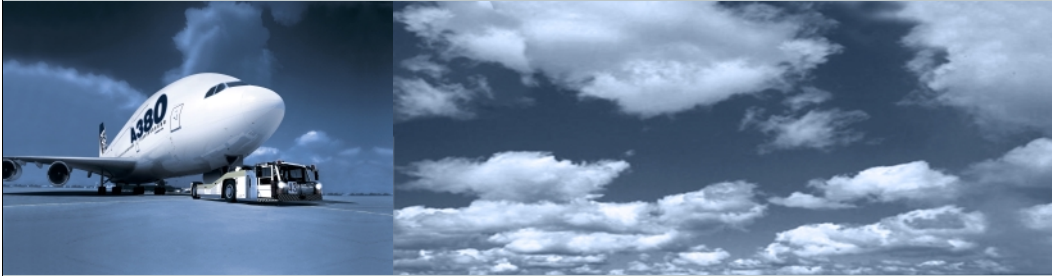


ICAS 2002



Toronto , September 12th 2002

Market Drivers and Innovation behind the Airbus Products



ICAS 2002

Presented by
Philippe Jarry
Vice President
Aircraft Evaluation



Toronto , September 12th 2002

Market Drivers and Innovation behind the Airbus Products



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Our Market drivers

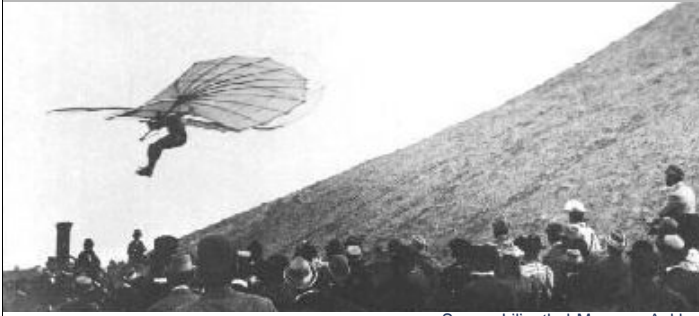
Using the new technologies



At any one time when we are to set the course for the future, we should first check that the objective is clear: not using whatever is available, but using it because it serves the objective. In the field of technology integration in airliners, we think we should first ask the market to tell us what the main drivers are, then ask the Engineering Community about the technical opportunities that are at hand.

But, prior to make a decision, we should be animated by a vision: our aim, our responsibility, our contribution to the needs people have to move around the planet.

Dream and vision



Source Lilienthal-Museum Anklam

O. Lilienthal,
letter to Moritz von Egidy,
January 1894

"I have often listened to you with enthusiasm, when you refer to the borders not as separating the countries but rather as connecting them. I, too, have made it a lifelong task of mine to add a cultural element to my work, which should result in uniting countries and reconciling their people.

Our experience of today's civilisation suffers from the fact that it only happens on the surface of the earth. We have invented barricades between our countries, custom regulations and constraints and complicated traffic laws and these are only possible because we are not in control of the 'kingdom of the air', and not as 'free as a bird'.



Dreams are authorized to build-up the vision. Some people have contributed to make dreams come true, and in the field of aviation, Herr Otto Lilienthal is certainly one person we should remember. Like others, he has not spared efforts, putting his engineering skills in the adventure, spending all his money, and at the end, giving his life.

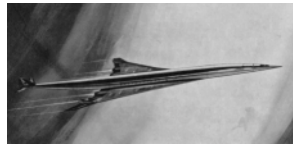
What people thought in year 1970

Many thought year 2000 would see

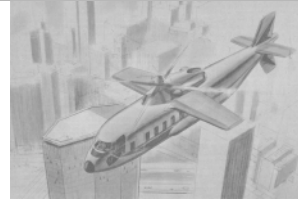
- VTOL aircraft dominate Short and Medium Range
- Supersonic & Hypersonic For Long Range
- Size go beyond 1000 seats and 150 tons of freight
- Propulsion to be either Hydrogen or Nuclear

...

Airbus vision was different



Family would be a keyword
And Technology that brings benefits
And Market Watch : what is needed ? and when ?



Dreams can remain dreams. When looking at what the "experts" believed in 1970 the air Transport industry would look like in year 2000, they were pretty definite!

Look at what happened in fact. Sometimes, the chains of the past are too heavy to allow us to imagine the ruptures that could happen. Sometimes, the rupture scenario is pushed in such a way that it would pre-suppose that all the environment also is subject to a rupture. In the pictures shown, there was absolutely no vision of the environmentalist pressure around the world that makes the air transport vehicle an "unfriendly" neighbor.

So, we need to enlarge our horizons.

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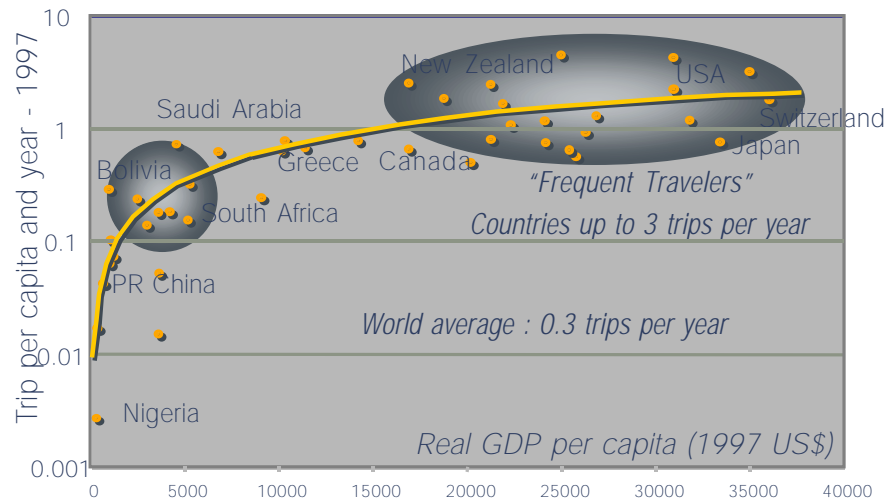
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Look at Passengers, what can they afford ?



Huge Potential, linked to Wealth

* Passengers carried by airlines domiciled in the country

SOURCES : ICAO, Standard & Poors



We all believe that air transport has become part of mankind way of life. Untrue!

Only a small portion of the world population "enjoys" the aircraft as a mean of transportation. There is room for improvement in our domain, before we will see the aircraft take part in everyone's life.

Growth, expansion is a buzz word in our industry. We will have to pay attention to the way we allow that growth to happen, and the consequences of such growth. Please note that as the economic development is determining the access to the airplane, the airplane operating cost is the prime issue here.

Lots of reasons why people use Air Travel ...



And people, they are so diverse! Different reasons for travel, meaning different expectations, different ways to enjoy the journey, different ways to look at the airplane. We believe that, in spite of the concurrent development of telecon supports, people will want to continue going around the planet.

