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Title of the STS presentation:

"Flow Control Technologies: Needs for Advanced Experimental Testing and Validation"

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Objectives:

With the increase in fuel prices, flow control technologies are becoming of greater interest as being the means of achieving a technology quantum leap in the next generation of aircrafts, providing the means to achieve significant reduction in drag (fuel burn) and improvements in aircraft performance, shortening thus the path to accomplish the challenging Vision 2020.

Although investigated and applied to some extent during the past decades, Flow Control Technologies are now experimenting a renewed interest with the development of micro and nanotechnologies, which make it more interesting and effective in today's strict standards, in particular in civil aviation. Flow Control Technologies need, in order to reach flight readiness level, extensive testing and validation at both sub-system level and representative scale before being flight-tested. These experiments will also serve to validate CFD tools, those of industrial use such as RANS and turbulence models, LES and DES, as well as more advanced codes such as DNS, which have experimented great advanced in the past few years.

This presentation will illustrate the need for new advanced CFD development/validation and experimental testing in view of what has been described above as the means to make Flow Control Technologies a reality in the next generation of aircrafts.

Applications:

Flow Control Technologies have a wide range of applications on the overall aircraft and can be applied on domains as varied as laminar-turbulent transition control, turbulent skin friction drag reduction, separation control, active loads control, acoustics, etc. Passive devices are of special interest since they provide a relatively simple means of controlling the boundary layer flow without any need for energy input and covering large areas of the aircraft easily. Their application is, however, of limited potential and dependant on the flow regime (i.e., these devices are not capable of adapting to different flow conditions). Active devices, on the other hand, provide the means of reacting to the flow behaviour by means of sensors and actuators, giving a more effective and "flexible" system although more complicated and needing energy input.

Results:

It is apparent that the two largest sources of drag for a representative civil transport aircraft are profile and vortex drag and it is these that Flow Control Technologies can target.
Profile Drag can be reduced through direct drag reduction technologies, for such as: transition control for extended regions of laminar flow, turbulent skin friction drag reduction. Other alternative is through indirect drag reduction technologies, such as: change in sizing criteria to reduce high speed drag penalty imposed by a low speed constraint as in horizontal tail plane case.
On the other hand, Vortex Drag can be indirectly reduced through the unlocking of traditional configuration constraints such as reducing buffet constraint on a design which, for a fixed aircraft weight will allow an increase in wing span. Also, for the same top level aircraft requirements, using active flow control to enable a simpler and/or smaller high lift system will allow for a more structurally efficient wing box.

Future:

To achieve the challenging goals set by ACARE SRA and Vision 2020 and guarantee a sustainable development of air traffic, as well as fighting the effect of soaring fuel prices, a step change is necessary for the next generation of aircraft when compared with the "classical" aircraft flying today. This change will come not only by new configurations but also by the use of advanced technology in all domains. In the case of flight physics, flow control technologies will allow that step change. Although studied for several decades, recent developments in science will allow a more effective and attractive application of flow control, developments such as micro and nanotechnology, energy harvesting systems, fuel cells, new materials and manufacturing methods, superconductors, etc. The future of these technologies, however, will go through the development of advanced experimental testing techniques and validation of adapted CFD methods, which will allow the maturing of these technologies to flight readiness level faster and more robustly.

