at the outset, then rigorously tested. Development involved production of a full-scale, three-quarter span pre-production wing, successfully tested to

ultimate load, replicating 150 per cent of the severest forces it was likely to experience. Resultant data was used to optimise design of production-standard wings.

Design testing is critically important at this stage because later changes can be expensive:

"You're working within the [industry] rules and they limit the changes you can make. If you make a change that is significant then you have to do a lot of testing to re-certify which adds to your costs and which can make the business case to the customer unattractive."

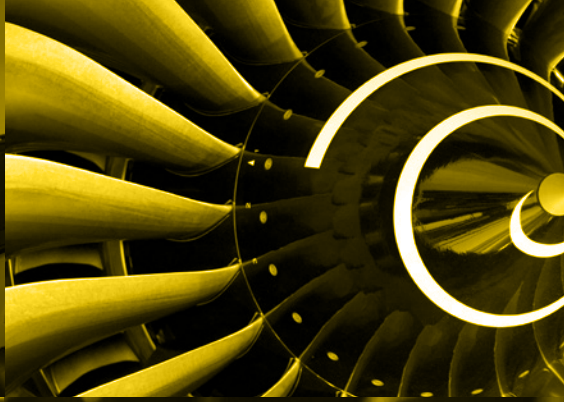
Director of Design Engineering and Technology

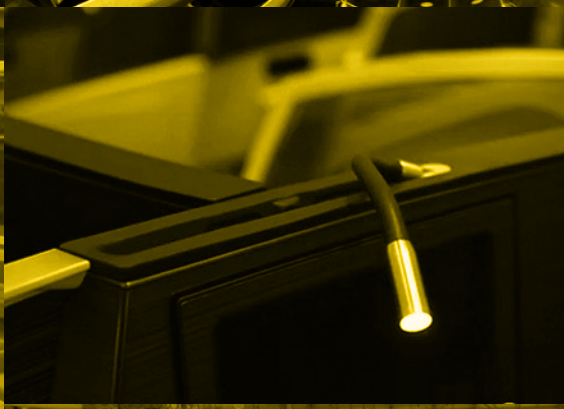
Wing production is now under way in a new Belfast facility, part of the £520m investment. The factory offers facilities for receipt of raw carbon-fibre material, cutting and lay-up space, the RTI production system itself, non-destructive testing and a final assembly area.

The aircraft programme's environmental and economic credentials are attracting significant interest and sales potential from the world's airlines.

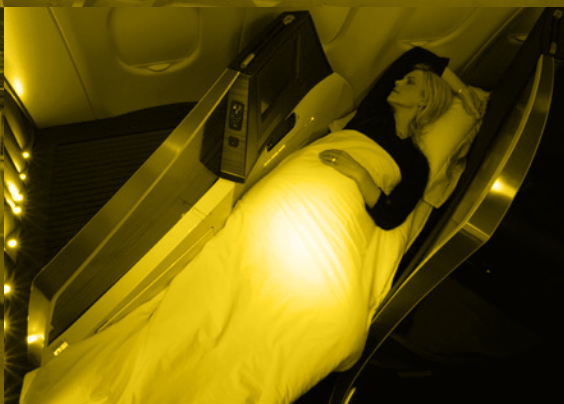

NOVA-TECH
Engineering

Case studies
Section 2: Collaboration







Section 2: Collaboration
Case study: GKN Aerospace

Employing more than 12,000 people across more than 30 sites worldwide, GKN Aerospace is a UK-owned first-tier supplier to the global aviation industry. A market leader in the manufacture of highly complex composite and metallic aerostructures and engine products, its customers include Airbus, Boeing, Rolls-Royce and Bombardier.

GKN Aerospace and design
GKN Aerospace operates seven major research and manufacturing sites in the UK. At its Cowes site, nearly 200 of the 1,200 employees are in design roles, either in development, manufacturing, composites or stress engineering.

This design focus is partly due to the company's commitment to driving innovation and partly due to the presence in Cowes of its collaborative Composites Research Centre (CRC). Managed as part of the National Composite Centre (NCC), this is the primary UK facility for research and development for advanced carbon fibre composites and new materials.

Equipped with state-of-the-art testing, production and analysis equipment, the CRC is the focal point for development, prototyping and implementation of innovative composite manufacturing and assembly techniques across the GKN Aerospace group on behalf of its customers worldwide. The company recognises that aerospace design and development's future lies in this area and has invested significant sums in achieving and maintaining pre-eminence in it.

Working with the NCC is already paying dividends: GKN Aerospace's most recent winglet designs use new carbon fibre placement and deposition techniques developed by its in-house designers. The resultant winglet is lighter, features fewer parts and is 20% cheaper to manufacture than predecessors, bringing real benefit to aircraft manufacturers who invest in this technology. For the future, GKN Aerospace has tasked the unit to look into structural analysis techniques to assist in the design of larger, flight-critical wing structures. Longer term, collaborative projects will explore the aerodynamic concept of laminar-flow, leading to new, ultra-efficient wing designs.

GKN AEROSPACE

Collaboration with OEMs

GKN Aerospace collaborates with many OEM[14] customers. As the company has a limited role in overall aircraft design per se, much of its work is to schemes handed down by the OEMs. OEMs look to GKN Aerospace for design approaches that can save money, time, weight and materials. This is where GKN Aerospace's CRC adds value.

"GKN Aerospace must continue its drive to innovate so as to remain competitive for customers such as Airbus. This is challenging, but we have the design engineers who can step up to take on this innovation. We have the manufacturing engineers who can develop innovative process that we can use in our design... and in the Composites Research Centre we have development engineers who drive our composites focus."

