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Advances in Aeronautical Systems Research

Kavendra Naidoo

Contents

- Aerospace systems design: challenging best practice
- Flight simulation: saving the planet one drag count at a time
- Unmanned systems

Aerospace systems design: challenging best practice

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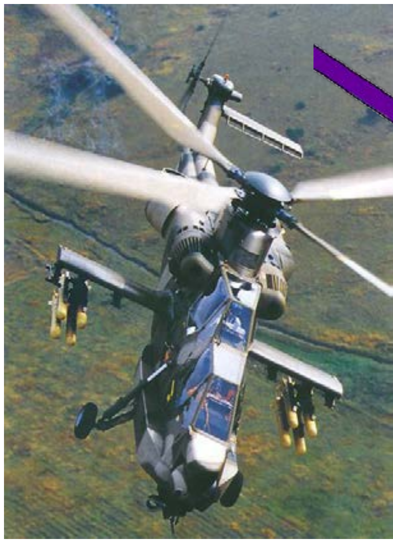
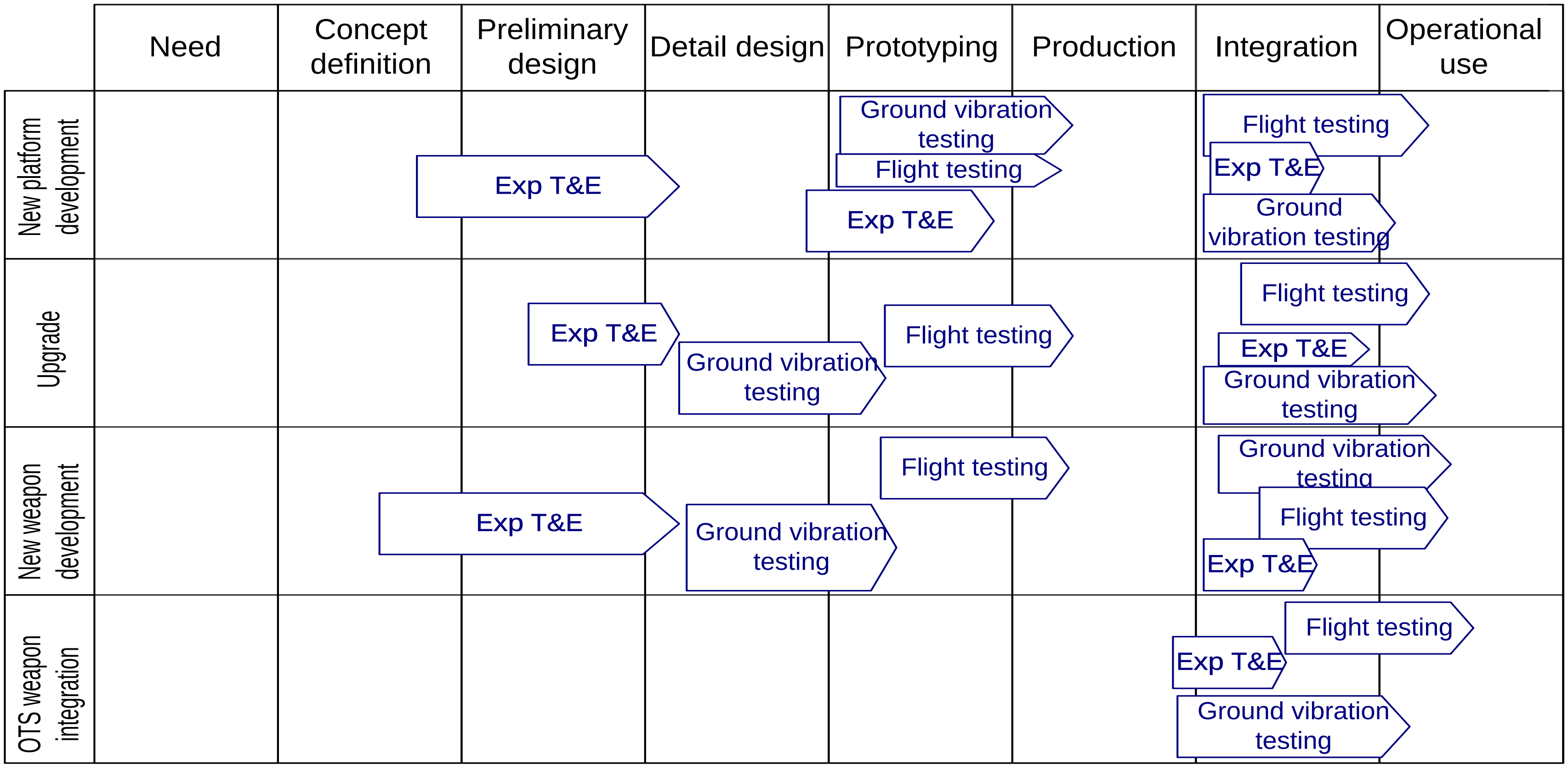
The challenge



- Traditional design approaches are expensive and time consuming
- Affordable by only the large aerospace nations
- Dynamic market and threat environment makes this undesirable
- The Aerospace industry has one of the largest multiplier and spill over effects
- Desirable for job creation, GDP growth and technology diffusion to other sectors

Flight simulation

Flight simulation



Challenging best practice

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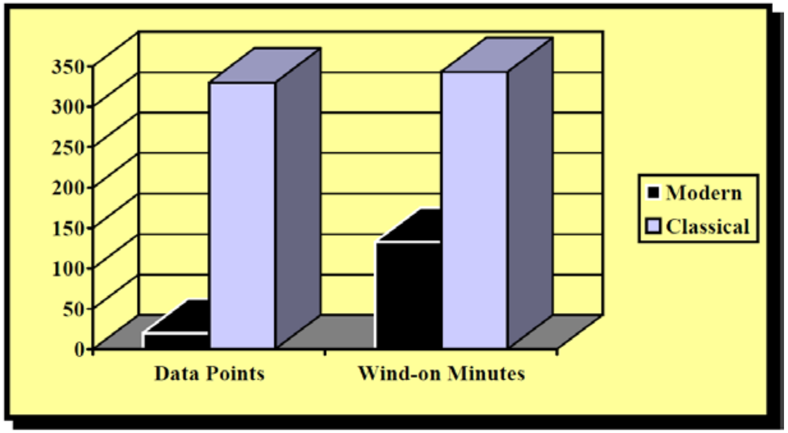

