New Generation of Cryogenic Wind Tunnel Models

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REMFI

HTP & HTP Remote Control System with elevator-rear fuselage Gap Sealing System Designs

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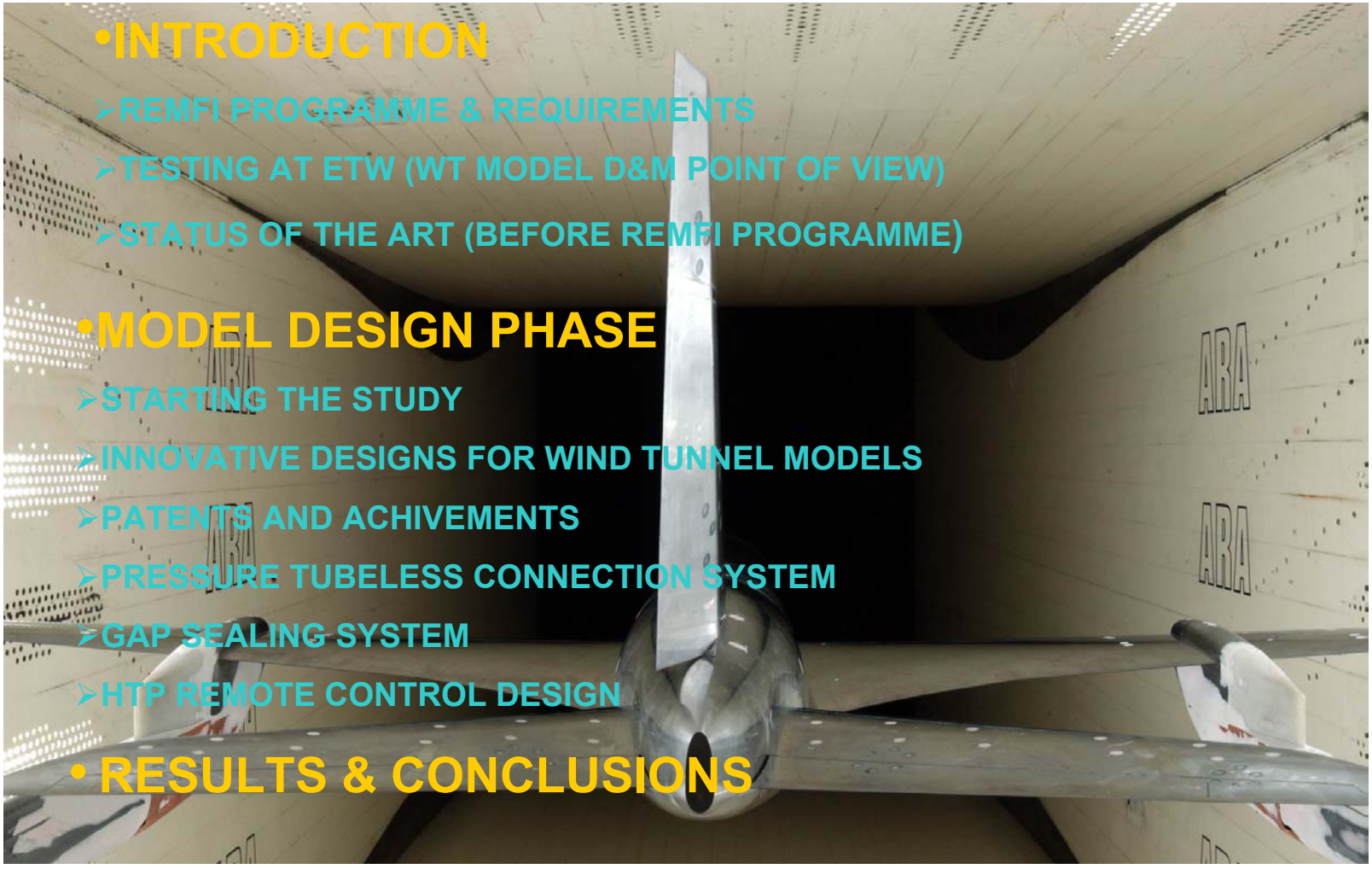


INTRODUCTION

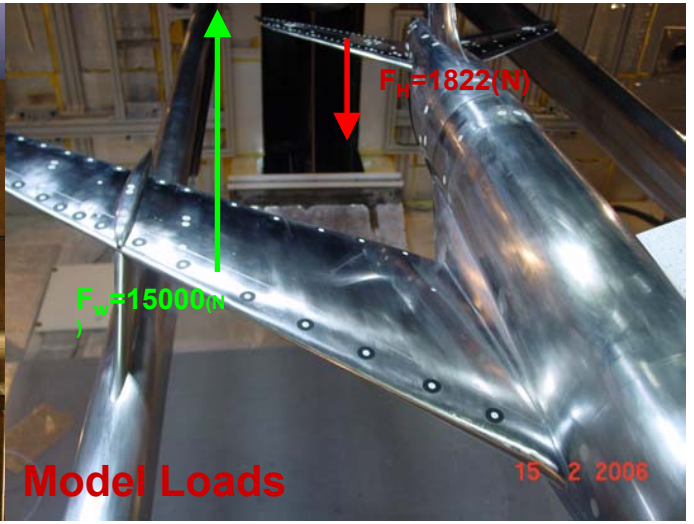
- Rear-fuselage/tail configurations are characterised by complex flow interactions and with tendency to massive flow separation. Adequate designs for tail-plane are necessary for providing enough control authority for flight safety.

- Research efforts dealing with the precise understanding of the flow physics around rear-fuselage/tail configuration are very limited while it is a crucial prerequisite for successful progress in the field of tail design.

- High Reynolds testing offers the possibility to reduce the significant differences between wind tunnel test and real flight performances.

- The European Transonic Wind tunnel ETW represents the preferred Airbus supplier for high Reynolds Testing under cryogenic conditions. Using nitrogen as the test gas, the High Reynolds is achieved under the combined effects of very low temperatures (110K-313K) and moderately high pressures (115-450 KPa).

INTRODUCTION .- Programme & Requirements



- REMFI wind tunnel model to be tested at European Transonic Wind Tunnel (ETW).-Test Conditions→Model Loads.

- M=0.95
- WT Total Temperature= 117 K
- WT Total Pressure= 310 KPa
- Reynolds Number (AMC)=38×10^6
- WT Dynamic Pressure= 106.4 KPa
- CL_W=0.90

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INTRODUCTION .- Testing at ETW.

