Commercial High Bypass Engine Instrumentation

New Product Development

Date: 17/11/2016

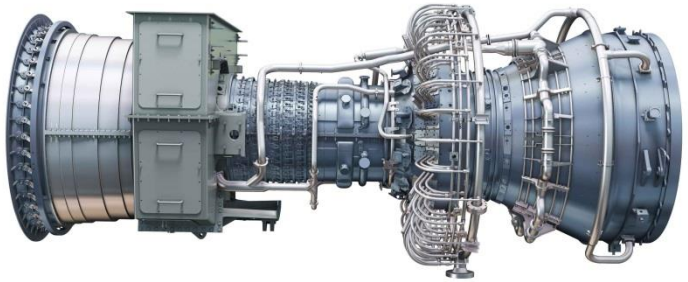
IAI Engines Division

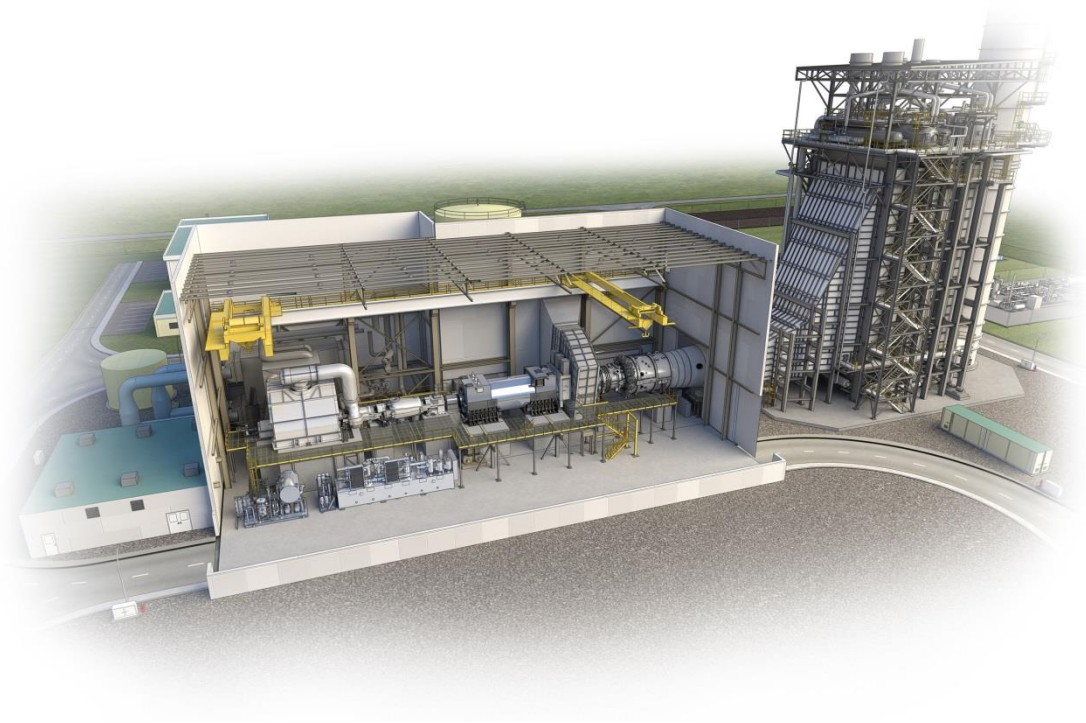
Lecture Topics

1. New product development in IAI
2. Turbofan Cross Section
3. Instrumentation process examples
4. Instrumented Load Cell (Thrust Plate)
5. Calibration Process
6. Conclusions

New Products Development at IAI

- IAI Engines Division main focus is in the area of Maintenance Repair and Overhaul (MRO) for commercial and military aero jet engines
- New products development formed to expand the division scope of future business
- A feasibility study to convert a commercial aero jet engine into a gas turbine was one of the key activities in the past years





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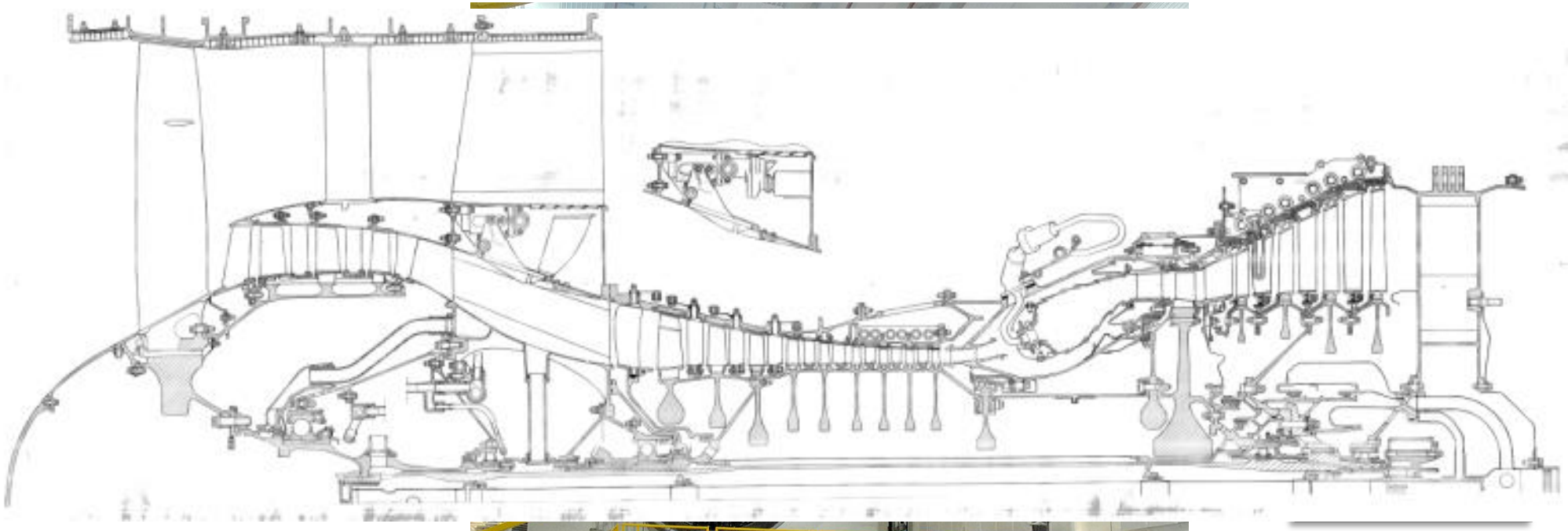
Turbofan Test Challenges



