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Aerospace Market White Paper -2019

Aerospace market and technology trends: meeting the needs of today and tomorrow with next-generation cabling services and solutions

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Synopsis

This whitepaper offers a general overview of trends, developments and prognoses for the global aerospace market. In addition, it provides information on Nexans products, solutions and services to serve the developing needs of commercial and defense stakeholders.

The document opens with a broad global Aerospace industry update, explains some general trends for commercial airlines and defense, introduces the major players and newcomers, and outlines current and upcoming challenges.

The second part of the paper examines a series of current trends related to cables and cabling solutions in detail. These trends are driving innovation in development, design and processes for cable and cabling solutions. These empower the aerospace industry to meet its strategic and commercial targets, always with the end-users, including flight crews and passengers, in mind. This section concludes with an overview of what to expect from a cable manufacturer.

The third section explains Nexans' integrated products and solutions for both the commercial and defense markets, focuses on several specific products and solutions to meet the trends outlined in section two, lists the current aviation standards being met, and explains Nexans dedicated aerospace services. The document concludes with a brief review of Nexans major aerospace achievements, and in the Appendix lists some headlines, milestones, projects and awards.

INTRODUCTION: INNOVATING WITHIN COST

The aerospace and defense industries should see strong worldwide growth in the coming years. [1] Overall, safety and quality remain paramount, but there is an increased focus on cost-efficiency and, related to that, supply chain management and optimization.

Commercial aerospace is seeing unprecedented growth and demand, with a record order backlog of large jets. Demand is expected to keep growing for the coming years, driven by increasing passenger numbers (nearly 3.5 billion passengers flew in 2018, according to the International Air Transport Association) and more airfreight. Increased demand is resulting in new building methods and materials that make production, which in turn puts considerable pressure on supply chains. Traditional single-aisle manufacturers are seeing new market entrants appearing.

In defense sector[2], economic growth is driven by global political developments, increasing spending by major powers in Asia, and a recovery of the US defense budget. However, changing budget allocation means spending will not necessarily directly benefit aerospace industry, but may provide new opportunities for new product and service developments.

Sustainability and cost continue to boost demand for greater fuel efficiency. This will continue to drive the need for weight reduction and electric aircraft. Electrification of flight and hydraulic and mechanical systems being increasingly replaced by electrical systems will drive the need for higher power. New approaches to (premium) on-board entertainment and connectivity, as well as faster communications between systems, which require more fiber-optic cabling. As a result of these developments, the architecture of aircraft will change, as will challenges in manufacturing.

To increase productivity, and introduce economies of scale, related parts of the supply chain are being consolidated. There has also been significant M&A activity in the Aerospace & Defense industry, especially during the past few years

In 2019 and beyond, fast changing demands and market dynamics will require an ecosystem of suppliers who are fully up to speed with all technological and other developments impacting the sector. They will need to offer products and services that add value in key areas: increasing production speed and preparing for future developments in the areas of electrification, data and connectivity.

1 https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-industry-facts.pdf

2 https://www sipri.org/sites/default/files/2018-04/sipri_fs__1805_milex_2017_pdf

General trends: commercial aircraft

Leading players in the commercial aviation market have confirmed that growth is currently the key driver for the aerospace sector. Safran and Airbus, to name just two major firms, have confirmed positive industry trends as well as significant long-term growth potential of air traffic volumes. The overall outlook for commercial aviation is very positive, and with solid deliveries of new (narrowbody) aircraft expected over the next 20 years.

Growth is primarily being driven by the growing numbers of passengers. Air traffic multiplied a factor 6 over the past 35 years. Between 1981 and 2015, air travel demand jumped 490%. ACI World predicts that aircraft movements will increase by 2% to accommodate a passenger traffic increase of 4.1%.[3] Last year, nearly 50 million people travelled by air. In Asia, a growing middle class will contribute to continuing this growth. [4] Across Asia, the maintenance, repair, and overhaul (MRO) market has grown and Airbus predicts this expansion will increase at a yearly rate of 4.5% in the region as compared to 3.7% worldwide. [5]
Worldwide, commercial airlines generated some 821 billion U.S. dollars in revenue in 2018.[6]

Airbus forecasts growth of traffic between emerging countries at just over 6% per annum. This share will expand from 29% of world traffic in 2017 to 40% by 2037. Three major flows connecting Western Europe are all expected to develop: Western-Europe – USA, Intra-Western Europe to grow 1.7 times and Western- Europe – Middle East 2.6 times respectively. Of the Top 20 traffic flows, 60% will involve Asia-Pacific and 25% the Middle East.[7]

According to the International Air Transport Association (IATA) present trends suggest passenger numbers could double to 8.2 billion by 2037. The latest update to IATA's 20-Year Air Passenger Forecast, expects a 3.5% compound annual growth rate (CAGR) over the next two decades, leading to a doubling in passenger numbers compared to current levels. [8]

The aerospace market has already reached a high level of maturity, with growth coming from developments that started in the 1980s and 1990s. Growth was especially high in the last ten years, but this is leveling off out. We see a trend of 4% growth for the next 20 years. A decade ago, this growth remained at 8-10% for several consecutive few years. According to the Air Transport Action Group (ATAG), air transport supports $2.7 trillion in economic activity and 65.5 million jobs globally. Nearly 62 million tonnes of freight, with a collective value of $6 trillion, are carried by air, representing 35% of all international trade.[9]

Estimates vary, but the consensus appears to be that air traffic volumes will double in the next 15 to 20 years. Airbus forecasts the world fleet will more than double over the next 20 years. According to IATA, over half of new passengers will come from the Asia-Pacific region. China is expected to surpass the USA as the biggest single market by the mid 2020s. Air traffic within China is forecast to increase 3.5 times in the coming years, with Domestic USA increasing by half. India is expected to come in third place, followed by Indonesia and the UK. This growth could support 100 million jobs globally.[10] IATA also points out that the vast increase in demand for air transport service is not fully met by increased capacity.

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3 https://www.internationalairportreview.com/article/82430/top-10-emerging-markets-aviation/

4 https://www.usinenouvelle.com/article/10-chiffres-pour-tout-comprendre-aux-tendances-des-marches-aeronautique-et-defense.N395942

5 https://www.strategyand.pwc.com/trend/2018-defense

6 https://www.statista.com/statistics/655057/fuel-consumption-of-airlines-worldwide/

7 https://www.airbus.com/content/dam/corporate-topics/publications/media-day/GMF-2018-2037.pdf

8 https://www.iata.org/pressroom/pr/Pages/2018-10-24-02.aspx

9 https://www.atag.org/our-publications/latest-publications.html - figures 2017

10 https://www.iata.org/pressroom/pr/Pages/2018-10-24-02.aspx

2017 saw the fastest growth since 2010, and was the third year in a row in which net profits exceeded $34 billion, with record levels of passengers and freight transport. As a result, global airline stocks went up 29% on average in 2017. [11] Air transport is boosting the global economy. This year commercial airlines are forecast to take delivery of over 1,780 new aircraft - an investment of some $80 billion. Some 50% of these year's deliveries will replace existing fleet, and this help increase fleet fuel efficiency. The fleet is expected to increase by more 1000 aircraft to reach a total of some 31,000 aircraft by the end of this year. The average size of aircraft is rising slowly and some 4.8 million seats should be available by the end of the year. More intensive use of seats is boosting profitability. The number of scheduled departures is forecast to reach 39.8 million.[12]

According to a recent report[13], the aviation market is anticipated to register a CAGR of more than 3% between 2016 and 2024. Key factors driving growth include replacement of aging commercial aircraft and procurement of current models of commercial aircraft. Growth is also largely driven by lower fares and increased demand from large, emerging markets such as China and India.

North America represented the highest market share across all global regions in 2018. Growth in Europe and North America is solid, while the Asia-Pacific region is rapidly developing. This region saw a healthy $8.3 billion in profit in 2017, $0.2 billion higher than the previous year. [14]

Several European Countries saw marked growth: the Group of French aerospace industries (Gifas) called 2018 'a solid year'. Activity in civil aerospace reached 50.4 billion euros, boosted by a record delivery of 800 aircraft to Airbus. [15]

A report from Airbus indicates that some 37,400 aircraft will be required over the next 20 years representing a value of € 5.8 trillion.[16] Half of the current total fleet (over 21,000 planes) is expected to be replaced, and more than 26,000 places will be added by 2037, representing more than 37,000 new deliveries.