To those who put the telecon and the air journey in a competitive situation, I might simply note that we are now asked to develop telecon means...aboard the airliners: the more you travel...the more you communicate...the more you communicate...the more you travel.

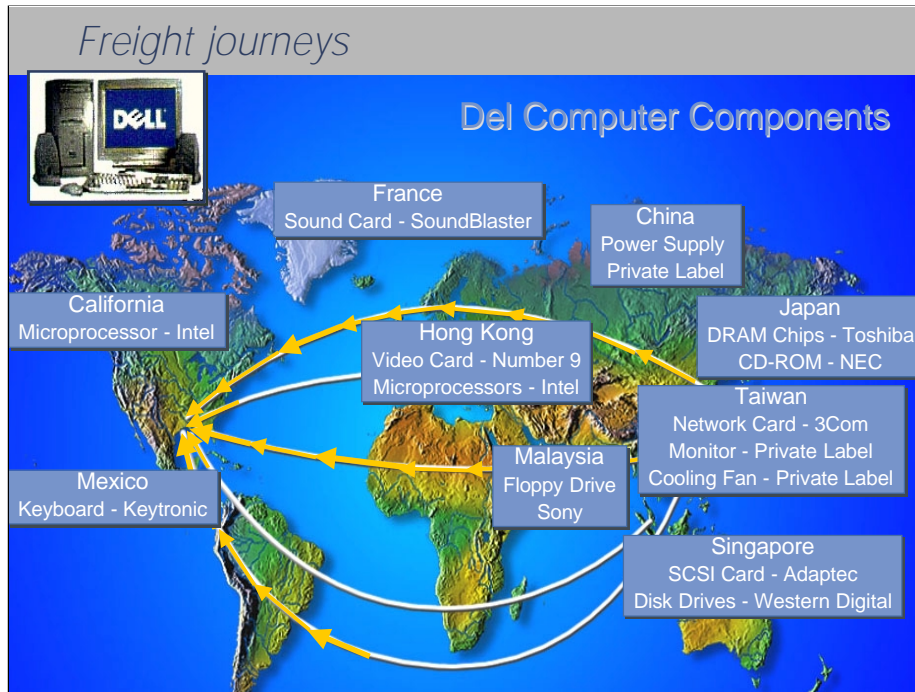
Another aspect that we have to consider when imagining the next vehicles and their interiors, access...is the population structure: the age distribution is changing, as is the size of the people.

But aircraft don't carry only passengers ...

- Aircraft carry only 1% of world-wide freight in volume ...
- ... but 38% in value
- Freight grows more rapidly than Passenger Market
- It's extremely diversified : flowers, racing cars, live animals, "Beaujolais Nouveau", computers ...



There is also the "silent" passenger, I mean the freight. A significant contributor to our industry, that is diversifying, and participate to the globalisation of the economy. Air transport of goods contributes to accelerate it. Speed and cost efficiency are the keywords here.



Just as an example, the pc on which I am working for this presentation comes from all over our planet. Flying one way, sometimes flying back and forth, just to make that little piece of equipment : it would be inconcievable to have the elements shipped from harbour to harbour, wasting time and increasing cost and risk.

A major Airlines' driver

A few quotes, read in Airline Business May 2002

"The business people are on the plane but *business fares* have declined"
G. Bethune, Continental

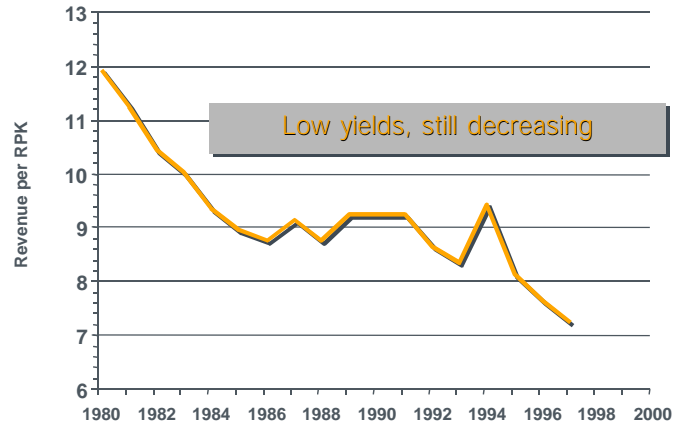
"We need to find an industry answer to the huge increase in war-risk *costs*"
L. Mullin, Delta

" The vicious circle of continuous operating *cash-flow* losses and spiralling debt to replace the aircraft fleet is unsustainable" A. Light, Salomon Smith Barney



Opening one magazine and retaining the keywords that some leaders of the airline industry are using when asked about their business: money, costs, revenues... It is all there. The economic efficiency of whichever airplane we deliver to them will determine success or failure in a very competitive market. We believe that our airplanes will be evaluated around their economic efficiency, that is their overall life cycle cost and their earning power capabilities.

The Airline revenue nightmare



Source: ICAO Civil Aviation Statistics of the World



We said earlier that more people wanted to travel, and that the market is always more competitive. The airlines see, and they contribute to it, a down trend in their unit revenue. They put tremendous efforts in the parallel reduction of their unit costs. Some operators are nowadays referred to as "low-cost".

The airplanes we will deliver over the coming years and decades will have to integrate the picture of the cost-revenue equation. As we do not believe that a significant portion of the passenger community will accept to see the ticket prices to go up.

The neighbours pressure



<i>High Speed Train 300 km/h, 100 m away</i>	<i>92 dB(A)</i>
<i>Express Train 100 km/h, 100 m away</i>	<i>88 dB(A)</i>
<i>Bus in town, 8 m away</i>	<i>82 dB(A)</i>
<i>A320 during take-off, 700 m away</i>	<i>70 dB(A)</i>



Flying is certainly exciting, but not for everybody... Airport neighbors don't seem to enjoy it. And they are more and more numerous.

Besides the airport neighborhood context, there is the growing concern that we share about the respect of the Environment and the aim of protecting a greener planet.

Air transport has a high degree of visibility, sometimes out of proportion with its real contribution in noise and emissions. It is a fact, and our airlines will need to be exemplary with their environment signature.

Answering the demand with the right tools



Life would be simple if one solution would fit everyone. This is not the case: diversity in demand, in geographic conditions, in markets require us to propose, at any given moment, a set of airplanes each responding to one set of requirements.

