ACM (Air Cycle Machine)

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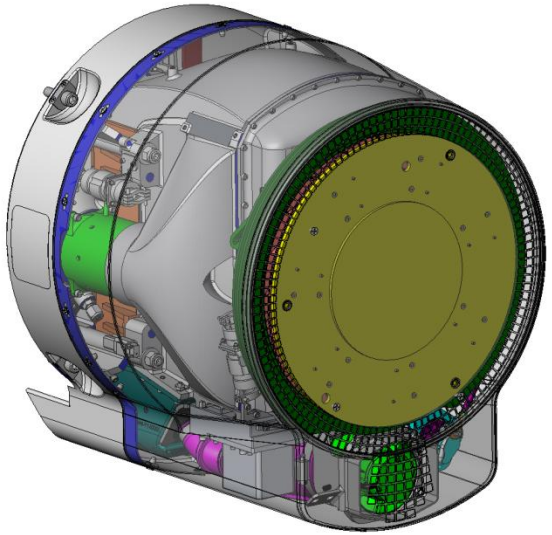
LITENIG Pod

ECU (Environmental Cooling Unit) for Rafael Litening Pod



LITENING Pod

Design Stages

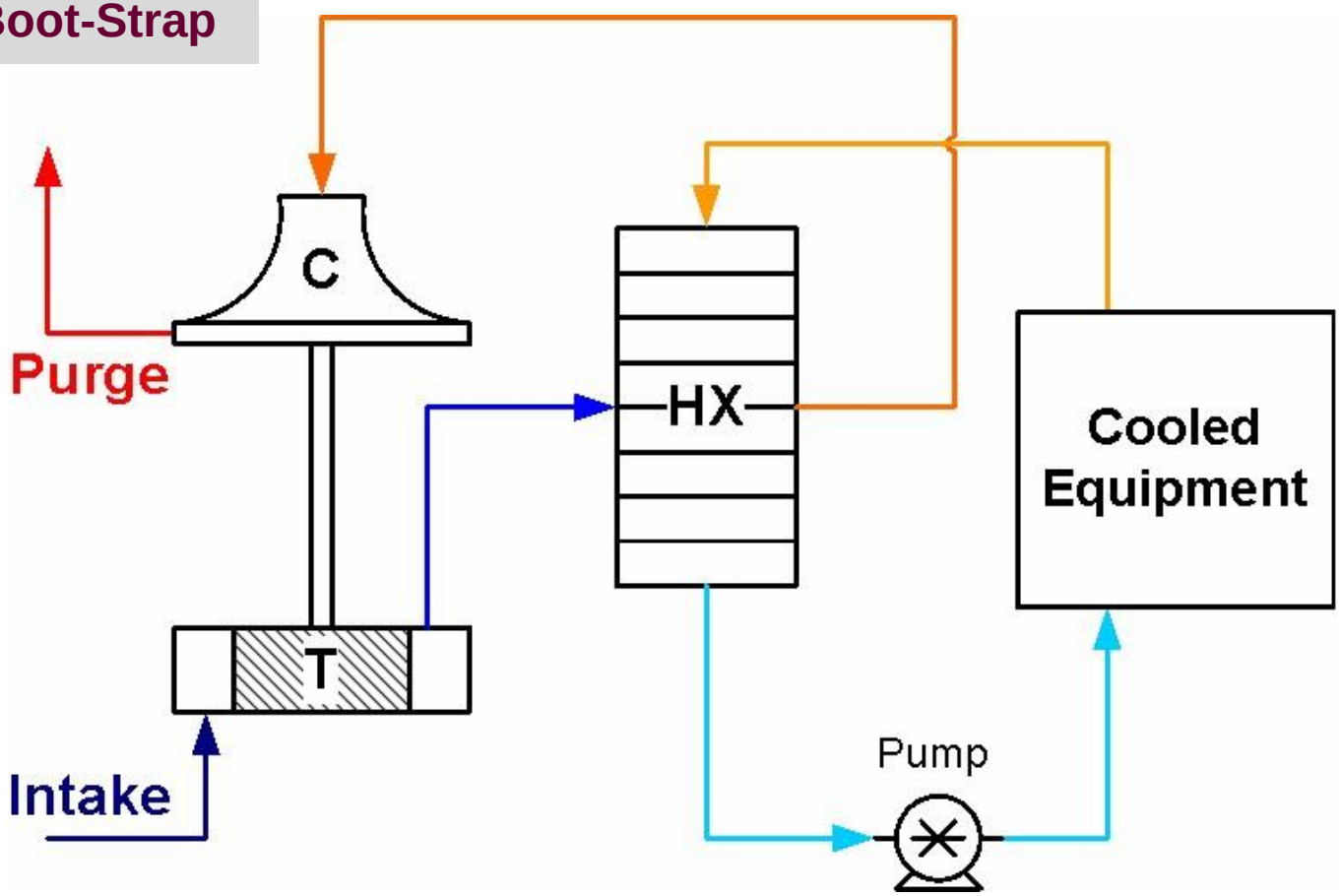
- Initiation
- Spec.
- Conceptual Design, Thermodynamic Cycle
- Components Design (Turbine, Compressor, Heat Exchangers, Flaps, Electronics…)
- Analyses: Thermodynamic, Aerodynamics, Strength, Dynamics, Heat Transfer, CFD, Balancing
- Test Facility Construction
- Flaps and Throttle Control unit Development
- ACM Control unit, Data acquisition
- Prototype manufacturing
- Prototype ground Testing
- Maturing in IAF
- IAF Performance Flight Tests