Over the next 10 years, 3-7 % net annual growth of the active global commercial fleet is expected, bringing the total to to 37,978. The fleet is forecast to grow 4.2 % per year from 2018-2023, and 3.3 % in the five years after that. Overall, the resulting fleet will be younger and have a larger average seating capacity. 44 % of nearly 20,700 new aircraft deliveries will be replacing in-service aircraft. [17]

The commercial aerospace industry needs to keep up with growing demand for flights as well as services, and address new markets and opportunities. Deloitte research estimates the commercial aircraft order backlog to be at its peak (some 14,000 orders) with around 38,000 aircraft expected to be produced globally in the next two decades.[18] However, the sector may be facing a risk that its suppliers will be unable to keep up with increased demand. [19] In 2019

11 https://www.pwc.com/us/en/industrial-products/publications/assets/pwc-tailwinds-report-2018-airline-industry-trends.pdf

12 https://www.iata.org/publications/economics/reports/industry-econ-performance/iata-economic-performance-of-the-industry-end-year-2018-report.pdf

13 https://www.mordorintelligence.com/industry-reports/aviation-market

14 http://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fact-sheet-industry-facts.pdf

15 https://www.usinenouvelle.com/aeronautique/

16 https://www.airbus.com/content/dam/corporate-topics/publications/media-day/GMF-2018-2037.pdf

17 http://www.oliverwyman.com/our-expertise/insights/2018/jan/2018-2028-fleet-and-mro-forecast-commentary.html

18 https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-a-and-d-outlook.html

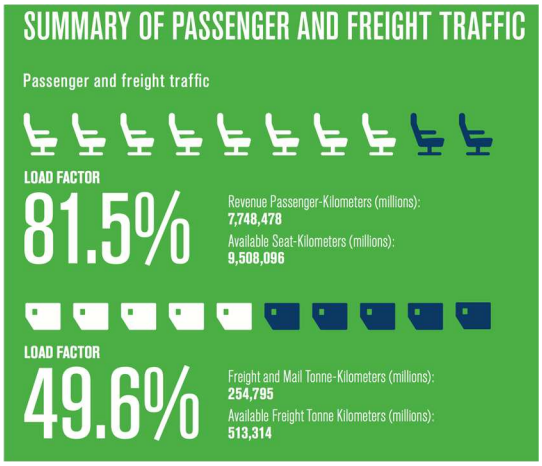
19 https://www.maalot.co.il/Publications/SR20181115142951.pdf

and beyond, suppliers will need to be fully up date with the technological developments and drivers affecting aviation in order to help the sector keep up and thrive.

For commercial airlines, the top priority is still safety. Other main concerns are operating costs and sustainability. The industry is dedicated to improving fleet fuel efficiency 1.5% per year until 2020 (largely through new and improved engine designs and biofuels); and by 2050, it is committed to reducing its net carbon footprint by 50% (compared to 2005). Moreover, OEMs are also drastically cutting disruptive takeoff and landing noise levels through new engine and fuselage designs.

Some key points to bear in mind concerning commercial airlines[20]:

- **Emerging economies (India, China, the Middle East, and other Asia-Pacific countries) are driving leisure, business travel and freight**
- **Passenger travel is expected to increase yearly**
- **Demand for new aircraft is challenged supply**
- **By 2025, commercial aircraft annual production is set to increase by 20%**
- **New global OEMs are encroaching on existing major duopoly (Boeing/Airbus) and their supply chains**
- **Innovation focuses on operational savings, fuel efficiency, maintenance, and passenger comfort**
- **Active OEMs will dramatically increase the rate of production of components, systems and services (and will expect very competitive pricing)**



Source: IATA

20 http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx-mnfg-2015-global-a-and-d-outlook.pdf

Worldwide airline Industry	2017	2018E	2019F
Spend on air transport*, $billion	787	854	919
% change over year	6.3%	8.6%	7.6%
% global GDP	0.9%	1.0%	1.0%
Return fare, $/pax. (2018$)	345	331	324
Compared to 1998	-58%	-60%	-61%
Freight rate, $/kg (2018$)	1.77	1.89	1.86
Compared to 1998	-64%	-61%	-62%
Passenger departures, million	4,093	4,343	4,588
% change over year	7.3%	6.1%	5.6%
RPKs, billion	7751	8255	8754
% change over year	8.0%	6.5%	6.0%
FTKs, million	254	265	275
% change over year	9.7%	4.1%	3.7%
World GDP growth, %	3.2%	3.2%	3.1%
World trade growth, %	5.4%	4.4%	4.1%

Note: RPK = Revenue Passenger Km, FTK = Freight & mail Tonne Km
GVA = Gross Valued Added (firm-level GDP). *Airline revenue + indirect taxes.
Sources : IATA, ICAO, OE, CPB, PaxIS, CargoIS

	2018 2027	2028 2037	2018 2037	SHARE OF 2018-2037 NEW DELIVERIES
AFRICA	450	680	1,130	3%
ASIA-PACIFIC	6,480	9,160	15,640	42%
CIS	580	640	1,220	3%
EUROPE	3,650	3,420	7,070	19%
LATIN AMERICA	1,330	1,380	2,710	7%
MIDDLE EAST	1,340	1,490	2,830	8%
NORTH AMERICA	2,970	2,990	5,960	16%
FREIGHTERS	450	380	830	2%
WORLD TOTAL	17,250	20,140	37,390	100%

Source: Airbus global market forecast 2018-2037

General trends: defense

Growth of investment in the aerospace defense sector is currently driven by several factors, such as geopolitical tension, defense expenditure recapitalization cycles, new programs and technological transformation. In 2018, total global military expenditure rose to $1822 billion - 2.6 % higher than the previous year. 21 This was the second consecutive year to see increased spending, which is now at the highest level since 1988 (the first year for which consistent data is available). This increase represents an increase of 76% from that year.

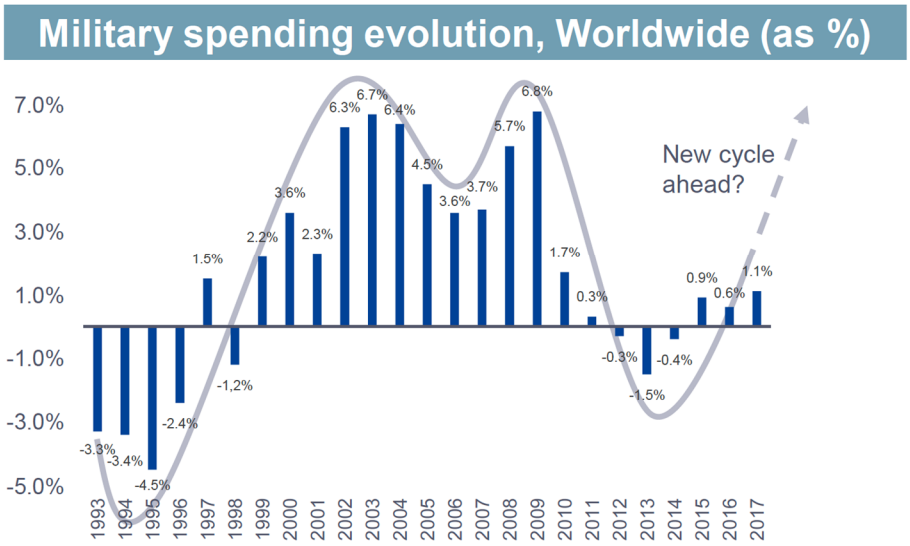
Looking at the top five countries: military spending by the USA – the world's biggest spender - grew for the first time since 2010 by 4.6%, to reach $649 billion in 2018. However, it should be noticed that in the final days of planning for the 2020 defense budget, the US government decided to reduce spending by US$ 33 billion. China, the world's second largest spender - increased military expenditure for the 24th consecutive year to $250billion in 2018 (5% higher than the previous year. India's 2018–19 defense budget stood at US$43.8 billion, a 7.7 % increase from the previous year. Military spending in France is projected to increase by 5%

21 https://www.sipri.org/media/press-release/2019/world-military-expenditure-grows-18-trillion-2018

annually until 2022, to reach €44 billion. Defense spending by the two key countries in the Middle East - the UAE and Saudi Arabia - has dropped, yet remains significant. The region is expected to see mid-single-digit growth annually over the next decade. [22]

However, although overall spending may seem to be on the rise, there is a drive to reduce cost, as funds move from traditional areas to, for example, IT investments. As cyber-related threats increase, global military strategies worldwide are evolving, and digital tools and technologies as well as cybersecurity programs are being introduced.

The global outlook for the aerospace defense market is positive. There are, however, major changes to be expected in relation to innovation, consolidation, relationships between governments and the OEMs regarding purchasing and supply chains. [23] New aerospace solutions need to be developed rapidly and need to be cost-effective. Costs are being reviewed across the board.



Source: SIPRI for 1990-2017

Major players and newcomers

The major players remain Boeing and Airbus (the former largely supported by NASA and the latter supported by organizations like the European Aviation Safety Agency). These giants build jumbo jets (wide-bodied, double-aisle aircraft), as well as a wide range of smaller aircraft, including single-aisle regional aircraft, business jets, and helicopters.)

Brazil's Embraer and Canada's Bombardier, who are largely involved in single-aisle aircraft for regional or short-haul flights, business jets and serve other specialized market segments, follow them. However, they occasionally compete with Boeing and Airbus when their passenger capacity exceeds 150 persons. Mitsubishi Aircraft Corporation, for example, is becoming increasingly competitive in the range of the regional jets

22 https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-mfg-2019-global-a-and-d-sector-outlook.pdf

23 https://www.boyden.com/index.html

Russian state-owned United Aircraft Corporation, the Antonov State Company in Ukraine and Sukhoi are also growing in significance. Relative newcomer China still clearly has the ambition to develop its own aircraft and aerospace industry, with its own technology and aircraft models, a development we are following closely. The Commercial Aircraft Corporation of China (COMAC) program is mobilizing resources to produce a single-aisle jetliner called the C919 24. COMAC has registered over 1,000 orders for its narrow-body C919 and is currently developing a wide-body aircraft. Although China is still fairly new to this complex and mature high-tech industry, the country has an incredibly high GDP and with passenger traffic growing by 11% per year is well-positioned to make some major breakthroughs.

