Active Flow Control for Aerospace Operations by Dense Wireless Sensor and Actuator Networks

CISTER – Research Centre in Real-Time & Embedded Computing Systems

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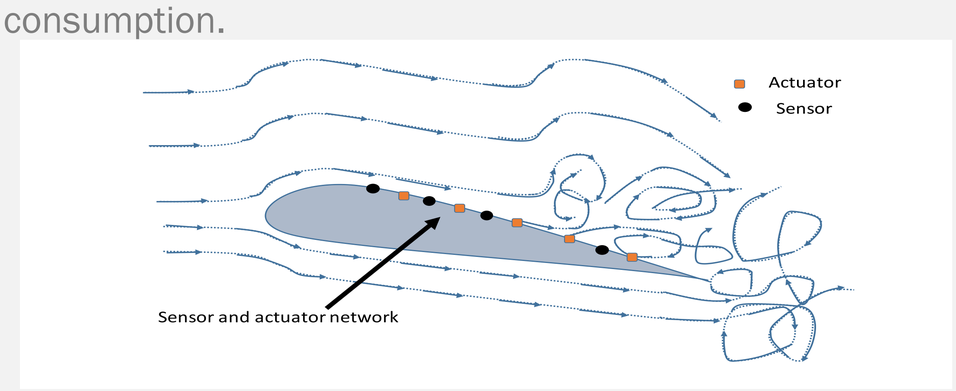
Objectives

- Delay of boundary layer formation of turbulent flows across the fuselage of an aircraft.
- Reduction of skin drag.
- Reduction of fuel consumption in modern commercial aircraft.
- DEWI bubble as enabler of a dense wireless sensor and actuator network for tracking and compensation of turbulence.

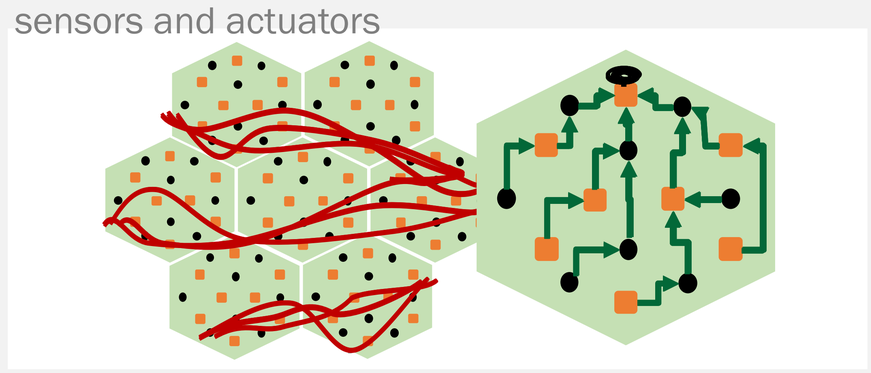
Basics

- Turbulence is created across the fuselage of aircraft due to complex interactions between viscous and shear forces of fluids in motion
- Flow control attempts to reduce the turbulent formation and delay the separation layer between laminar and turbulent streams.
- Laminar flow is desirable on the fuselage of aircrafts.
- Turbulence reduces the lift force on the plane
- This reduces the efficiency of the plane and thus increases fuel consumption.