2. Data Acquisition System (DAQ)
   - Plane
   - Transducers
   - Calibration
   - Interface

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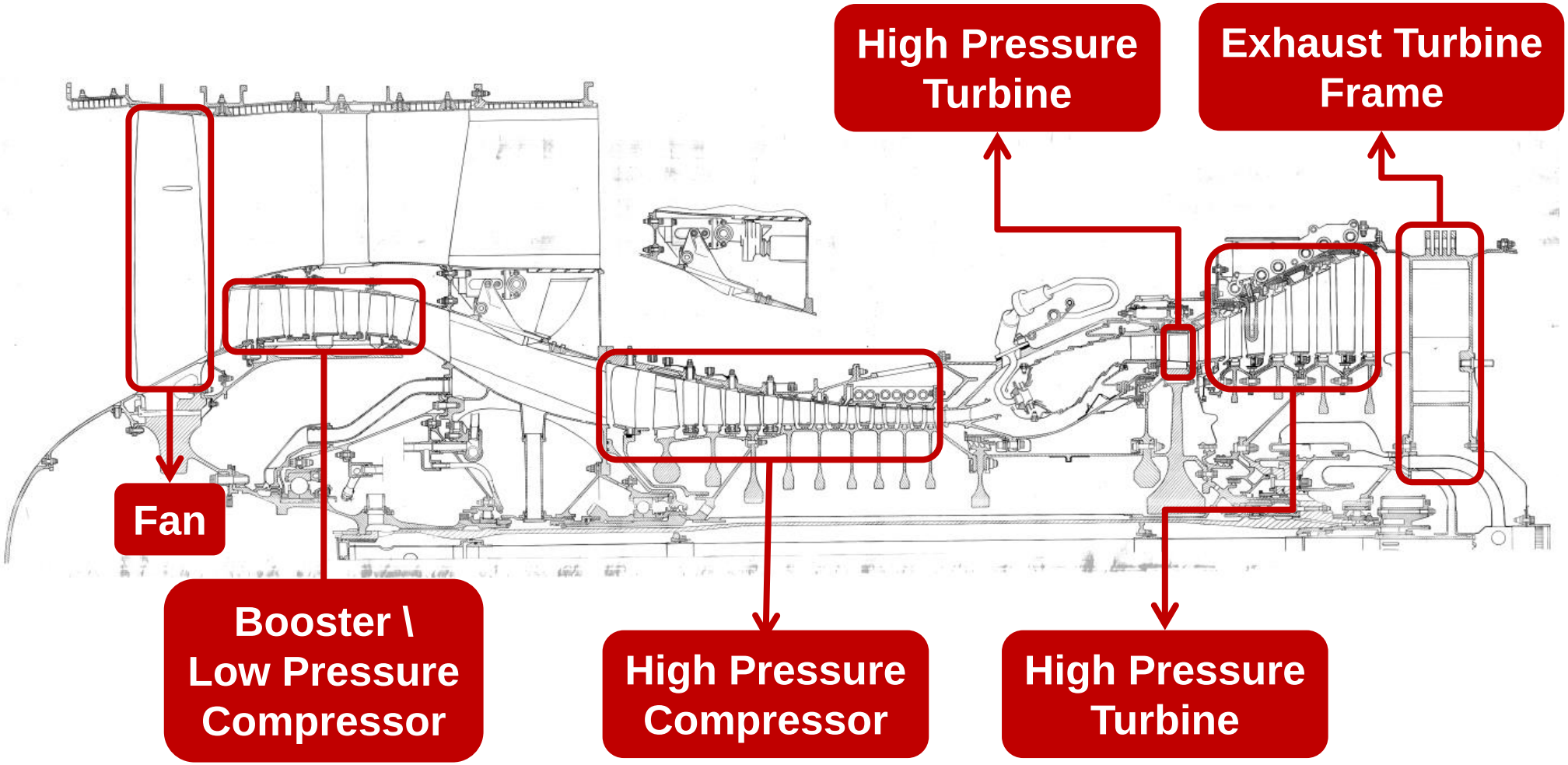
Turbofan Engine Cross Section



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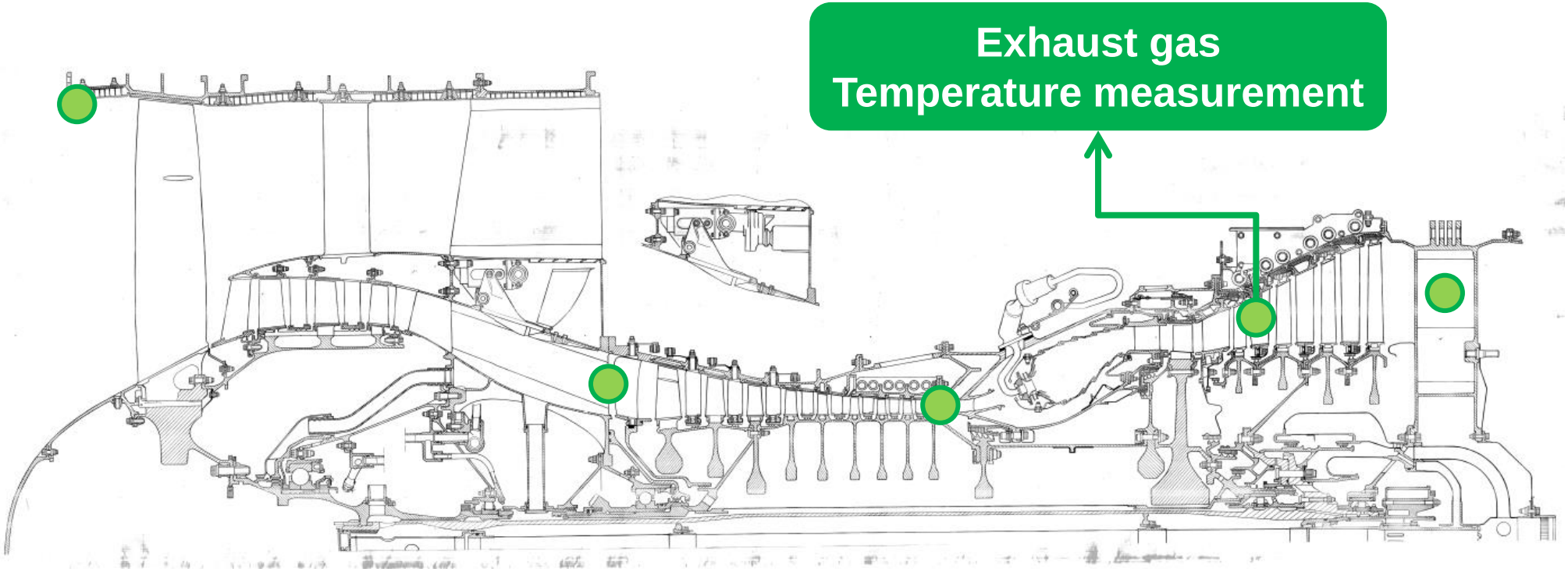
Basic Engine Measurements (MRO)



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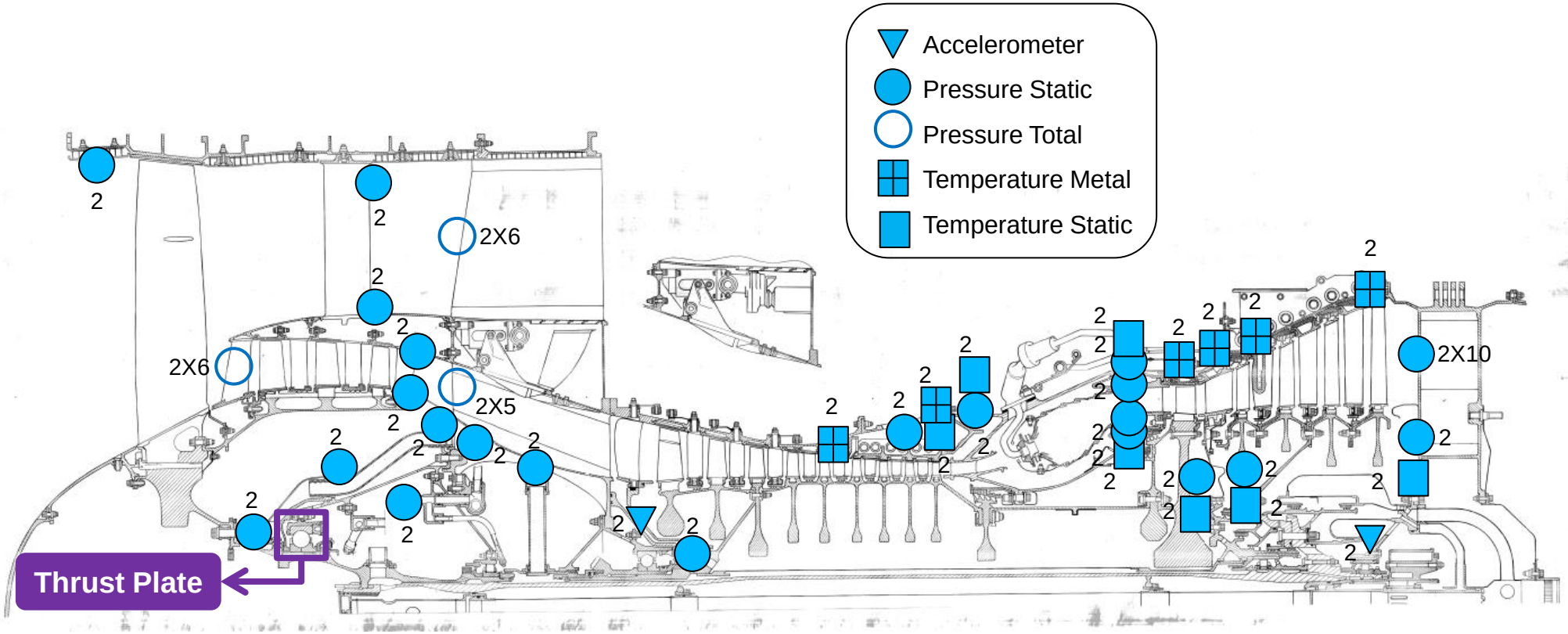
New Additional Instrumentation (~200 lines total)