At present, there is an overall trend towards consolidation. At the level of equipment manufacturers, we have seen considerable M&A activity over the last 5-6 years, often involving large players such as Saran and Zodiac, which resulted in the birth of a key French player in this area. In the USA, we've seen mergers around usage areas such as equipment, engines, and electronics. Looking at the Components we have been seeing quite a few acquisitions, especially around 2005, but fewer mergers. Around 2000 -2005 there have been many acquisitions related to components.

Commercial air challenges in an expanding market

Technology and innovation are essential to the future of the aerospace industry. 400 global companies surveyed by Deloitte plan to invest $ 7 billion in new technologies over the coming two years, in order to optimize their supply chains and secure the ramping up of production. According to the firm, there are still significant obstacles: the lack of visibility (36%), and the lack of talent trained in the use of new digital tools (31%) [25] New deliveries from Bombardier (CSeries), integrated in Airbus company as A220 and Embraer (E-Jet E2) are underway (which use variants of Pratt & Whitney geared turbofan engines.) New types from Irkuts (MC-21), Comac (C919) and Mitsubishi Aircraft (MRJ) are in the test phase and should be available within the next few years. This has resulting in reorganization and consolidation in the supply chain to meet increasing demand. [26]

Looking at power, we see several potentially disruptive technologies related to power, for example hybrid or full electric propulsion aircraft, small e-taxis or drones for applications such as delivery. The term 'full electric' is often used for aircraft in which hydraulic and pneumatic systems are replaced by electrical systems. (also known as ' fly by wire'). This is a trend has been around for several years and had led to the introduction of 230V/400V systems (where formerly 115V/200V was standard). The new "disruptive" trend is related to hybrid or electrical propulsion. Considering the aircraft interior, there is a clear demand for cabin connectivity to enhance the passenger experience, enabling high-quality inflight entertainment, as well as the use of tablets and Wi-Fi. Reduction of weight, which is also related to electrification, is another factor to be taken into account. Furthermore, aircraft OEMs might also increase demands in the areas of economic efficiency, viability, and safety. (Specifications from A380, B737Max and other aircraft seem to imply this). Customers in the commercial as well as defense sectors are currently strongly focused on reviewing costs. High quality, functionality and safety remain the main demands in both areas, but cost has become more

24 https://apex.aero/2019/01/23/comac-aims-high

25 https://www.usinenouvelle.com/article/10-chiffres-pour-tout-comprendre-aux-tendances-des-marches-aeronautique-et-defense.N395942

26 https://www.atkinsglobal.com/~/media/Files/A/Atkins-Corporate/aviation-trends-white-paper-digital.pdf

essential. This has become particularly prevalent over the past five to eight years. Traditional players now have to think about competition with lower-cost countries.

Across global regions, the trends at 'macro' level are the same However, at the level of equipment and components, there are marked differences and standards, for example between manufacturers. Expectations and needs in the areas of pricing, emissions, performance and so on are different. The same is true of the installation methodology for cables, which may vary strongly depending on system, aircraft type, and materials used and so on. Major players such as Boeing and Airbus set standards, and regional makers follow standards generated in the EU and USA. Sometimes, however, these are not completely applicable to their needs. This affects cable definition and design as well as how product quality is tested. Products might look exactly the same, but qualification and specifications may be completely different. As a result some specific issues are introduced – for example, it can be hard to create synergies in a particular market when all major customers have requirements that are (slightly) different Work needs to be duplicated, specifications translated into designs, follow up with clients needs to be organized… This all has to be taken care of by people who are fully up to speed on a specific customers' account.

- **Increasing focus on cost-efficiency**
- **Accelerated innovation needed**
- **Optimize supply chains and manage consolidation**
- **Ensure knowledge is up to date, especially in electrification and IFE/data**
- **Process and analyze high data volumes provided by high-resolution optics, communication sensing and other multispectral sensors**
- **Lower fuel costs and increase operational efficiency**
- **Reduce downtime and improve overall airline performance**
- **Transmit key parameters to maintenance while in the air**
- **Decrease production costs through automation, robotics and computer-assisted design, and lower life cycle costs**

Defense air challenges: changing budget allocation, new opportunities

As pointed out previously, defense spending may be on the rise, but changing focus means that this does not automatically means increased spending on defense aviation across the board. There is a greater focus on technology-related defense spending. However, as R&D spending in defense is generally low,[27] these developments may be a significant opportunity as well as a challenge to developers and manufacturers.

Currently, the most significant global program is the Lockheed Martin F-35 Joint Strike Fighter, which is set to be delivered to nine partner nations and three additional customers in the near future. Airbus Defence & Space is preparing delivery of the A400M military transporter in Europe. Northrop Grumman will provide B-21 Raider bombers to the US Air Force, and France and Germany are looking into a joint combat air system. Other countries, such as Japan, South Korea and Turkey are also working on next-generation development projects. [28] There is some consolidation here, just as in commercial aerospace, necessary to keep up with demand and new requirements.

Current changes require even greater agility and dynamic strategies in a market that is changing rapidly and doesn't work according to 'traditional' annual financial planning cycles.

27 https://www.strategyand.pwc.com/trend/2018-defense

28 https://www.atkinsglobal.com/~/media/Files/A/Atkins-Corporate/aviation-trends-white-paper-digital.pdf

Today's changing requirements are bringing new types of projects and cooperation. Thales, for example, acquired Dutch-based cyber security leader Gemalto for more than US$5 billion. Airbus' is working on development of complex drones to buttress its military unmanned device product lines. Sierra Nevada Corporation is working with Embraer Defense & Security to retrofit Embraer's A-29 light attack aircraft. Boeing, Airbus, LM, and Raytheon have all bought interests in high-tech firms, covering everything from cybersecurity and drones to light electric aircraft and augmented reality.

Geopolitical changes are affecting defense spending. In recent years, several countries in the APAC region have completely reassessed their defense strategies and resources, for example. These changes are also affecting international trade agreements, which are expected to disrupt the global supply chain and increase costs. [29]

- **Need for greater flexibility and agility**
- **Defense market increasingly focused on technology enhancements**
- **Implement next-generation Intelligence, Surveillance and Reconnaissance systems (ISR)**
- **Promote faster product development and leaner production**
- **Partner more closely with customers and suppliers**
- **Overcome asymmetrical and unconventional threats**
- **Meet competition from non-traditional defense manufacturers**
- **Eliminate inferior and counterfeit products from the supply chain**
- **Develop new unmanned platforms**
- **Geopolitical changes and increased APAC activity**

29 https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-a-and-d-outlook.html

CABLE-RELATED AEROSPACE TRENDS

The quest for profitability, the pressure from low-cost carriers, tougher regulations on noise and greenhouse gas emissions are boosting the need for lighter, more energy-efficient aircraft, while improving In-Flight Entertainment (IFE) systems to enrich the air travel experience.

Aircraft designers have also increasingly replaced mechanical and hydraulic systems with electrical systems (fly-by-wire) causing the amount of electrical power carried by the aircraft Electrical Wire Interconnection System (EWIS) to almost double. And engines are undergoing significant upgrades, which are generating revolutionary aerodynamic design changes.

Defense aerospace has seen a similar shift towards next-generation platforms: a move to all-electrical systems, full computerization (leading to a dramatic increase of the amount of data carried), and a transition to all-composite airframes requiring more shielded cables.

Let's explore these trends in greater detail.

1. Lighter weight and fuel-efficiency

Fuel continues remains the largest cost factor for airlines, accounting for some 30% of airline costs[30]. The global airline industry's fuel bill is some $180 billion in 2018, which is 20.5% higher than the previous year and almost double the $91 billion fuel bill for 2005, which accounted for 22% of operating expenses.[31]

Big steps have been made in the reduction on engine fuel consumption big over the last ten years. The near future will see these developments being taken to the next level. There will be an increased focus on hybrid solutions and, in the more distant future, fully electrical aircraft. In some regions, the possibilities of 100% hydro-electrical power are being examined. We see electrification as one of the key milestones to be tackled. Developments from the auto industry in this area will be increasingly translated to the aerospace sector.

The heavier a plane, the more it costs to fly, and the greater the environmental impact. Carbon fiber composites, which are lighter than aluminum, are increasingly found on planes such as Boeing's 787 Dreamliner and Airbus's A350. Composites also provide a smooth finish for components and therefore less drag, and open the way to manufacturing techniques whereby multiple single parts can be molded together at the same time, saving manufacturing time and money.