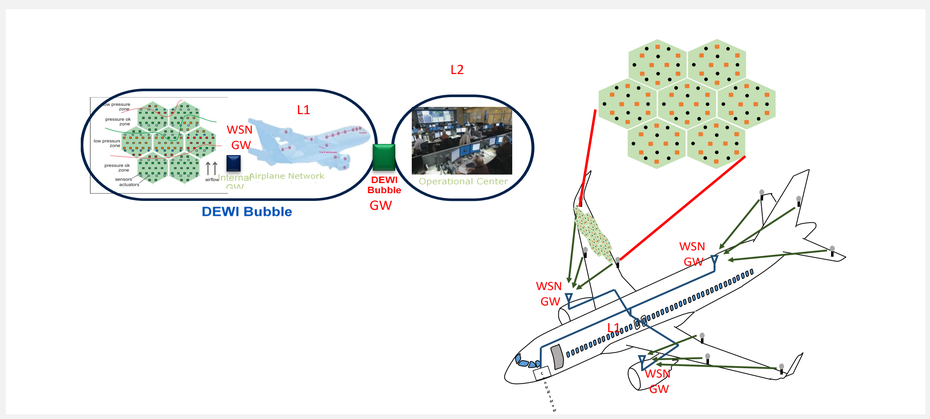
Patch design

- Dense arrays of sensors and actuators will be wired together forming a patch
- Each patch will have a master node in charge of resource management and provided with a wireless transceiver
- Fuselage will be covered by a wireless network of patches of sensors and actuators



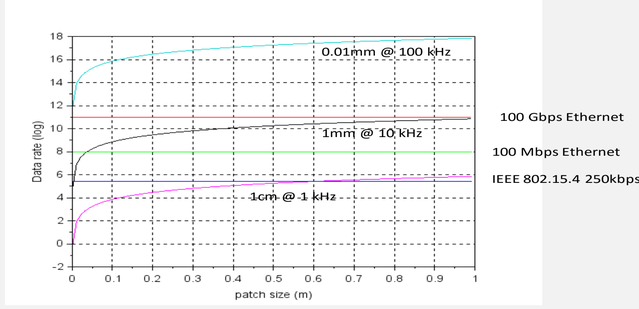
DEWI Bubble

- The DEWI (dependable wireless infrastructure) Bubble is a higher level abstraction of a wireless sensor and actuator network with improved management and interoperability.
- DEWI bubble will track the boundary layer formation between turbulent and laminar flow (2D curve).
- The 2D curve information can be compressed (using fit models)



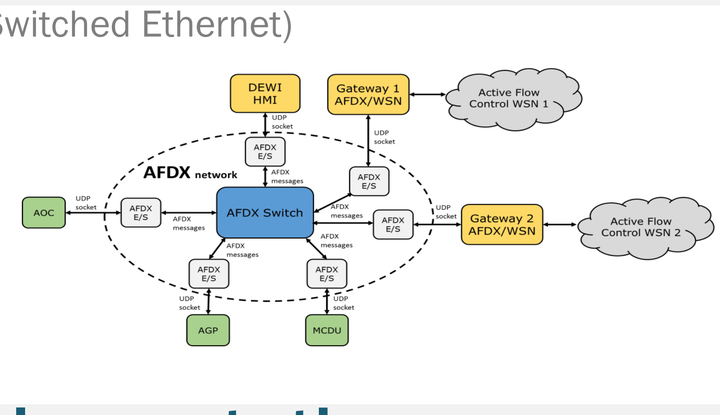
Scalability

- Turbulence phenomena can be characterized at different levels of spatial and temporal requirements
- Mix of wireless and wireline technology will be able to control different aspects of turbulence
- Size of patch and the number of sensors and actuators per patch can be obtained by mapping capacity of wireless and wireline components to turbulence measurement requirements



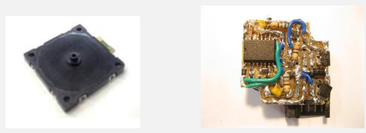
Integration with internal aeronautical subsystems

- Sensor information has to be passed to the internal network of the aircraft.
- The most common standard for this network is AFDX (Avionics Full Duplex Switched Ethernet)



Implementation

- Pressure sensors will track the formation of the low pressure area created by turbulent flows
- Synthetic jet actuators (SJAs) will be used to delay the separation between laminar and turbulent flows.



Concluding Remarks

1. An active flow control system for skin drag reduction was proposed using a combination of wireless/wireline technology under the DEWI Bubble concept
2. Requirements and architecture have been defined
3. Scalability studies, integration with internal aeronautics network, and simulation work have also been completed.
4. Implementation work has been started using pressure sensors and synthetic jet actuators (SJAs)

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