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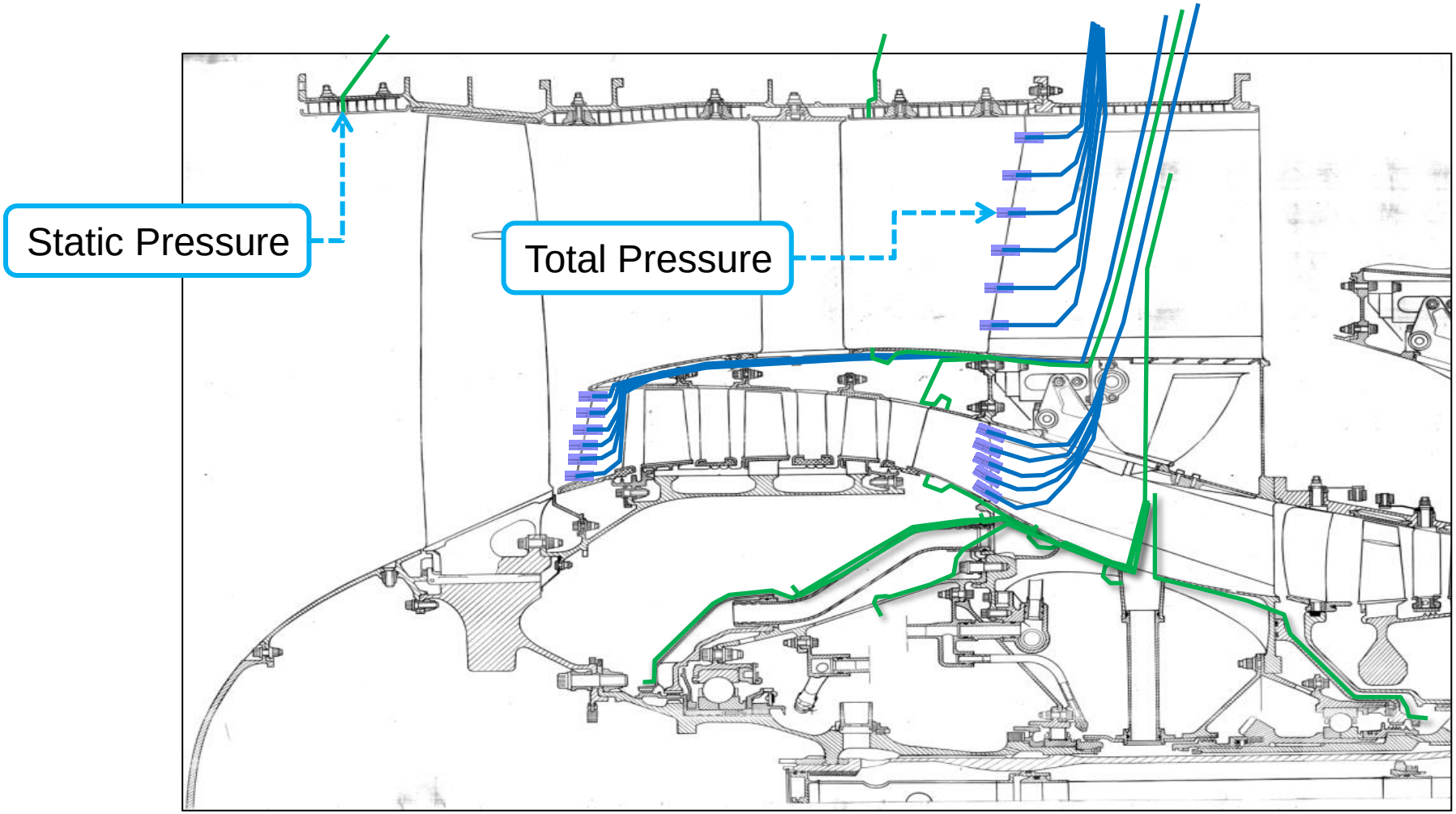
Cold Section- Fan & LPC (Install and Rout)



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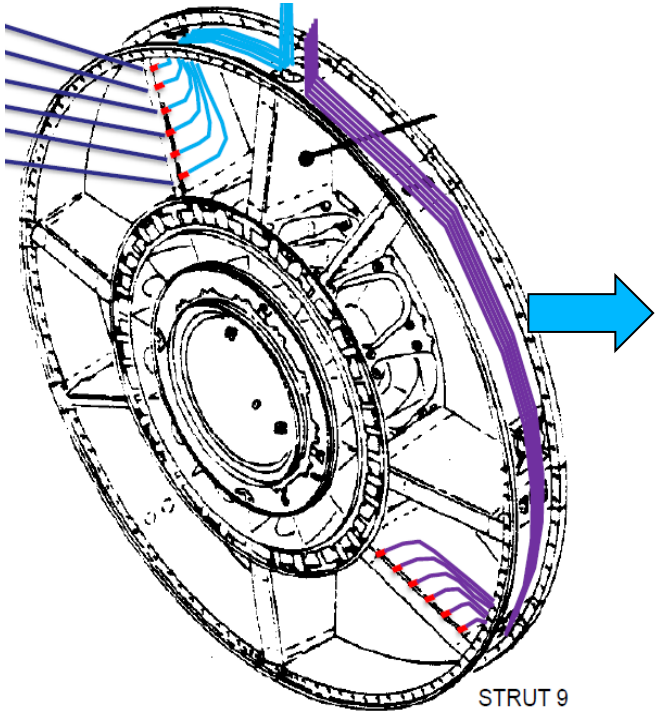
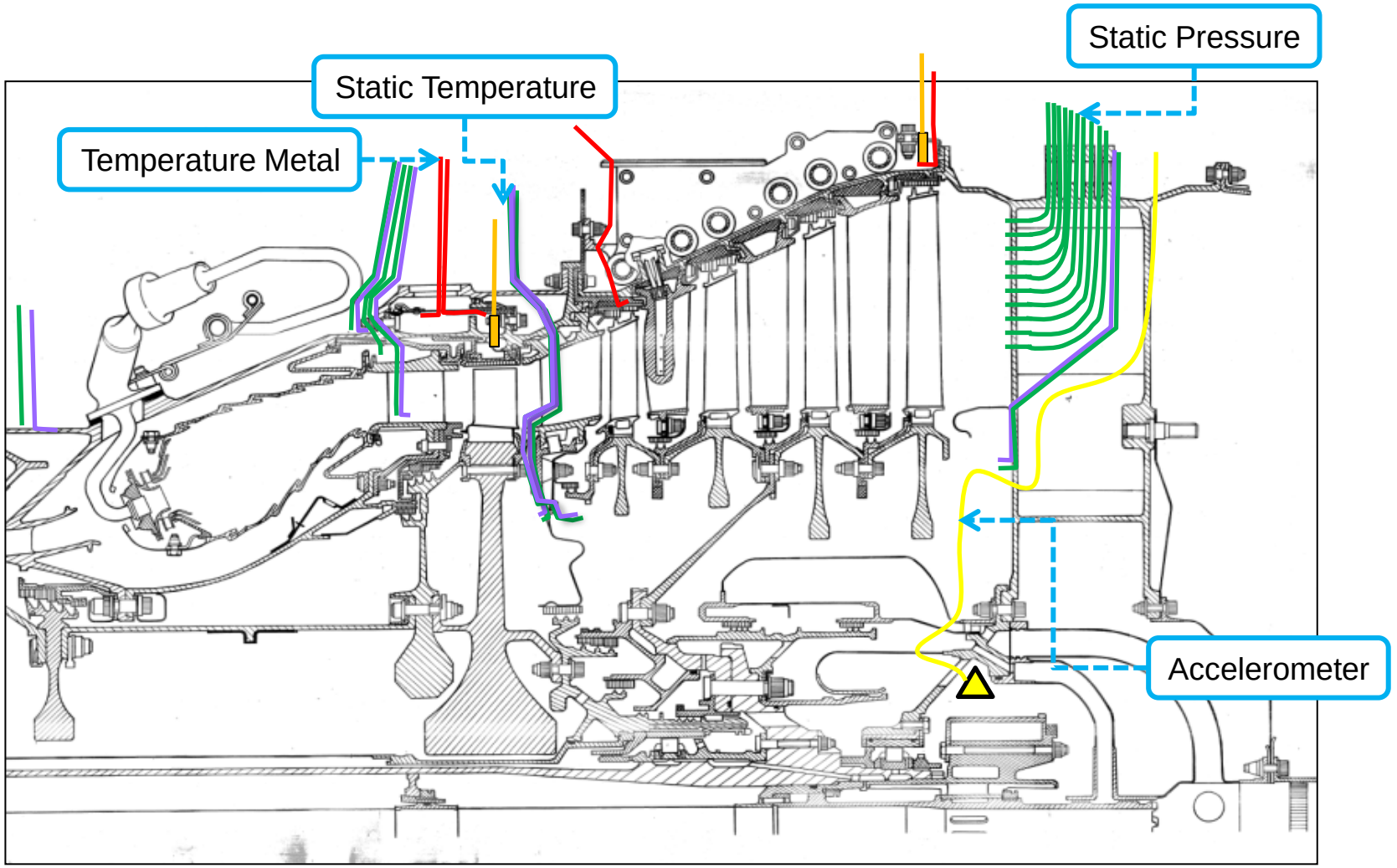
Cold Section- Fan & LPC (Install and Rout)