Figure 1: Comparison of Modern and Classical data volume and wind-on minutes

From: DeLoach, R. (2000), The Modern Design of Experiments: A Technical and Marketing Framework, 21st AIAA Advanced Measurement Technology and Ground Testing Conference

- Challenge practice of exploring and evaluating problem dependencies One Factor at a Time
- How do input factors X impact on output variables Y?
  - Which factors X are most significant?
  - What is relationship between X & Y?
- Modern design of experiment (MDOE) is more productive, less costly & has higher quality compared with conventional test methods in aerospace industry known as One Factor At a Time (OFAT) testing

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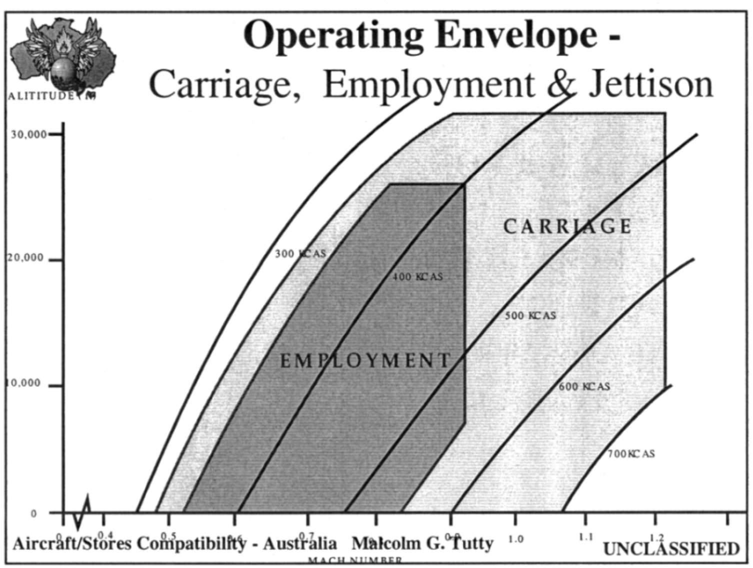
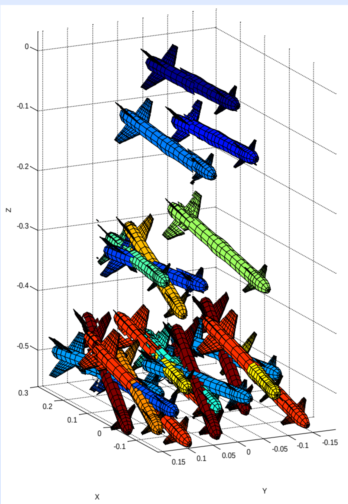
Challenging best practice



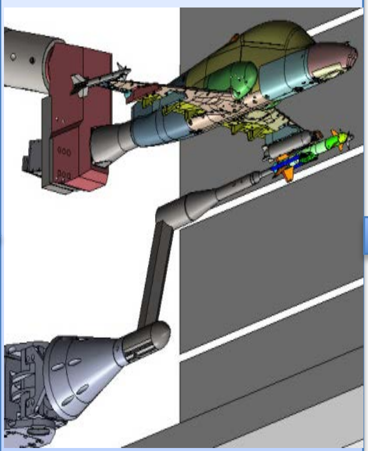
- Regulatory requirements - store integration:
  - Verify stores can be released safely over full employment & jettison envelopes
  - Includes all perturbations of:
    - store mass and physical properties
    - ejector release unit performance
    - aircraft release flight conditions
    - stations on aircraft
    - neighbouring stores
  - MIL-HDBK 1763: 271.4
  - Results in a very large analysis matrix!