Head of Design Europe

An example of internal collaboration between the CRC and GKN Aerospace's product design team is wing development for Airbus's A400M transport aircraft. The wing was expected by Airbus to withstand significantly greater dynamic loads than previously. Thanks to the CRC's early involvement, GKN Aerospace was able to design a lighter, composites-based wing offering the enhanced load-bearing capability required. The 20-metre main wing spars were the first large aircraft primary wing structures created entirely in carbon-fibre composites.

Design development for this – both in terms of manufacturing technique and testing and feasibility required prior to initial production – was undertaken by GKN Aerospace's CRC. Detailed design work commenced in 2014 and the company now has two design engineers working exclusively on the project, managing updates, changes and modifications, ensuring development is always in line with the customer's product specification.

14 Original Equipment Manufacturer (OEM) are usually the final assembly maker in the supply chain. As many aerospace companies use parts from various brands within the manufacturing process, OEMs generally refer to airframe manufacturers.

Section 2: Collaboration
Case study: Simon Pengelly

Simon Pengelly is an agency specialising in the design of furniture for home, office and institutional purposes. Its work for Virgin Atlantic resulted from the airline's requirement for an Upper Class cabin look for its new Boeing 787-9, drawing more on furniture design than conventional aircraft interiors.

Design within Simon Pengelly
The agency lives and dies by the quality of its design, not only at conception but also prototyping, crafting and manufacturing stages.

"We look upon ourselves as pure designers but with a technical approach. We work very holistically, immersing ourselves in our products and their context. In the aerospace example we soon realised that we would have to get under the skin of the technology."

Founder

An important priority for the agency is to design timeless, not trend-led furniture. This chimes with Virgin's own approach, which accounts for aircrafts' extended lifespans and the number of seating reinstallations that may be required. A timeless design is one less reason for change.

Essential design principles for Simon Pengelly – applied just as much in its aerospace as its furniture work – are as follows:

- Understanding of materials
- Understanding of the end user
- A harmonious mix and understanding of the functional and the emotional response
- Knowledge of the market and operational milieu
- Adherence to the brief, its letter and spirit.

Entering the aerospace world

Simon Pengelly's work with Virgin Atlantic launched them into an unfamiliar world. In the spirit of their guidelines, they immersed themselves in the brief and in building an understanding of the environment. As well as the aesthetic stipulations, the brief also required maximisation of seat numbers without diminution of comfort or perceived spaciousness.

A study of innovative space usage in closely confined environments, together with the agency's own furniture design heritage, led to an early realisation: a herring-bone seating pattern down the aircraft centre would allow three extra seats per cabin and offer every passenger a coveted aisle seat. Moreover, seat dimensions would be generous: 2.2 metres, allowing for the longest flat-bed in the air. A unique ottoman feature provided additional storage, an extension to the flat bed area and protection for feet from passing aisle traffic.

"We felt pride in our innovative approach and believe that our preparedness to consider a radical solution and think laterally enabled us to over-deliver in terms of the brief's original stipulations."

Founder

> *"There is a real ripple effect. One small change will affect so many other aspects. That's part of the reason why lead times are so long."*
>
> **Founder**

The learning curve was steep. Simon Pengelly identifies the regulatory strictures and industry complexity as having led to some frustration.

Nevertheless, the eventual design survived certification relatively intact, representing the original ambition closely.

Simon Pengelly points to the Virgin Atlantic design team's close involvement as vital in the assignment's success. The Virgin designers were close to customer expectations and priorities and guided the agency designers through aerospace's unfamiliar intricacies. This close collaboration within the aerospace supply chain is crucial in designing and delivering successful and award-winning solutions. In addition, Simon Pengelly considers the following factors critical in such aerospace design collaborations:

- Complete immersion
- Recognition that the customer is king
- Understanding across all aspects
- Discipline and attention to detail.

Section 2: Collaboration
Case study: Rolls-Royce

Rolls-Royce's Civil Aerospace Division is a major aircraft engine manufacturer. The engines it designs and develops power more than 35 commercial aircraft types and the company has almost 13,000 engines in service around the world.

It also provides comprehensive service packages for managing engines throughout their lifecycle, delivering these by combining its knowledge as engine designer and type-certificate owner with data generated from its infrastructure and supply chain network and engines in operation. The Rolls-Royce supply chain is extensive (around 600 suppliers) and design is critically important to the business with approximately 1,800 design engineers working across the organisation.

Managing 600 supplier organisations

Rolls-Royce component suppliers fall into two categories: those that both design and make components, and those that 'make to print' – manufacture to Rolls-Royce specification/design without design input of its own. Because roughly 30 per cent of Rolls-Royce components are designed outside the organisation, it has established a Department of Supply Chain Collaboration for Component Engineering. This focuses on communicating and collaborating effectively with supply chain partners while also working to improve suppliers' design capability and ensuring in-house design engineers are designing for the future. The aim is not to blunt or control creativity but ensure that agreed parameters are met. The business has also designed an Integrated Commodity Strategy to ensure that internal design, manufacturing and purchasing departments work together effectively alongside supply chain partners.

Designing innovation in the supply chain

In the safety-focused, risk-averse world of aero-engine development, surprises are, of course, unwelcome. However, Rolls-Royce is also acutely aware of how important it is to ensure its competitive advantage by encouraging design innovation among both its design engineers and suppliers. It therefore encourages design innovation through development of an innovation framework focusing on three time windows:

- **Vision 5 (years)** Work on existing technology
- **Vision 10** Work on next-generation technology
- **Vision 20** Work on the possibilities and potential of emergent technologies.

