GE Aviation

Thermal Management System Overview

November 15, 2017

Approved for public release

Solving Thermal Management Challenges

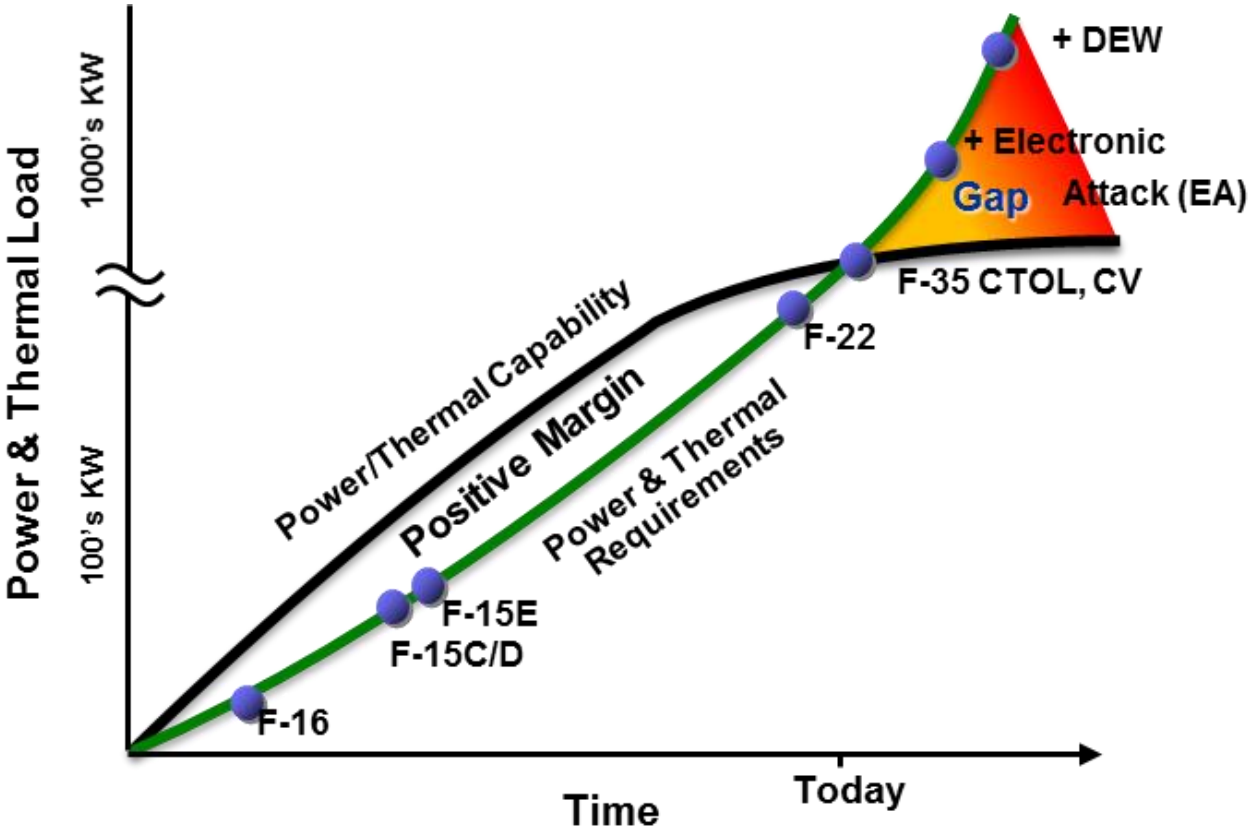
Modern military aircraft have thermal management challenges

- Avionics and weapons system electrical needs and thermal loads are increasing exponentially
- New methods are needed to provide heat rejection

Large numbers of heat exchangers and secondary sources are no longer a feasible solution

– Weight, volume and complexity

– Secondary inlets not viable



Objective: Develop and demonstrate integrated power and thermal management technologies that enable future aircraft to operate without thermal restrictions