Tutty, M.G., “Aircraft/Stores Compatibility - The Australian Perspective”, 1998

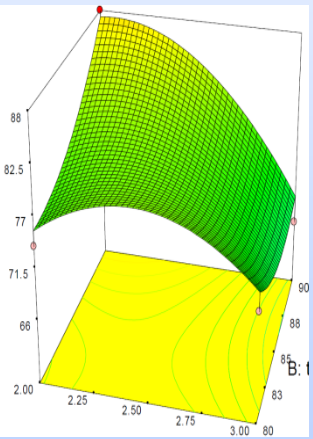
Challenging best practice



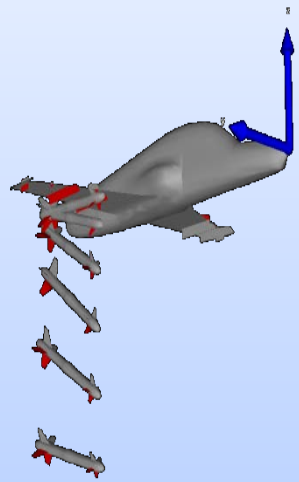
Optimise design test matrices



Flight simulation & analysis



Fit response surfaces to data



Flight envelope clearance for safety board

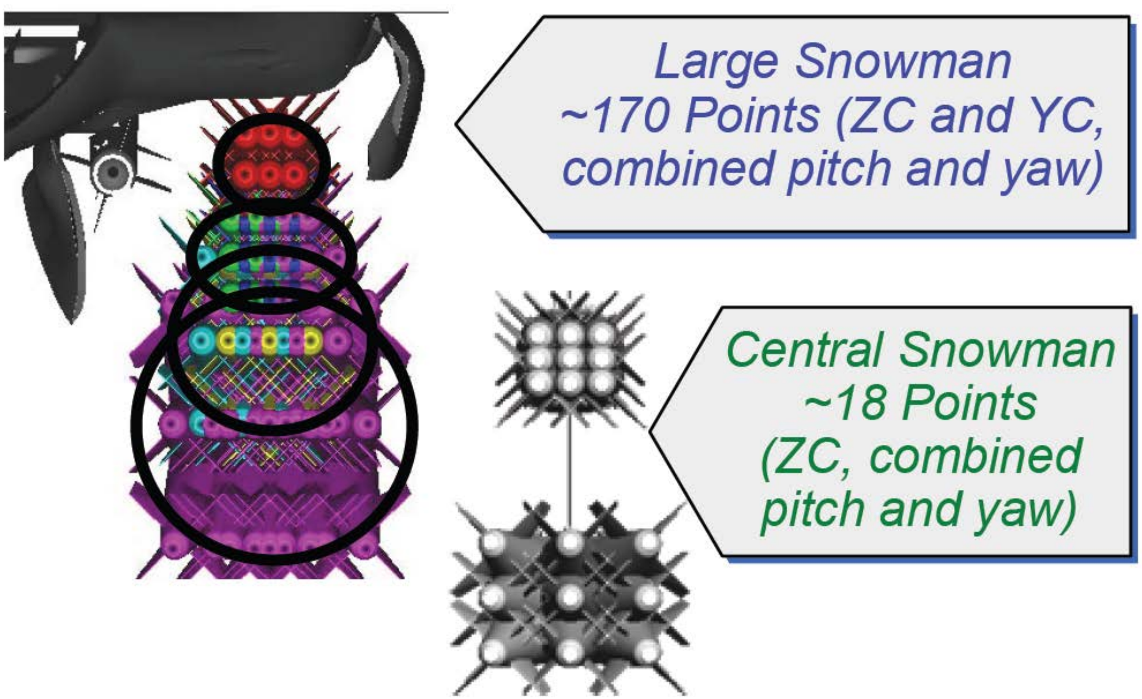
Process of Test Design to Submission to Safety Board

Challenging best practice

Lockheed Martin F-35 Joint Strike Fighter Programme

Challenging best practice

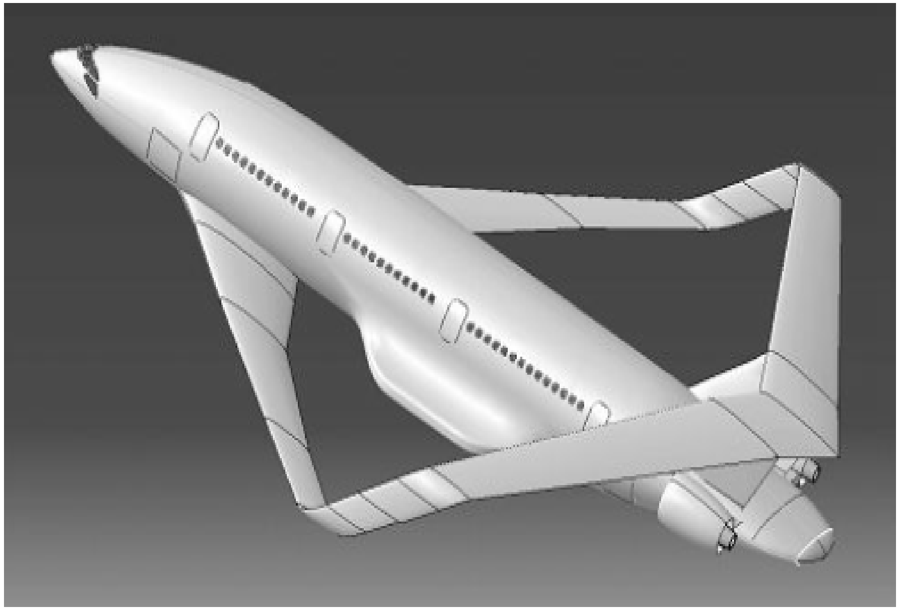
- MDOE applied to store grid points
  - Precedent: MDOE-like (Taguchi matrix) technique applied to JSF (F-35) tests
  - JSF tests used just 18 points for one configuration

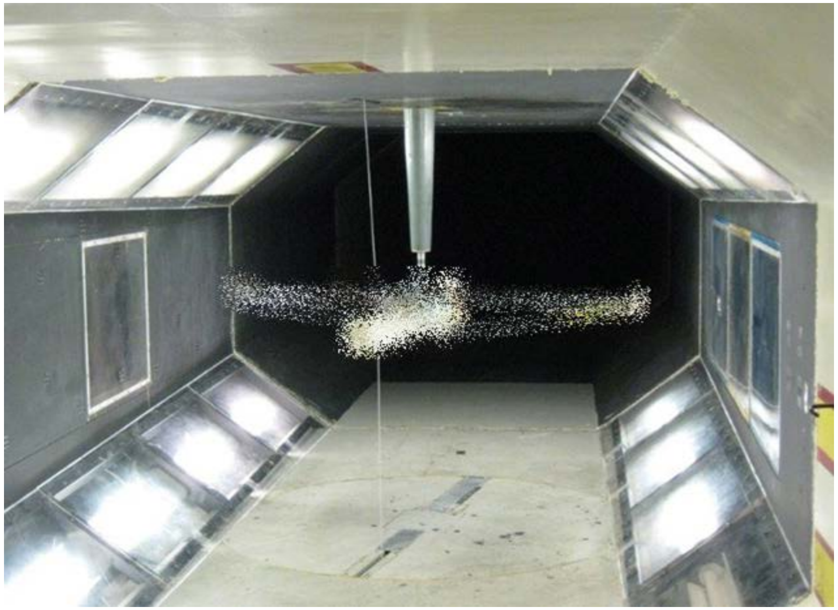


Hetreed, C., Purdon, M., Hudson, M., *Safe separation analysis of the internal GBU-32 JDAM from JSF*, MSC Software VPD Conference, July 2006.