- Cryogenic WT models require and special and unconventional design and manufacturing. Most challenging is the design to cope with the high loads achieved in the pressurized enviroment. In addition, for High Reynolds Number testing, the tolerances for surface quality have to be more accurate that for common wind tunnel models.

- Due to the restricted access to the model test section (cryogenic temperature, pure nitrogen), for configuration changes, the complete model has to be transported out of the tunnel to a temperature controlled room (VTCR)

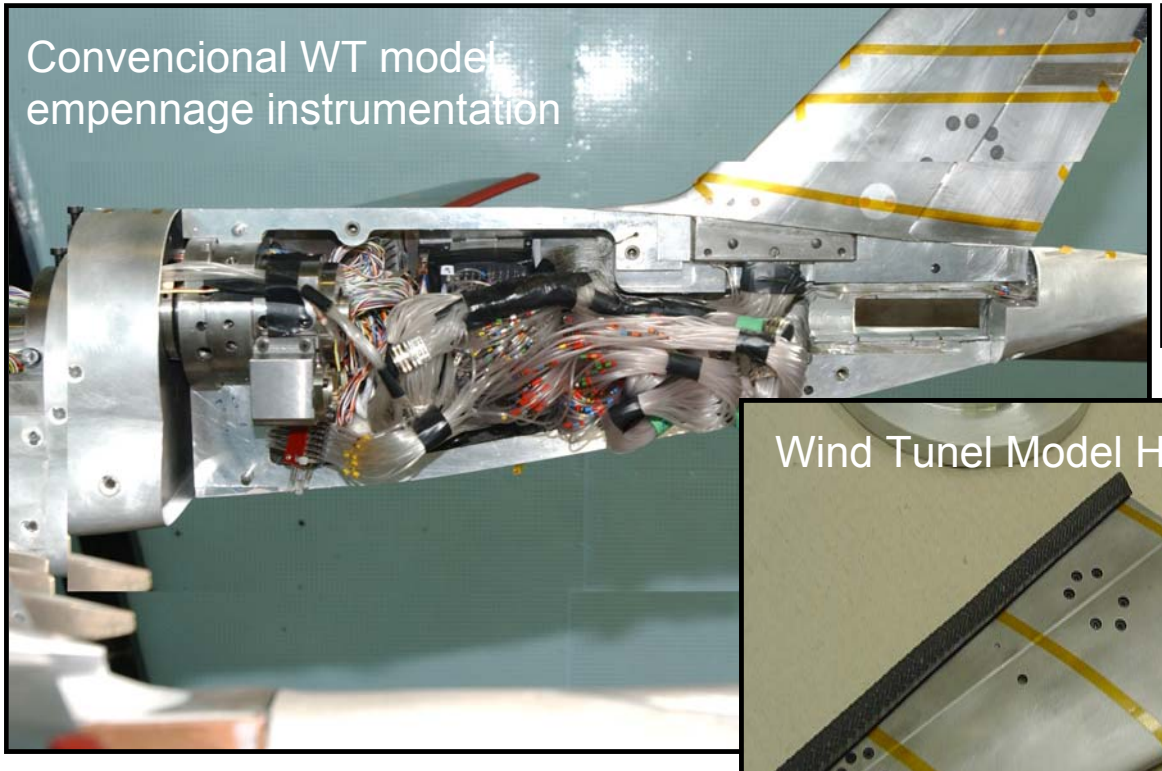
- After warming-up the models, riggers can start the model change. HTP setting changes requires to remove the HTP, open the rear fuselage, replace the angle insert,and assemble all again. After filling all remaining holes, the model is transported back to the cold section.

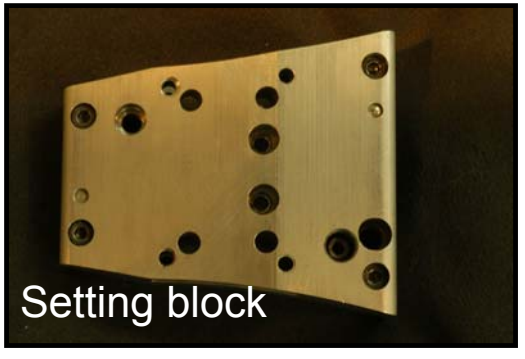
- This process is quite time + cost intensive: ~2 hrs. for transport/warm up, ~2hrs. Mechanical change

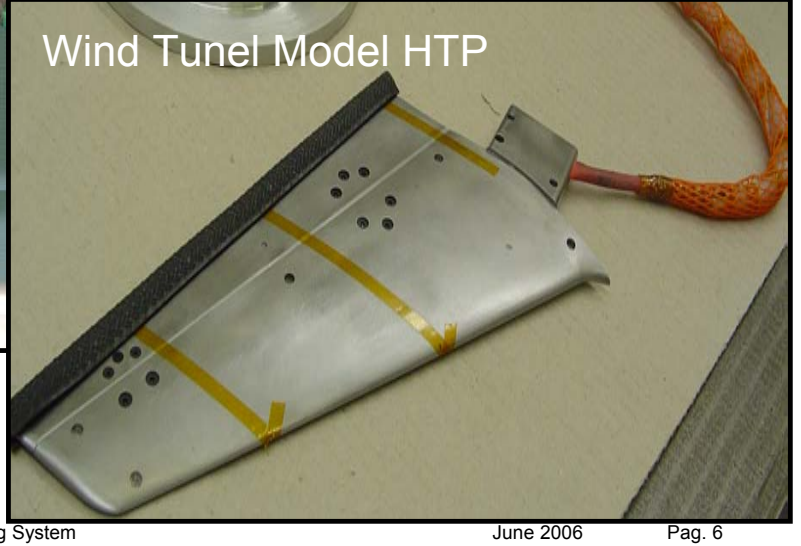
- For REMFI Programme, ETW designed and manufactured a HTP Remote Control System for HTP setting changes in test section

INTRODUCTION .- State of art before REMFI Programme

- HTP wind tunnel model component for a HS test at ETW.- State of art.
  - HTP Model D&M constrains: Limited space allocation & High Loads







MODEL DESIGN PHASE .-Starting the study…

- WT HTP model. Design Constrains.
  - **Due to Test requirements:**
    - ✓77 Pressure Taps installed across 5 sections.
    - ✓ Elevator root- Rear fuselage gap sealed.
  - **Translated into mechanical design constrains:**
    - ✓ HTP-Remote control interface.
    - ✓Pressure routing through complex HTP-Remote control interface.
    - ✓Continuous sealing system for cryogenic conditions.