Total Pressure

Hypo: AMS 5580 In600 / Kielhead: 7570 (Up to 500F\ 100 psi)



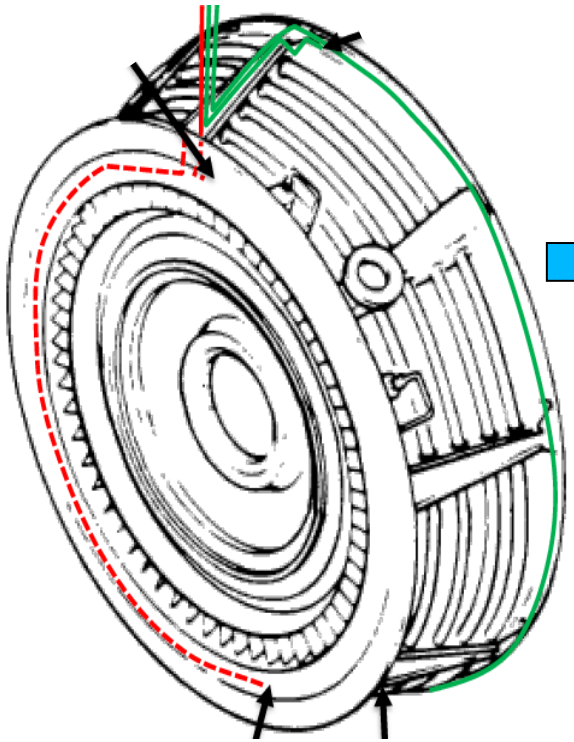
Hot Section- HPT, LPT & Exhaust (Install and Rout)

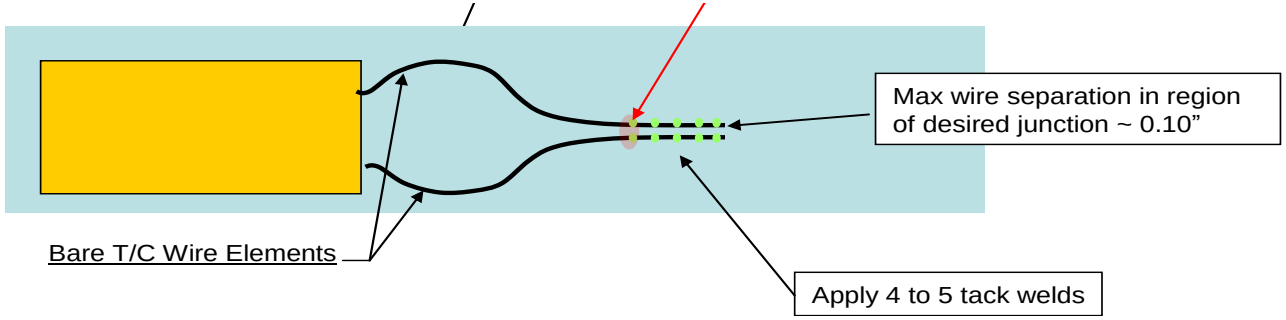


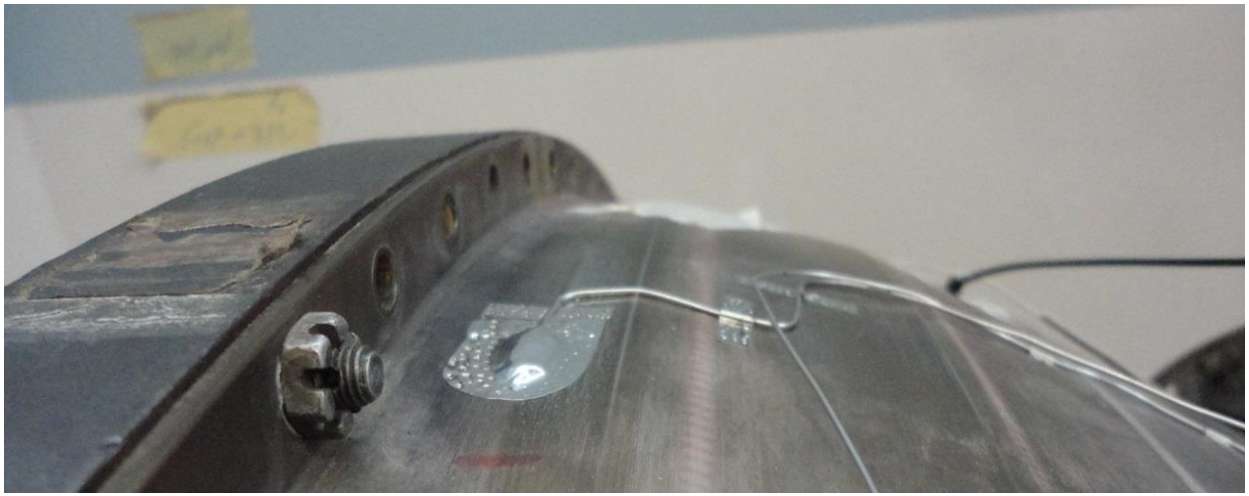
Hot Section- HPT, LPT & Exhaust (Install and Rout)

Metal Temperature

TC wire Type: N / Termination: Type K male connector (up to 1200F\ 400 psi)



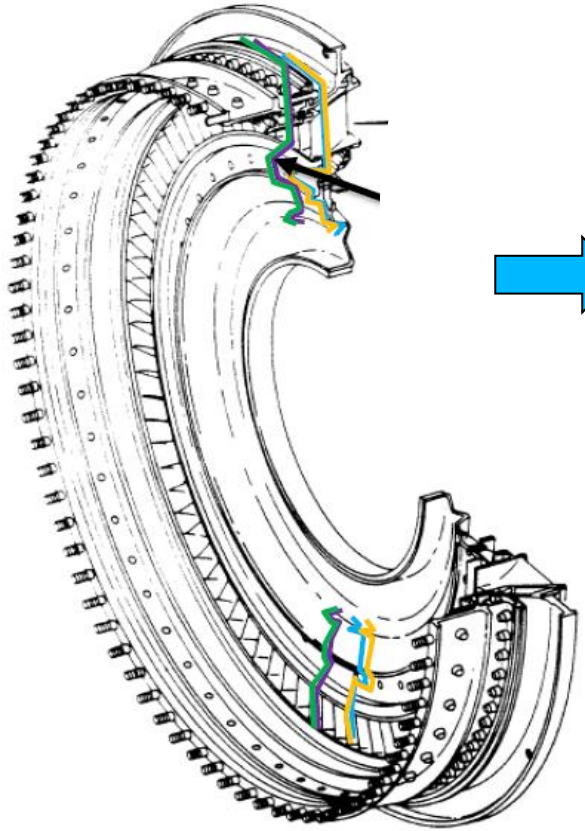




Hot Section- HPT, LPT & Exhaust (Install and Rout)