Award of patents is a clear innovation incentive, but Rolls-Royce has also sought to drive it through establishment of a corporate innovation portal, a shareware programme allowing dissemination and free discussion of innovative ideas and concepts.

It is also striving to keep supplier briefs from constraining free-thinking. As the Head of Supply Chain Collaboration, (Component Engineering) says: "We must ensure that we don't automatically fall into solution mode." This is particularly important for an organisation that has sought, historically, to acquire any adopted technology or innovation's intellectual property, a tendency often viewed as inhibiting innovation further down the supply chain:

> *"We must allow and encourage creativity within the context of a heavily prescribed process. There is a trade-off between capability and process compliance that we need to stay on the right side of."*
>
> **Head of Supplier Engineering**

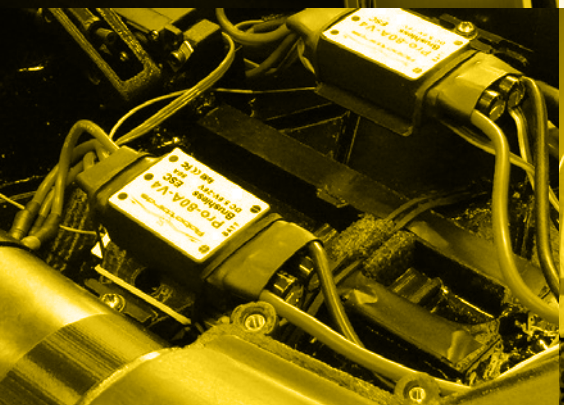
To help achieve this, Rolls-Royce has fostered collaborative, partnership-style working with key suppliers. Integrated design teams are formed, working in a common space with additional representation from manufacturing and purchasing. Occasionally, meetings will take place off-site at venues such as AMRC (Advanced Manufacturing Research Centre) where designs can be tested and debated in a laboratory environment. Rolls-Royce has also encouraged a search for design innovation in parallel fields such as motor sport, where best-practice innovation has been benchmarked to maximise learning potential.

Risk aversion is endemic in aerospace and across Rolls-Royce. Acknowledging this, the manufacturer has provided suppliers and in-house designers with clear guidelines for working collaboratively, ensuring that creative thinking and design innovation are encouraged. The supply chain's ability to use design strategically is crucial in driving design innovation up the supply chain and ensuring a competitive advantage for Rolls-Royce.

"We don't want to give the airline any surprises... That's when we are doing our job best."

Head of Supply Chain Collaboration

Case studies
Section 3: Designers' skills and competencies




Rolls-Royce

Section 3: Designers' skills and competencies

Case study: James Park Associates

London-based James Park Associates (JPA) delivers design solutions to global clients in the transportation and hospitality industries for thirty years. Its work on cabin interiors for global clients such as Singapore Airlines and American Airlines and for manufacturers such as Zodiac Aerospace is well respected throughout the aerospace and design worlds.

One of the key drivers of JPA's success has been its dual-focused appreciation of the human and technical elements of interior design. JPA's parallel focus on transportation and hospitality sectors allows it to apply cross-sector knowledge to help its clients in the aerospace sector.

A unique sensitivity

"Design is a human-centred endeavour. Design is in anything that contributes to the way we live and what we do.W"

Founder

As JPA's founder explains passionately, it is his agency's 'human-centric' approach to design issues that underpins its approach to business development and its design philosophy.

From their earliest days in the agency, JPA staff are trained to develop an understanding of the impact their designs can have at an emotional level. Nowhere is this more relevant than in the case of cabin interiors. Airline flight can generate high levels of emotional stimulation, from excitement through to emotional and physical discomfort, social disorientation and genuine fear. This appreciation ensures that JPA designers take a holistic view of the discipline and the use of valuable space on board airliners. They look at cabin concepts, configuration and prototypes with a view to assessing how elements combine to impact both physical and emotional wellbeing.

Technical skills

Empathy and customer-closeness are crucial attributes expected of JPA designers. However, design necessitates a firm grasp of technical complexity, not least in the intensely regulated arena of aerospace. One key tenet of JPA's approach here is the way they work in close concert with manufacturers - understanding the language they speak and the technical production concerns that challenge them. In order to ensure that manufacturing issues are solved, JPA invites manufacturing partners to form co-located working teams from the earliest stages of a project. In this way complexities and intricacies are addressed and critically important chemistry, rapport and understanding is established between concept originators and producers.

"We do the concept work and then carry it through to work very closely with manufacturers and builders to make sure that the design vision is maintained."

Founder

JPA DESIGN

Cirrus Business Class Seat

The Cirrus Business Class seat, designed by JPA and produced in collaboration with SICMA Aero-seat (now part of Zodiac Aerospace), is the flat-bed business class seat design that is becoming the dominant archetype in this highly competitive market. The design of Cirrus is a particularly good example of where the JPA approach and skill set has paid dividends.

Initially, JPA's designers drew upon their understanding of the consumer and their expectations. The starting point in designing the seat was to understand the dynamics of a premium cabin stay – how is the seat used? What emotional role does it play for the passenger? JPA's founder explains that this seat and the space around it address multiple requirements: "A seat, a bed, a workstation, an entertainment unit, a dining table..." In all of these roles the seat environment must excel. JPA designers used their skill in understanding ergonomic and psychological requirements to drive the design of the many unique features of the seat - including direct aisle access for all, a window view (not possible in other herring bone style configurations) and enhanced stowage.