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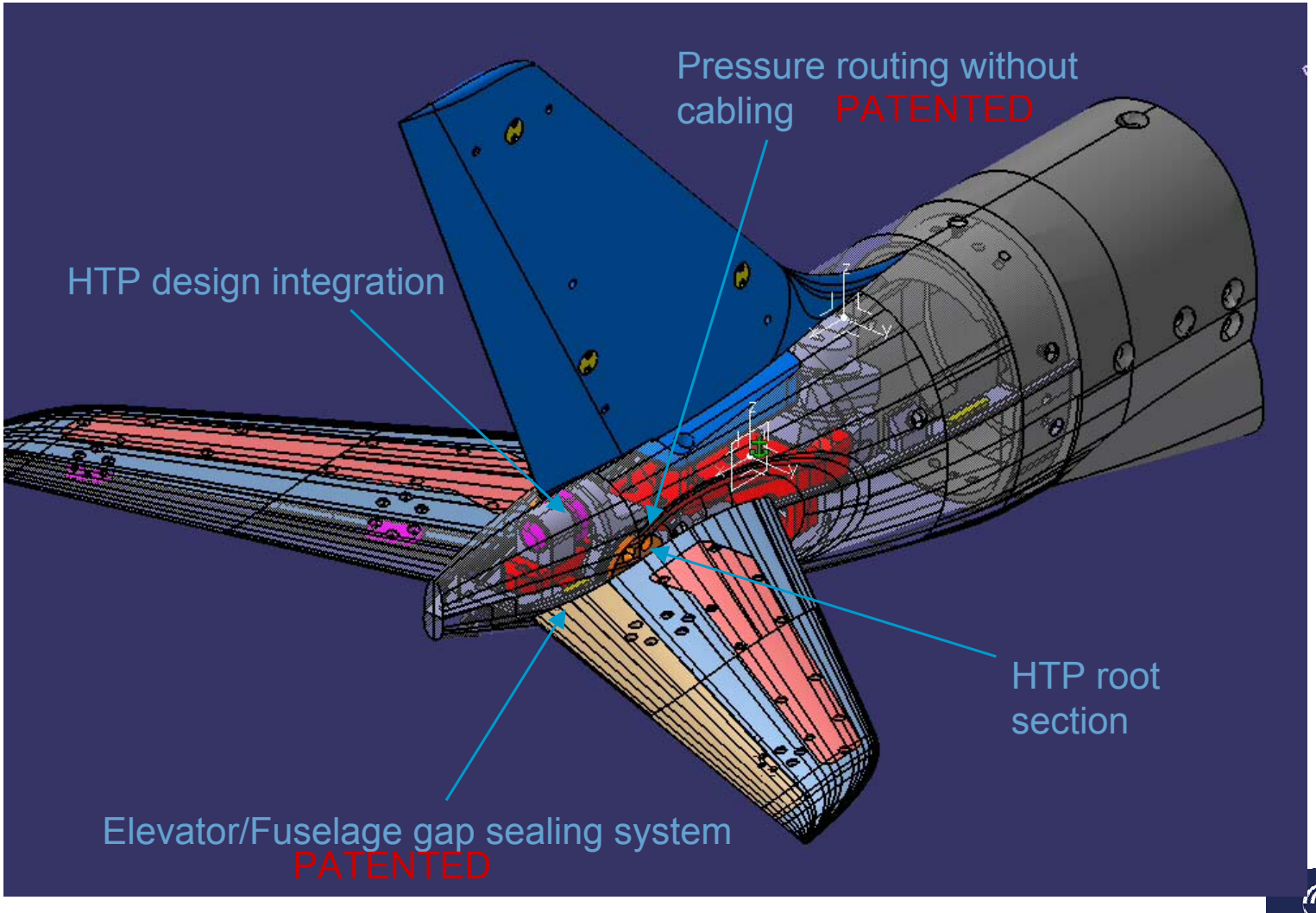
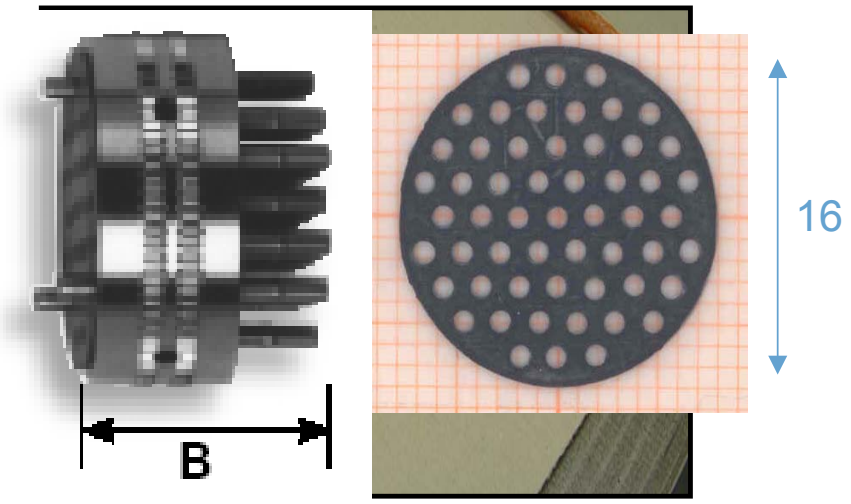
MODEL DESIGN PHASE .-Patents and achievements