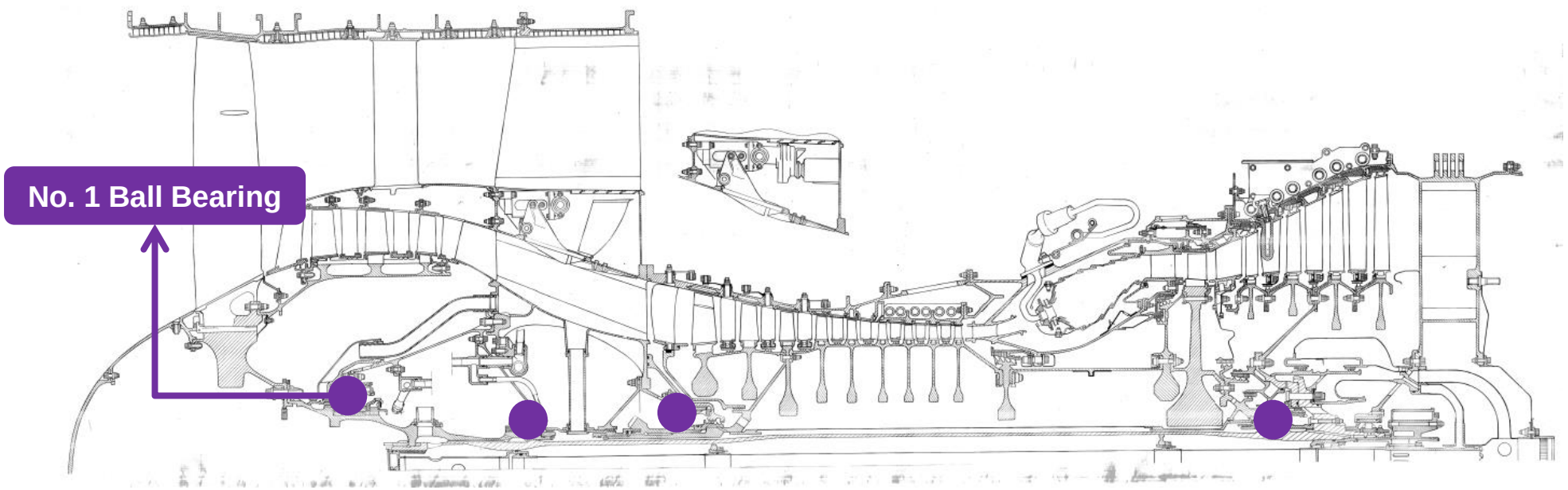
Wall Temperature

TC wire Type: N / Termination: Type K male connector (up to 600F\ 400 psi)



Thrust Plate

- A very important measurement is the axial load on the main engine bearing (No. 1)



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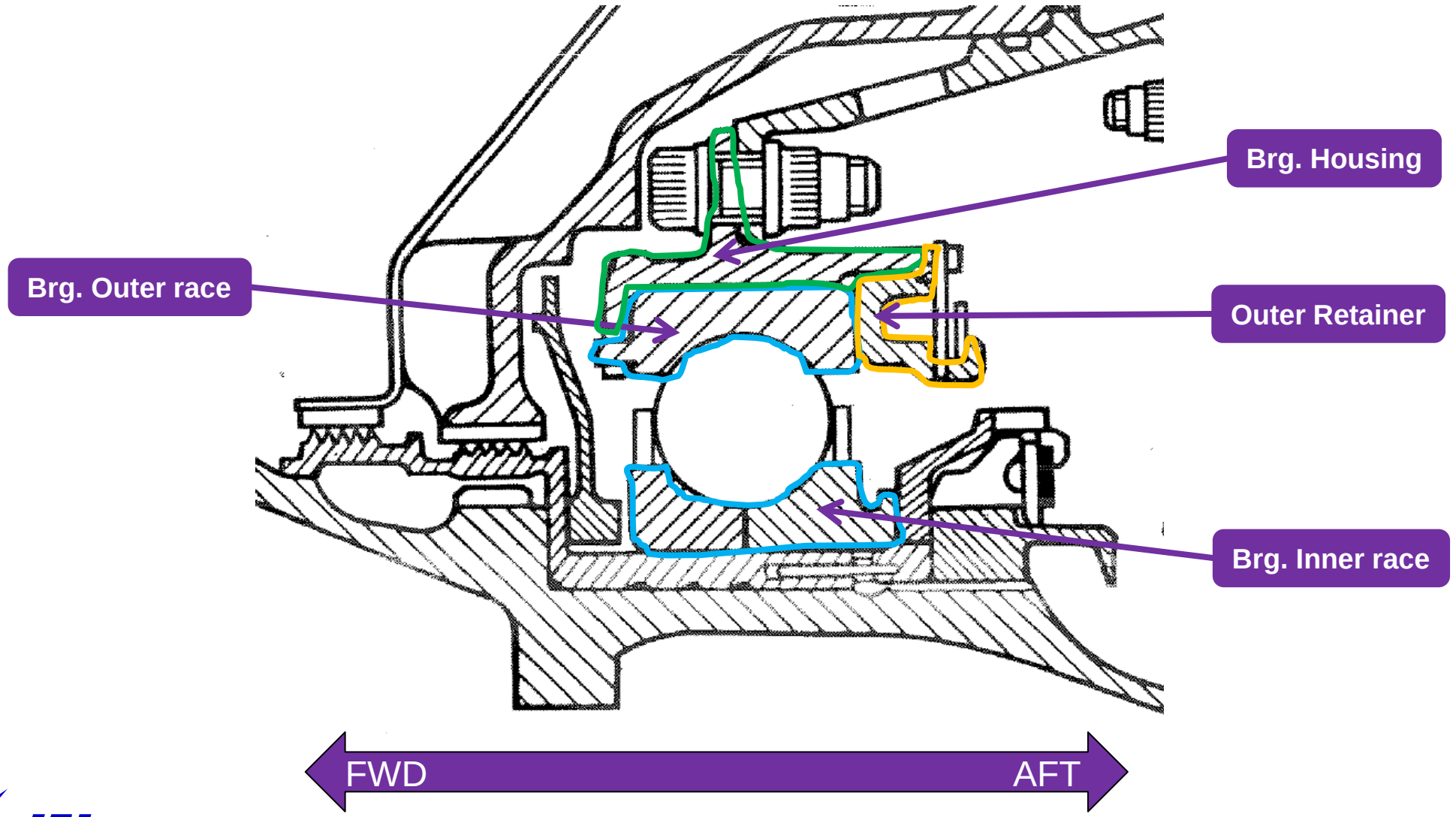
Original No. 1 bearing Assembly



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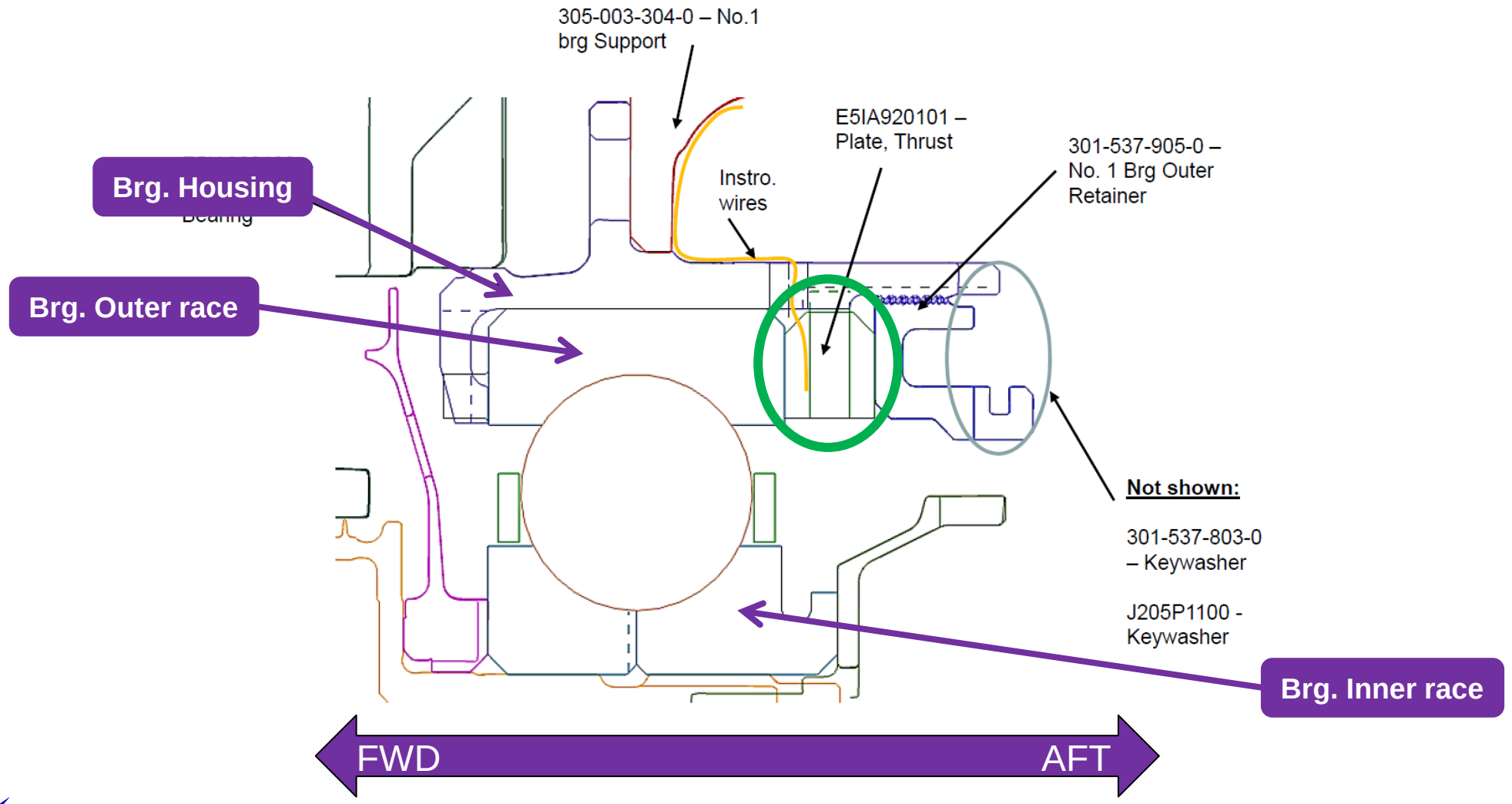
Thrust Plate Addition To The Assembly



