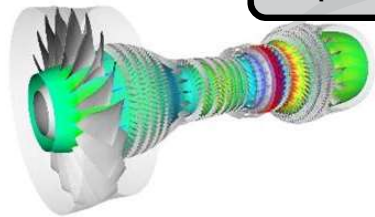


Full Engine Simulation

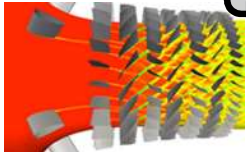
Om Sharma
Senior Technical Fellow
Raytheon Technologies Research Center
411 Silver Lane, East Hartford, Ct 06108

June 16, 2020

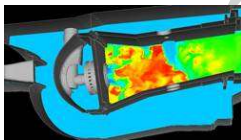
Propulsion Grand Challenge Problem



Integrated, Multicomponent



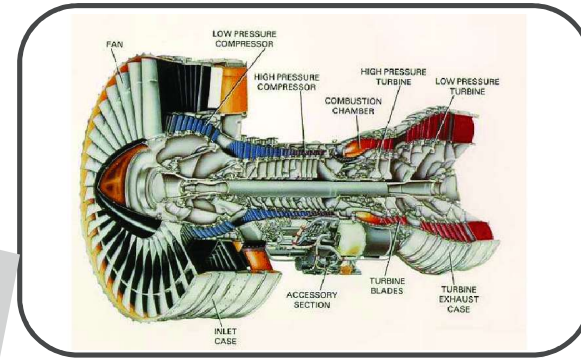
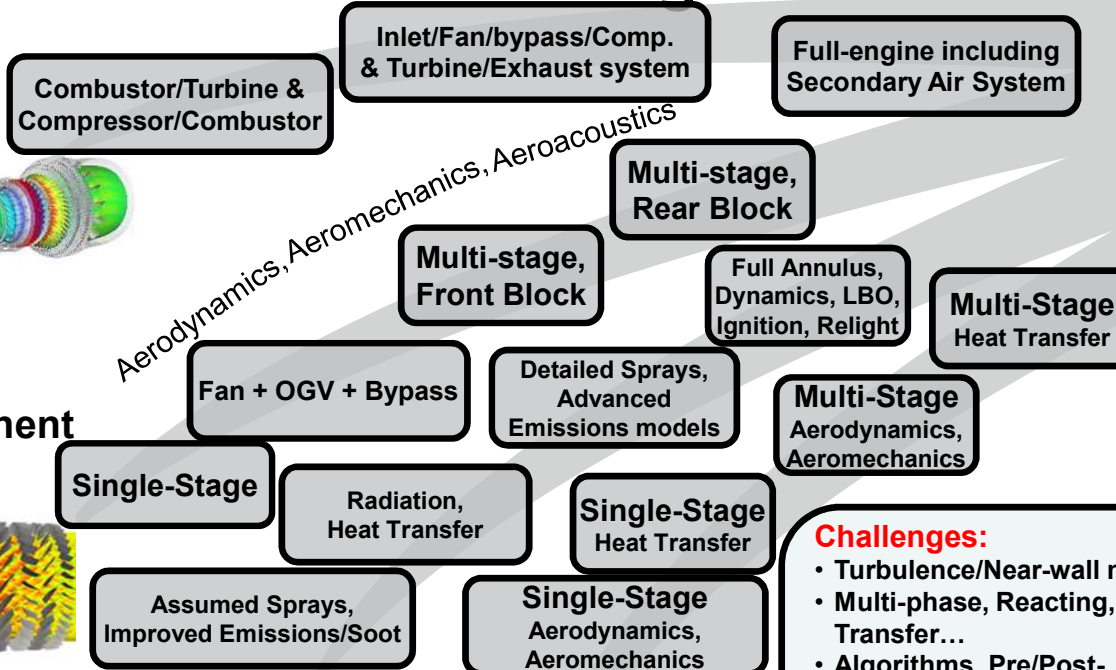
Fan, Compressor
(Inlet, Fan, OGV, Bypass, LPC, HPC)



Combustor (Diffuser, Fuel-Nozzle, Liner)



Turbine
(HPT, LPT, Exhaust System)



Full Engine Simulation in Less Than 1 Week

From model build to results enabling:

Meeting performance, operability, emissions, durability metrics with geometric fidelity & accuracy of physics to:

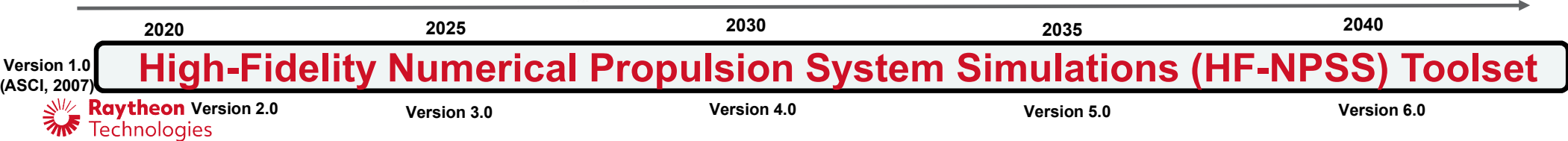
- reduce/eliminate testing
- deliver billions of dollars savings per year
- enable advance propulsion/airframe concepts

Challenges:

- Turbulence/Near-wall modeling
- Multi-phase, Reacting, Heat Transfer...
- Algorithms, Pre/Post-processing, Infrastructure

Enablers:

- Test Data – Common Research Models; HPC exploitation



High-Fidelity Numerical Propulsion System Simulations

Progress since 2007:

- ✓ Sector simulations, similar to ASCI with 20X finer grids, can be done ~ 1.5B computational cells, 3000 cores, 2 weeks ~ $O(10^6)$ core hour
- ✓ Full-wheel, with local hybrid RANS/LES can be done with ~ 15B computational cells, 30,000 cores, 2 weeks ~ $O(10^7)$ core hours
- ✓ Eddy simulation explored in turbines, and localized areas of compression system
- ✓ More details of cooling in turbine/combustor
- ✓ Wall temperatures – towards CHT
- ✓ Fuel spray atomization

Outstanding issues:

- ✓ Hard to track progress on individual elements, based on existing CFD Vision 2030 roadmaps
- ✓ Funding is scarce and intermittent, computational resources still limited
- ✓ Government-funded full engine simulation activity is needed, if we are serious about making progress in this Grand Challenge!

Propulsion Grand Challenge Problem – Panelist’s Opinion

- **Design, Execution, and Importance of the Grand Challenge effort:**
 - Design can be enhanced with limited modification suggested in an earlier slide
 - Execution of the tasks are being done with very limited resources, engagement of the funding agencies is needed to accelerate the execution
 - Very important, it has the potential to provide 10-15% “cradle to grave” cost savings for the propulsion system
- **Effective ways to engage the science and engineering communities to efficiently tackle these long-term focus activities:**
 - Identify funding in strategic areas
 - Monitor the progress in annual AIAA meetings and workshops