Structural composites got their start in aerospace, but they are prevalent today in cars, buses, trams, and trains, driven by a demand for low costs and higher production rates. However, increasingly, aircraft manufactures are taking a leaf out of the book of carmakers that have proven that composites can meet new design challenges in terms of aerodynamics, packaging, structural stiffness and crashworthiness.[32]

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30 According to IATA Annual Review 2014.

31 https://www.iata.org/pressroom/facts_figures/fact_sheets/documents/fact-sheet-fuel.pdf

32 Consult: http://aviationweek.com/technology/automotive-industry-embraces-composites-can-aerospace-benefit

According to Colin Sirett, Head of Research at Airbus UK: "Each kilogram cut means a saving of roughly $1 million (€900,000) in costs over the lifetime of an aircraft, and the use of such composites can reduce the weight of an aircraft by up to 20%."[33] An EU-funded research effort has improved carbon nanotubes to create exceptionally strong, lightweight and cost-effective materials for aircraft parts, further reducing the fuel burn.

Another positive is that a great advantage of using carbon fiber instead of traditional aluminum is that it allows designers to find the ideal "equation" to resolve the demands of aerodynamic efficiency, fuel savings and reducing engine noise (which we will see below has ramifications for travel sustainability and long-term environmental concerns).

As with certain blended fuselage-wing designs in Stealth bombers, tomorrow's airliners will find ways to improve a plane's lift-to-drag ratio and reduce its overall weight, as it moves away from the current winged-tube design. Already, new aircraft are 70% more fuel efficient than 40 years ago, and 20% better than 10 years ago; as clearly stated in the IATA Technology Roadmap: LESS FUEL = LESS EMISSIONS.[34]

Among recent developments in weight reduction is a new titanium-making process that could reduce the number of steps and need for high temperatures used in production. Titanium powder (instead of ingots) can be pressed into final aerodynamic forms with little machining. The lightweight, corrosion-resistant material is also ideal for certain engine parts, like fan blades, and seamlessly merges with carbon composites, unlike aluminum.[35]

Moreover, new research is being done on protecting wing leading edges from the laminar flow-destroying effect of residue left by insect strikes, as well as improving the performance of the tail through active flow control (AFC). By using "bug-phobic" coatings to increase natural laminar flow on an aircraft wing, fuel burn could be improved by as much as 15%, while AFC could lead to a 17% reduction in tail size, which would reduce drag and weight, cutting as much as 2% in fuel burn.[36]

All of the above efforts to lighten passenger aircraft draw on sophisticated engineering, process and materials science capabilities in at least a dozen different disciplines.

However, apart from these many initiatives to save weight on aircraft, one important component – largely metallic – is hidden from sight: cables. According to model, size, passenger capacity and specifications, every airliner contains from 200 to 600 km of cables interconnecting vital equipment throughout the airplane.

They provide everything from power, data, sensor information, flight management control, avionics, and communications to overhead and emergency lighting and in-flight entertainment. The challenge is how to make lighter-weight cable designs to meet every airborne need, with no compromise on safety, performance and reliability.

33 See BBC News' "Carbon fiber planes: Lighter and stronger by design" at http://www.bbc.com/news/business-25833264

34 For a brief sketch, see: http://www.iata.org/whatwedo/ops-infra/Pages/fuel-efficiency.aspx

35 Consult: http://www.technologyreview.com/news/535386/new-titanium-making-process-could-result-in-lighter-aircraft/

36 See : http://aviationweek.com/technology/757-ecodemo-focuses-laminar-and-active-flow

2. Need to boost electrical power onboard

As aircraft became bigger and flew higher, farther, and faster, power was required for flight instruments and passenger services, including galley units, lighting systems and heating. Aircraft electrical components operate at many different AC and DC voltages. However, most systems use 115 volts AC at 400 hertz or 28 volts DC. Running at 400 Hz allows the use of smaller transformers - an important weight saver. Traditionally, generators were driven by the engines to create electricity, and pneumatic systems 'bled' air from the engines to power other systems, like hydraulics. However the latest airborne electronic systems use electricity directly to power hydraulics, engine start and wing ice protection. By using more generators on engines, and auxiliary power units (APUs) in the tail, recent designs can greatly reduce wiring. In the case of the Boeing 787 this led to 32 km less wiring, with significant weight savings.[37]

As electric systems increasingly replace hydraulic and pneumatic systems, power requirements will continue to grow, while weight needs to be reduced. Weight reduction is a key driver for higher voltage, which makes it possible to increase power while maintaining or even reducing cable weight. Increasing current would require larger conductors leading to heavier cables! Therefore, increasing voltage is the most viable solution. The advent of more on-board electrical power, as well as the introduction of new technologies such as optical fiber to speed up communication between functions and decrease electromagnetic interference, is also introducing changes to designs and architecture. Higher voltage is a particularly big challenge for aerospace, when compared to other markets like rail. High voltage in the air introduces some specific challenges (like partial discharge) that need to be solved.

Typically, 115 volts have been used for practically all on-board systems. Some ten years ago, this was ramped this up to 230 volts for specific applications on the Airbus A350 and the Boeing 787. Solutions in this area are now fully mature and ready to be implemented in other parts of the aircraft. The next step is likely to be systems operating at 540 volts. Hybrid battery-powered airplanes are already on the horizon. Boeing foresees a hybrid airplane the size of a 737, which could seat 150 passengers by 2030.[38] General Electric has developed the 'Sugar Volt' hybrid turbofan that runs on both jet fuel and batteries for Boeing; and Rolls Royce is working on 'E-Thrust' for the Distributed Electrical Aerospace Propulsion (DEAP) project for Airbus. Rolls Royce, Siemens and Airbus are developing a near-term flight demonstrator, which will be a significant step forward in hybrid-electric propulsion for commercial aircraft. One out of four aircraft gas turbine engines is being replaced by a two megawatt electric motor. Once system maturity is proven, a second gas turbine could also be replaced with an electric motor. [39] This works with a generator feeding batteries and power electronics that convert AC to DC, which is then sent to the engine passing through variable frequency converters.

The Airbus CityAirbus is another exciting project: a Vertical Take-Off and Landing multirotor that seats four. Its fully integrated drivetrain has eight propellers and eight 100 kW (130 hp) Siemens SP200D direct-drive electric motors. Four electric batteries total 110 kWh (400 MJ) and can produce a combined output four times 140 kW (190 hp). [40] Electric propulsion is less suited to a long-haul twin-aisle. But for regional airliners, 100-seaters, short-takeoff-and-landing aircraft and helicopters, it could work well. Research suggests that hybrid electric propulsion will generate lower emissions and be quieter, while

37 See: http://787updates.newairplane.com/787-Electrical-Systems/787-Electrical-System

36 https://www.ft.com/content/f7f56adc-a96a-11e7-ab55-27219df83c97

39 https://www.airbus.com/newsroom/press-releases/en/2017/11/airbus--rolls-royce--and-siemens-team-up-for-electric-future-par.html

40 https://www.airbus.com/helicopters.html

conserving energy and releasing less heat into the atmosphere. Electrical systems are expected to be more reliable than conventional turbines. But integrating slow-responding gas turbines with fast-acting power electronics and motors will pose a major challenge.

The more efficient the engine, the higher the temperature. The need for cables that can endure prolonged elevated temperatures in engine zones is one particularly important trend. Today, the maximum temperature at which cabling remains operational is 260 degrees, and some cables can withstand 321 degrees for a limited duration (10,000h). Going forward, there will be a need for cables that withstand 400 degrees for longer periods.

3. Higher data capacity for flight operations and in-flight entertainment (IFE)

The third key trend, besides higher fuel-efficiency and more onboard electrical power, is the increase in onboard data requirements. This is related to every aspect of flight operations, including avionics. Avionic systems include communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to aircraft to perform individual functions. The latest aircraft are constantly generating several hundred thousand parameters for collecting and analyzing data, and for spotting problems. Airlines are turning to IT solutions to improve operational efficiency, decrease costs and enhance safety. For electronic documents and charts, heavy electronic flight bags (EFBs) have been used for decades. However, when American Airlines became the first US carrier to obtain FAA approval to use iPads for all phases of flight in 2012, other airlines followed suit. Available applications include airport moving maps, satellite weather, electronic technical logs, route profile optimization for fuel saving and electronic document and static charts.[41]

However, portable devices cannot be used to run applications that pilots use to communicate with controllers via data link or navigating the aircraft, which must still be handled by high-end EFBs, meaning that NextGen systems will be a mix of installed and portable devices. One solution is to future-proof EFBs with Aircraft Information Servers so that tablets can 'mimic' EFB functions, like charting, electronic documentation, en route real-time weather maps, terrain awareness, camera surveillance, and aircraft data monitoring and reporting.