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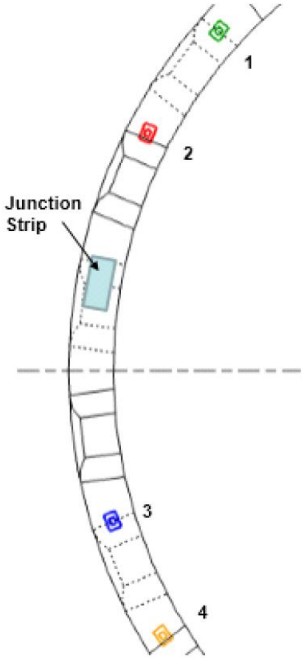
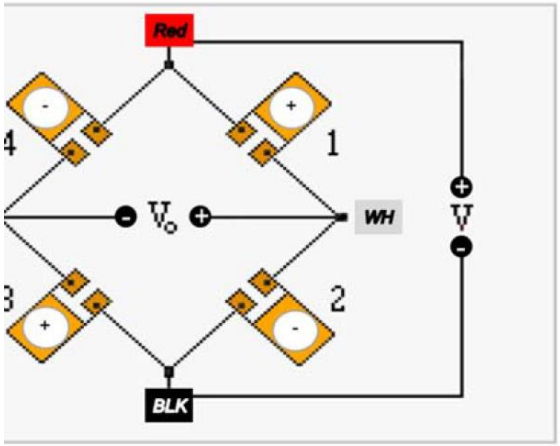
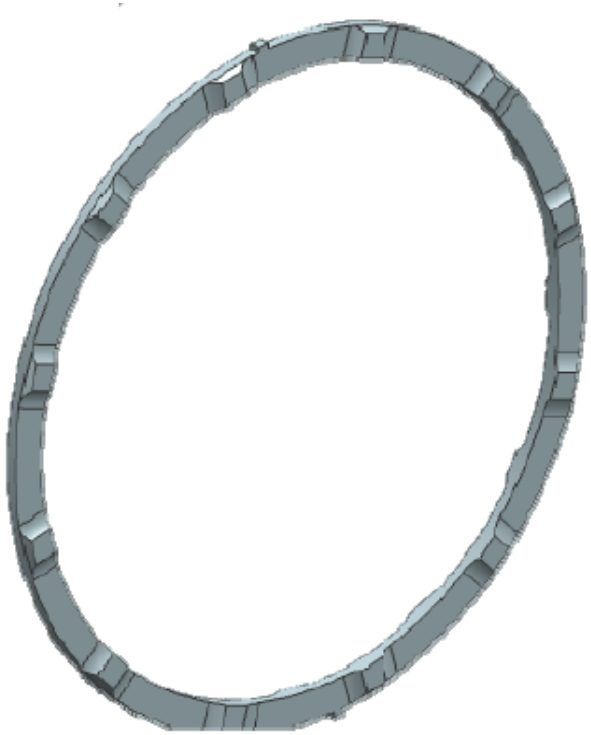
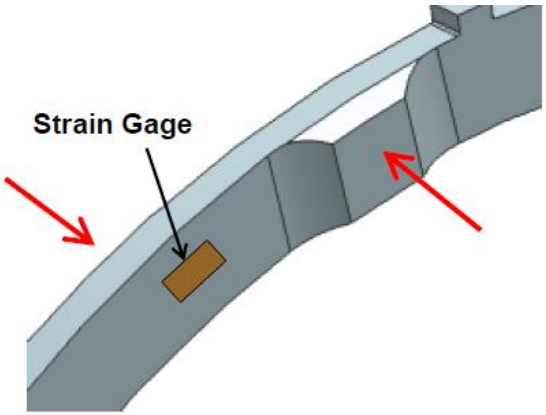
Thrust Plate- Design & Fabrication

Design Concept
- Material: 17-4 PH H1025
- 12 pads on each face offset
- 2 Anti rotation tabs at OD
- Pads chamfer at OD to allow wire routing
- Designed for a preload of 8,000 lbf









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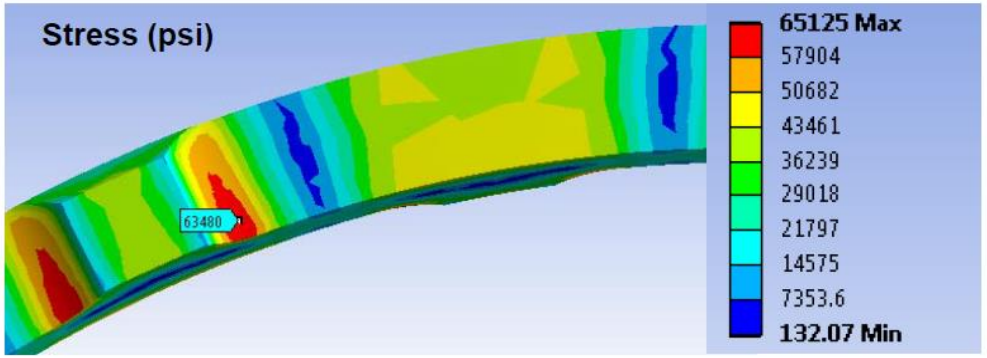
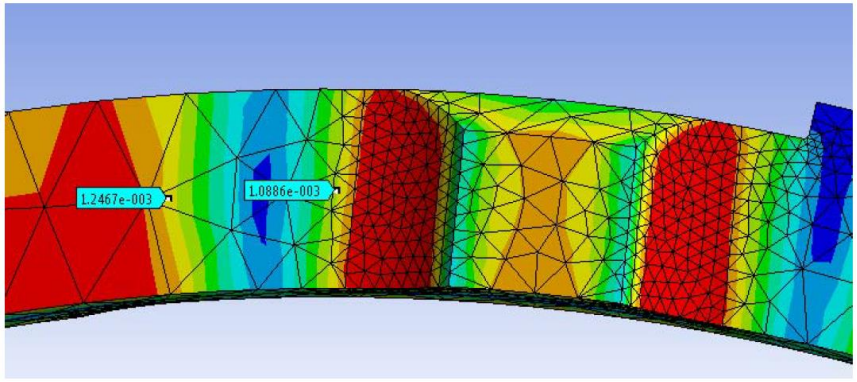
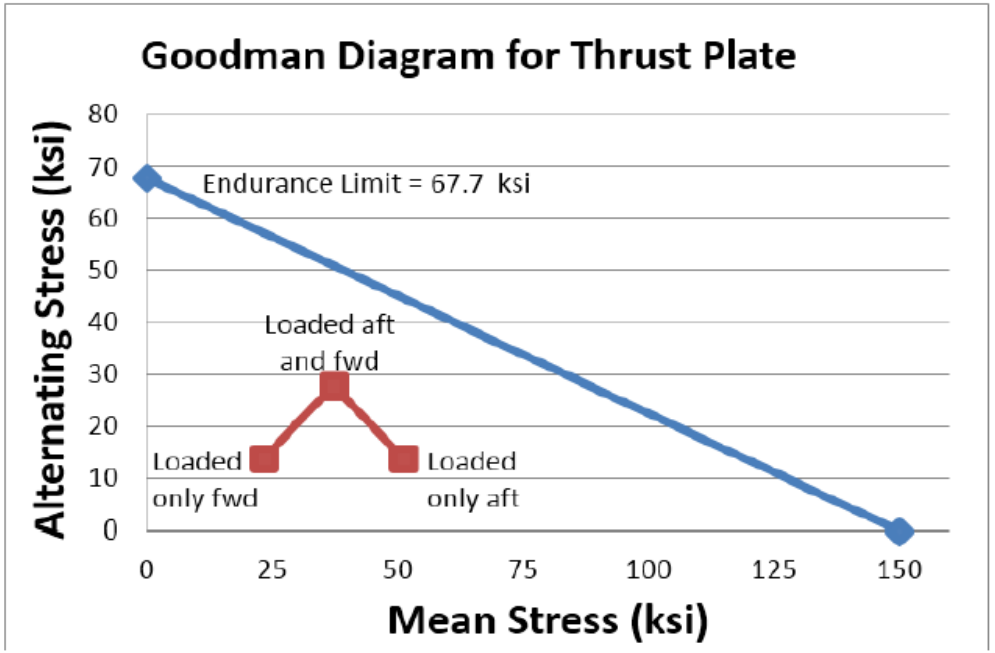
Thrust Plate- FEA Analysis