The technical skills nurtured at JPA also proved important in the development and eventual success of the seat. The performances demanded of aircraft seating are extreme in terms of acceleration resistance (16G, that is 16 times the force of gravity) and of fire retardation. These requirements place important demands on material and mechanism choice, impacting timings and cost. To ensure that the certification and manufacturing process moved ahead smoothly JPA worked hand-in-hand with manufacturer SICMA.

Designing seats and other passenger-related aspects of aircraft requires designers who have the ability to appreciate and understand the many technical requirements of the regulator and to comply with the weight-related concerns of the manufacturer and the carrier. It is equally important for designers to feel empathy with the psychological and emotional requirements of the passenger and the roles that the seat fulfils in these contexts. JPA has succeeded in instilling this knowledge within its workforce of designers and is reaping the benefits.

Section 3: Designers' skills and competencies

Case study: MEL Aviation

MEL Aviation provides design, overhaul and manufacturing solutions for both the global civil and military aerospace sectors. The breadth of offerings is unusual, extending to not only design of electronic engineering items such as pilot headsets but, at the other end of the scale, major design engineering components such as escape slide systems.

In the civil aerospace sector MEL Aviation works on behalf of British Airways, Virgin Atlantic, easyJet and Emirates, among others. The group employs 170 and has a turnover of about £25m. Whilst most employees are UK-based, it has strong representation in the USA, Germany, India and Serbia.

No-nonsense skills

MEL Aviation's Head of Projects explains that the company expects its design engineers to share its "no-nonsense approach" and requires them to have a broad skill set: "Experience of electro-mechanical engineering is preferred, but proficiency in electrical engineering is essential." He points to the company's concern that apprentice designers and those directly from higher education often focus on the aesthetically pleasing rather than a more functional approach: "They can draw things that look nice from the outside, but they're not thinking about making things work… They think design is about making things look nice, but being reliable is more important." MEL Aviation believes the government should develop and support apprenticeship programmes that not only build design skills but enhance students' technical and commercial understanding.

Whilst MEL Aviation strongly advocates in-house training, it also brings in design talent from other sectors; 80% of its design engineers have come from outside aerospace. The business also scours parallel and unrelated sectors for innovative ideas that can be implanted and developed in civil aerospace: "My teams are constantly looking at what new technologies are available and new ways of doing things. We send them off to look at stuff and then go off and brainstorm to kick ideas around."

One recent design engineer recruit brought valuable experience of injection moulding that has now been incorporated into the modus operandi: "I've got a guy that used to work for Bosch power tools and he's influenced us in how to mould things rather than machine them in blocks."

The business's military side has also been mined for transferable technologies and ideas.

"We like to look at gaps in the market – for example, stuff that is used in the US military that we can bring into a civil context. We bring the technology across if it is feasible and economical."

Head of Projects

The MEL Group

Hearing protection

A recent example of design innovation from MEL Aviation is a design for ground crew ear defenders. The skills to design and produce this innovation did not exist within the business, so MEL Aviation looked outside for a solution and purchased HSL (Headset Services Ltd). The specific innovation feature is that of high-attenuating earpiece shells with optimised acoustic design and additional ear space for best possible sound quality and comfort.

Despite its success in growing the business like this, MEL Aviation is concerned about its skills gap that exists within their business and across the design engineering sector. As the Head of Projects notes, “There is a clear design-engineering skill gap, age-wise. Most of my team are 35 and up. Very few employees are under 25… There is a huge skills gap and a mental block - younger people don’t want to get their hands dirty.”

The company is doing all it can to address this. It offers an apprenticeship scheme for talented young designers to ensure its reputation for ‘cradle to grave’ project involvement can be maintained.

MEL Aviation has looked to source design skills from outside the aerospace sector. Additionally, it has developed its own design apprenticeship scheme to address the shortage of skilled design-engineers and to help instil in its young designers some of the commercial, technical and practical skills it feels are lacking in the market.

“The fact that we do the whole package is attractive because that drives good designs, being able to produce a whole product rather than just a thing you bolt on.”

Head of Projects

Section 3: Designers' skills and competencies

Case study: Controls and Data Services

Part of the Rolls-Royce group, Controls and Data Services specialises in designing and producing systems and solutions that enable safe operation, reduce costs, improve efficiency and optimise performance across civil aerospace and other sectors. It employs approximately 1,500 design engineers worldwide.

Controls and Data Services' civil aerospace product offering is essentially twofold. First, there is the controls business, providing a single solution for design, manufacture and supply of safety-critical software, electronic, electrical and hydro-mechanical products. Secondly, the other part of the business provides data analytics, measuring engines' and other aerospace assets' operational performance continuously for over 300 customers globally. According to the Engineering and Technology Executive, the two elements' integration lets customers "sense, acquire, transfer, analyse, and act" throughout an engine's lifecycle, delivering reduced costs, greater fleet availability, lower emissions and improved safety standards.

Software, an abstract technology

Controls and Data Services collaborates very closely with parent company Rolls-Royce's engineering divisions. Its clearly defined design process begins with understanding customer requirements, then moves through architecture design, component requirement assessment, the design process itself – with subsequent testing in isolation and in context – and then validation. Controls and Data make a clear distinction between 'verification' – "Does this product do what we thought it would do?" and 'validation' – "Have we built the right product?"

"One of the things that is changing in the world of design is that validation is happening much earlier. The later in the process problems are identified, the more expensive it is to put things right."