According to Boeing, improved connectivity onboard will allow a substantial improvement in flight operations, maintenance, safety and customer service:

> Pilots [can] quickly upload the latest navigation charts to their devices and monitor weather in flight, adjust flight plans to optimize fuel use, use moving runway and taxiway maps for improved situational awareness, and use a wide variety of applications to improve crew productivity and enhance safety. Cabin crew members use mobile devices with in-flight connectivity for onboard sales (including verification of credit cards to eliminate fraud), passenger services, and crew communication and to access crew reporting tools.[42]

Advanced avionics and flight operations increase onboard data, requiring significant improvements in broadband data capacity: i.e. high-end cable solutions, optical fiber replacement of the copper network for what is virtually a flying Local Area Network (LAN). Fiber enables faster communications and reduces weight (compared to copper cabling). In addition to higher bandwidth, it is less sensitive to electromagnetic noise. In the long term copper won't only be replaced for IFE, but everything related to data transmission, included

41 For a state-of-the-art explanation see: http://aviationweek.com/aftermarket-solutions/next-generation-efbs-integral-nextgen-cockpit

42 From Boeing's "Current Market Outlook 2014-33": http://www.boeing.com/assets/pdf/commercial/cmo/pdf/Boeing_Current_Market_Outlook_2014.pdf

* Note that these figures can vary significantly from year to year.

in-flight information and processing sensor data. An increased number of onboard wireless systems is also driving demand for more data and control cabling.

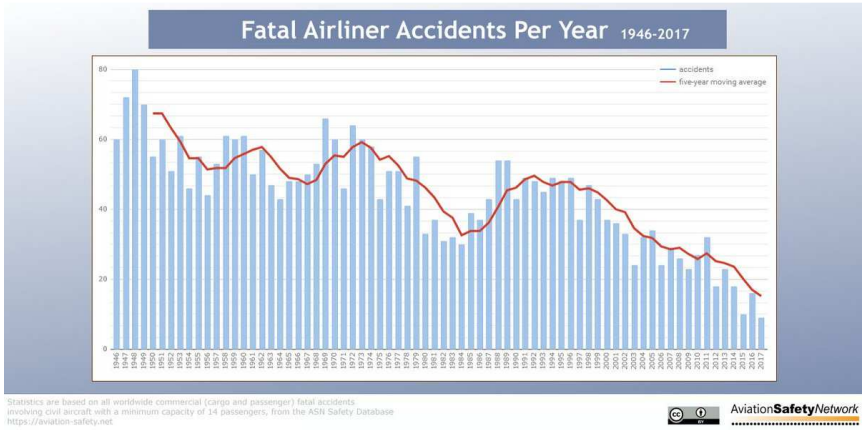
Increasingly, airlines are aiming to improve the travel experience for passenger. Improving services related to passenger experience, and taking into account the fact that people are used to ubiquitous connectivity, could be a strong differentiator for airlines. Tiered service levels is one option. Passengers could use their own personal electronic devices such as laptops, tablets and e-readers as airlines make in-seat digital services available and phase out costly and weighty bespoke entertainment systems. In some regions, onboard Wi-Fi has been available for some time. New systems using light to make connections (Li-Fi) are becoming available, too, which may have implications for on-board connectivity.

4. Operational Safety

Although flying has a well-established reputation for safety compared to other modes of travel, 'fear of flying' seems to be a real concern, largely due to the dramatic nature of airline crashes and the way they are reported in the media. In terms of deaths per billion kilometers, air travel is exceptionally safe.

According to the Aviation Safety Network (ASN) the average yearly number of aviation deaths have been falling steadily since 1997. This is mainly the result of international aviation organizations' ongoing safety efforts. 2017 – the most recent year on which data is available – proved the safest year to date. [43] IATA's most recent five-year data analysis (2013 - 2017) shows decline in the total number of accidents, hull loss, fatal accidents and fatality risk. [44] EASA's reporting confirms this. [45] IATA's Director General and CEO has recently stated that "Flying as a mode transport is safer than it has ever been."

The aerospace industry continues to improve its record by a series of improvements through design, engineering, navigation aids, safety protocols and procedures. Safety issues are omnipresent in aerospace and concern manufacturers, operators, pilots and passengers. However three important trends are extremely relevant to cables: fire and toxicity, synthetic vision in the cockpit, and overall airplane health management, which concerns maintenance.



43 https://aviation-safety.net/statistics/

44 https://cdn.aviation-safety.net/airlinesafety/industry/reports/IATA-safety-report-2017.pdf

45 https://cdn.aviation-safety.net/airlinesafety/industry/reports/EASA-Annual-safety-review-2018.pdf

a. Fire and toxicity

In the early eighties, two dramatic fires had an impact on the industry: Air Canada Flight 797 (1983) which resulted in death by smoke inhalation and flash burns to 23 passengers in an emergency landing in Cincinnati; and the British Air tours Flight 28M accident in Manchester, England (1985), when a takeoff was aborted, resulting in the loss of 54 lives. Both tragedies raised the question of 'survivability.' In the Late 1990s, cabling safety was placed high on the agenda by industry, civil aviation authorities, and government agencies. The Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) undertook a three-phase plan to develop and propose recommendations for airworthiness enhancements to the FAA. As the Committee found earlier regulations fell short of providing specific wiring-related requirements, the wanted specific wiring-related requirements to be included in certification and operational regulations. Wiring, wiring devices and termination systems were to be referred to as the Electrical Wiring Interconnection System (EWIS) and treated as an airplane system. New requirements for certification of electrical wiring interconnection systems were introduced.[46]

The Air Canada in-flight fire spread between the outer skin and inner door panels, filling the plane with smoke. The fire also burned through crucial electric cables that knocked out most of the instrumentation in the cockpit and key electrical systems, making descent physically difficult for the pilot. In addition the Public Address (PA) system failed, hampering communication to passengers. The Manchester flight was aborted due to port engine failure, which generated fire and smoke that seeped into the fuselage.

As a result of these accidents, aviation regulations around the world were changed, requiring smoke detectors in lavatories, automatic fire extinguishers, in-cabin fire enhancements, fire-blocking seat materials, emergency track lighting, etc.

"Survivability" also impacted aircraft cabling standards, since one possible cause of fires in airplanes is wiring problems that involve intermittent faults, such as wires with breached insulation touching each other, electric arcing (flashover), or short circuits.

In July 1, 2017 the EU CPR (Construction Products Regulation[47]) came into force. This also governs safety in the event of fire for all power, control and communication cables placed on the EU market intended for permanent installation in buildings and other civil works, but does not include aircraft. For cables on aircrafts mainly fluorinated insulation materials are used due to their excellent thermal and chemical resistance and fire properties. Safety aspects such as smoke density and toxicity levels are defined by Airbus and Boeing (albeit with different limits)

b. Synthetic Vision Systems (SVS)

Since 2003, loss of control has been highlighted as the major cause of fatal accidents. To remedy this, Synthetic Vision Systems (SVS) offering "virtual reality" will be increasingly deployed in commercial flight decks within the next five years. Already, Airbus, Boeing,

46 https://www.faa.gov/training_testing/training/air_training_program/job_aids/media/EWIS_job-aid_2.0_Printable.pdf

47 CPR covers all construction products including cables: http://ec.europa.eu/growth/sectors/construction/product-regulation/

Bombardier and Embraer have committed themselves to the new systems in primary flight displays on new-build aircraft by 2018.[48]

Synthetic Vision gives a 3-D clear sky picture of runways, terrain and obstacles on the flight path ahead. It has already been widely available in business jet displays, but has not yet been installed in the cockpits of modern jetliners. SVS also includes "optical flow" which artificially mimics aircraft movement and energy awareness cues, including a flight path vector, flight path acceleration and speed error indicator that would eliminate loss-of-control accidents.

Looking even further ahead, a Synthetic Vision System (SVS) is very likely to be an integral part of a sophisticated Combined Vision System or CVS which fuses several vision inputs depending on the phase of flight.

Evolving systems like SVS and CVS confirm the need for more data capacity in tomorrow's airplane, which means light and reliable cables, Wi-Fi capability, and a host of data, communication and sensor cables of all kinds. When it comes to flight safety, the right cables provide an imperative "nervous system" to heighten awareness, detect danger, and enable appropriate intervention.

According to the Commercial Aviation Safety Team (CAST) new systems like these, once widely installed in the global airline fleet, could eventually reduce loss-of-control risk by some 73%.

c. Airplane Health Monitoring (AHM)

Onboard data analytics are also going to revolutionize aircraft maintenance, which has traditionally been "by the book," via timely and periodic A, B, C and D checks under the guidance and approval of the FAA, Transport Canada or the European Aviation Safety Agency (EASA).

Technological advances and massive global fleet renewal by 2025 will completely reshape the Maintenance, Repair and Overhaul (MRO) business. More onboard data will power predictive maintenance to minimize unplanned work on next-generation aircraft.[49]

With aircraft like the Airbus A350 generating hundreds of thousands of parameters, with the right software they can be processed and analyzed to spot problems before they lead to service disruption, or even worse.

> Airbus is already scratching the surface with it real-time health monitoring service, available for the A380 and A350 and being tested on the AS330. Far more than pushing status information to the ground in real-time, Airbus uses onboard communications functionality to query sophisticated computers […] to obtain specific parameters related to a fault. The data help the manufacturer's around-the-clock technical support team get to the root of an issue and, working with the carrier's maintenance control center, determine what to do.

Data is thus rapidly becoming the primary driver of maintenance programs, and onboard wires and cables are key to this information highroad that is bound to redistribute the total MRO spend, estimated to reach $100 billion by 2025.