Thermodynamic Principles

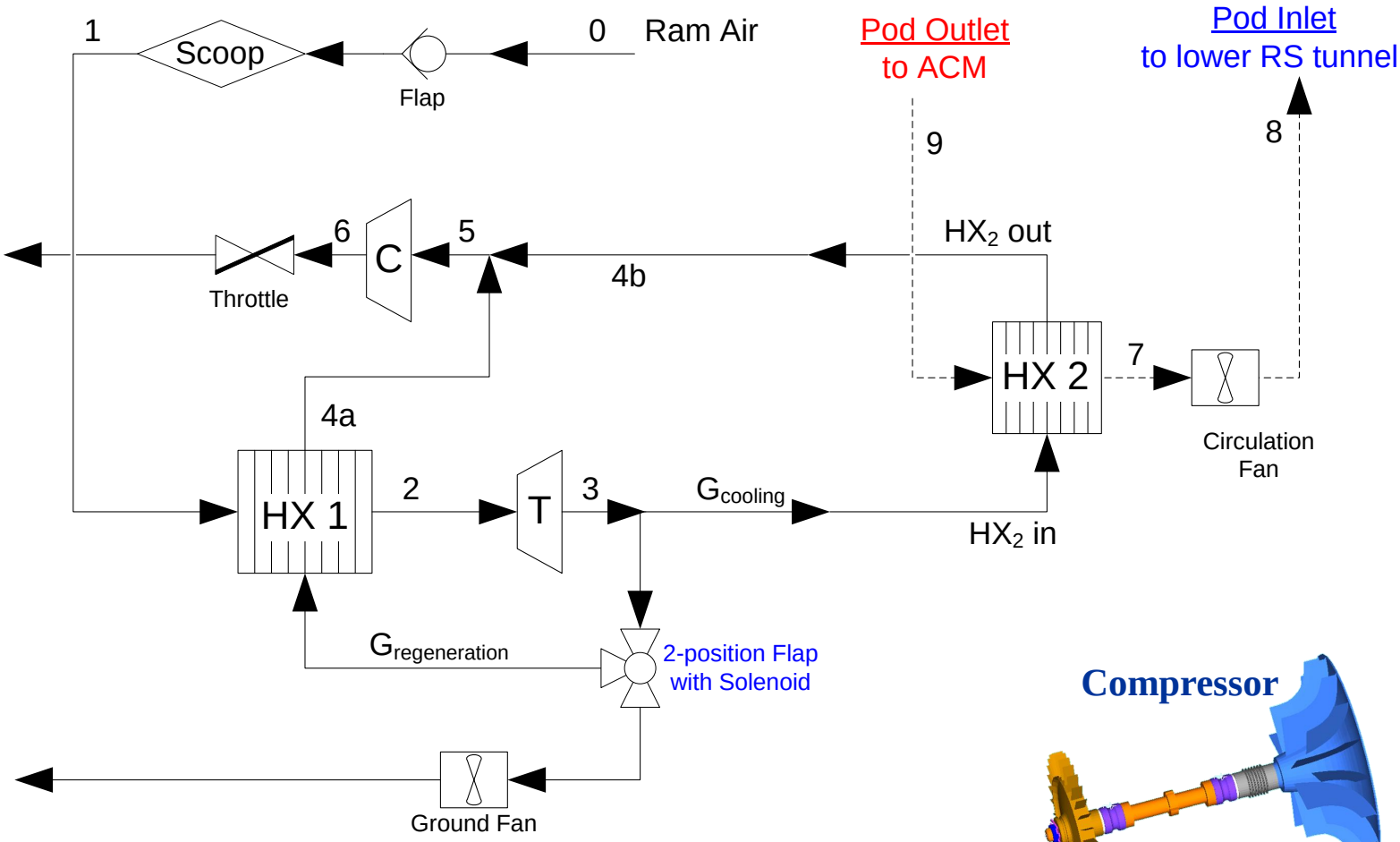
- VCS – Standard Vapor Cycle, using Refrigerant like most home refrigerators and airconditioners
- ACM – Air cycle using reverse-bootstrap rotor and pre-cooled heat exchanger, depends on Ram air to drive the TCU (Turbine Compressor Unit)