Engineering and Technology Executive

An important skill for software designers is understanding the distinction between what customers says they want and what they actually need. This is validation's benefit.

controls and data services

Part of the Rolls-Royce Group

The software design skills required in civil aerospace

The interface between the software design and design engineering disciplines can be fraught, simply because aircraft engines are tangible whereas software is an abstract technology producing a virtual product. Very different design skill sets are required and there can be tensions. One of the major skill issues facing software designers in this sector is identified as follows:

"Aero systems/software development is done to rigorous industry standards which force us to be structured with requirements capture, validation, failure mode identification, implementation and verification. Gas turbine engineering has tended to not be exposed to the same requirements for showing evidence of structured flow. This has in the past allowed engineers to go straight to design implementation once the basic engine architecture is defined."

Head of Sub-System Engineering, Controls & Monitoring

The structured approach allows architecture and design to be analysed for correctness but also requires significant manpower, and therefore cost. To improve cost and lead time, a re-use/ Product Line approach becomes vital. Controls and Data services challenges its design engineers to re-use design successes wherever possible to maximise a powerful design's benefit and provide commonality appreciated by operators. A constraint here is that turbomachinery engineers higher in the supply chain do not always feel the same challenges around re-use, so design re-use can be challenged by bespoke engine designs.

Some of this behaviour is specific to certain sectors. So, for example, developing a new gas turbine engine for a new airliner may take several years and become bespoke. An engine for a helicopter may find many applications with only limited technical change, so the systems/software re-use model becomes particularly powerful.

Another area of difference requiring upskilling and focus is that gas turbine engineers tend to focus on the built product and generating verification evidence from it. The systems/software engineers will, by the nature of their product, be more interested in functional behaviour and can become remote from end product and customer. This requires sustained focus to ensure that design engineers do not "lose sight of what they are there to do. A great software design is only good if it makes the aircraft fly safely, reliably and for the right cost." (Head of Sub-System Engineering, Controls & Monitoring)

So Controls and Data Services work closely with the parent company within an understanding of the different outlooks found in gas turbine and in software design approaches. Designers at Controls and Data Services have built an appreciation of the different emphases to be able to work effectively.

"Rolls-Royce understands the strategic need for what we offer, but we do have an internal educative task on our hands. Some of the engineers we work with get it, others don't. Increasingly they are coming to rely on us more and more as we add competitive advantage to the group."

Engineering and Technology Executive

Case studies
Section 4: Future trends


18:48


ANA

Section 4: Future trends

Case study: The Advanced Manufacturing Research Centre

The University of Sheffield's Advanced Manufacturing Research Centre (AMRC), operated in association with Boeing, is a world-class centre for advanced machining and materials research for aerospace and other high-value manufacturing sectors. It is an important part of the new High Value Manufacturing Catapult, a network of technology and innovation centres across the UK.

Aerospace manufacturing of the future

AMRC works closely with aircraft and aerospace component manufacturers such as Boeing, Airbus and Rolls-Royce, designing and developing technologies and techniques to streamline aircraft manufacturing and maintenance.In addition to its commercial focus, it also initiates and develops blue-sky scientific and technological projects purely to further aerospace development and push the boundaries of what's possible. These open-source projects serve a dual purpose: building the knowledge stock in aerospace and familiarising teams with cutting-edge manufacturing technologies.

AMRC specialises in taking aerospace projects through Technology Readiness Levels 4-6, the "no man's land" that exists between laboratory theorising and pre-production prototyping. The AMRC Design and Prototyping Group is clear that a design mind-set is key to this:

"Design is what we are all about. We must be creative and unrestricted at the front end, but have the capability and discipline to work within the constraints of the sector to turn ideas into something tangible and valuable."

Senior Project Manager, Design and Prototyping Group

The Design and Prototyping Group has developed a radically different approach to design methodology that informs innovation. It minimises what it calls 'innovation trauma and sunk cost thinking' – the fear of expensive failure that drives safer, less innovative, solutions. Instead it encourages prototyping as early as possible, using building blocks and other low-cost materials, successfully encouraging innovation. It was used, for instance, to design a testing rig for the ducted fan engines that power AMRC's pioneering Flying Wing project discussed below.

The University Of Sheffield.

Advanced Manufacturing Research Centre

BOEING

Rapid manufacturing in action: the Flying Wing

As airframe and engine manufacturers seek to wring ever more fuel efficiency from engines, it has been asked whether diminishing returns are now in play. Should the search for greater efficiency move from engines to airframes, wings and aerodynamics? AMRC considered this recently when looking for a project to push the boundaries of design and rapid manufacturing technology.

An unmanned flying-wing glider was developed using a computer aided design (CAD) approach. The prototype aircraft was produced using a 3D printing technique known as Fused Deposition Modelling, or FDM. An innovative approach reduced manufacturing time and the amount and cost of material required, ensuring parts could be built up without any need for expensive and wasteful support material. Also, a new design technique allowed a smooth outer skin to be produced with features directly bonded to it on the inside of the wing, providing mounting points and enhanced structural strength.

Following a successful flight programme, the concept was further developed into a powered prototype. CAD, fluid-dynamic modelling and rapid manufacturing approaches were used to develop a larger vehicle, now with a mid-section housing dual-electric, ducted-fan propulsion units. Pitch control in flight was optimised by development of a “ducktail” feature borrowed from Formula 1 racing technology. This harnesses air leaving the aircraft’s engines for aerodynamic effect.


AMRC
AVIATION

The next stage is to upscale the aircraft to a three-metre wingspan and introduce gas turbine power. Unmanned aircraft are already used in civil applications such as farming, environmental monitoring, search and rescue operations, pipe and powerline inspection and the construction industry. This may well prove to foreshadow passenger and cargo operations. While AMRC's principal focus is development of new aerospace design and manufacturing possibilities, the choice of an unmanned aircraft as proof of concept may be inspired. Recent pilot-error incidents have certainly served to cast a spotlight on the potential safety gains from remotely or autonomously piloted aircraft, whether in cargo or passenger operations.