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48 For details, consult "Airbus, Boeing Set Sights On Synthetic Vision" in Aviation Week's 4 May 2015 issue: http://aviationweek.com/commercial-aviation/airbus-boeing-set-sights-synthetic-vision and http://aviationweek.com/business-aviation/regulators-market-determine-fate-synthetic-vision-guidance-systems

49 See "MRO Bracing For A New, Data-Driven Future" at: http://aviationweek.com/commercial-aviation/mro-bracing-new-data-driven-future on which this brief section was based.

Already, engine manufacturers (our next trend) have gained a larger share of the aftermarket with guaranteed service agreements, by using AHM to know exactly when their engines will need overhaul.

5. Lighter, more reliable and powerful engines

If data are the brains of the aerospace business, engines are often the real drivers of change. Halfway through the millennium's second decade aerospace stands at a turning point. Order books for lighter, better and more fuel-efficient engines are at record highs.

According to a recent 2015 overview, we will soon see a generational change across the board from nearly all manufacturers:

> In addition to the fuel-efficient CFM Leap-1 and Pratt & Whitney PW1000G geared turbofan on the new narrow bodies, the next step in high-performance engines will fly on new large business jets in 2015: General Electric's Passport on the Bombardier Global 7000, and Pratt & Whitney Canada's PW800 on the Gulfstream G500.[50]

Note that the Leap engines are currently being flight-tested for the Airbus A320neo, Comac's C919 and Boeing's 737 Max.

In the military sector, there is also a move towards turboshafts for helicopters and adaptive-cycle engines for fighters that combine high power with fuel efficiency. The goals are higher performance with around 30% lower fuel burn.

In other developments, Rolls Royce is continuing to develop a new series of large turbofans for jumbo jets for the next decade and beyond. Buoyed by growing volumes of business in the widebody airliner market with its three-shaft Trent engine family, it continues to ramp-up to support expanding fleets of Trent 1000-powered Boeing 787s and XWB-powered Airbus A350s.

Rolls' new Advance, which is planned to go into service in 2020, will have a 20% better burn level than the current Trent 700 and have weight savings of 750 lb. per engine. The follow-up engine, the UltraFan will have a fuel burn at least 25% better than the Trent 700. Key technologies for the UltraFan will be an all-new power gearbox, variable pitch blades and variable area nozzle. The higher pressure ratios planned for Advance and UltraFan will mean higher operating temperatures and increased generation of nitrous oxides.

Other recent developments include Pratt & Whitney's Geared Turbofan concept (mentioned above), which is being designed to meet the high-efficiency goals of airframe-engine integration. It is intended to overcome installation challenges for NASA's new D8 Double-Bubble airliner that could enter service around 2035. The D8 is designed to burn at least 60% less fuel than the current generation of narrowbody airliners.[51]

Airbus and Snecma are working on a 2030-timeframe for short/medium-range airliners driven by counter-rotating **open-rotor** engines that can deliver vast fuel savings over conventional turbofans. Open-rotors burn less fuel because they can have large diameters for ultra-high bypass ratios without the drag and weight penalties of a large nacelle. To power a future narrowbody, Snecma maintains that this solution could achieve 16% fuel savings and 20dB less noise than the upcoming CFM Leap-1.

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50 https://www.statista.com/statistics/655057/fuel-consumption-of-airlines-worldwide/

All of the above developments and breakthroughs demand high-temperature and fire-resistant cables in fire zones where manufacturers have never gone before, often with reduced weight as an added desideratum, and in high vibration environments. Within years, cables will have to handle temperatures well in excess of 300 degrees, while offering twice as long survivability.

6. Environmental concerns

According to the International Civil Aviation Organization, the environmental impact of aviation occurs because aircraft engines emit heat, noise, particles, and gases that contribute to climate change and global dimming. In spite of fuel-efficient, less polluting turbofan and turboprop engines, recent increases in air travel has continued to raise levels.

Global fuel consumption by commercial airlines has increased each year since 2009. This is expected to hit an all-time high of 97 billion gallons in 2019. Air freight traffic grown considerably in recent years, presumably related to the growth of e-commerce, which is set to keep expanding in the foreseeable future.[52] At the same time, airlines environmental targets can't be achieved with technologies available today. The European Commission's Flightpath 2050 Vision for Aviation, for example, stipulates a reduction of CO2 by 75%, and a reduction of NOx by 90% and noise reduction by 65%.[53] Realizing this requires a rethinking of current approaches.

NASA's Environmentally Responsible Aviation (AERA) continues to promote cuts in drag, weight, fuel burn, noise and emissions. Europe does not have a consolidated NASA-like organization, but it does have Clean Sky which promotes ground tests of open-rotor, geared turbofan, turbo shaft and diesel engines, and other tests, including smart flaps, all electric systems and power-efficient rotor blades.[54]

Clean Sky's environmental targets for 2020 include a 50% cut in CO_2 emissions from 2000 levels, and new technologies to cut CO_2 by an additional 50% before 2050. It also wishes to bring cabin noise level down to 80 dbA, and reduce external noise by 10 dbA to meet noise reduction goals. These recommendations are in keeping with the European Space Agency's goals under the "Observing the Earth" program.

NASA has calculated that it would be possible to reduce an airliner's noise footprint 80% by 2025, but only by abandoning the traditional tube-and-wing configuration. Airliners of the future are likely to be radically different. New shapes could include blended wing designs, where engines, fuselage, wings and flight surfaces blend into one organic entity, like some military aircraft today.

Airbus' 2050 concept plane – the airliner of the future – has a broader body, curved and shaped to improve airflow and provide more living space. Its wings are longer and slimmer to reduce drag and save on fuel. The U-shaped tail section shields the passengers from engine noise, while the motors themselves could be hybrid-electric-fuel-burning and nearly maintenance-free.

Materials science and new aerospace technologies involving power systems and the laws of aerodynamics will contribute to this kind of transformation. But at the core of future

52 https://www.statista.com/statistics/655057/fuel-consumption-of-airlines-worldwide/

53 https://ec.europa.eu/transport/sites/transport/files/modes/air/doc/flightpath2050.pdf

48 https://www.cleansky.eu

developments will be the essential energy and data provided by invisible networks of countless cables, hidden well out of sight from air travellers.

Recently, Airbus CEO Guillaume Faury stated that 'The goal must be to fly with zero emissions". His plans include offering fully electric flights on a large scale. "Polluting emissions will decrease as older planes are replaced by modern ones, but this is not enough. By improving air traffic management, it is possible to reduce fuel consumption and CO2 emissions by 10 to 15 %."[55]

What to expect from a cable manufacturer?

Over the next ten to twenty years, some major changes are expected in the commercial and defense aerospace industries, which are likely to have a significant effect on cabling. Evolution in these industries is far slower, so close monitoring of developments at an early stage and understanding of how cycles progress is essential.

OEMs and suppliers of systems, subsystems and components are playing a critical role in aerospace worldwide. They want to meet growing demands for quality, safety and reliability. They are also interested in improving supply and delivery logistics and creating new customer-driven services. Airlines, cargo transport and military operations are increasingly global and need a wide range of cable solutions that are aircraft fully compliant with national and world standards.

- **A comprehensive range of aerospace wires and cable solutions**
- **Products that are compliant with a range aircraft specifications and standards worldwide**
- **Lighter, smaller, tougher, and more reliable wires and cables**
- **Abrasion, arc-track-, fire, and fluid-resistance and low maintenance**
- **Customized solutions and support for complex and advanced designs**
- **In-house expertise, consulting and dedicated client teams**
- **Ability to provide on-site service around the world**

55 https://www.faz.net/aktuell/wirtschaft/unternehmen/airbus-chef-faury-will-emissionsfreies-fliegen-16148800.html

NEXANS: ADVANCED CABLE SOLUTIONS FOR AEROSPACE

Nexans has decades of experience developing and creating durable, high-performance, technologically advanced solutions that add real value for the aerospace industry. We are currently a key partner for the leading names in aircraft manufacture, such as Boeing and Airbus. We have started developments in China and are ready to ramp up production to meet demand growth. We have reallocated production to different plants and made some changes to how we operate, in order to keep serving the industry in the most convenient way possible.

Today, the main focus is on creating and implementing a new generation of solutions to meet new and upcoming requirements. This is made possible by our experience in the aerospace industry, familiarity with all applicable standards, partnerships with qualification companies, and our know-how in other areas that can be leveraged for aerospace, such as fire safety, optical communications and high voltage solutions. We develop new technologies by working closely with customers, identifying their needs, translating these into prototypes, and conducting rigorous testing.

Understanding exactly which needs are not yet sufficiently covered by our existing portfolio helps us provide required alteration or new products. To contain this understanding, we are in close contact with manufacturers and OEMs and examine how our products work in their applications. This information is presented to our product developers, who can innovate in line with customer demand and provide the desired product quality, meeting or exceeding performance and safety requirements, on time and at the right cost.