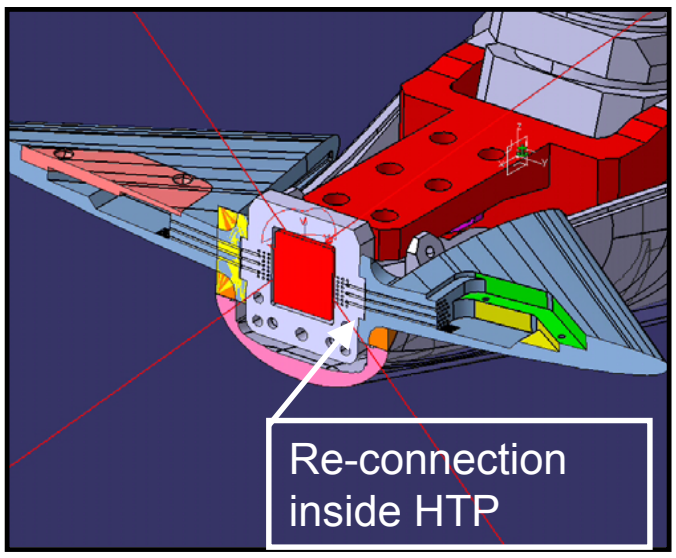


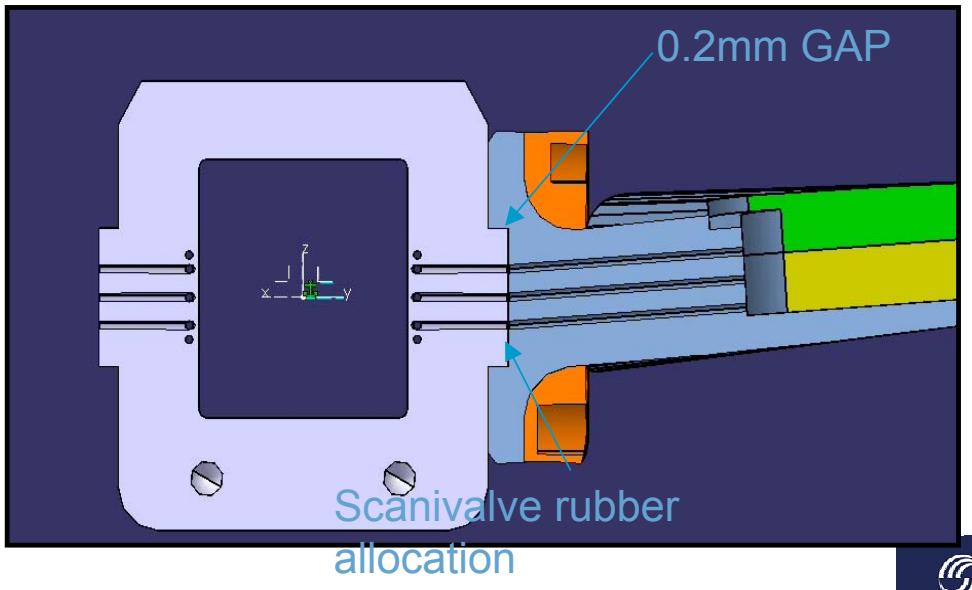
MODEL DESIGN PHASE .-Pressure Tubeless Connection System (I)

•Traditionally, a hole per pressure tap is drilled in a EDM process over the HTP surfaces. Then, a metallic cable is connected to each hole and joined with the rest of cables to be routed into the fuselage through a big hole at the HTP root. Finally a scannivalve connector enters on the PSI.

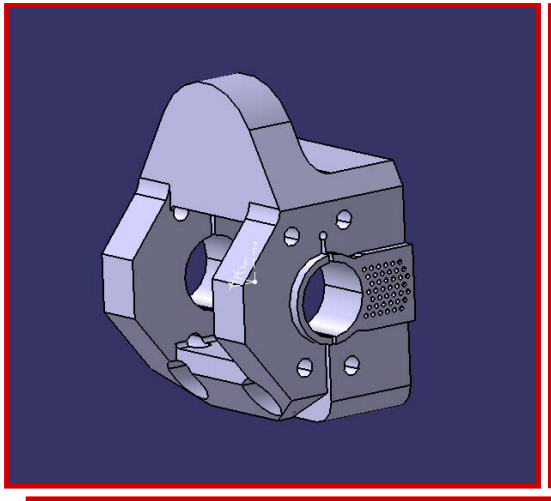
•Pressure Tubeless Connection System, avoids the amount of cable holding from the HTP, saving space and facilitating rigging operations