> *"The aircraft was developed using both an incremental design philosophy, as well as trialling experimental manufacturing techniques in carbon fibre production... The project was a success on all levels - from team building, experience gained in structural and systems design, design for manufacture through to testing and validation of computational fluid dynamics."*
>
> **Senior Design Engineer, Design & Prototyping Group**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Section 4: Future trends
Case study: Virgin Atlantic

Founded in 1984, Virgin Atlantic Airways is the UK's second largest long-haul carrier, operating a mixed fleet of wide-bodied Boeing and Airbus aircraft. It has always enjoyed a reputation as customer-centred, both in its in-flight service and in its ground-based provisions. Not least of these are the Virgin Clubhouses, which have long set the standard for premium lounges.

In 2014, Virgin Atlantic took delivery of its first Boeing 787-9 Dreamliner. Four are in operation, with an order placed for more. Eventually, this game-changing aircraft will replace the 747-400 fleet, bringing higher levels of in-flight comfort and reliability.

Differentiation through design
The principal value of customer-driven design at Virgin Atlantic is its role as an engine for differentiation and a bringer of personality.

Design thinking suffuses the organisation, with design considerations driven by the Virgin passenger and his or her priorities, perceptions and concerns. This ethos protects design from some of the compromises Virgin Atlantic feels undermine its competitiors.

The Design Team sits within the Customer Experience area alongside the airline's Customer Insight Team. The two departments work side-by-side to ensure that the customer's voice is loud and clear in the airline's design priorities. Customer Experience is viewed by its Head as being "the custodian of customer requirement."

> *"The key is to retain as much of the spirit and intent of the original vision as possible and to arrive at a compromise that is far removed from the realms of the undifferentiated solutions you see elsewhere in the industry."*
>
> **Design Manager**

virgin atlantic

Bringing the digital experience to aircraft

Recently, the company has focused on ensuring that its cabin interior qualities are translated successfully into the most recent aircraft types to join the fleet, the B787 Dreamliner and the Airbus A330. A key focus has been on in-flight entertainment and connectivity. Passengers experience constant high-speed connectivity and online access in their everyday lives. This has far-reaching implications for the on-board experience. The 'phygital' interface between hard product and digital delivery is expected to become a battlefield for airline differentiation in years to come. An important design team remit is to monitor ground-based developments and evaluate which can be leveraged on board.

Keen to explore ways in which 'phygital' approaches could be harnessed for an immersive, heavily differentiated cabin experience, the design team worked on a proof of concept event, The Festive Flight, to showcase digital technologies and new media on a Christmas-time transatlantic Boeing 787 Dreamliner service.

> *"We need to look sideways – into auto design for instance, but the trick is to build on what we see there, not simply to replicate it."*
>
> **Customer Experience Manager**

The Festive Flight: A 'phygital' customer experience

The Festival of flight was a carefully designed and orchestrated 4D customer experience, adding the fourth dimension, physical experience, to an already 3D digital offering. It drew on all the in-flight repertoire's digital possibilities and also tap into aspects of media delivery previously only used in earthbound contexts:

"We have to have our eyes on the next thing – to different extents depending upon the project – customer, environment, technology. We need a global perspective."

Head of Customer Experience

Design partner Microsoft worked closely with Virgin Atlantic teams to develop a memorable event for adult and child passengers alike, as a testing ground for further development. As they boarded the aircraft, passengers were each handed a state-of-the-art Windows tablet but not told what to expect.

Preloaded on the tablet was 'Santa tracker' software showing the air-bound whereabouts of Father Christmas as he delivered gifts around the globe. As the aircraft flew over Greenland, the captain announced that the aircraft's track had coincided with Santa's and he was now within talking range.

The aircraft's Wi-Fi broadband allowed passengers to talk to Santa in real time via their tablets. As conversations progressed, it became clear that, at 34,000 feet over an icy Atlantic, an in-flight rendezvous was imminent. Images of an approaching sleigh were beamed through the tablet and holographic projectors revealed Santa landing on the aircraft roof, brushing aside snow to reveal a hatch and making a dramatic entrance through the ceiling. As he walked through the cabins he made a Christmas gift to each passenger of the tablet they had been using.

Of course all this proved an enthralling delight for younger passengers – but also for some fairly hard-bitten road warriors in the premium cabins.

'Phygital' development is key to Virgin's goal of exceeding passenger expectations. This particular instance provided the proof of concept to let the airline – and its designers, marketing team and engineers – move ahead with confidence in designing and implementing similar events to support and embody the Virgin Atlantic brand.

Section 4: Future trends

Case study: PriestmanGoode

PriestmanGoode is a design consultancy that delivers exceptional brand experiences for leading international companies, with a strong specialism in aerospace interior design. A principal consideration in its cabin interiors work has been reduction of aircrafts' conventional metal box ambience, creatively using space to build atmospheres that are more like lounge-style experiences on the ground.

Another key element of the company's success, and a very positive trend for the future, is that its design incorporates a variety of relevant viewpoints: not only the needs of the end-user but also service deliverers, maintenance teams, manufacturers etc.

Moving beyond cabins as aircraft interiors

One of the agency's co-founders argues that aircraft interiors are very often "underwhelming." The aircraft itself is a highly-advanced work of engineering but, all too often, the interior fails to live up to its promise. PriestmanGoode's design philosophy, increasingly picked up on by other agencies, is to minimise conventional cabin interiors' "tube effect" while at the same time ensuring that seat volume/revenue is not disadvantaged. Taking its cue from from ground-based development, the agency aims to design cabin interiors that feel like more open environments, maximising the use of space and featuring 'non-aircraft' style furniture, fittings, materials and configurations. An unrelenting focus on passenger experience is central to this.