For example, we are looking into how electrification is changing aircraft architecture and how we can improve power distribution and feed back information on systems. As hydraulic and electromechanical systems increasingly replace electrical systems, we will develop high voltage offerings, relying on our many years of expertise in developing power cabling and systems for a wide variety of applications. Our high capacity cables have proven to last for a very long time in the most extreme conditions and environments. These properties can be transferred to products for aircraft.

The same applies to new communication and radar systems and IFE, using our practical knowledge of combined copper and fiber systems. For example, our experience in telecoms means we have a benchmark for cable performance, ensuring temperature resistance, high data throughput, and reduced attenuation variation, even when cable installation in confined areas introduces a great deal of bending. Our knowledge of installation in, for example, office buildings helps us develop solutions that make cables easier and faster to install in confined spaces. We are also at the forefront of technology and examining how, for example, LiFi (data transmitted using light) might be applicable in aerospace.

As aircraft manufacturers need to speed up installations to keep up with growing demand and avoid order backlog, we can help with solutions for simplifying installation, avoiding reinstallation or disconnection.
When it comes to saving weight and reducing dimensions, we are currently examining the limits of existing technology at a fundamental level and considering alternatives. We are looking for ways of improving cables' performance, safety and efficiency and introducing new materials. Every day, Nexans R&D are looking into how implementing new materials and designs can make cables more suitable to next-generation requirements, for example allowing cables to handle higher voltages.

Our innovations and services extend far beyond cabling and help the aircraft industry face today's challenges. What's more, we remove unnecessary complexity by offering the option to work with a single supplier and point of contact. We can also help (re-)design solution to enhance their environmental performance and recycle materials.

Solutions, such as our inventory management products, are designed in such a way that customers can apply them to their entire supply. What's more, these can also be used with cables from other suppliers than Nexans, helping you avoid vendor lock-in. A dedicated team develops and implements a full range of services for each client, complementing a proven existing product family.

For commercial aviation

In keeping with current trends in commercial aviation, defense and space, Nexans provides a comprehensive range of cables and wires, compliant with all world standards. This includes a full range of cables for aircraft, helicopters, spacecraft and satellites; it also covers customized cables that suit specific technical requirements fully supported by quality control, R&D and aerospace-specific services.

From a safety standpoint, Nexans is continuing to meet increasingly stringent international regulations (FAA and others), but is also responding to the significant growth in market share of low-cost carriers, and is adapting its supply chain to the traffic shifts in the Middle East and the Asia-Pacific zone of operations and the needs of vibrant emergent economies.

Safety issues are also addressed through the highest quality standards (AS/EN 9100, EN14001). Nexans offers a range of arc tracking, fire-resistant and fire zone cables now being widely used in the USA, Europe, Russia and China. It also sits on major normalization committees (SAE-AS, ASD, Arinc…) and provides in-house test lab and qualification capability to its customers.

Because enriching the passenger air travel experience is important for leisure and business fliers, Nexans is meeting needs for comfort, in-flight entertainment and connectivity. It has developed new fiber-optic solutions for high-speed data, achieved important space savings with databus rather than airframe cables, created lightweight and flexible power feeders for electronics systems, and fine-tuned interconnect solutions.

For airlines, Nexans has contributed to reducing the cost of fleet ownership and enhancing sustainability by contributing to innovative technical development to lower fuel consumption, optimize engines, lower maintenance costs, redefine electrical architecture (fly-by-wire and other electrical systems to replace pneumatics and hydraulics), and has supported efforts to create "greener" and quieter aircraft.

Aluminum-based power cable solutions save weight, while smooth cables ease and improve installation. Also, Nexans made significant innovations to meet higher voltage requirements and ultra-high temperature demands for engines. Its advanced engineering support also includes redesign-to-cost and value-added services. Nexans achieved much of the above

through an optimized supply chain via Electronic Data Interchange, Kanban, kitting, and forecast integration.

NEXANS is also closely involved in the EU High Voltage Aerospace Cable System(HIVACS) research and development program, focusing on propulsive energy components for hybrid aircraft. This requires transmission of electrical power across the airframe at unprecedented levels, which will not be possible without the development of power dense and safe cabling systems that operate at higher levels of voltage and current. To this end, the objective of HIVACS is to bring together a coherent suite of experimentally validated simulation models to permit the design exploration and optimisation of future aerospace cable systems to allow the aeronautical industry to meet the high-power design requirements of future aircraft programs. The project will also provide recommendations for future standardisation to the relevant standard committees and identify key axes for further development. Models will be validated by comparison to experimental test bench activities undertaken on existing cables. Once the models are qualified and accepted by NEXANS as being appropriate for adoption in an industrial setting, they will be used in a design optimisation process to determine optimal geometry and sizing of the candidate cables and predict their expected performance.

For the defense market

Nexans is helping defense builders eliminate hydraulic systems, incorporate all-electric actuators, and meet new power and data requirements. Its cable solutions also reduce arcing and arc propagation, adapt to weight and space limitation requirements within the airframe, and prevent dangerous corona discharges. The company has also focused on value creation in areas perceived as essential by the customer, including investment in R&D, supporting low intensity platforms with new technologies, and developing strategic relationships with distributor channels and harness manufacturers.

For special needs, such as flexibility, dynamic cut-through resistance, electromagnetic interference resistance, corona resistance, Nexans supplies products customized to specific military requirements that can be used in various types of harnesses.

In addition to delivering products that conform to most national, international and OEM standards, Nexans also has a worldwide industrial footprint that is fully adapted to the new military and defense landscape. Three international sites serve both commercial and military customers, assuring harmonized procedures and facilities, shared skills and resources, and a common aerospace vision.

Aerospace cable solutions for safety, reliability, efficiency and adaptability

Almost half of all commercial aircraft in service today are equipped with Nexans cables. Nexans is the only cable manufacturer worldwide to offer a broad spectrum of wires and cables, supported by a full range of aerospace services:

- Composite tape wrap
- Smooth surface composite
- ETFE and cross-linked ETFE extruded
- PFA and cross-linked polyalkene/kynar extruded
- PTFE extruded
- Design & Prototyping
- Testing & Qualification
- Manufacturing
- Engineering Support

Standards and specifications
Nexans wires and cables meet most national, international and OEM standards for both commercial and defense applications. They include EN, AS, WC, NSA, ASN, MIL, ABS, BMS, etc., in addition to our own rigorous aerospace standards.

A full list of standards is available online at www.nexans.com/aerospace

A full range of products and solutions

Airframe wires and cables

General-purpose airframe wires and cables are used on the flight deck, in the passenger area, in the wings and surfaces. They are used to carry signal and low level power at 28 Volt DC, 115 Volt AC, or 230 Volt AC controlling everything from fasten-seatbelt signs to complex fly-by-wire sub-systems.

- Copper, copper-alloy, copper-clad aluminum or aluminum alloy
- PTFE polyimide wrapped insulation, laser markable
- Smooth surface technology, laser markable
- High temperature, mechanical and chemical resistant
- Low weight, small diameter, and arc-tracking resistant

Cables for power transmission

Power feeders energize motors and equipment from APUs and batteries. Nexans' offer includes both European and American standards. Compact nickel-plated copper versions provide high conductivity, while larger nickel-plated aluminum and unplated aluminium versions achieve significant weight savings.

- AWG 8 to 4/0, copper or aluminum conductors to save weight
- Polyimide-wrapped/PTFE/glass-fiber insulation
- Smooth surface technology
- Operating temperatures up to 260°C

For Airbus A350 and A380, we created a new range of cables allowing 5% weight savings.

Fire-zone and high-temperature area cables
For hot areas, engines and the nacelle environment. Their functions vary from carrying signals to transmitting energy. Nexans' offer includes both European and American standards. Our range of cables answer both flame/fire retardant and fire-resistant requirements.

- AWG 24 to 4/0
- Fire-proof and fire-resistant insulations
- High temperature from 260°C to 310°C
- Arc-tracking resistant
- Nickel-clad copper/copper-alloy conductors

Fire-resistant cable offer**s** two benefits: light weight and arc-tracking resistance in bundled configurations to reduce power malfunction.

Coaxial cables
For onboard HF data transmission (radio/radar/anti-collision/communications/navigation/avionics).
Improved coax designs: KX for enhanced high-frequency, WZ for signal transmission, and KW, featuring an all-aluminum weight-saving conductor.

- Silver-plated, copper, copper-alloy, copper-clad steel/aluminum
- Aerated fluoropolymer, PTFE low density extruded, wrapped insulation
- Single or double screen (braids, tapes, etc.)
- Low attenuation

A "daisy" design uses air rather than foam insulation. Meeting the latest environmental regulations, it is lighter and greatly improves dielectric performance.

Databus, quad Ethernet and optical fiber
In addition to avionics, these cables serve various in-flight entertainment and communication needs. To increase data volume without increasing space requirements or weight, Nexans has optimized shielding and armoring to reduce weight by 20-60%, and offers solutions based on optical fiber.