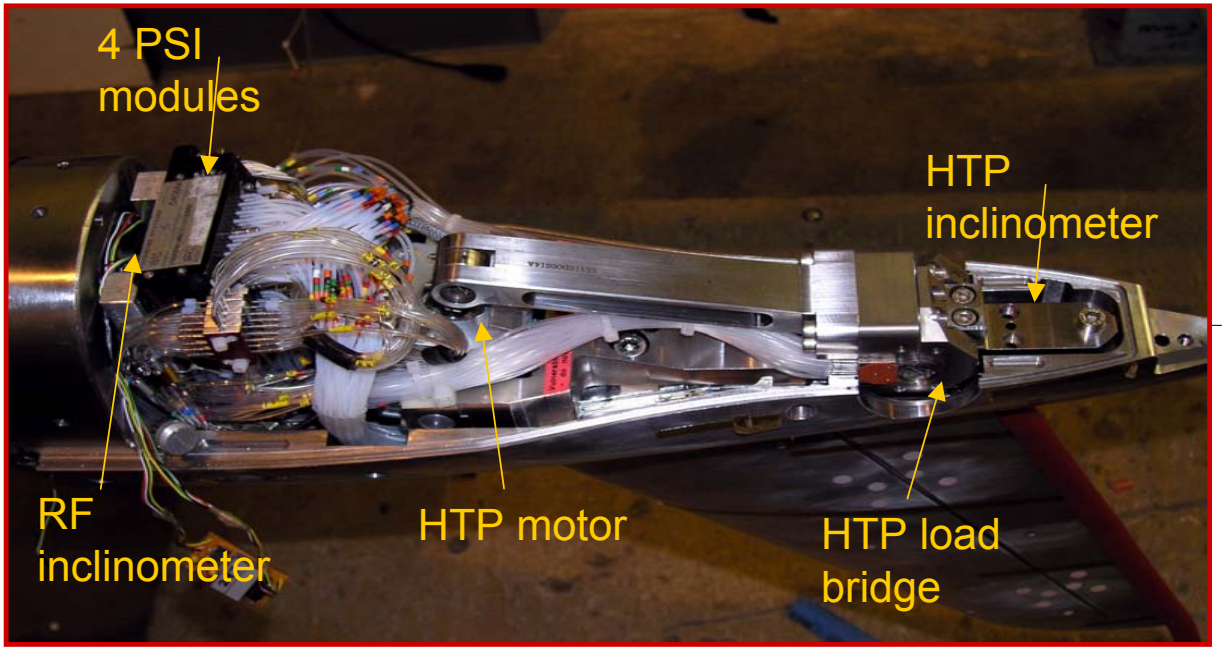


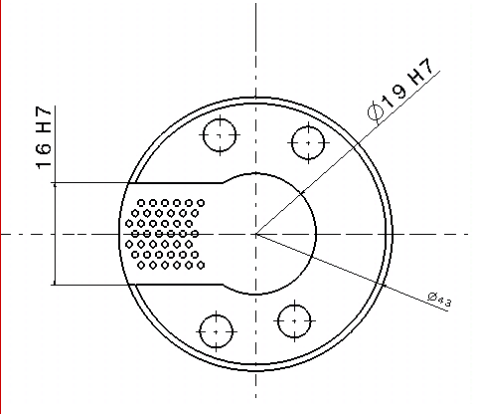




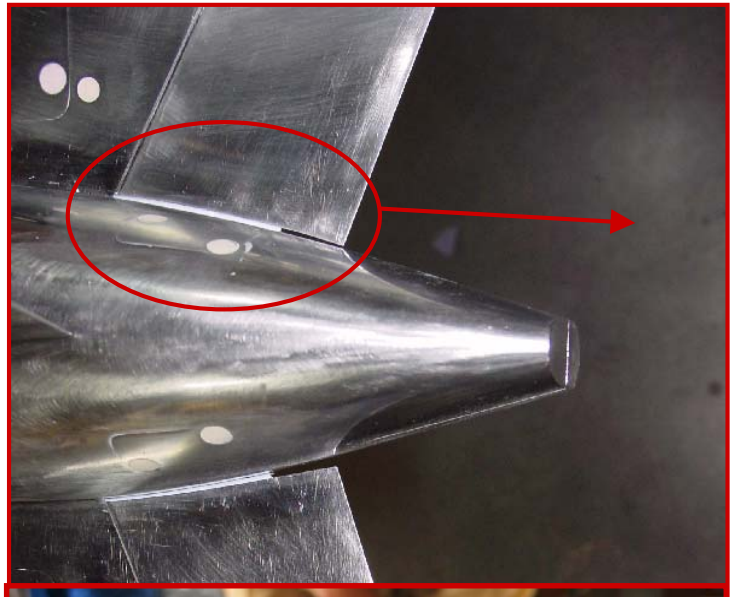
MODEL DESIGN PHASE .-Pressure Tubeless Connection System