Challenging best practice

Typical configuration tested in CSIR flight simulation facilities: joined wing configuration





-6° ≤ angle of attack ≤ 18°
-10° ≤ side slip ≤ 10°
-15° ≤ forward control surface deflection ≤ 15°
-8° ≤ after control surface deflection ≤ 15 °
10 Factors

Flight simulation: saving the planet one drag count at a time

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Future trends : commercial travel

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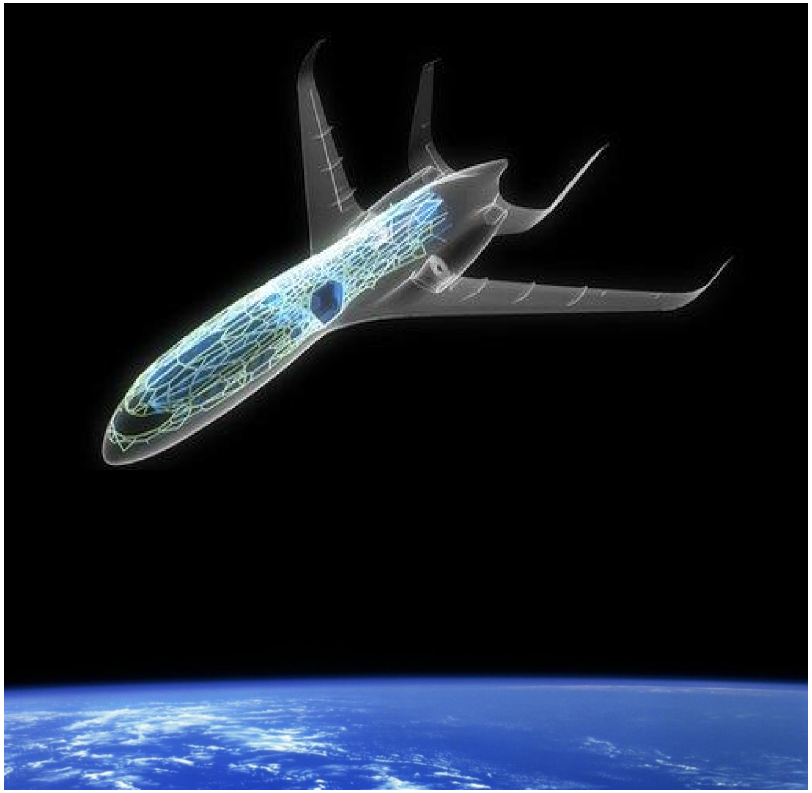

- Increase demand for global mobility
- Increased demand regional mobility
- Increased pressure on natural resources and climate change
- Faster, cheaper, lower environmental impact, more comfort.

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Pioneering air transport of the future

- Project NOVEMOR
- Novel Air Configurations: from Fluttering Wings to Morphing Configurations
- European Union Consortium Programme to Pioneer Air Transport of the Future through breakthrough and emerging technologies
- Investigate the benefit of wing leading and trailing edge camber and modifications to wingtip geometries

SEVENTH FRAMEWORK PROGRAMME

NOVEMOR
NOVEL AIR VEHICLE CONFIGURATIONS

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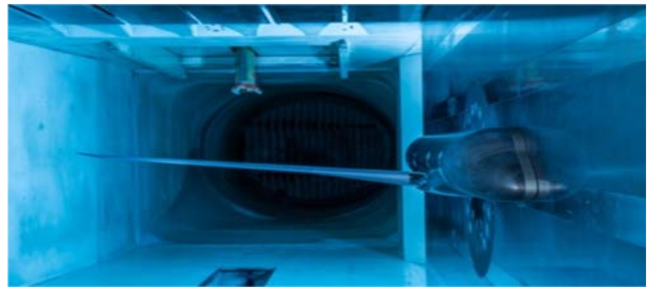