Key TMS Performance Metrics

- No vehicle Thermal Management System restrictions throughout the operational envelope
- Support improved vehicle KPPs for increased range/persistence relative to current air dominance baseline
- On-demand, adaptive, wide temperature range and efficient utilization of available vehicle system sink(s)
- Robustness, reliability, and performance in all systems

Key System Interfaces

Engine bleed
- Interstage
- Comp Discharge

Engine lube loads
- Heat Load

Engine Fan duct
- Heat sink

Engine fuel system
- Heat sink

Engine fuel pumps
- Heat Load

Air Cycle System

Vapor Cycle System

Electric Power

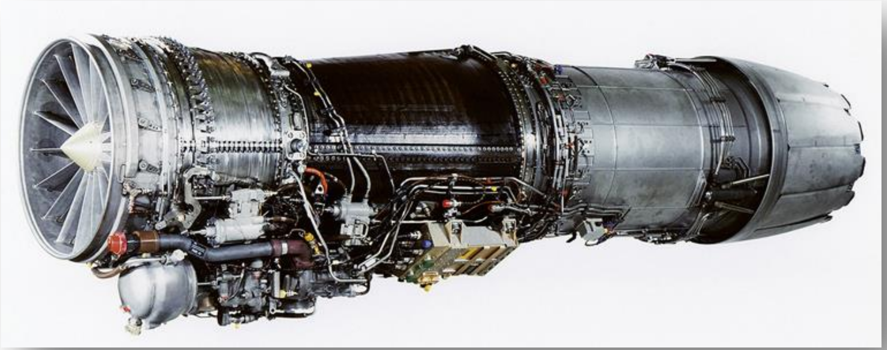
Power & Thermal Management

A/C Power Gen
- Heat Load

A/C LCL
- Heat Load

A/C Fuel Tanks
- Heat Sink

A/C Air Conditioning
- Heat Load

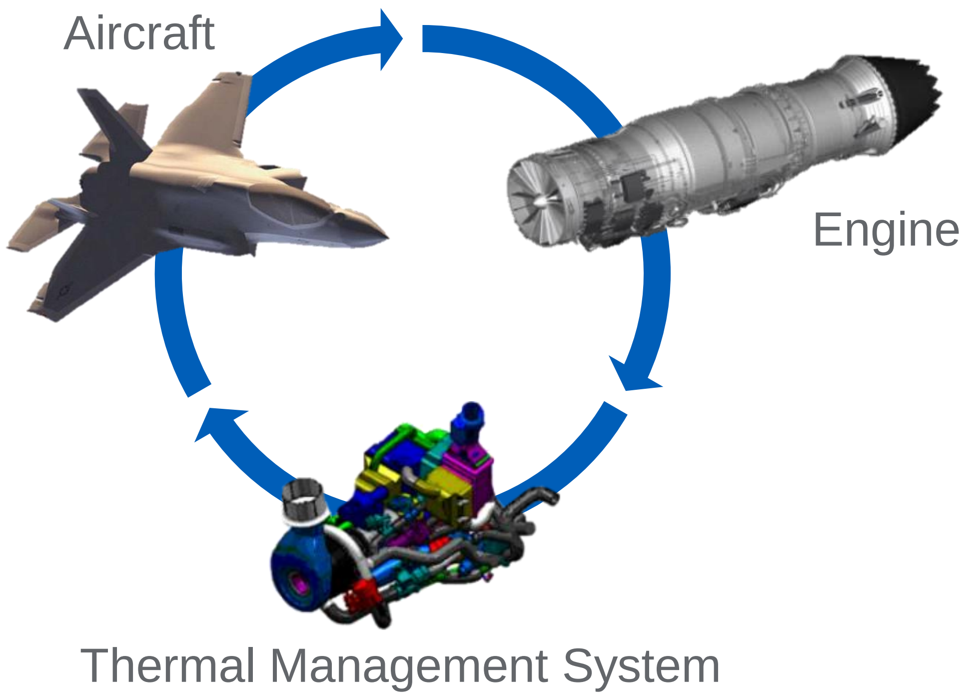


Tip to Tail Integrated Design

Optimize all aircraft systems to consume less energy and produce less heat

Create systems that efficiently move thermal energy

- Provide hybrid cooling schemes
- Utilize advanced engine third stream to transfer heat to the engine exhaust.
- Mission adaptive systems