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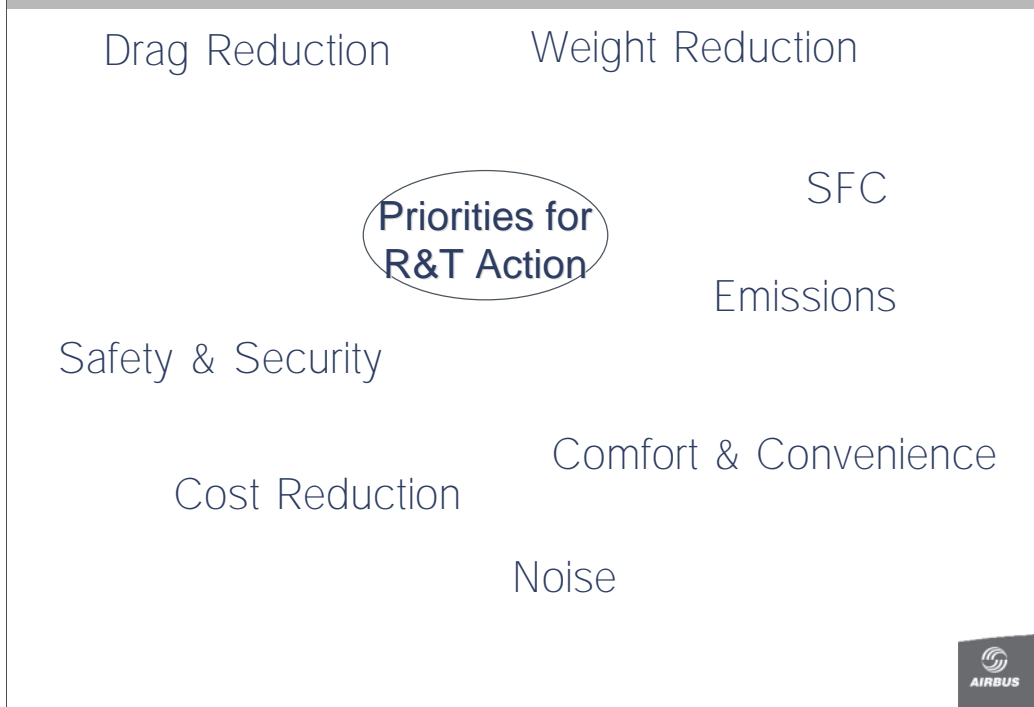
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Meeting the Challenges



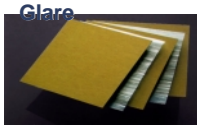
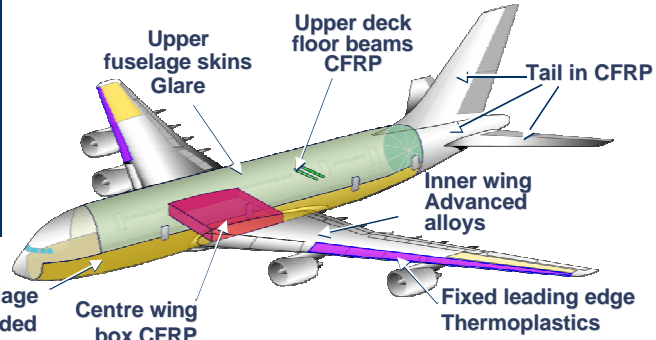
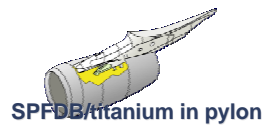
In facing the challenge of diversity and the need to address the cost/revenue elements, the environment and the passenger service issues, we will have to integrate simultaneously aerodynamics, structure weights, noise reduction, manufacturing cost reduction, while offering a better space for the end customer.

Anti-weight technology

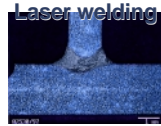
- New structural concepts
- New light-weight materials



A380 horizontal tail plane



Glare



Laser welding



Starting with the aircraft weight, weight being one enemy of the aircraft performance, new materials and new structural concepts contribute to reach our targets. Significant testing is needed to validate the new materials before the decision is made to apply them.

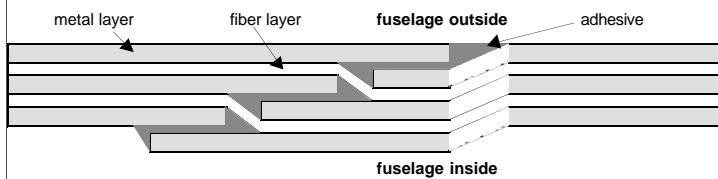
GLARE Technology

→ GLARE is a hybrid material, build-up from alternating layers of aluminum foils and unidirectional glass fibers, impregnated with an epoxy based adhesive.



→ The "splicing concept" arranges two aluminum foils adjacent to each other (or with a slight overlap), resulting in one of the aluminum layers. Such splices are staggered with respect to each other, while the fiber adhesive layers are continuous.

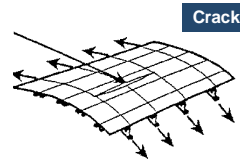
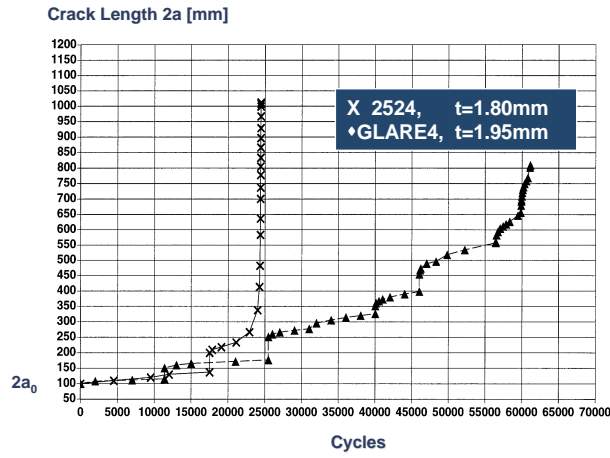
Overlap splice using the "Self Forming Technique"



This is the case with Glare, a hybrid material that is selected for some of the fuselage panels of the A380