Results

- Analysis up to 14,000 lbf load
- Axial deflection of 0.064”
- Peak stress: 65.1ksi (safety factor- 2.22)
- Max stress occurs when bearing is loaded in both directions:
  - Mean stress: 37.2 ksi
  - Alternating stress: 27.9 ksi







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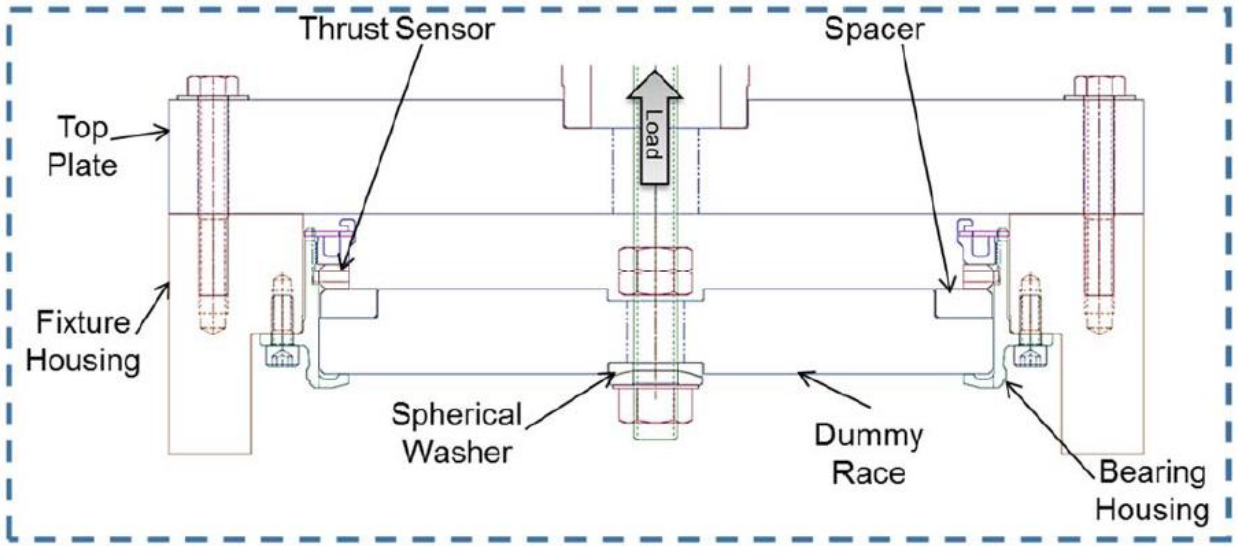
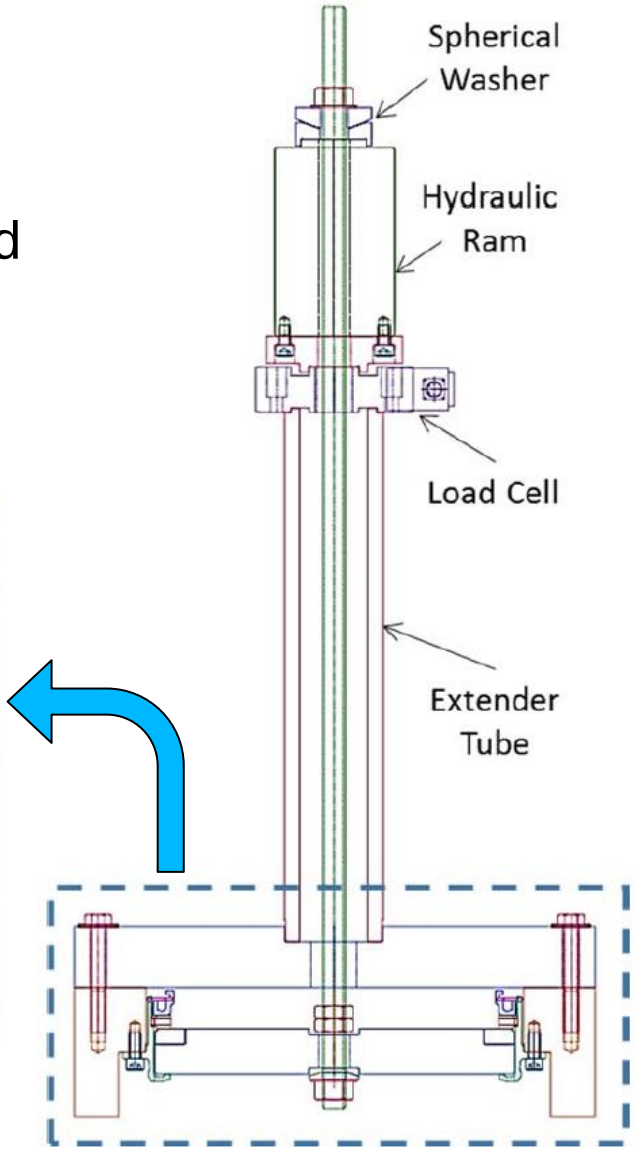
Thrust Plate Calibration

- 2 Calibration Steps with 2 different configurations:
  - I. Setup using only the spanner nut installed
  - II. Setup using the T/P, housing, spanner nut and dummy bearing