- Silver-plated, copper, copper-alloy, copper-clad steel/aluminum
- Aerated fluoropolymer, PTFE extruded, wrapped insulation
- Single or double screen (braids, tapes, etc.)
- Optical fiber: robust, fluid-resistant, rated at 135°C

Lightweight databus cables are widely used on helicopter programs

Customized cables for specific applications

Our AS9100 and ISO9001 certified facilities manufacture ultra-low-weight shielded cable for satellites and coiled cables for cockpit, special sensor cables, flight-test wires, low-noise cables for vibration-prone areas, custom-built coaxial assemblies for SATCOM systems, and various hybrid cables.

- Multi-core, screened, jacketed, and extendable coil cords
- Coaxial assemblies for SATCOM
- Ultra-low-weight shields
- Hybrid cables combining hook-up wires, power feeders, shielded cables and coaxes
- Specialties, such as low-noise, flight-test, and thermocouple extension cables

A suite of services designed for aerospace

To further support OEMs and their first-tier customers, Nexans provides services tailored to aerospace needs, adding value to products and facilitating new approvals in keeping with national and world standards.

- Supply chain & operations services

We offer customers technologies and systems that allow them to optimize and streamline their operations, especially in the area of supply chain management. This is particularly important as demand grows and aircraft production must be maintained at a very high level. The challenge is no longer just bringing aircraft to the market – the challenge is to make sure planes, engines and components are delivered on time, according to spec, and at the right cost.

By adding technology content such as RFID and IoT capabilities to our products we can closely monitor the supply chain, and even manage this on the clients' behalf. This means high supply chain reliability while reducing working capital costs throughout the chain, optimizing every delivery moment between when each product is completed and when it is needed and ensuring permanent availability of various cables to customers. Our platforms are accessible 24/7 from everywhere. We always know asset whereabouts and stock levels, even in subcontractors' warehouses. Increased visibility means physical inventory is done in minutes instead of hours or days. These solutions have already been deployed with 15 customers and more are being added.

By embedding technologies such as RFID into cables, harnesses and other products to be mounted into planes, we can offer customers long-term traceability of equipment to simplify and secure future maintenance and repair activities. If maintenance is required to cables or components some years from now, accessing information and specifications via RFID will be easy. Customers can have access to traceability information for every cable and component in the aircraft, including part name, serial, manufacturers info, technical data , batch numbers and so on. Nexans can propose customized kitting and packaging to its customers, especially for pre-cut power cables. Kits can include other components, according to customer needs and specifications.

We can also deliver cables that are precut to right length with pre-mounted connectors. Customers such as customers or subcontractors only need to unpack and mount the cables onto their final products such as harnesses.

- Engineering services

We can help customers optimize engineering for design of machines and system components, which are to be built into aircraft of helicopter. We have been providing (re-)engineering services for many years in other areas, such as cruise ships, rolling stock and wind turbines, and have made these available for aerospace.

If a customer has issues or questions related to wires and cables, we can assign a resident engineer to work with their research department to help them make the right choice, or facilitate acceptance according to design criteria, test information and applicable standards. We dispatch a resident engineer to work permanently at the customer premises as part of the customer engineering team. We can take charge of integrated engineering and R&D projects, optimize the cost and installation of specific cabling systems or optimize the Bill of Material, for example.

If required, we can design new products that will meet the functional needs of future platforms. For example, one customer designing new generation of wind turbines asked us to decide on optimal cable and connector routing and sizing.

As size, weight and reliability are of the utmost importance, we can help suppliers, harness makers and OEMs find optimal solutions by redesigning to cost. For example, we have pioneered the use of aluminum to achieve significant weight reduction.

At the request of OEMs, harness makers and distributors, we also provide custom training on our products to explain their specific performance characteristics and benefits.

Nexans can also integrate with customer portals, or set up dedicated portals to offer customized information according to design, manufacturing and operational needs (including technical data, commercial information, specifications, and billing).

- Business services

We offer direct financial support for customers' bottom line. Nexans' financial instruments limit exposure to inflation on metal prices - especially practical as copper pricing has a tendency to change – and currency fluctuations. Products can be bought at a fixed dollar value so customers know exactly how much they'll be paying without exposure to currency fluctuations.

We can also buy back obsolete products. This avoids loss for clients who might otherwise get stuck with products they don't need and can't resell for a good value. We also take back products and recycle them, and take back scrap.

Dual distribution channels

Nexans has changed its approach to distribution and we are now taking a two-channel approach, with the goal of helping manufacturers keep up with demand without any compromises on quality, safety and cost.

- Direct OEM channel supporting the manufacturing process, for big volumes' customers
- Distribution for small OEM volumes' customers, implementing inventory of Nexans cable in most parts of the world and supporting the MRO markets in very short lead time

In recent years we've seen big aircraft manufacturers begin to capture value in this area. This is also driving M&A, with Boeing acquiring KLX, for example, and Airbus acquiring Satair A/S. This is changing parameters that govern how we will sell and support business going forward.

We have been interacting with key aircraft manufacturers and negotiating with distributors, aiming for more constant business with fewer, but more powerful, stakeholders, but stronger ones so that there is greater leverage when it comes to price and other negotiations.

Our focus is on adding value end ensure on-time deliveries through a high level of service, increasing reliability throughout a mature supply chain and being attentive to user needs. This performance is to be maintained, and improved even further, in spite of increasing quantities and volumes.

In addition, we want to help speed up installations through simplification, and avoiding reinstallation and disconnection.

CONCLUSION

Nexans provides a full range of cables for commercial aircraft, fighter and transport aircraft, helicopters, spacecraft and satellites.

We have a full range of capabilities in design, prototyping, testing, qualifying, manufacturing and customer support, in addition being key members and contributors to the world' most influential Standard Committees (SAE-AS and Arinc in the US, and ASD in Europe).

We are proven leader in standard, new and advanced aerospace wires and cables, particularly in new generations of tape wrap products (EN standard, special corona-free cables and lighter aluminum solutions in Europe).

We are also process experts in design and manufacture on our own machines especially for tape wrap machines with integrated control and full data acquisition.

Nexans has consistently produced lighter, smaller, smoother, safer and more robust solutions. For example, in the area of nacelle and engine solutions we are aiming at +400°C for a 90,000 hour life cycle.

In terms of weight savings, we have achieved:

- -10% by reducing the wall thickness of power feeders
- -20% via an aerated design for coax, bus and quadrax cables

- ≤20% for aluminum shields
- ≤30% for smooth and composite insulations
- ≤40% for aluminum for conductors and shields
- ≤90% for optical fiber cable instead of copper

What makes Nexans unique is vertical integration on conductors, with support from a Metallurgy Research Center; dedicated Aerospace manufacturing sites in France and Morocco and our own Research Centers. Nexans is the only supplier to offer both irradiated and composite tape-wrap, including smooth technology.

For our customers this means improved safety and reliability, common and fully approved products, a highly reactive supply chain, and quality cost-effective products from nose to tail and from wing-to-wing.

APPENDIX: Some Nexans aerospace headlines and milestones

- For important space and weight gains, Airbus needed a new generation of power cables compatible with lugs and terminations. Nexans created a new range of tape-wrapped cables that achieved a 5% weight gain over previous cables. Airbus is now using it in the A350 and A380 aircraft.

- To resist arc tracking and reduce power malfunction, Nexans drew on its long experience in bundles, assemblies and harnesses to create a new generation of safer fire-zone cables for densely cabled aircraft areas. This lightweight solution adheres to rigorous European norms.

- To meet new REACH regulations for coaxial cables used for navigation, avionics and anti-collision systems, Nexans developed a new "daisy" or "wagon wheel" design which uses air rather than extruded foam to deliver a lighter coax with improved dielectric performance.

- Nexans is involved in the EU HIVACS project as an independent approval body for high-voltage aerospace cabling technology models.

- 2013 Best Improver Awards from Airbus

- 2014 Industrial Excellence Award from Airbus: See Link

- 2017 Special project management Awards from Airbus

- Five year contract with Airbus: See Link

For more information about the above, please consult:
http://www.nexans.com/eservice/Corporate-en/navigate_310994_1096_20_12666/Success_stories.html

About the authors

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Frederic SCHULL, is Global Product Manager Aerospace Nexans, since 2018. He was previously Head of Engineering and Global Product Manager at Staubli Electrical connectors for 15 years. Bringing to Nexans an improved view of the product life cycle and technological trend evolution.

About Nexans

Nexans brings energy to life through an extensive range of cables and cabling solutions that deliver increased performance for our customers worldwide. Nexans' teams are committed to a partnership approach that supports customers in four main business areas: Power transmission and distribution (submarine and land), Energy resources (Oil & Gas, Mining and Renewables), Transportation (Road, Rail, Air, Sea) and Building (Commercial, Residential and Data Centers). Nexans' strategy is founded on continuous innovation in products, solutions and services, employee development, customer training and the introduction of safe, low-environmental-impact industrial processes. In 2013, Nexans became the first cable player to create a Foundation to introduce sustained initiatives for access to energy for disadvantaged communities worldwide. We have an industrial presence in 40 countries and commercial activities worldwide, employing close to 26,000 people and generating sales in 2014 of 6.4 billion euros. Nexans is listed on NYSE Euronext Paris, compartment A. For more information, please consult: www.nexans.com

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