GLARE: Excellent Crack Growth Behavior

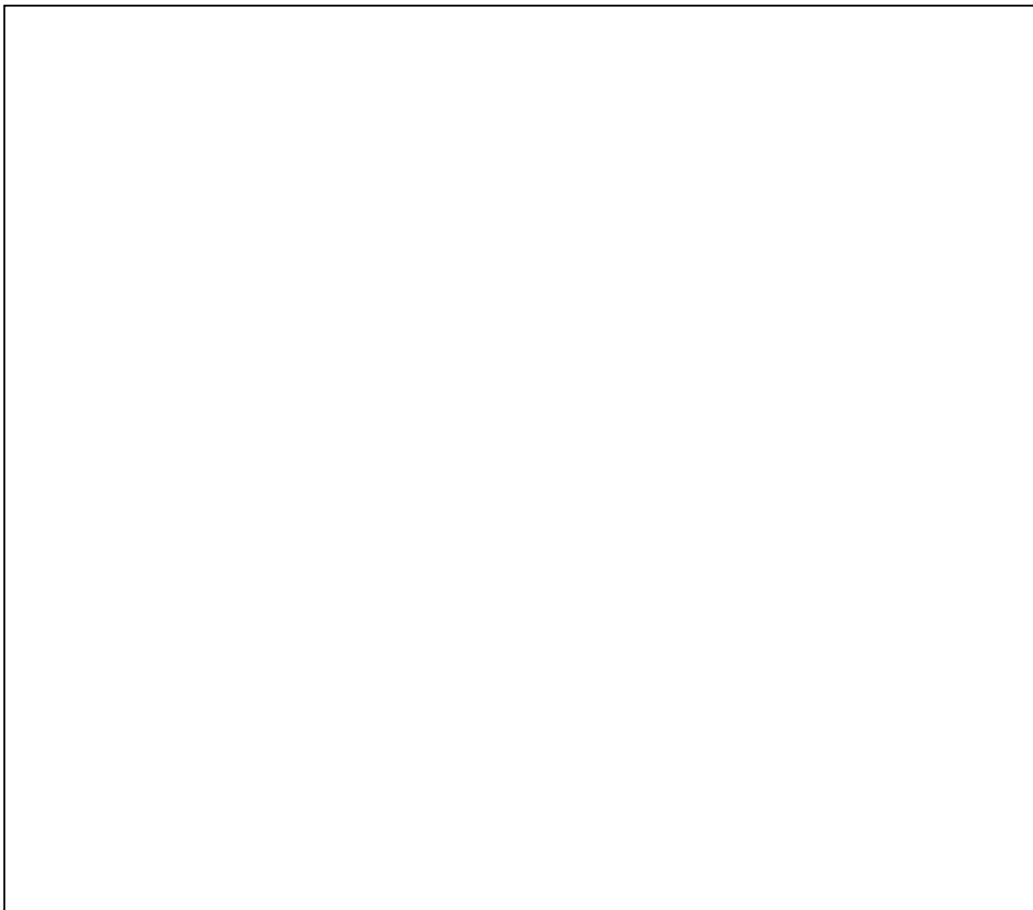
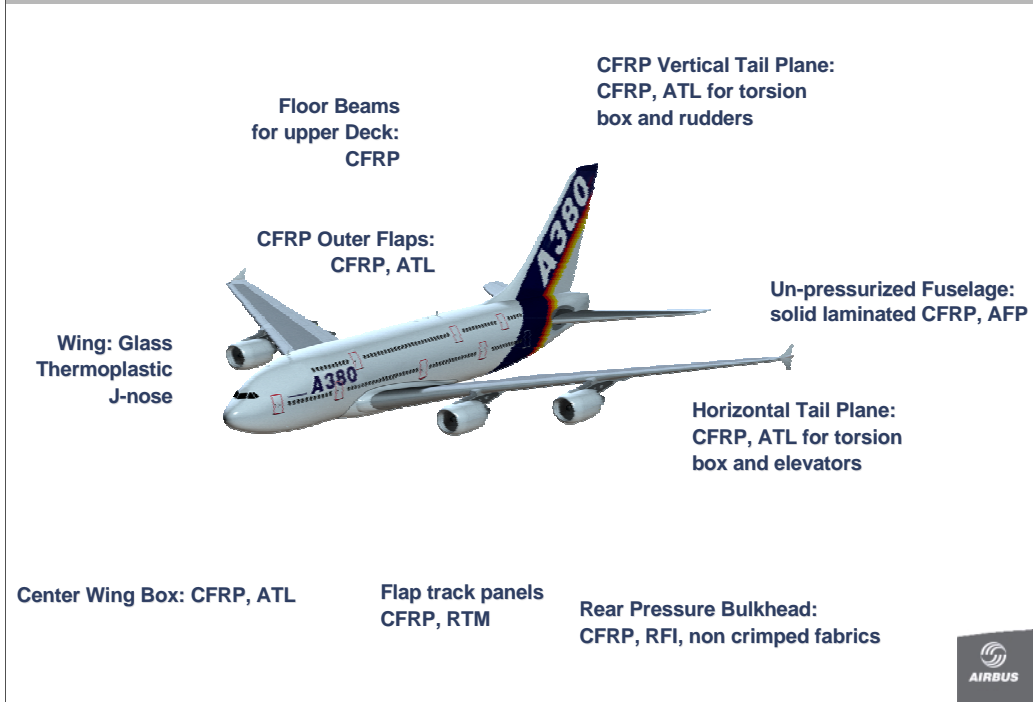
- ➔ A340 Large Panel Damage Tolerance Tests
 - crack above broken frame



Crack extension by sawcut necessary, since crack stopped propagation.



Major Monolithic CFRP and Thermoplastics Applications



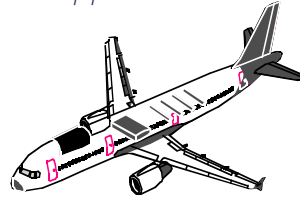
Future Perspectives- Structures

Vision of Composites / Hybrid Materials Application 2020

Immediate Future

25% Weight Share in A380 (2004)

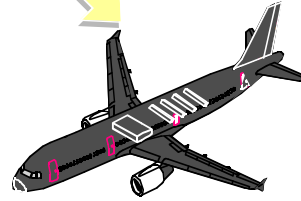
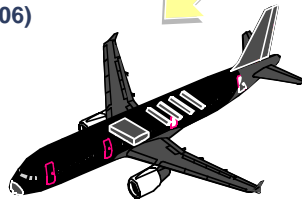
- Section 19 and 19.1
- HTP / VTP
- Movables
- Beams
- Center Wing Box
- Wing Ribs
- Cowlings, Fairings
- Fuselage partly GLARE®



30% Weight Share in A400M (2006)

- Wings

Alternative



Future (2020)

> 65% Composite Weight Share

- Composite / Hybrid Fuselage
- Objectives:
 - 30% Fuselage Weight Reduction,
 - 40% Cost Reduction

• GLARE® Fuselage

• CFRP Fuselage



It has been an Airbus tradition to introduce new technologies step by step, as new airplane programs or new variants were under study.

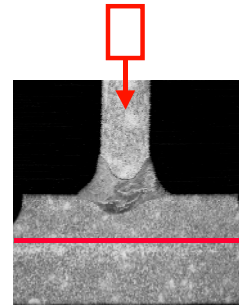
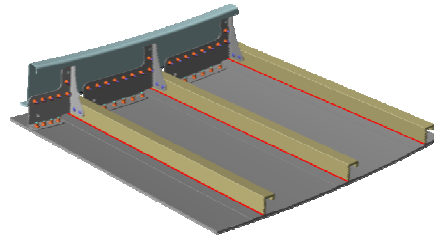
Future Perspectives - Structures