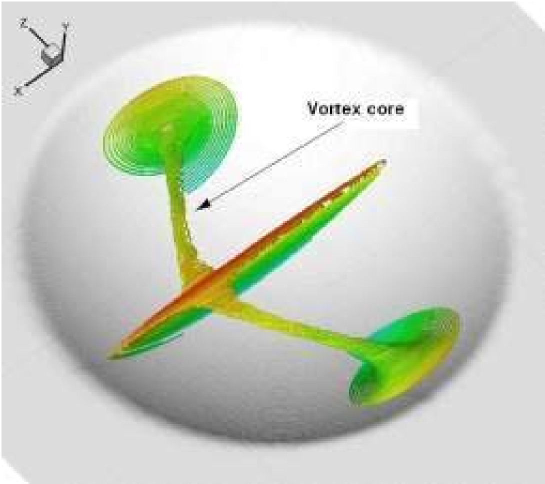

Figure 1 - Dimple structure example

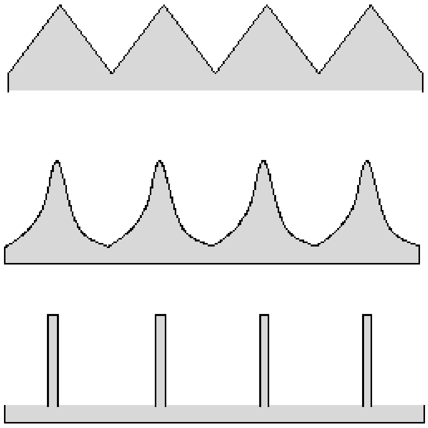

Figure 2 - Riblets

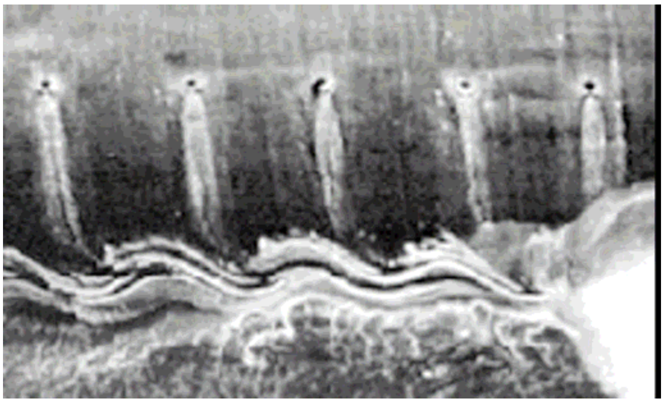

Figure 3 – Massless Jets

Figure 4 – Sub-Boundary layer VG

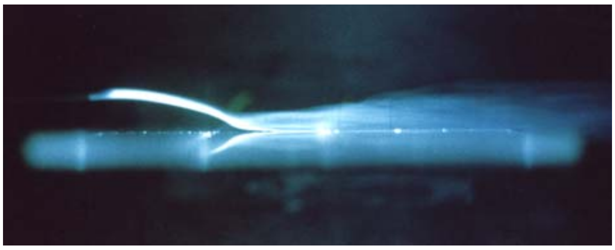

Figure 5 – Plasma Discharge

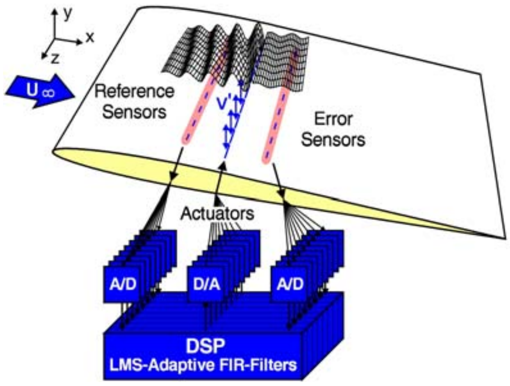

Figure 6 – Active BL control system

Figure 7 - Cryoplane: BL control by heat transfer

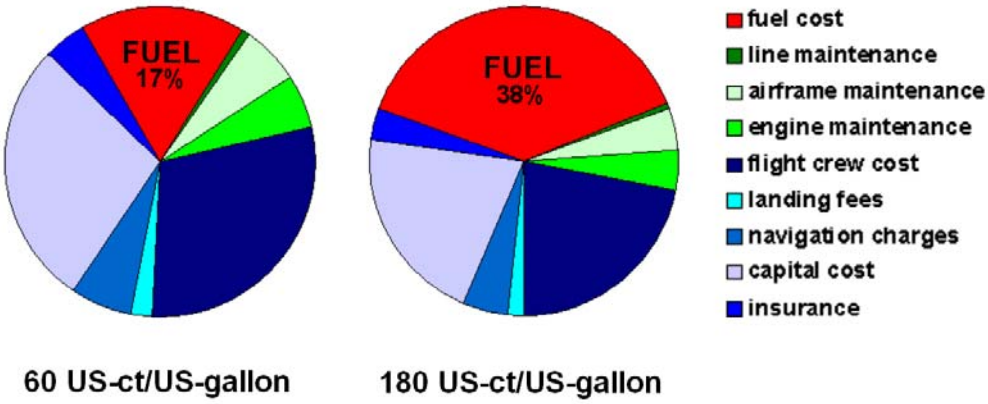

Figure 8 - DOC shares for typical mission – fuel cost comparison

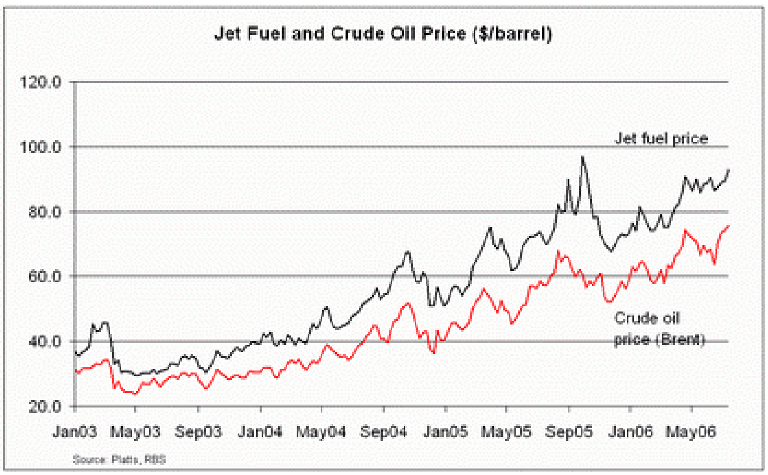

Figure 9 - Jet Fuel and Crude Oil Prices Comparison