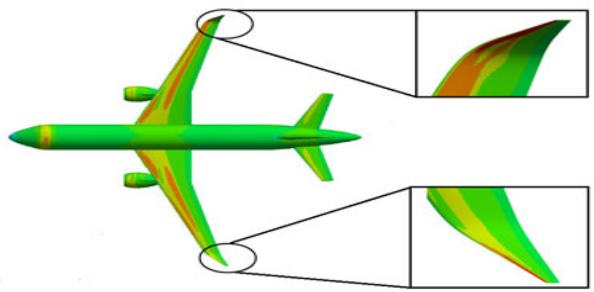

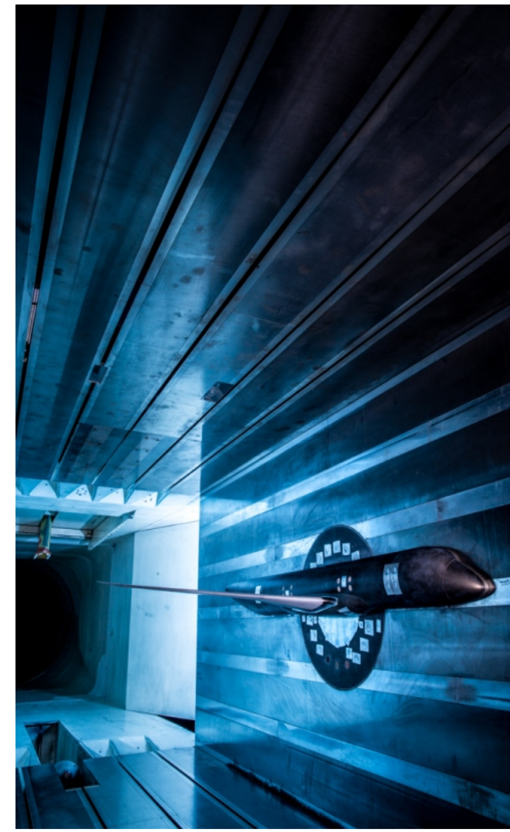

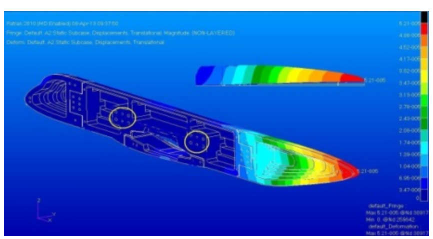

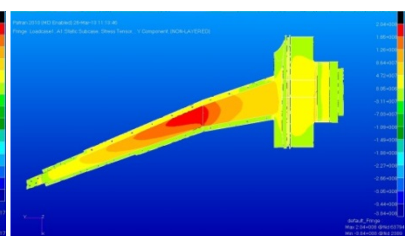

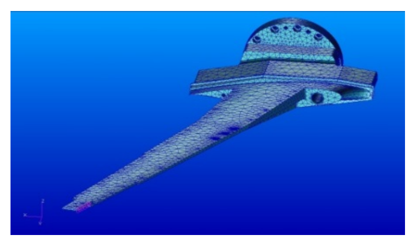

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Pioneering air transport of the future

- Development of aerodynamic concepts including structural mechanisms
- Development of computational tools for optimisation and characterisation
- Wind tunnel flight simulation and validation of computed data
- Consider energy, cost and impact on green house gas emissions

SEVENTH FRAMEWORK PROGRAMME

NOVEMOR
NOVEL AIR VEHICLE CONFIGURATIONS

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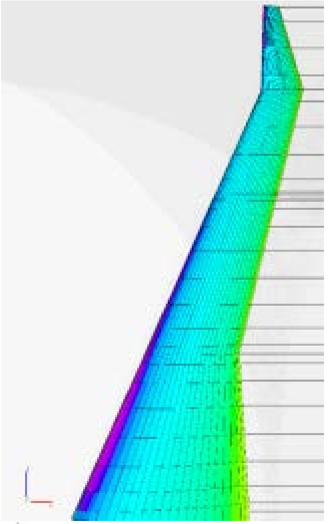
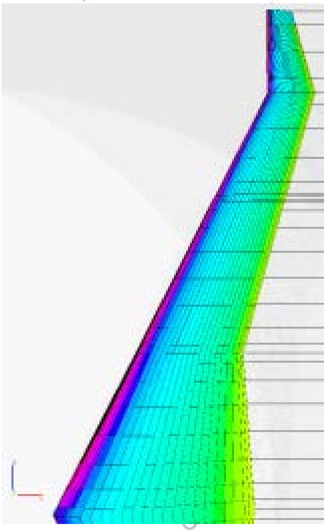
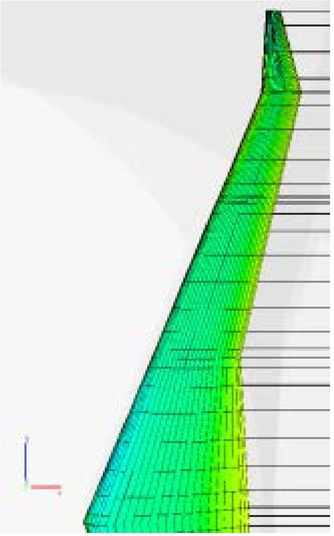
Computed results

Gains	Cruise	Climb		Hold	
	Optimum Wingtip	Optimum Angles	Optimum Wingtip	Optimum Angles	Optimum Wingtip
Fuel Consumption [%]	8.21	12.54	13.02	-2.33	-2.31
Range [%]	9.84	-	-	-	-


Optimum Cruise Winglet


Optimum Climb Winglet


Optimum Hold Winglet

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Pioneering air transport of the future

SPECIFICATIONS

[redacted]		
Maximum Takeoff Weight	127,943 lb	58,034 kg
Maximum Landing Weight	116,920 lb	53,034 kg
Maximum Zero Fuel Weight	105,896 lb	48,034 kg
Basic Operation Weight	75,032 lb	34,034 kg
Maximum Payload	30,865 lb	14,000 kg
Maximum Fuel*	39,683 lb	18,000 kg
*Fuel Density: 0.803 kg/l (6.70 lb/gal)		
[redacted]		
Maximum Operating Speed	M 0.82	M 0.82
Time to Climb to FL 350, TOW for 600nm	17 min	17 min
Takeoff Field Length, ISA, SL, MTOW	4,889 ft	1,490 m
Takeoff Field Length, ISA, SL, TOW to 600 nm	3,780 ft	1,152 m
Landing Field Length, ISA, SL, MLW	5,334 ft	1,626 m
Range 113 PAX @ 220 lb (100 kg), LRC	2,369 nm	4,387 km
[redacted]		
Wingspan	56 ft 6 in	17.23 m
Length Overall	120 ft 11 in	36.86 m
Horizontal Stabilizer Span	38 ft 12 in	11.88 m
Fuselage Width	11 ft 6 in	3.5 m
Fuselage Height	11 ft 6 in	3.5 m
[redacted]		
Cabin Length	94.50 ft	28.805 m
Cabin Width	10.54 ft	3.214 m
Cabin Height	6.97 ft	2.125 m
Aisle Width	15.75 in	0.40 m