CFRP Wing – Full Scale Test



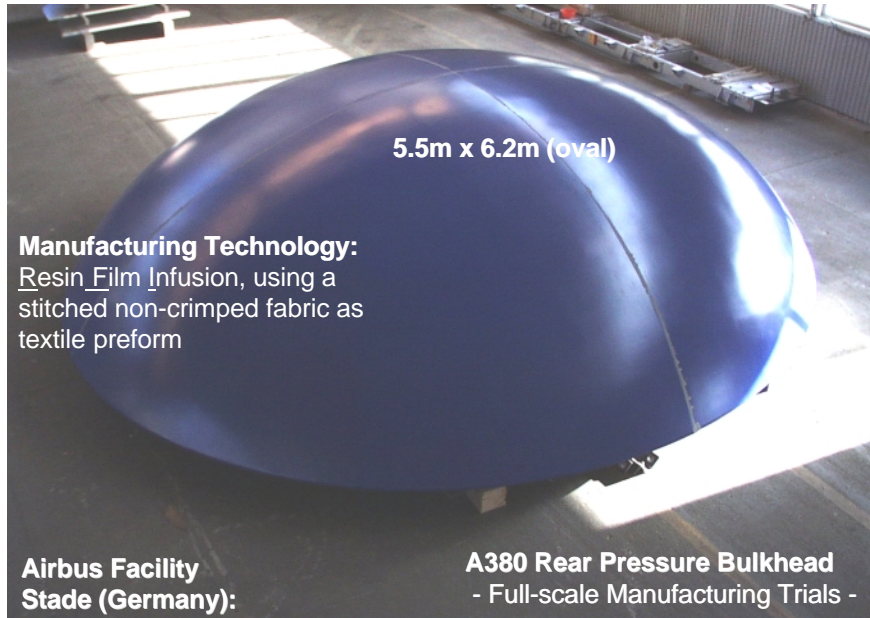
Welding Technology for lower Fuselage Panels

- Near term material candidates:
Al 6xxx-series Alloys: Al 6013, Al 6056
- Advanced alloys under development:
AlMgSc & AlMgLiSc & AlCuLiSc
- Initial application: Stringer-to-skin LBW for lower fuselage skins.
- Technology readiness for fuselage panels:
 - LBW of single & double curved panels confirmed.
 - More than 50 panels manufactured and successfully tested.
 - Initial application: A318
- Examples for potential further applications.
 - Fuselage panel/clip and clip/frame.
 - Panel/frame in cockpit area.
 - Center fuselage pressure bulk heads.



We estimate that welding techniques could lead to about 10% in weight reduction while delivering a 20% reduction in production costs. As an example, the panel riveting speed goes from typically .15 or .25 meter per minute up to 8 to 10 meters per minute.

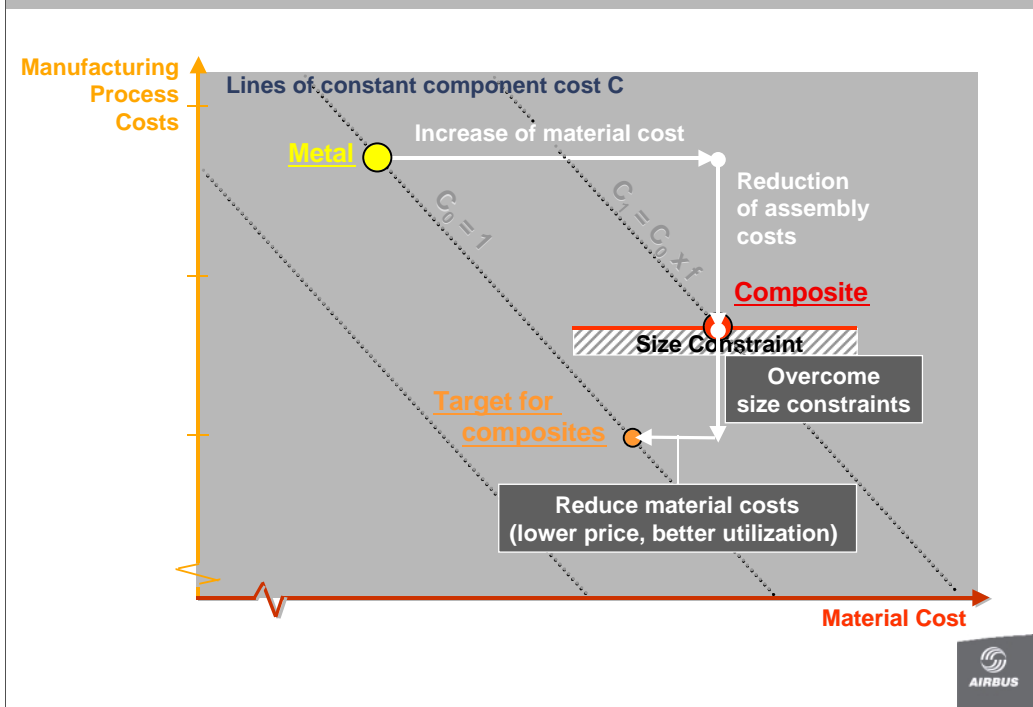
Full-Scale demonstrator: Resin Film Infusion (RFI)



A380 rear pressure bulkhead produced with resin film infusion technology using a non-crimped fabric as textile preform. A340-500/600 bulkhead is manufactured with prepreg tapes. The advantage of CFRP design is a weight reduction of 27% compared to Al-design.

Another composites manufacturing technology is resin transfer moulding. One of the difficulties with "conventional" composites manufacturing, using pre-impregnated material - "prepreg", is that because the component is cured in an autoclave on a tool, all tolerances are thrown to the other surface.

Cost of Composite Structures



A careful cost/advantage analysis has to be conducted before the application of composites is made.

Laser beam welding for fuselage shells



Here we see 2 Airbus facilities for the welding of both stringers to skins, and frame sections to skins.

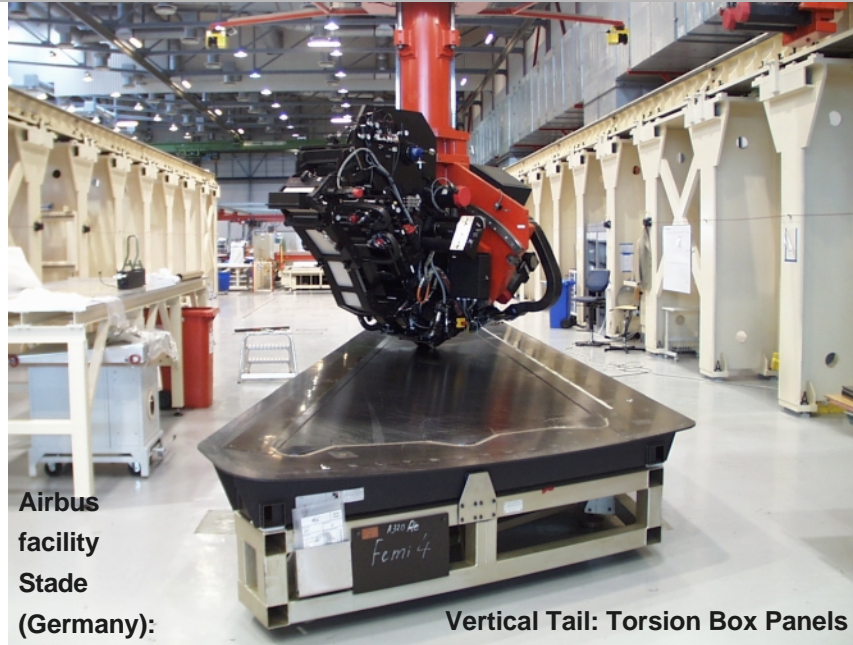
Quality control is ensured through rigorous in-process monitoring

The tooling is also very simple and flexible, a holding fixture is all that is required.