Simple ACM Scheme

Reverse Boot-Strap



LITENING ECU- ACM Scheme

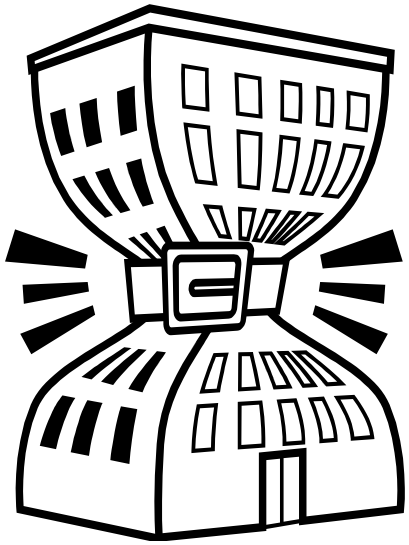


Advantages of ACM vs.VCS:

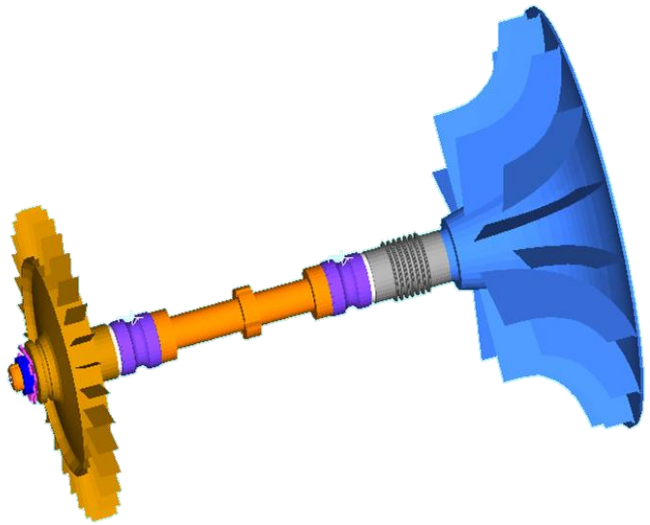
- **ACM driving Power is supplied by Ram air, VCS by the aircraft**
- **Typical COP of airborne VCS is 1.0. ACM COP is larger than 10**
- Cooling Capacity on all Flight Envelope
- Enable Future Increase in Heat rejection
- Significantly Less Power Consumption on Flight
- Lower Induced Vibration
- Simple Maintenance
- Safety: No Refrigerant, Lower pipes pressure
- Higher MTBF
- FFF (Fit, Form, Function)

Design Challenges

The architecture must enable the required performance in the given volume & weight



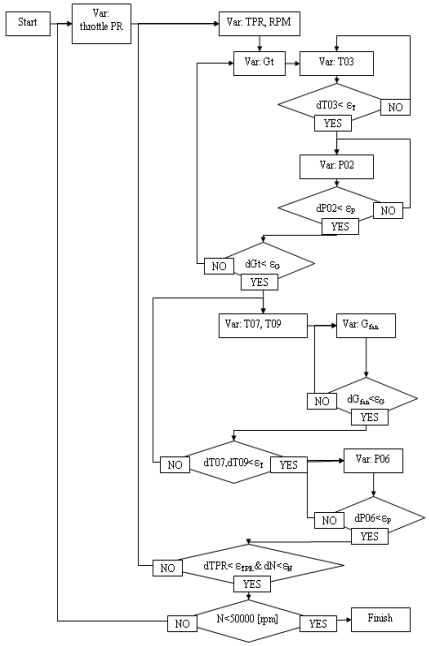
The reverse-bootstrap rotor provides further challenges in assembly and aerodynamics