"We build huge aircraft cabin mock-ups to trial the appeal of new concepts – and of course to help manufacturers to sell their concept on to the airlines. This collaborative approach raises the bar of what can be achieved in production and pushes the whole industry to new heights."

Co-founder

Designing for flexibility and modularity

While, in terms of experience, an innovative cabin design's principal beneficiary is the commercial passenger, it is also crucial to consider how the cabin can be maximised for those who work in it: manufacturers, engineers, maintenance staff and cabin crew. For airframe manufacturers, for instance, an important requirement is cabin adaptability to airlines' and leasing companies' differing needs and business models. PriestmanGoode designs accordingly. Reconfiguration and retrofitting costs can be extreme, so it is essential to design and build cabins that allow flexibility and modularity.

Embraer E2

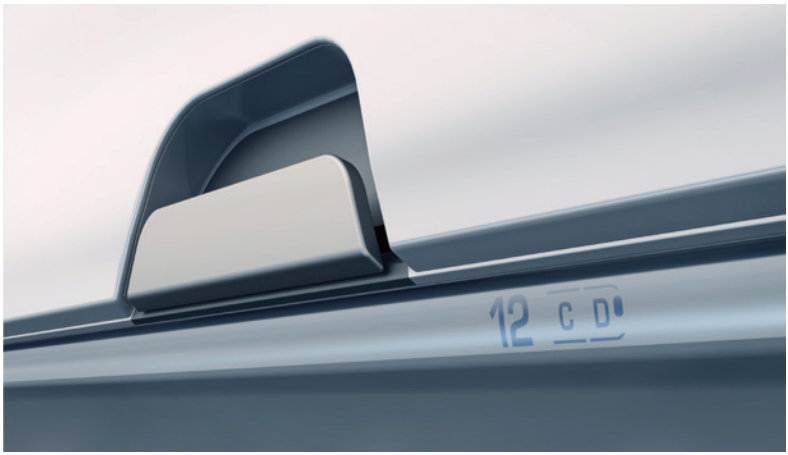
Recently, PriestmanGoode unveiled an industry-benchmark cabin for Embraer's E2 aircraft. The original design goal was to create a cabin clearly differentiated from those of Embraer's competitors. Working closely with Embraer's in-house engineering team, PriestmanGoode assumed design responsibility for the entire interior, delivering sector-leading ambience, comfort and convenience while also achieving engineering, service and maintenance efficiencies.

The demand for personal space and comfort is a fast-evolving trend. PriestmanGoode met it head-on in the E2. For example, overhead bins were designed to integrate seamlessly into the cabin ceiling, ensuring greater capacity and cleaner, more elegant aesthetics. Every passenger is now able to stow an airline-standard piece of carry-on luggage wheels-in-first.

"When you board a plane, the luggage bins always look a mess so why not make it look beautiful as well as practical?"

Co-founder, PriestmanGoode

Understanding passengers' desire for more privacy resulted in the design of the first individual personal service units (PSUs), allowing people to control their



seat's light and air conditions without disturbing their neighbours. The perception of spaciousness was enhanced by enlarging cabin windows, enabled by use of composite materials.

Equally important was the way PriestmanGoode designed-in structural flexibility, providing Embraer, airlines and leasing companies with important commercial and operational benefits. Particularly innovative was the First Class seat, equipped with all the usual premium seating comforts and features, but staggered. This allows use of the same floor seat tracks as Economy seats, reducing weight and enhancing fuel-efficiency. One set of seat tracks across the cabin also means much simpler fitting and maintenance. Airlines and leasing companies can reconfigure the cabin to suit both a single or multi-class operation much more easily. Carefully incorporating flexibility into the design literally future-proofs cabins.

Considering not just passenger needs but also those of both stakeholders and personnel from engineering, maintenance and operations is increasingly important in innovative design. This approach is especially important in aerospace where so many parties are involved in almost any product or service-delivery decision.

Appendix

Methodology

What we wanted to know
To better understand the current and potential uses of design in the aerospace industry more fully, this project focuses on five main areas:

- The rationale for design, both as it relates to different stakeholders in the industry (passengers, airlines, airframe manufacturers and their supply chain) and different products
- The interplay between design and wider industry innovation trends
- The effect of the supply chain on design, both in terms of collaboration and competition between different entities and the implications for design in terms of corporate structure within individual companies
- Design's impact and, in particular, how it contributes to the success of those in the industry most committed to it
- The skills needed by designers as individuals and by the discipline more generally. Whether there are skill shortages and approaches to tackling them.

Approach
In common with the original *Leading Business by Design* study, the approach was exploratory and qualitative. A discussion guide was developed based on the previous study (so that common themes could be identified), but modified to reflect the sector.

To better understand design's role, interviews were undertaken with senior executives across the supply chain. Firms were chosen from the following categories:

- Airlines – commercial airlines providing passenger air transportation services. Examples include Virgin Atlantic
- Design Agencies – working directly with commercial airlines. Examples include PriestmanGoode and JPA Design
- Airframe Manufacturers – assemblers of airframes which are typically considered to include the fuselage, wings and undercarriage (but excluding the propulsion system). Examples include Bombardier
- Tier One Suppliers – large manufacturers supplying complex and critical components directly to airframe manufacturers. Examples include Rolls-Royce and GKN.