INITIAL SPECIFICATION

Transonic Regional Jet

Maximum Operating Speed of M=0.82

113 PAX LRC(113 PAX @220lb) = 2369nm

LRC distance from FRA

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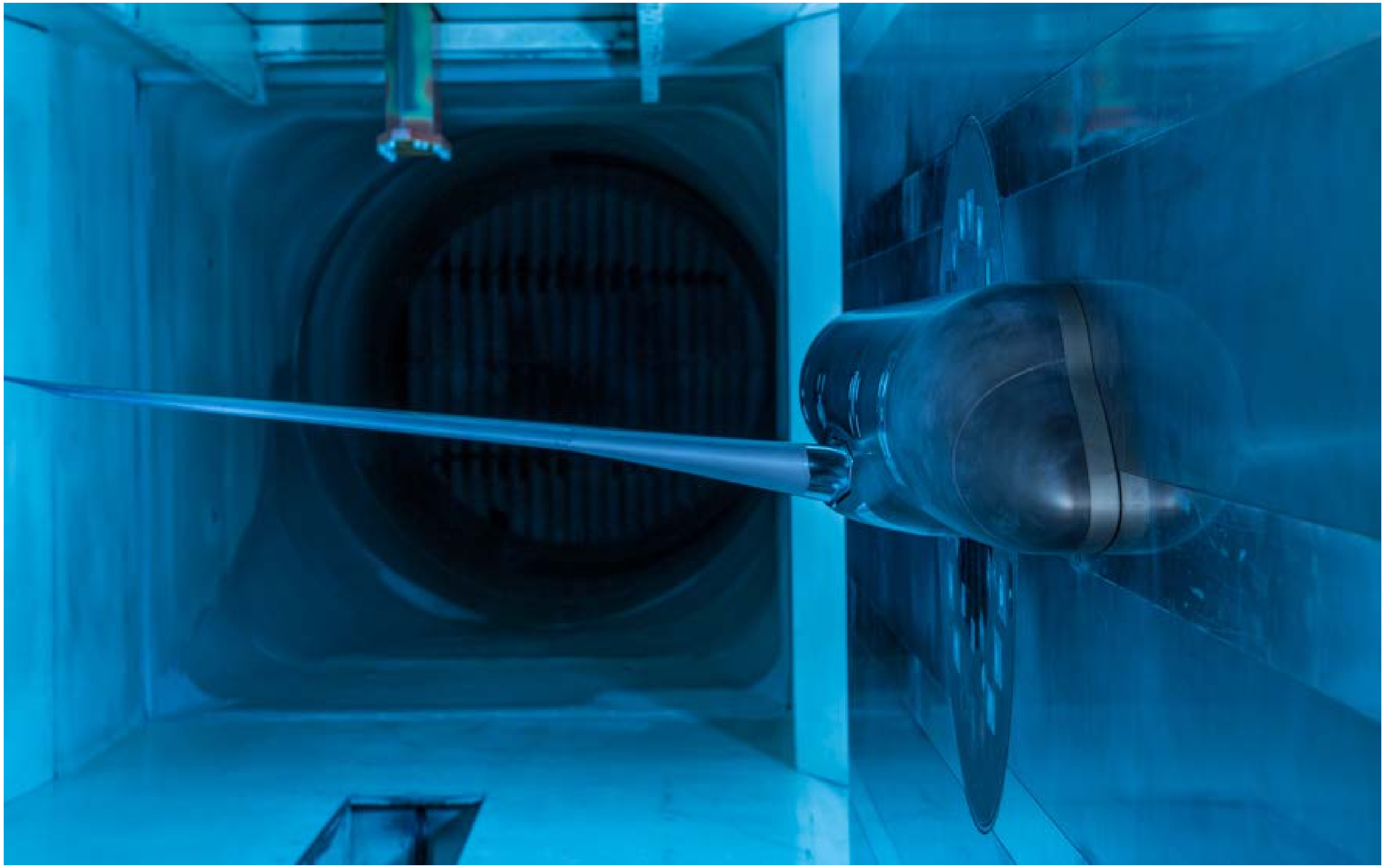

Proposed regional aircraft concept

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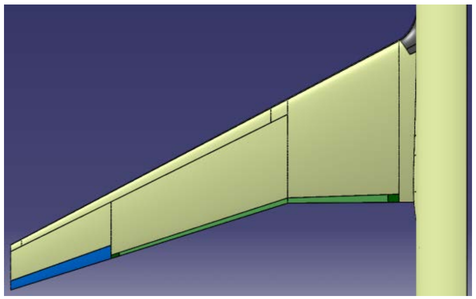
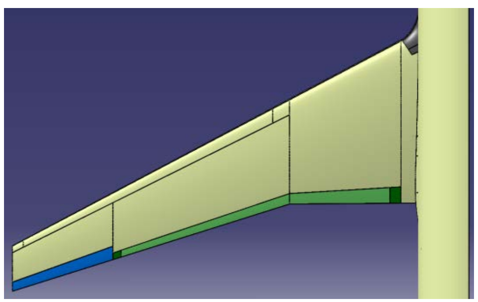
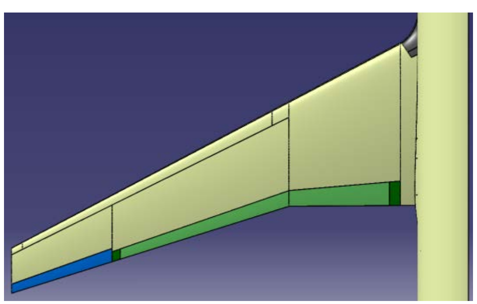
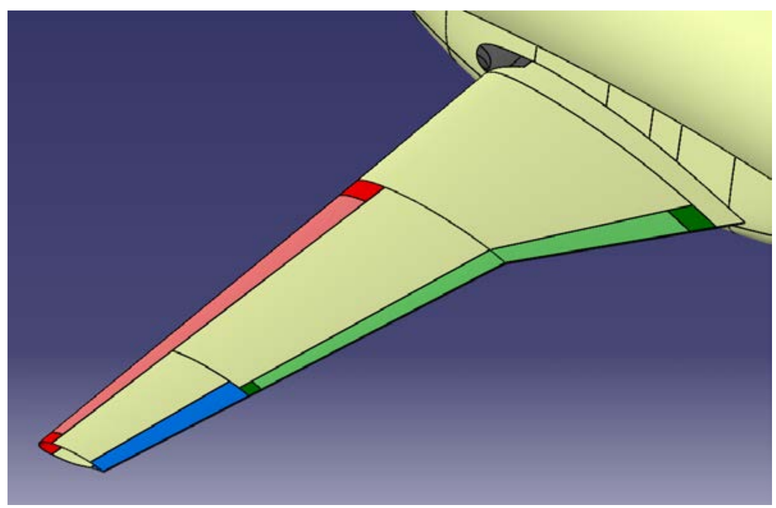
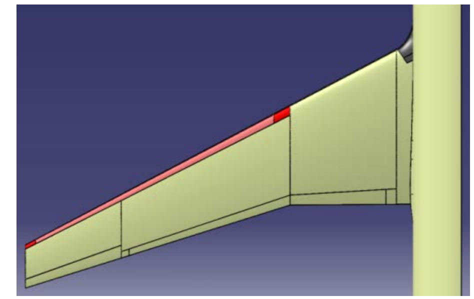