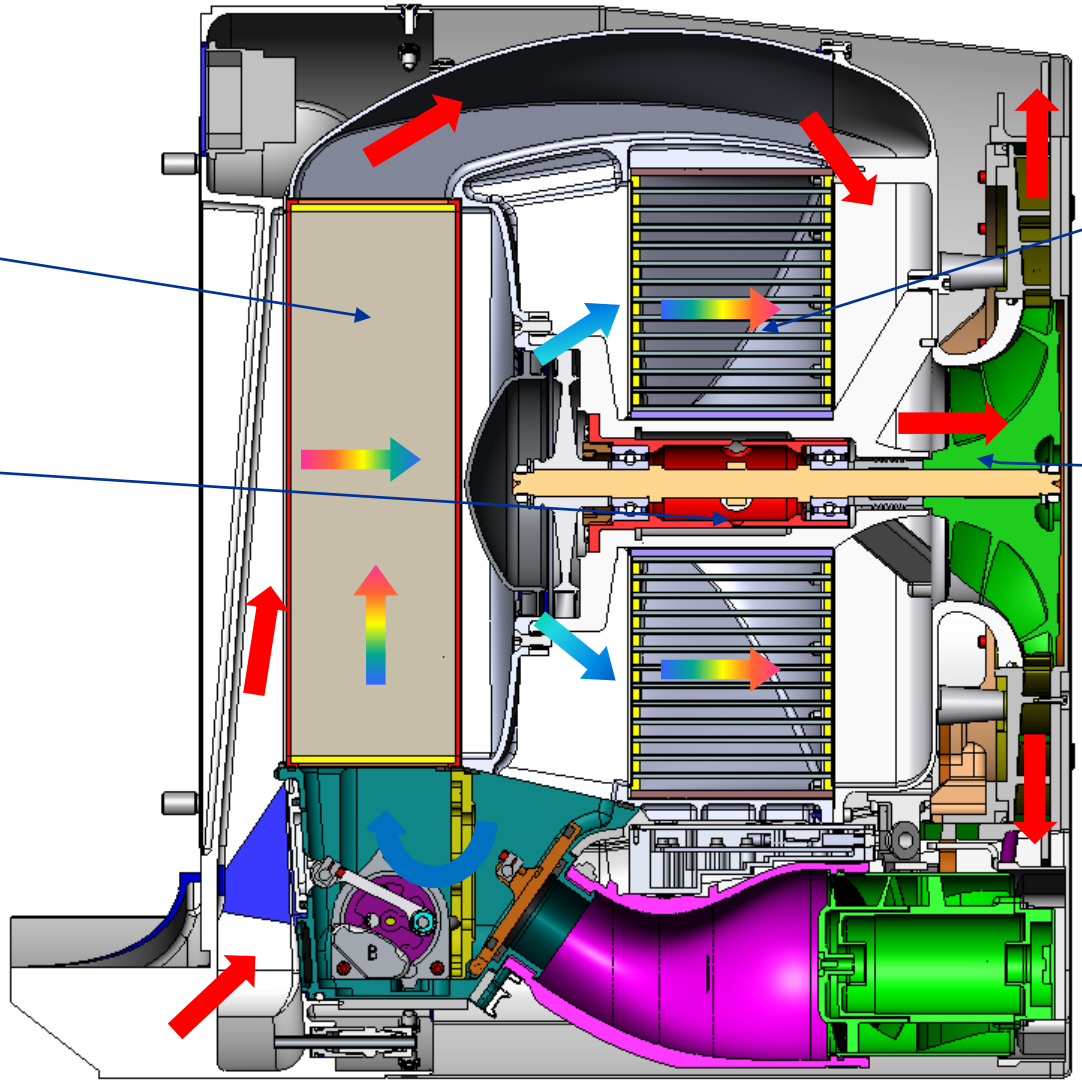
Design Challenges

Wide turns, low velocities & constant cross-sections will ensure aerodynamic efficiency

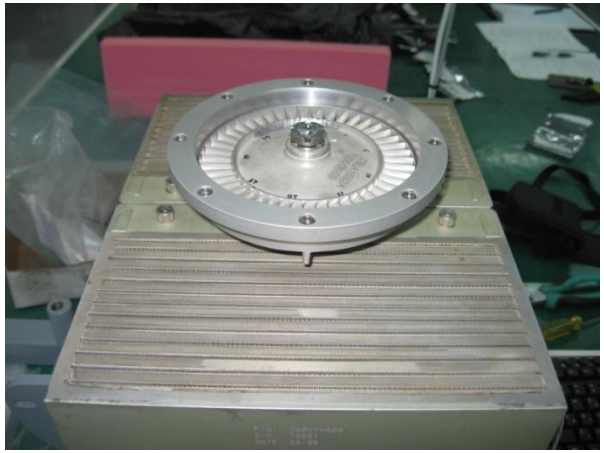
The Modeling approach is very different than turbine engines (Deck)