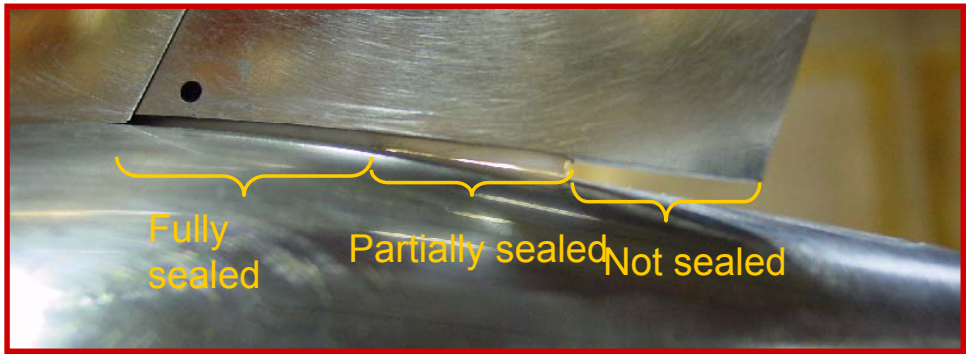


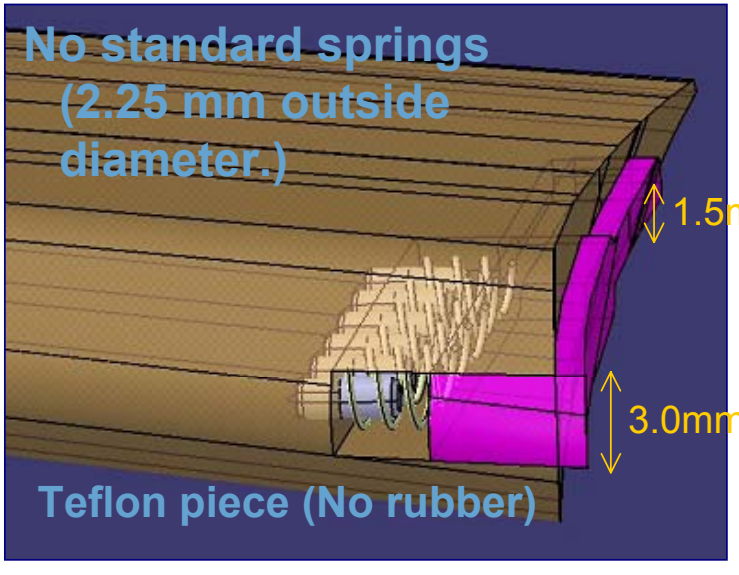




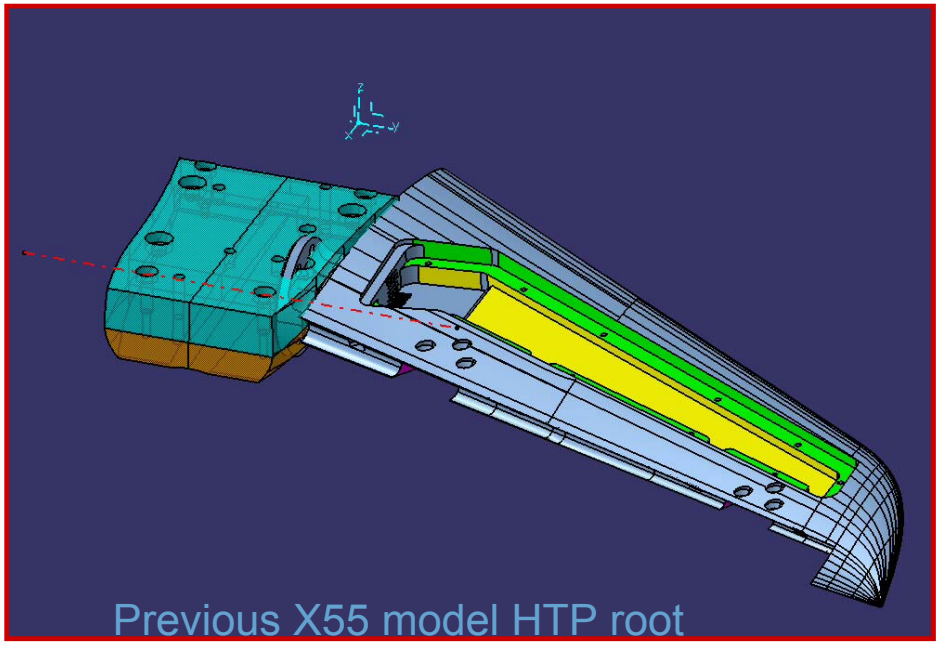
MODEL DESIGN PHASE .-Gap Sealing System





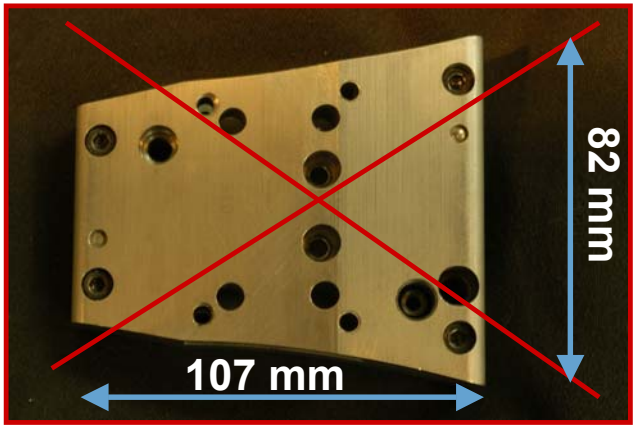


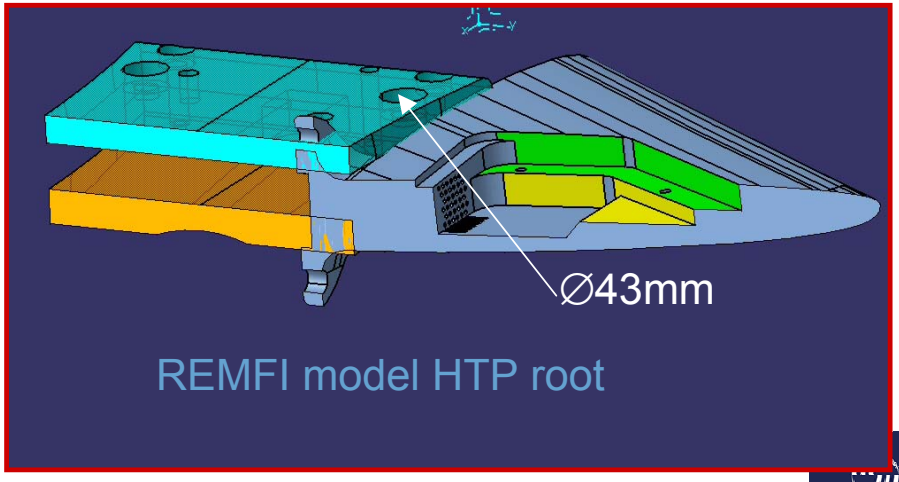
MODEL DESIGN PHASE .-Refined root design



New HTP root design based on concurrent design process (Stress concentration factor & Thermal loads).

- Resultant Force: 1822 (N)
- Combined stress at root section:198 (MPa)



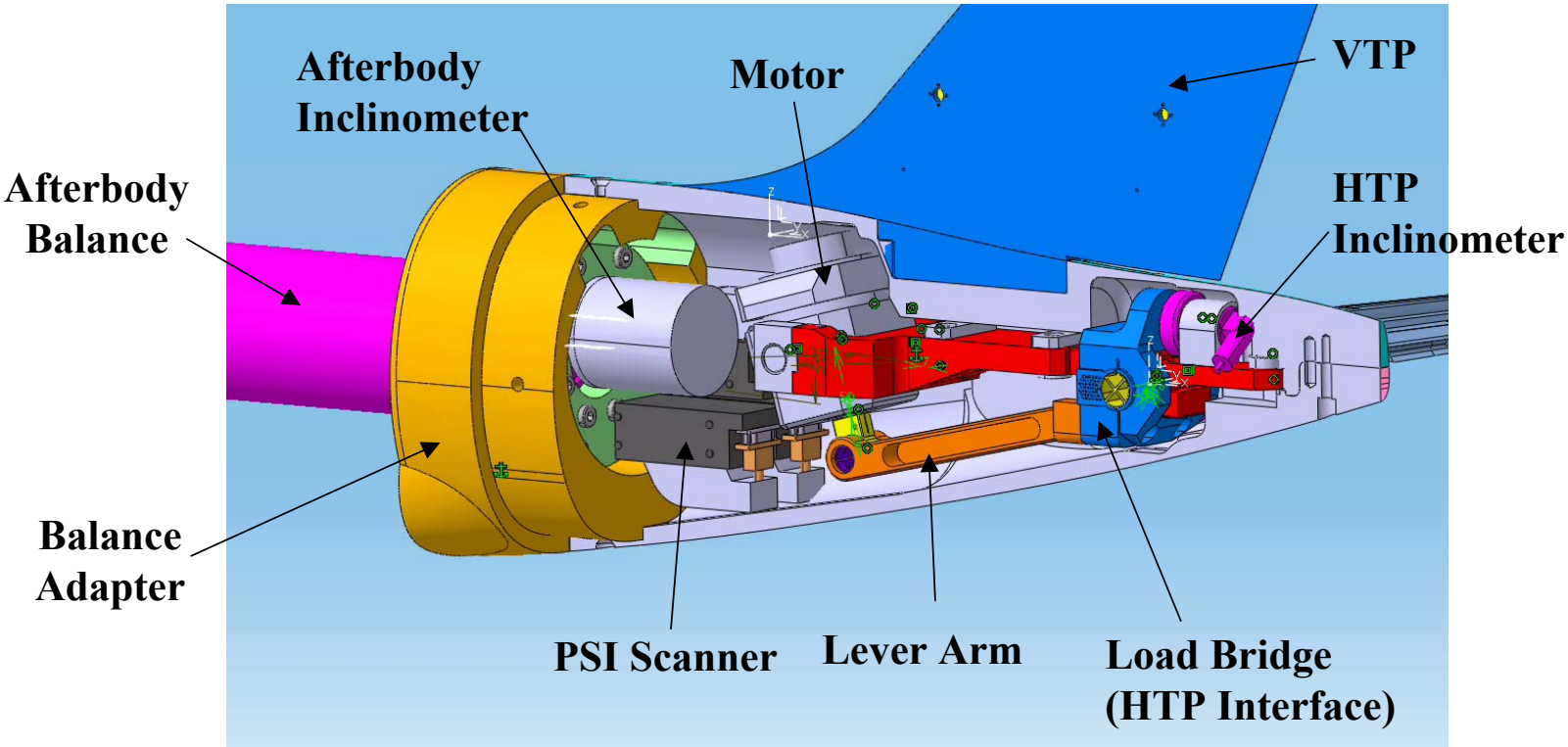


MODEL DESIGN PHASE .-ETW HTP REMOTE CONTROL SYSTEM

- Design requirements:
  - HTP setting in test section during wind-on conditions, setting angles: -2, 0, +2deg
  - Operation in cryogenic environment (-160° C)
  - High accuracy for setting and actual position measurement required (0.3° setting, 0.03° measurement)
  - Very high Loads on HTP in ETW
  - HTP Pressure routing to inner fuselage, therefore new sealing method required
  - As small as possible to provide sufficient space for afterbody instrumentation