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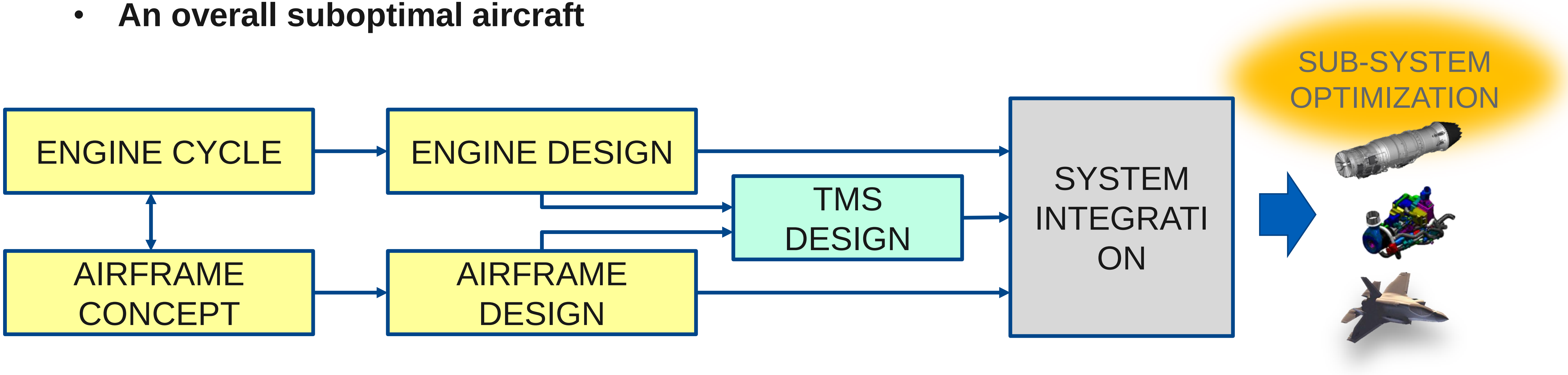
Past and Current TMS Design Approach

Traditionally, TMS design follows development of the engine/aircraft design.
TMS dependencies are mitigated

This method results in:

- Extended schedules
- Inadequate envelope
- Unplanned engine cycle impacts
- **An overall suboptimal aircraft**