LITENING ECU- ACM Nominal Cycle

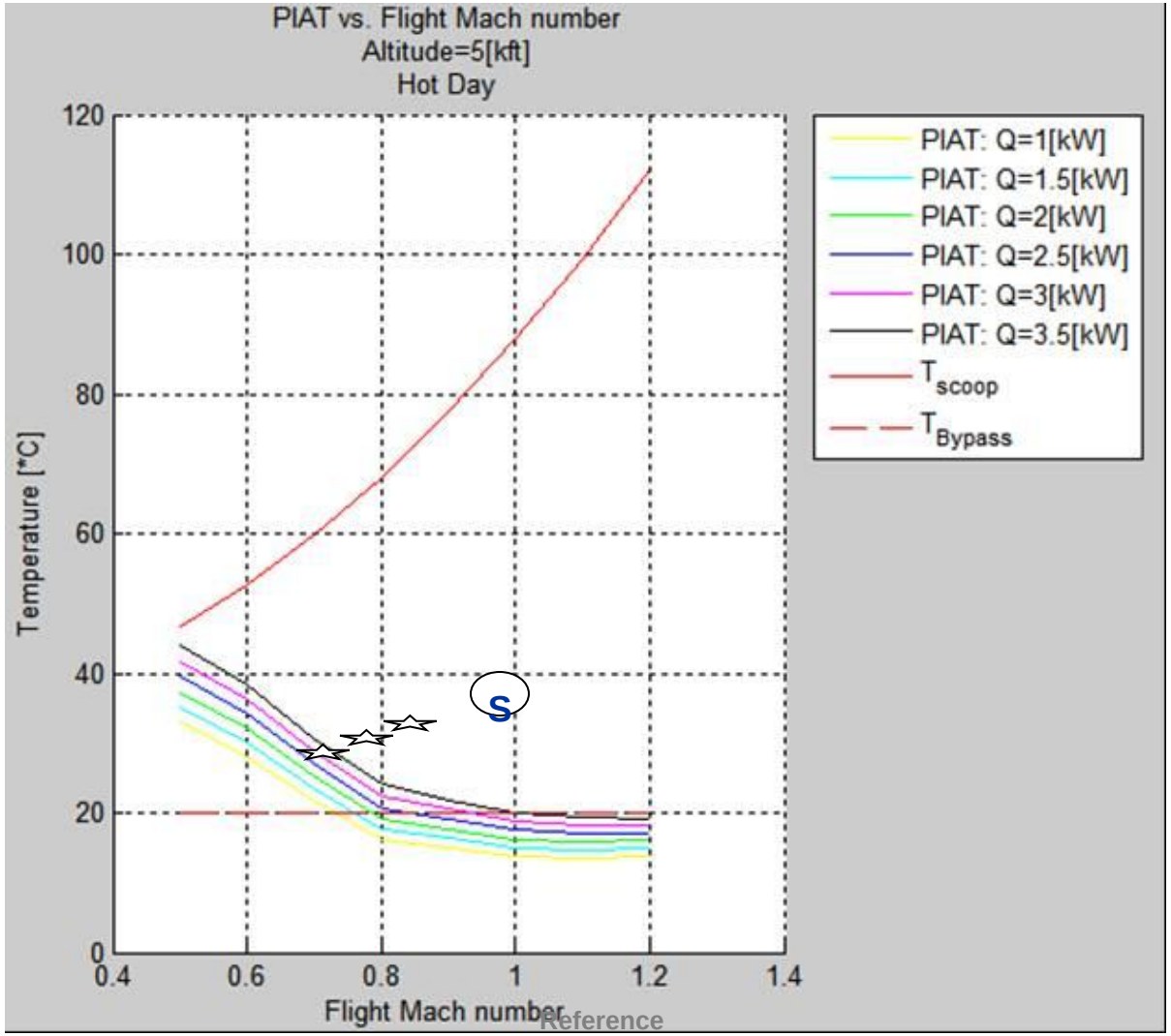


Subassemblies



LITENING ECU- ACM Testing Facility

LITENING ECU- ACM vs. VCS PIAT Performance Example on 5Kft Hot day.



VCS Temp. at 1KW Heat load

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VCS Limitation

LITENING POD with ACM Ready to be Mounted on A/C

Summary

- ACM system was successfully developed by Rafael and Becker Engineering
- Performance tests were conducted using “connected pipe” facility that was designed and constructed to address the full flight envelope
- Comparing performance with the current VCS shows clear advantage to the ACM
- Several flight tests on F16 with Litening Pod equipped with ACM were found to be successful
- ACM ECU is ready to be implemented in the future Pod generation