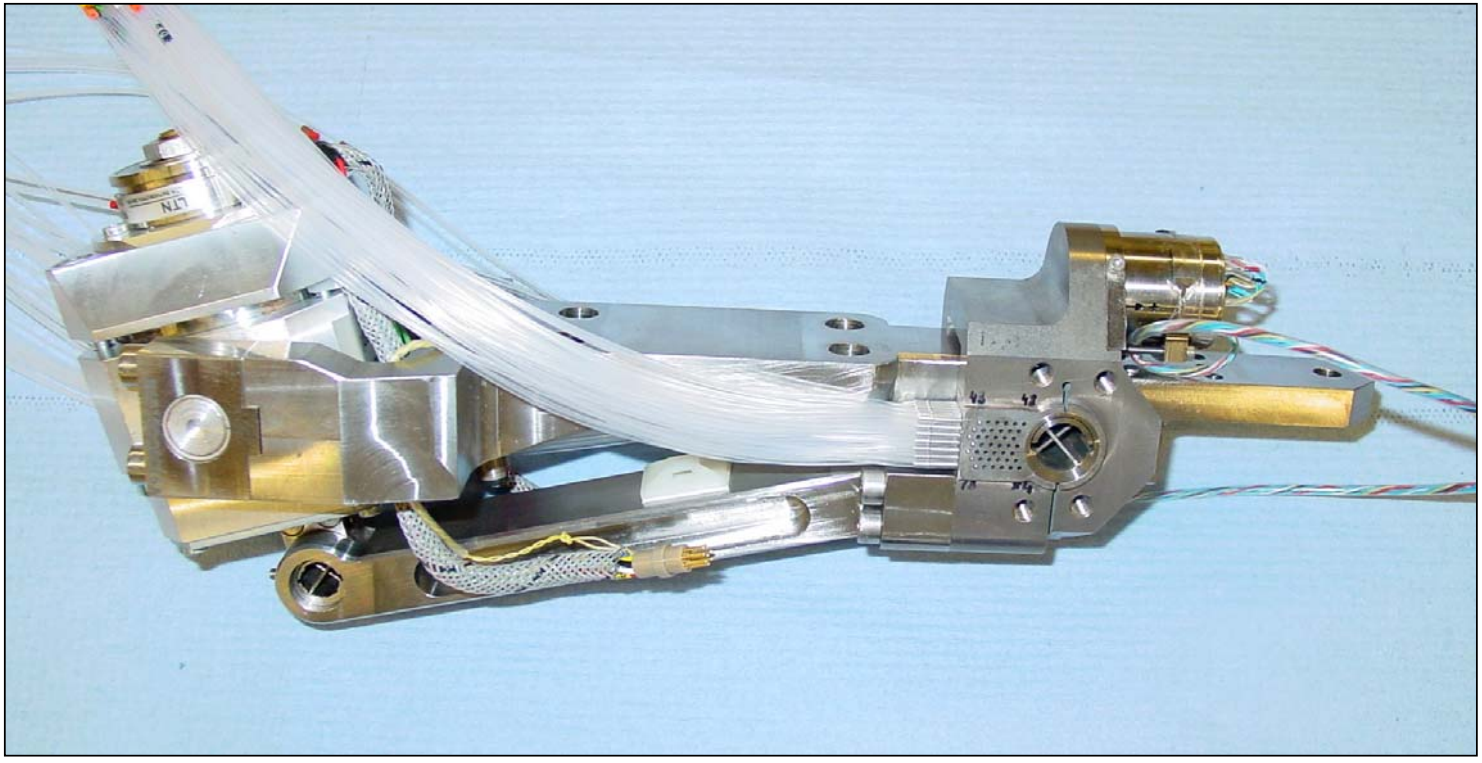
MODEL DESIGN PHASE .-ETW HTP REMOTE CONTROL SYSTEM

- Design process:



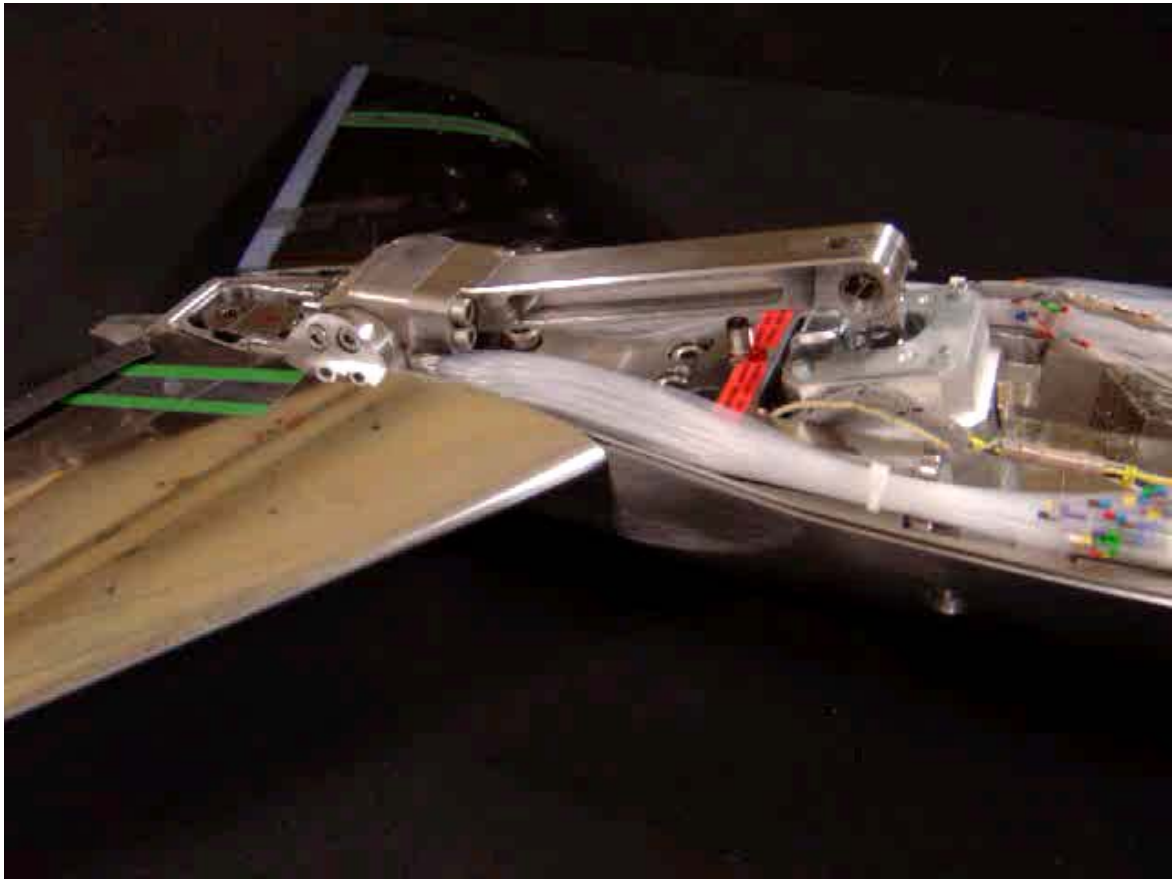
MODEL DESIGN PHASE .-ETW HTP REMOTE CONTROL SYSTEM

- Final result:



MODEL DESIGN PHASE .-ETW HTP REMOTE CONTROL SYSTEM

- Final assembly checks prior to first entry in Sepember 2005



RESULTS AND CONCLUSIONS (1)
TUBELESS AND SEALING SYSTEMS

- ✓To optimize time during configuration changes means an unquestionable improvement for testing at ETW. The use of Remote Control Systems with tubeless connections, brings the fact of easier configuration changes without moving the whole model out of the tunnel testing section, reporting a huge time saving.

- ✓For Tail-Off configurations, the HTP component can be easily removed from the model without any cable holding, being unnecessary to open the rear-fuselage in order to disassemble that piece.

- ✓The tubeless connection concept can be applied to several WT model pieces pressure plotted (ailerons, spoilers, wing tips….) with the subsequent save on time and gain on operation.

- ✓Gap investigations are even more important for High Reynolds Number testing.

- ✓Gap sealing system has allowed to test the gap closed with acceptable sealing.

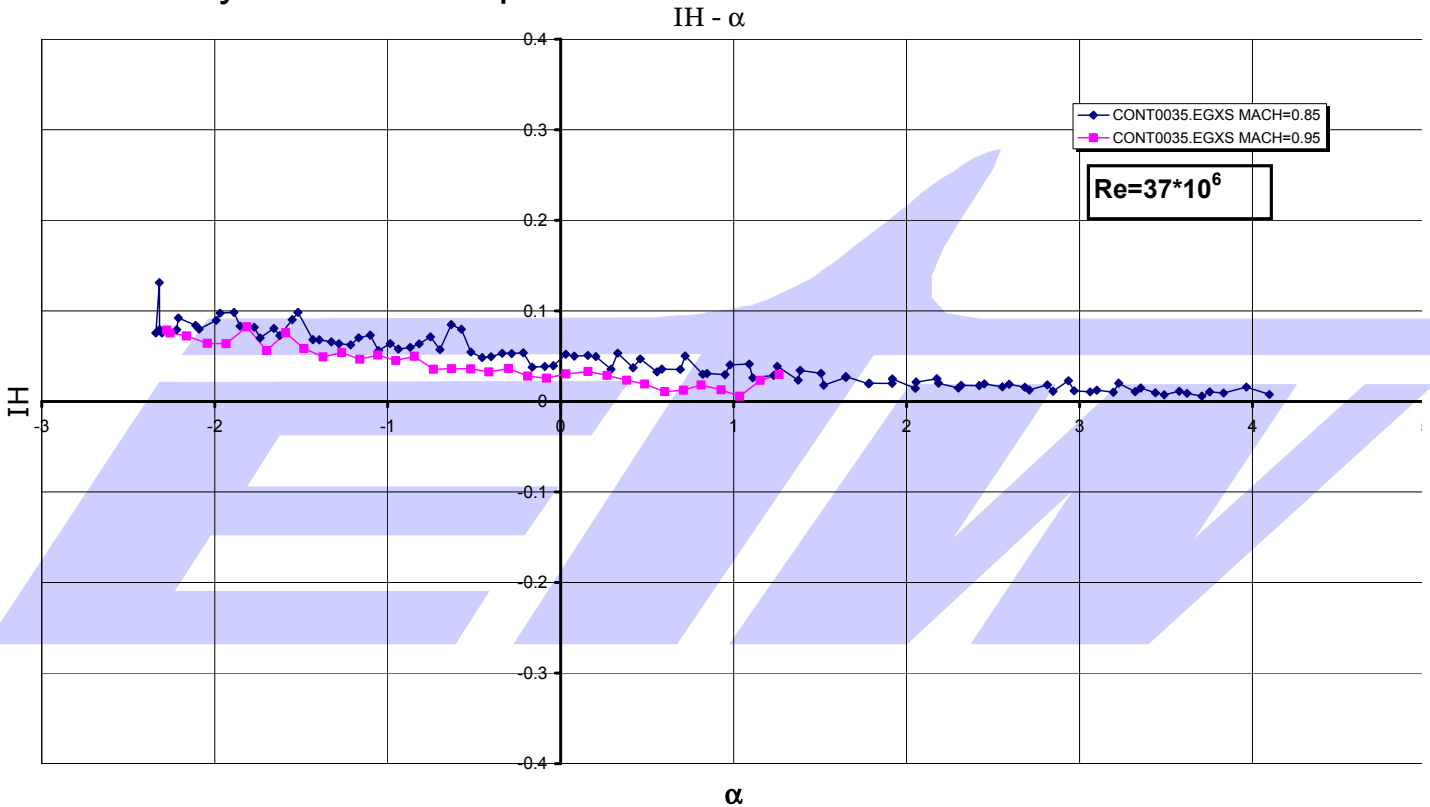
- ✓Both innovative designs, were successfully tested within the REMFI project and worked perfectly over the complete temperature and pressure range of ETW.

RESULTS AND CONCLUSIONS (2)
HTP REMOTE CONTROL SYSTEM

- ✓The HTP Remote Control Systems operating excellently over the complete temperature range of ETW.
- ✓Using RC Systems for setting changes into ETW test section, makes rigging activities obsolete. Hence, that is saving money and therefore reducing the cost of the test.
- ✓Especially for cryogenic tests, where the model has to be transported out of the tunnel for configurations changes, the HTP Remote Control means a remarkable reduction of testing time.
- ✓Within REMFI 34 HTP setting changes (19 at cryogenic conditions) were performed remotely controlled.
- ✓Since this design was proven to be fully operational, further investigations started for additional RC Systems of other wind tunnel model components.
- ✓REMFI programme has represented a platform to ramp design concepts which improves ETW wind tunnel models.

RESULTS AND CONCLUSIONS (3)
HTP REMOTE CONTROL SYSTEM

- HTP Remote Control System stability:
  - During the test and for all configuration, the system demonstrated a stability within the required limits.



  - Total cost saving~ 4 hours per HTP setting change .

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