SMART TESTING BOMBARDIER THOUGHTS

FAA Bombardier Workshop

Montreal

15-18th September 2015

BOMBARDIER
l'évolution de la mobilité

SMART TESTING

LEVERAGING ANALYSIS METHODS

- As the knowledge base increases through test validated analytical solutions, potential for increased efficiency of subsequent test validations increases.
- The efficiency should not be only observed through natural tendency to reduce direct cost by reducing the number of test specimens, but also as overall efficiency of certification process resulting from increased ability to recognize critical failure modes in a given structure.
- As we go through certification process, acceptable level of safety becomes more and more recognizable which ultimately becomes the basis for the optimization of subsequent testing programs.
- Relevant field experience should also be considered.
- We should possibly think of applicability to large (full-scale) sub-components and full scale aircraft components where validation is required and where failure modes and their interactions can be relatively easily recognized on the basis of previous (validated) experience for a given design space.
- Optimizing testing program at coupon level (allowable) is not necessarily an objective unless equivalency of engineering space can be demonstrated

BOMBARDIER
l'évolution de la mobilité

SMART TESTING

LEVERAGING ANALYSIS METHODS

- Essentially analysis drives the selection of test articles in terms of loading (mechanical and thermal), complexity and novelty of design features, recognized failure modes, anticipated utilization, hybrid structure considerations etc.
- One could think of the process as addressing design features that were not part of previously interrogated design space.
- Analysis can also be used to establish “compatibility” of the new design with previous (referenced) designs in order to optimize test program for the new design.
- It is considered critical to establish boundaries (limitations) of analytical solutions (configuration, design space, environmental and accidental threats, anticipated utilization etc.
- Leveraging analysis would ultimately mean utilization of previously test validated analytical methods in order to optimize test interrogations (number and complexity) for new designs that are found to be similar in critical design features to previously certified products

BOMBARDIER
l'évolution de la mobilité

SMART TESTING

TESTING OPTIMIZATION

- Increased reliance on analytical evaluations to guide test specimen selection and protocols, possibly involving details, large sub-components and full scale components (analysis used to search for critical failure modes).
- Increased reliance on pre-production test articles (demonstrators) as oppose to complete aircraft and think of complementing “gaps” (near production configuration) by sub-components and details which may be due to alteration of critical manufacturing process parameters).
- The approach allows for more timely (also less risky) structural interrogations given that static strength interrogations are adequately addressed after fatigue cycling.
- Optimizing testing program by breaking down major structural components into typical and representative elements (i.e. typical fuselage segment, wing, etc.) offers potential for early interrogations of simpler articles
- Rationalizing to a single full scale test component (cycling + static)

BOMBARDIER
l'évolution de la mobilité

SMART TESTING

UNIQUE ISSUES/CHALLENGES

- One of the major challenges remain hybrid structure test interrogations including environmental effects.
- Incompatibility of fatigue loading spectra relative to different sensitivity to load magnitude between composite and metals
- Application of Load Enhancement Factors (LEF) in fatigue interrogations potentially triggers premature cracking in metallic structure
- Environmental Compensation Load Factors (ECLF) in static strength interrogations
- Difficulty in adequate thermal loading applications and ability to compensate for temperature via mechanical loading (in most cases not representative) as the mechanical loads are balanced differently compared to thermal.
- Nearly adjacent structural detail may be critical for different environmental conditions
- Thru-thickness temperature gradients (i.e. fuel tank)
- Upper and lower surfaces could be at significantly different thermal state (i.e. wing, horizontal stabilizer etc.) for the same aircraft thermal condition
- Some structural elements are driven by the internally generated heat (i.e. effects of systems)…..

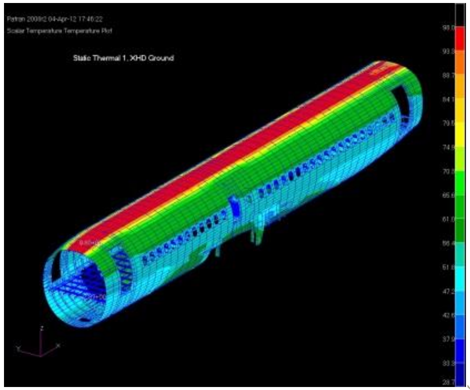
BOMBARDIER
l'évolution de la mobilité

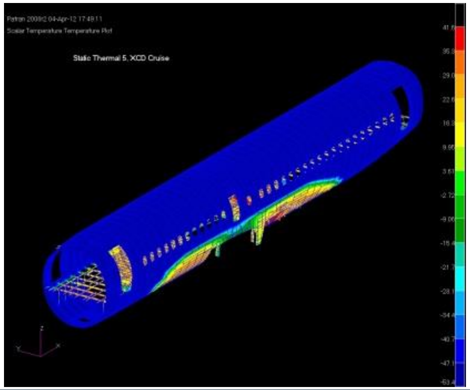
SMART TESTING

UNIQUE ISSUES/CHALLENGES

- Some challenges in full scale sub-component thermal-mechanical test interrogations:
  - Boundary effects reduce zone of test interrogation
  - Cycling at constant, analytically evaluated critical temperature, further narrows down interrogation zone – focus on particular critical thermal/mechanical load combinations
  - Complex analysis and coupon testing required to validate zone of interest
  - Difficulty to control environment – costly thermal chambers
  - Residual Strength (after cycling) at critical temperature somewhat less complex

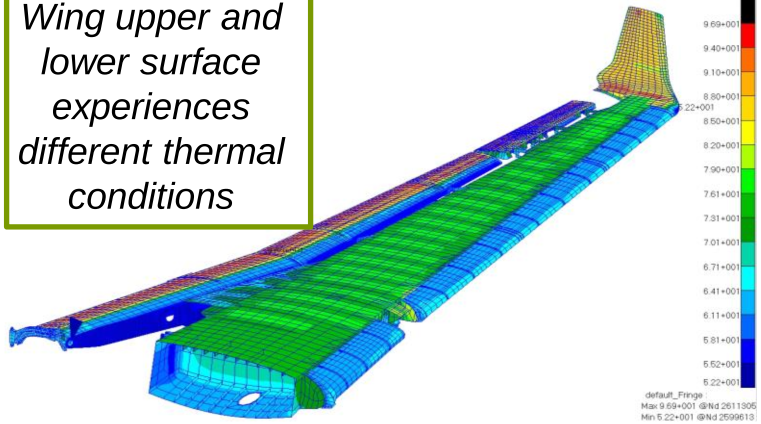
Variable thermal state of stress in fuselage





“Local” Effect of system generated heat

Wing upper and lower surface experiences different thermal conditions



BOMBARDIER
l’évolution de la mobilité

SMART TESTING

REGULATORY ACCEPTANCE

- Reliance on previously test validated analytical solutions for which boundaries of applicability are well established
- Leveraging analytical methods can be to a point based on principles for derivative models

BOMBARDIER
l'évolution de la mobilité