System Setup Overview



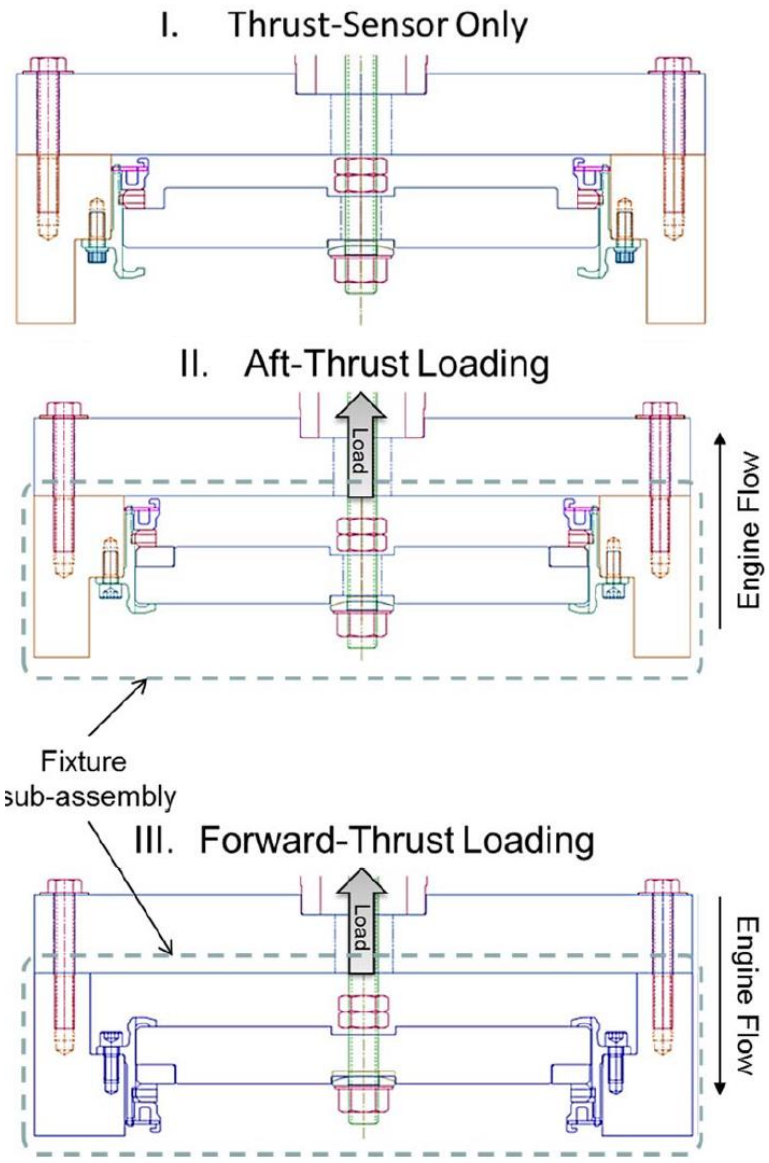


Thrust Plate Calibration Configurations

1. **Thrust sensor only** - removing the spacer ring from housing assy .Records load- strain relationship without influence of bearing stiffness

2. **AFT loading** -Full assy preload to the T/P. Records load- strain relationship due to AFT load

3. **FWD loading** - Full assy preload to the T/P Records load- strain relationship due to AFT load



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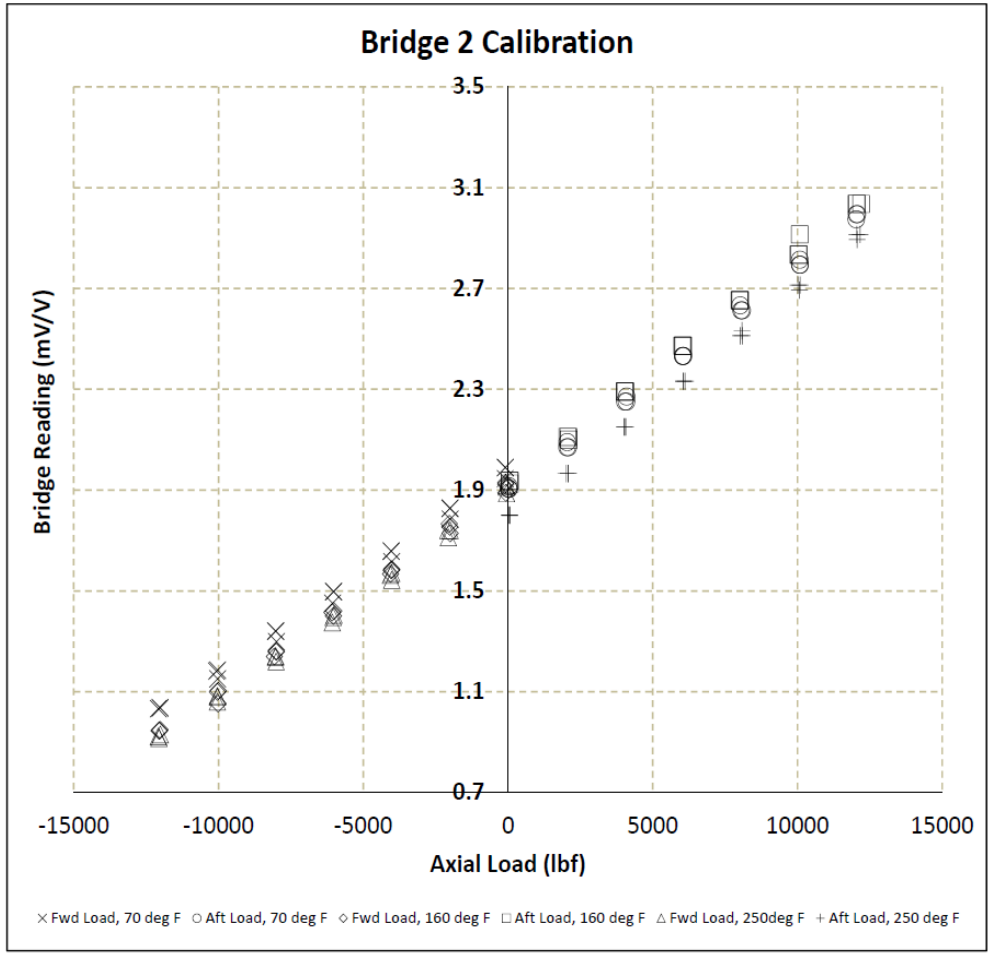
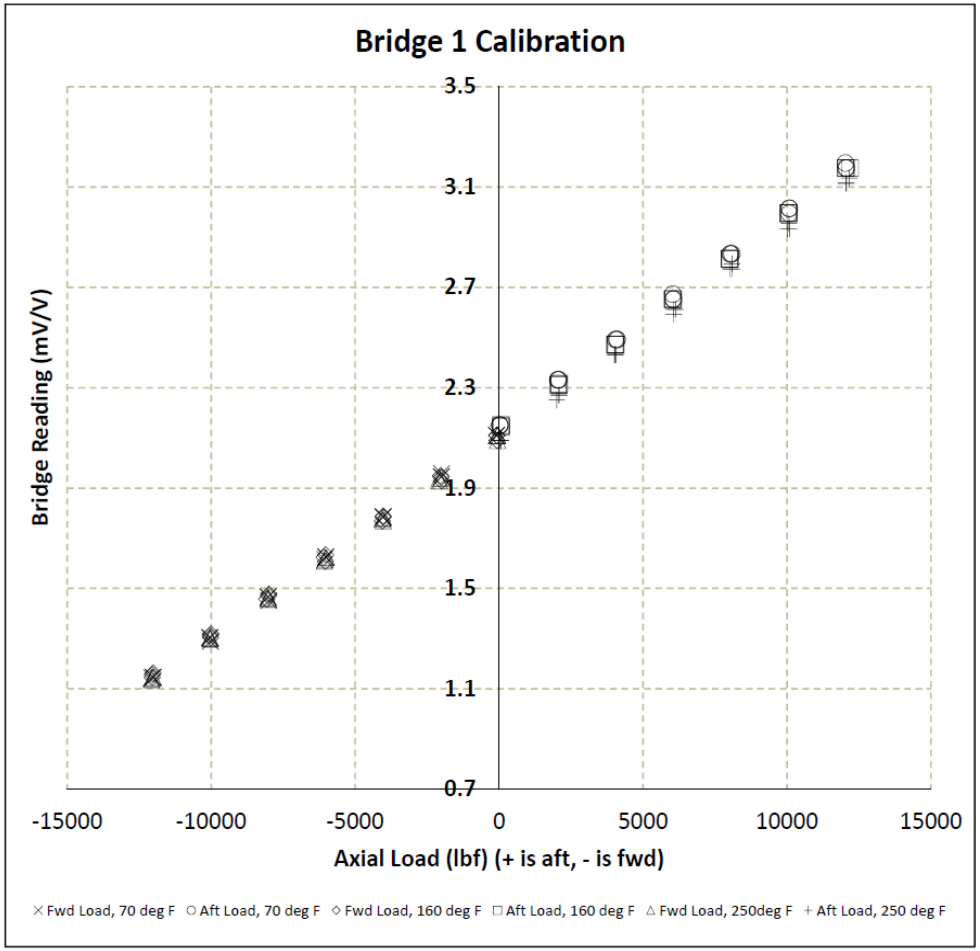
Thrust Plate Calibration Results





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Conclusion

- First time that a commercial certified turbofan engine is being instrumented in Israel
- Modifying engine parts and engine final assembly with new instrumentation present a challenge
- In addition to the engine instrumentation, a compatible DAQ system was fabricated at IAI
- The Turbofan final test is designed to begin early 2017
- The test will cover all engine's basic run modes and also explore some off design operating points

Thank you!