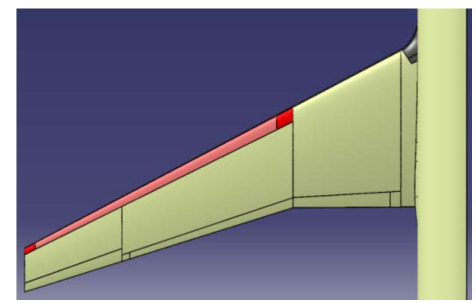


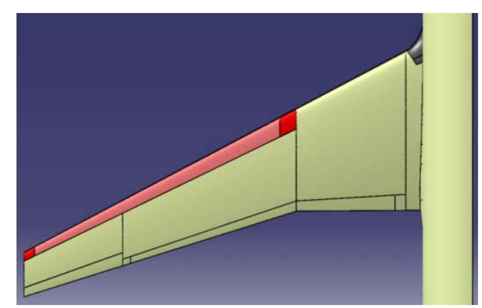


- 3 morphing devices:
  - Morphing leading edge for low speed;
  - Morphing leading edge for high speed;
  - Morphing trailing edge for low speed;







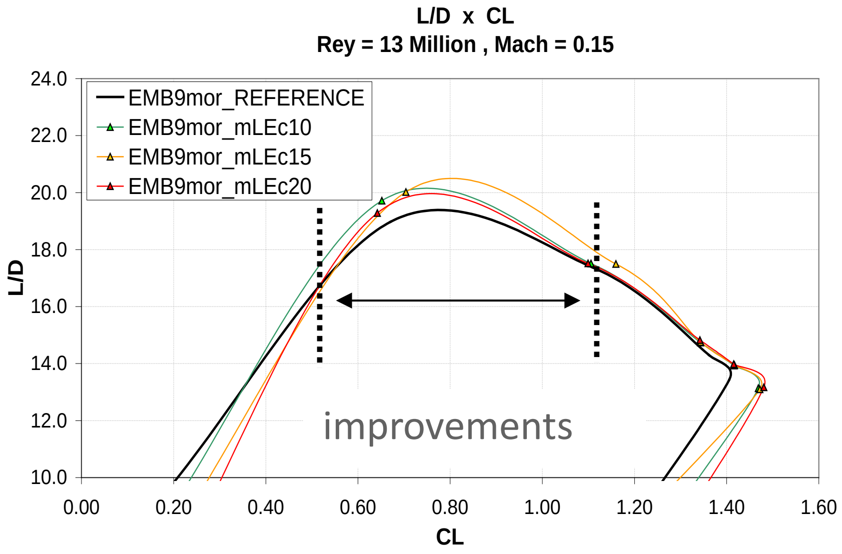


Pioneering air transport of the future

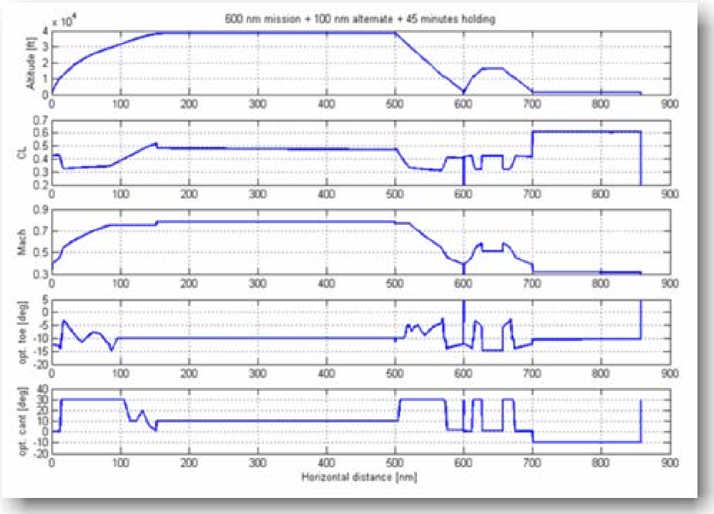
Typical mission + 100 nm alternate + 45 minutes holding

Payload	= 12000kg
Range	= 600nm
Mach Number	= 0.78
Cruise altitude	= 38000ft

TOW = 51126kg



Holding 45 minutes @ CL = 0.6



CL	mLE_c10	mLE_c15	mLE_C20
0.6	5%	0%	3%
0.7	3%	6%	1%
0.8	3%	5%	1%
1.0	1%	3%	1%

Δ fuel ≈ 62 kg (5% of 1236 Kg)

Pioneering air transport of the future

- Embraer foresees the morphing devices as a promising technology that can and will provide benefits to ACARE main goals
- The employment of the morphing devices, at the regional aviation, might occur in at a later stage due to the following peculiarities
  - It is not possible to rely entirely on the morphing devices to satisfy the demanded aircraft field performance
  - High-lift devices are still necessary
  - Regional jet wings are relatively small, which brings difficulties to have any kind of mixed solution: conventional high-lift devices and morphing devices