– Tier Two Suppliers – mid to small-sized manufacturers supplying aircraft components usually to Tier One Suppliers and not directly to Airframe Manufacturers. Examples include MEL Aviation and MEL Group.
– Consultancies – firms providing specialist consultancy services for the civil aerospace sector. These range from systems integrators (a company that specialises in bringing together component subsystems into a whole and ensuring that those subsystems function together) through to firms advising on safety certification.

In addition, interviews were undertaken with an 'expert sample' of informed stakeholders, including associates of Design Council, the Department of Business, Innovation and Skills (BIS), a number of universities, the Institution of Mechanical Engineers and NATEP (National Aerospace Technology Exploitation Programme). A combined total of 40 interviews were undertaken, lasting on average 60 minutes.

All data were collected between March and April 2015. All interviews were recorded, transcribed and analysed through content and thematic analyses. Case studies and relevant sections of the draft report were also sent to the participating companies for validation.

Sampling strategy

The sampling strategy was designed to reflect both the structure of the industry and the dynamics affecting each player (although inevitably it was affected by the willingness of potential respondents to cooperate).

At the top of supply chain (airlines, airframe manufacturers), we sought to interview multiple decision makers, ideally from different departments, within a relatively small number of companies.

For the Tier Two suppliers, we tried to interview companies manufacturing a broad range of components. These included seats, interior fabrics, precision components, tooling, fuel lines and electronics. Reflecting the very large number of suppliers and their often specialist nature we conducted single interviews with a larger Tier Two company selection.

Interview questions

Introduction

1. What is your position within the company? Can you briefly describe your role and responsibilities?
2. What is the age and size of the unit (headcount and turnover)? One interviewee per organisation
3. How would you describe the role of design within (a) the organisation and (b) your own department/role?
4. Can you briefly outline the different types of design activity that take place in your organisation?

Strategic use of design

5. How does design inform your organisation's strategic choices, for example in creating a vision for the organisation?
6. What drives this focus on design?
7. Why is the organisation investing (or not) in design? Are there examples of where design could/should have had a greater role to play?
8. Are there specific barriers to the adoption of design at a strategic level?
9. What role does your department/division play in the adoption of design at a strategic level? What role do other departments play?

Design in more detail

10. What role does your department/division play in working on design at a day-to-day level?
11. Can you describe the main steps of your product/service development process?
12. What are the roles of design and designers in the product or service development process? How and when does design come into play?

Design for innovation

13. To what extent are employees required or encouraged to look for new ideas and explore new technologies, products or services?
14. Could you name two specific projects, one where design innovation was high and one where it was low?
15. Were there any tensions between different business areas during either of these projects?
16. Looking at the two projects, were there different ways of thinking/operating at play?
17. What way of thinking and operating do you feel is best practice? What would the organisation have to do to realise best practice in design?

Design in the supply chain

18. Could you describe the supply chain arrangements you are involved in? To what extent is design involved/ influential at any stage?
19. To what extent are suppliers/ customers influential in driving design practice within your organisation and its processes?
20. Are there tensions across organisations in the aerospace supply chain?
21. What type of collaboration with other industries, if any, takes place in terms of new materials (e.g. composites), design skills and design technology?

Skills

22. What are the skills and competencies required for designers in your organisation and in the industry?
23. Do you feel there are currently any skills shortages? In what areas of the supply chain?

Impact

24. What evidence is there that the strategic use of design has led to improved business performance?
25. Specifically how does design contribute or impact your company's exports?
26. Have your products/services received design awards?

Future of design

27. How do you see priorities in the civil aerospace changing in the future? What role do you think design might play in this?
28. How do you feel the skills and competencies of designers working in aerospace will need to change in order to take account of these changing priorities?
29. How do you think government could better support design in the aerospace sector?

Bibliography

David Hough, Chris Rhodes, Matthew Ward. The Aerospace Industry, House of Commons Library, 2014. Available at http://www.parliament.uk/briefing-papers/SN00928.pdf

Randy Tinseth. Current Market Outlook, Boeing, 2014. Available at http://www.boeing.com/boeing/commercial/cmo/

Danish Design Centre (2003). Design Ladder. Available at http://www.seeplatform.eu/casestudies/design%20Ladder

Flying on demand; Global Market Forecast, Airbus, 2014. Available at http://www.airbus.com/company/market/forecast/

The Future of Civil Aerospace. KPMG and ADS, 2013. Available at http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/AerospaceandDefence/the-future-of-civil-aerospace.pdf

Lifting Off – Implementing the Strategic Vision for UK Aerospace. Department for Business, Innovation & Skills, 2013. Available at https://www.gov.uk/government/publications/lifting-off-implementing-the-strategic-vision-for-uk-aerospace

Market Forecast 2014 – 2033, Bombardier, 2014. Available at http://www.bombardier.com/content/dam/Websites/bombardiercom/supporting-documents/BA/Bombardier-Aerospace-20140717-Commercial-Aircraft-Market-Forecast_2014-33.pdf

National Aerospace Technology Exploitation Programme, 2015. Available at http://www.natep.org.uk/documents/Web%20presentation%20Jan%202015%20v3%200.pdf

Reach for the skies: A Strategic Vision for UK Aerospace, Department for Business, Innovation & Skills, 2012. Available at https://www.gov.uk/government/publications/aerospace-growth-partnership-a-strategic-vision-for-uk-aerospace

What does the UK aerospace industry look like today? Office for National Statistics, 2014. Available at http://www.ons.gov.uk/ons/rel/uncategorised/summary/changing-shape-of-uk-manufacturing---aerospace/sty-uk-aerospace-industry.html

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