Lasers are not only used to cut and weld parts, but increasingly for measurement.

Flexibility in tooling is a key objective within AIRBUS, especially for the A380 programme, and the use of laser measurement helps to make major strides towards this goal even in major assembly stages.

Automated Tape Laying (ATL)

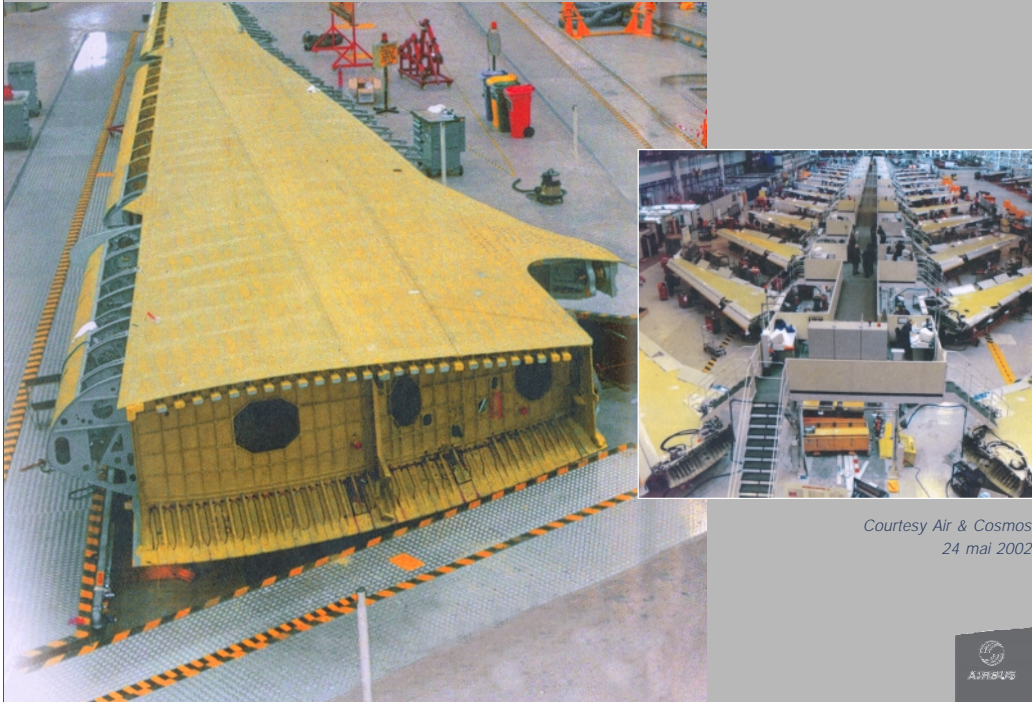


**Airbus
facility
Stade
(Germany):**

Vertical Tail: Torsion Box Panels



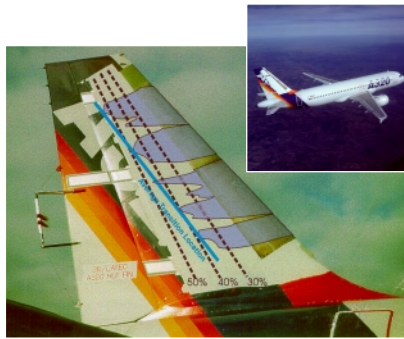
Wing production



Going to a moving line concept on a sub-assembly like the A320 wings allows for a reduction of production costs and delays by more than 10%. This concept, we feel, is very appropriate for an airplane part that is insensitive to customer customization.

Drag/lift technology

- Laminar flow research to improve air flow



- Winglets technology



BEFORE

Conventional wingtip with larger vortex and higher drag

AFTER

Blended winglet with smaller vortex and less drag

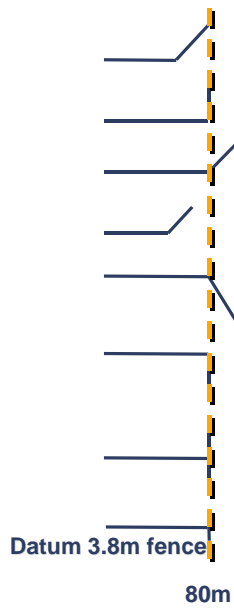


Operating costs reduction and added airplane productivity is obtained through a refinement of the aerolines . Improving the airflow on the surface is one area for research, here above shown in actual flight testing on an A320. The way the wing works evolves with the addition of wing tip devices, whether wing fences, or winglets. Each wing design must be tested with different shapes to determine which gives the best result overall.

Airbus has now launched a technology programme entitled Aircraft Wing with Advanced Technology OpeRation (AWIATOR). It is contributing 60% of the 80 million Euro budget. A large variety of technologies will be investigated, developed and flight-tested on Airbus' flying testbed A340, MSN001. AWIATOR aim is to achieve a five to seven per cent reduction in drag, a two per cent reduction in fuel burn in long-range operation, and a noise reduction of 2 EPNdb. The programme will look at new devices to reduce the aircraft wake, new airbrakes, very large wing tip devices, new devices for flow control..

Alongside Airbus engineering teams in Europe, more than twenty industrial partners in Europe and Israel as well as European research institutes will jointly work to develop and validate the sophisticated technologies. They will be supported by a number of European universities and test centers.

Matrix of wind tunnel test options



- Many different options tested
- 23 options tested at low speed (initially)
- 8 options tested at high speed (initially)
- Range of sizes from 3.8m to 6m
- Variations of cant angles & toe angles included
- 3.8m fence included (+ toe effect) at both low speed & high speed for correlation with datum



Drag / lift technology

- ✦ « Three surface aircraft » concept:
 - Lift distribution
 - Operational consequences
 - On Board noise



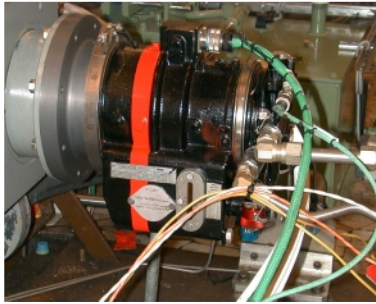
This is an example of research being conducted on lift surfaces .

Innovation in systems



High pressure hydraulic test bench

Water test bench



Variable frequency test bench



All systems can be the target for innovation. New technologies in electrical supply and distribution, in hydraulic supply, in water and waste that matters so much (weight, comfort, aircraft dispatch reliability). Full scale testing must be in place years before the airplane is put in service.