Pioneering air transport of the future

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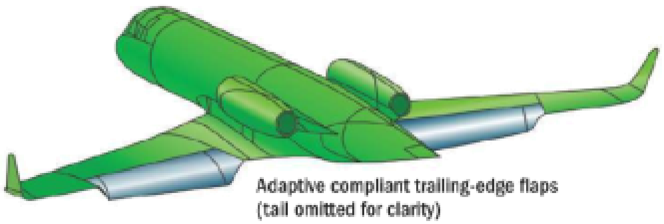
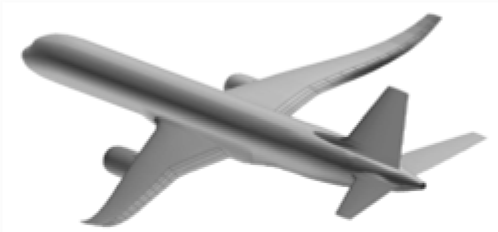
- Embraer envisions the initial employment of the morphing technology at the following aviation segments:

UAVs

Business jets

Long-range commercial jets





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Unmanned systems

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Unmanned systems

- Autonomous flight a reality
- Significant platform advances
- Ongoing payload advancements
- Thousands of COTS systems
- Reduced Cost and improved access in some classes
- Increased cost, complexity and restricted access in other classes
- SA developing unmanned systems for decades and has operated a UAV squadron previously

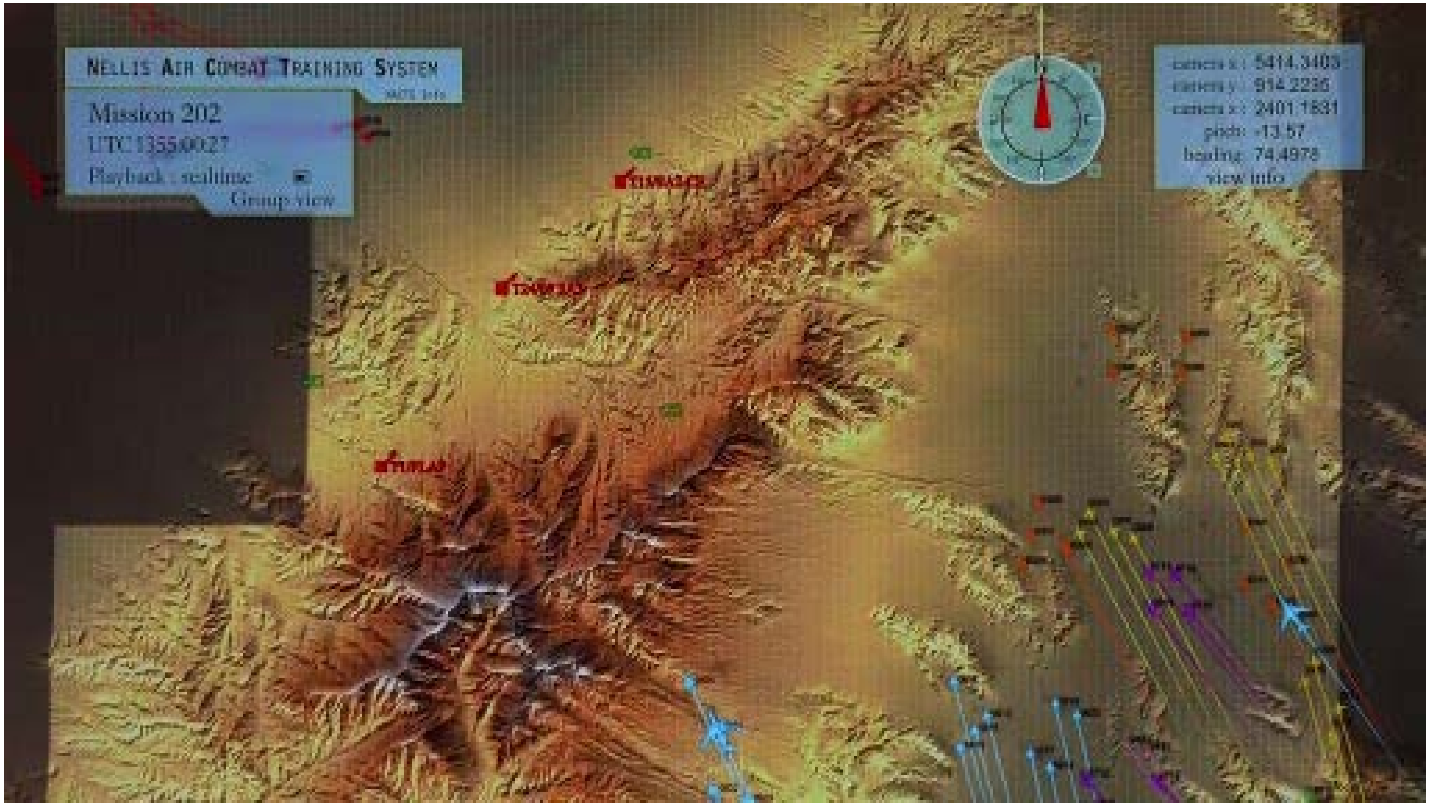
Unmanned systems

- Understanding the entire problem
- Identify Friend or Foe
- Can you see and confirm the nature of the threat
- Required system functions and performance
- Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)
- Acquisition
- Bringing into service and integration into operations for mission effectiveness

Unmanned systems

Screen shot from IMAX production: Operation Red Flag
Nellis Air Combat Training System

Unmanned systems



Screen shot from IMAX production: Operation Red Flag
Nellis Air Combat Training System

Unmanned systems

- Concept of Operations including C4ISR
- Sensor Performance
- Data Management and Data Fusion
- Damage tolerance for hostile environment
- Endurance and mass (including power)
- Time and distance

Thank you