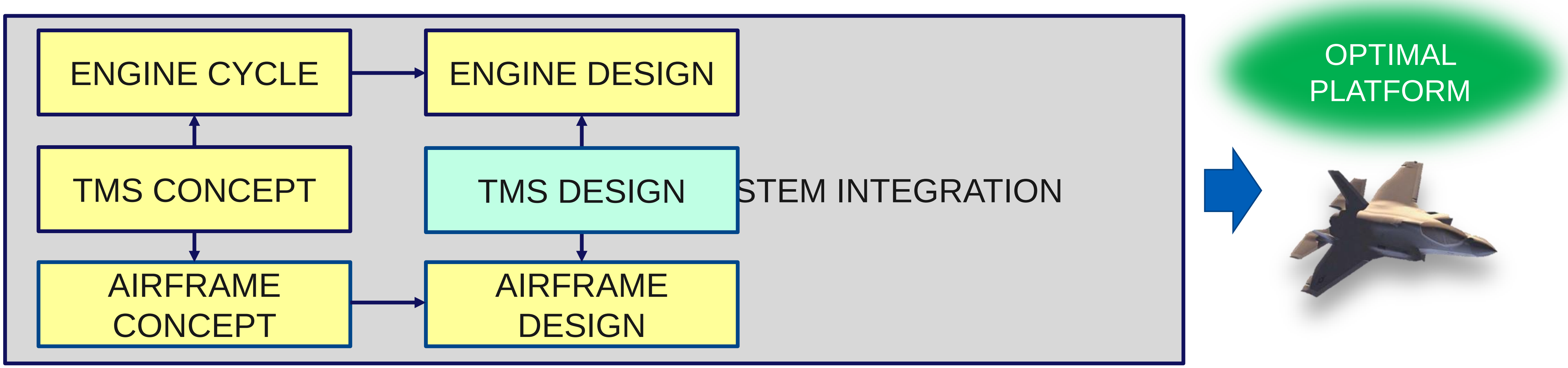


Future TMS Design Approach

TMS design should occur simultaneously with cycle design to balance the cycle impacts to TMS component sizing and vice versa. System integration must occur across the platform.

This method results in:

- Improved schedule
- Better volume management
- **Optimal system performance**



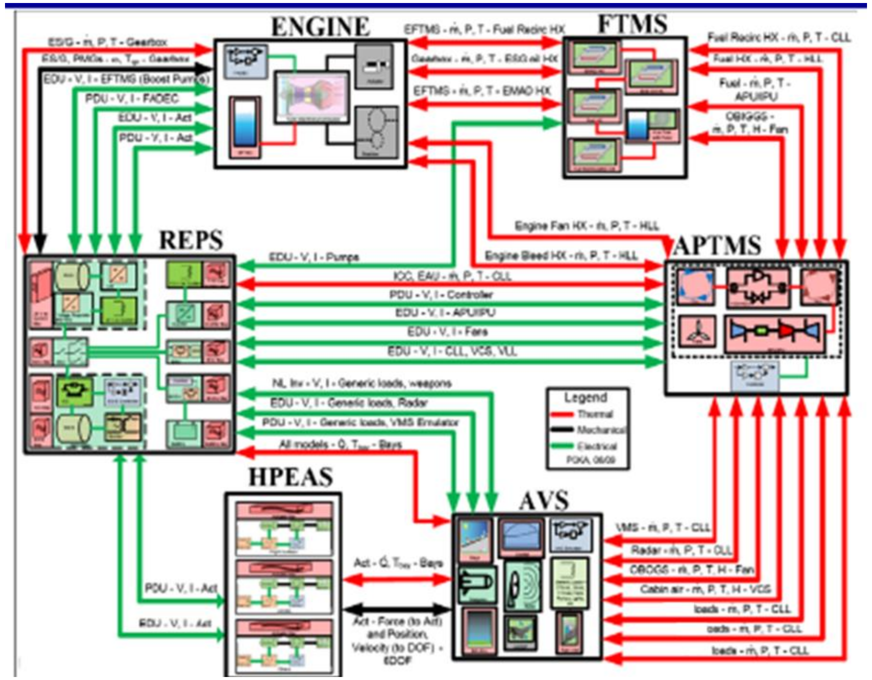
Modeling and Simulation

Develop integrated system models and conduct full system optimization

- Enables rapid iterative system design approach

Creation of time accurate mathematical models

- Scalability and applicability to multiple architectures and missions
- Allows modeling of system level interactions and transient responses
- Segment level models utilized small time steps to capture rapid transient behavior
- Mission level models to predict overall system capability



Advanced Testing Capabilities

GE Aviation – Cincinnati, Ohio

- **High pressure, high temperature, high flow air facility systems**
- **Combustion test cells**
- **Engine test cells**
- **Altitude test cells**
- **Diverse engineering expertise**
- **Extensive test facility expertise**

Summary

- Next Generation platforms must use fully integrated systems and understand their interactions

- Key technologies being developed at GE to achieve challenging goals and objectives for next generation platforms

- Full scale, integrated demos necessary to achieve sufficient risk reduction