A380 innovation in cockpit & navigation

- Cockpit improvements are driven by *Flight safety enhancements, Lessons learnt from airlines and product added values:*



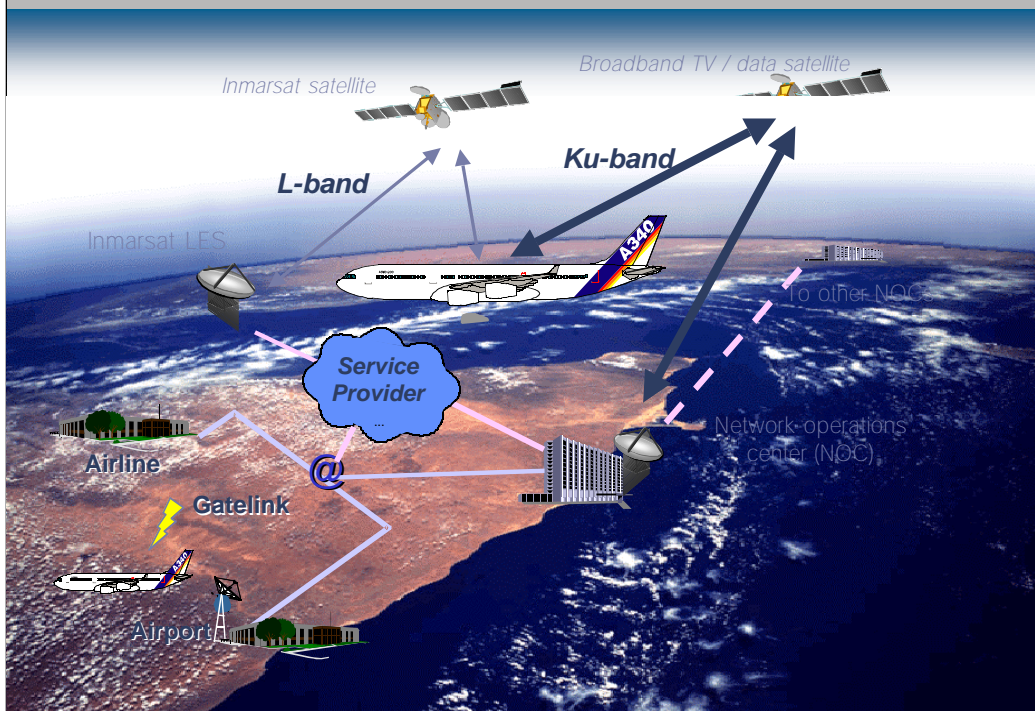
- camera/video, taxiing aids
- larger & interactive displays,
- FMS interface,
- enhanced ECAM,
- navigation on airports,
- take-off acceleration monitoring,
- on-board Information System
- thrust indication
- vertical situation awareness, collision avoidance
- enhanced crew rest

The “Airbus Cockpit Philosophy”, results of customers feed-back, experience, and research on new technology



The Airbus approach in the domain of cockpit innovation is to retain the much airline praised inter-operability (Crew cross qualification between families of airliners) while introducing on the last generation the new technologies that enhance the safety, the crew procedures, the crew awareness, its comfort, etc.

AFIS - global scope



- Access for several users of various applications and services:
 - Flight crew
 - Cabin crew
 - Passengers
- Communication media
 - Existing ones: VHF/HF/ Satcom
 - New ones: Gatelink
 - High Speed Data communication through satellites
- Ground network Airport / Airline / Ground operation center
- End to end service provider: from the airline to the aircraft including content:
 - weather maps
 - e-mail and internet connections for passengers

Conclusion: Wide scope
 Many potential users
 Many players

Addressing the noise sources



The aircraft external noise is an area that receives close attention and benefits from extensive research. Although the engines are the principal source of noise at take-off, the airframe contributes significantly during approach, a phase that concern significant populations around airports.

Outlined above are the main sources on which we are working: landing gears and high lift devices.

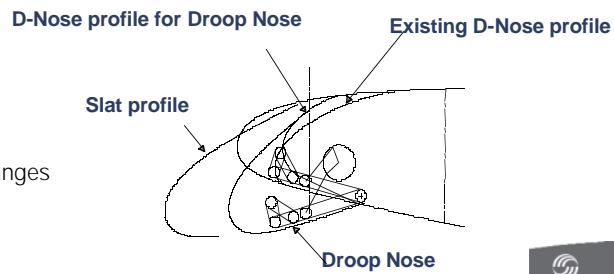
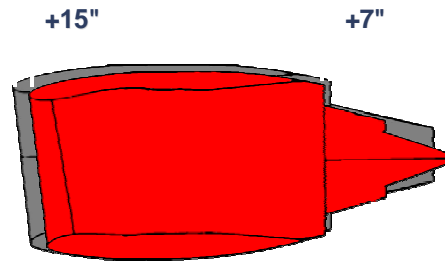
Reducing the noise generation (1)

→ Moving from QC4 to QC2 on the A380

→ Improved aircraft trajectory

→ Actions taken :

- Powerplant
 - Engines (116" fan,...)
 - Nacelle
- Aerodynamic
- Flutter
- Aircraft configuration
 - Slides
 - Rotor burst
 - Wing/nacelle/pylon changes

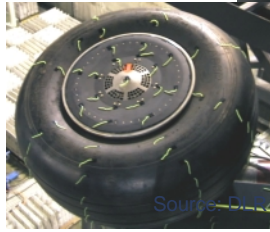


When it became apparent that the market expected that an airplane like the A380 due to enter service in 2006 had to pass the stringent noise requirement of London Heathrow airport (QC2 at take-off), a significant redesign of some areas of the airplane/engine combination was initiated. There was a cost in weight and performance, however the noise performance level was considered as having the n°1 priority.

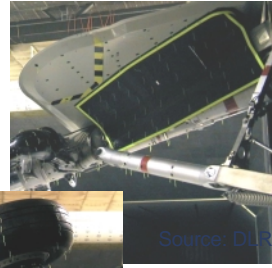
Fairings for Noise Reduction



Theoretic Optimum



Realisable Fairings



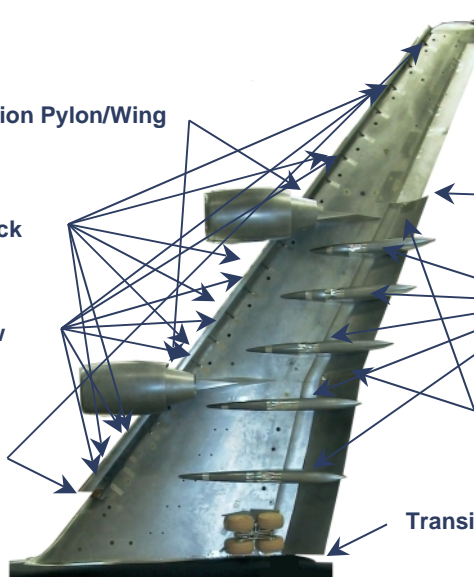
Aerodynamic Noise – High Lift Devices

Slat:

Transition Pylon/Wing
Slat Track
Slotflow
Slat edge

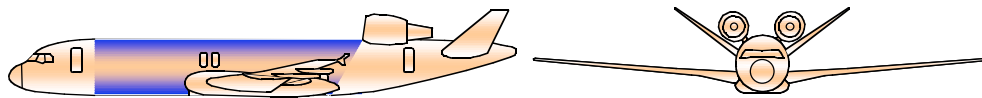
Flap:

Flap edge
Flap Track
Interaction Jet/Flap
Transition Wing/Fuselage



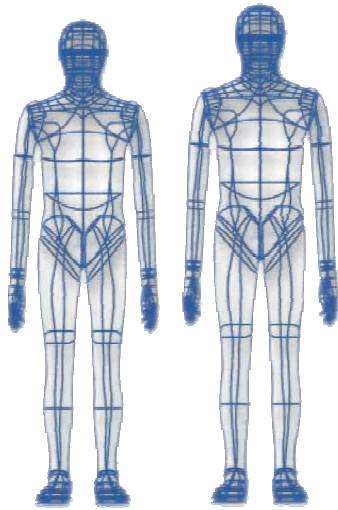
Noise Reduction – Aircraft Configuration

- Rear fuselage-mounted engines with appropriate empennage (V tail...)
- Shielded noise sources:
 - Upstream: Fan noise
 - Downstream: Fan, Combustion, Turbine noise
 - Limited shielding for jet noise;
- 5-9 dB improvement before source modifications



One could think of using the fuselage and the tail to shield the engine noise from reaching the ground. This is one configuration that the Airbus Future projects organization works on when looking for the lowest possible noise signature.

The ever-changing passenger



1960

1990

→ On-board baggage



1960



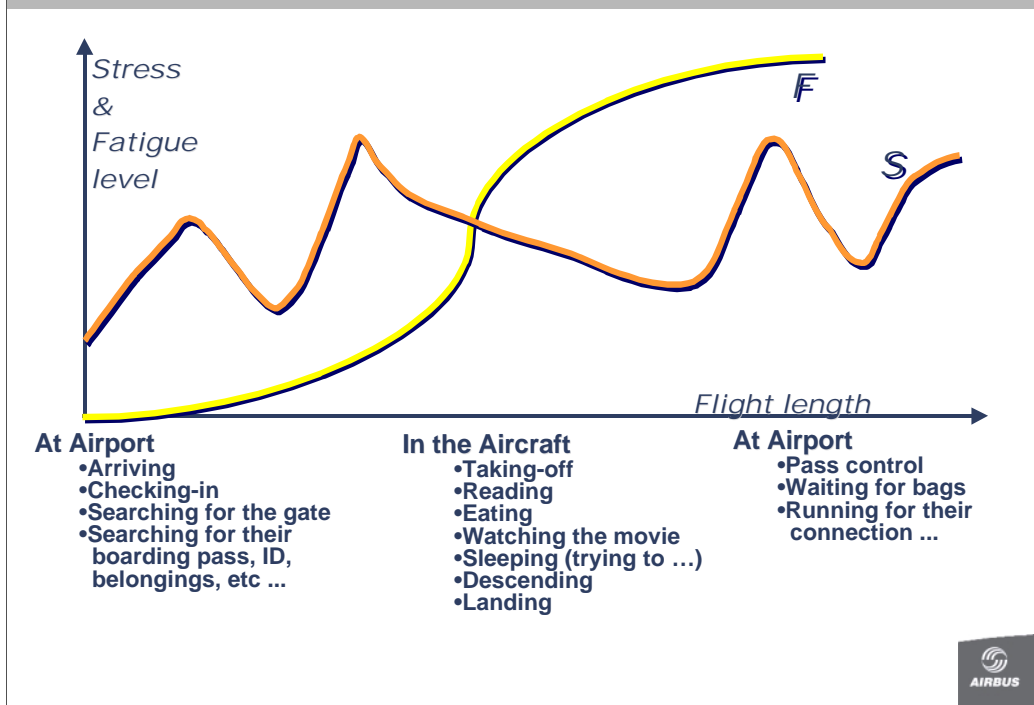
1990

- More leisure
- Less Business
- More demanding



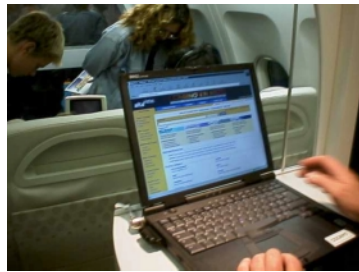
Don't forget the passenger who, by the way, is paying for the trip. He keeps changing, getting bigger, heavier (in most cases), more demanding, and wants to carry more stuff along... We will need to accommodate his numerous requirements.

Dealing with passenger stress ...



The air journey is not a complete pleasure: the body suffers, the brain and the heart, because of the stress. What can we bring to the passenger to relieve the tension, guarantee his health (air quality, enough volume, some freedom of movement, etc).

Passengers Access to Services



- Via personal laptop
 - E-Mail
 - On-board Internet
 - News, Sports, Business, Weather
 - Live Internet (under study)
 - Connectivity via
 - low speed modem
 - high speed USB or Ethernet
 - wireless LAN

- Via interactive seat-display
 - E-Mail (message service)
 - On-board Internet
 - News, Sports, Business, Weather

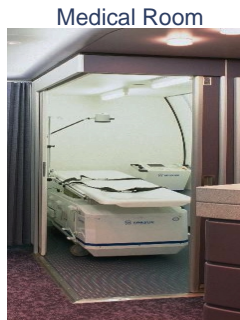


The passenger does not want to be disconnected. The air journey is not a journey on a cloud. He/she has left a place, certain people, he/she is going to meet with other people in another place. He/she is leaving, or he/she comes back, leading to a different set of feelings.

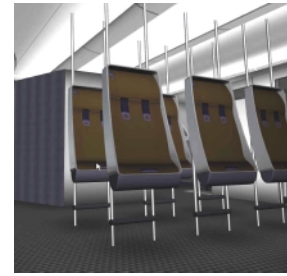
Future Perspectives - Cabin Comfort



Business Class Beds



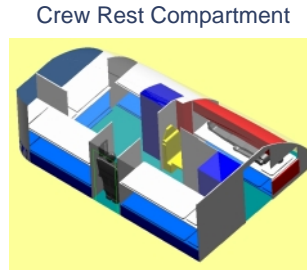
Medical Room



Standing Supports



Information Center



Crew Rest Compartment



Place to meet



Whether in materials, in connections, or in cabin volume uses, new technologies allow for less weight, better flexibility//convertibility, or new opportunities.

And beyond in time ? Product Line of 2020 ?



SMALLER ?

FARTHER ?

FASTER ?

CHEAPER ?

BIGGER ?

GREENER ?



Where do we go from now? We will keep the eyes and ears open to make sure the market drivers are well understood and not overlooked. As far as we can see, we are convinced that the Air Transport industry shall be governed by economic efficiency and environmental concern.

AIRBUS ***Setting the Standards***