Parametric Subsonic Engine Model

2024 NPSS Annual Meeting: Government & Industry Day
San Antonio TX
March 8rd

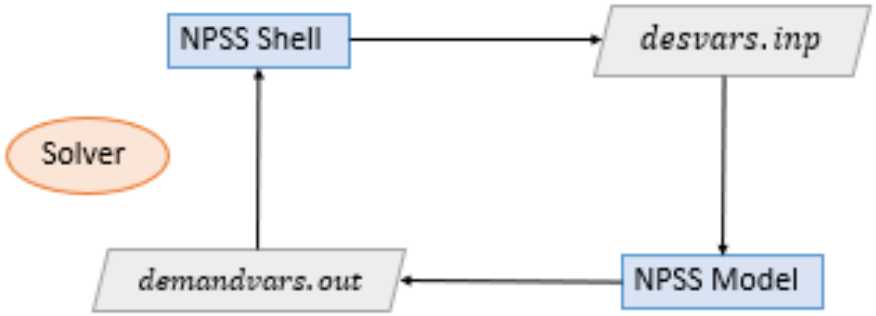
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Goals

- **Create a rubberized subsonic engine model**
- **Respond to changes in design variables**
  - Obtain the correct engine performance impact to changes in each and all design variables
    - Example increasing HPC pressure ration raises T3 impacting cooling flow
- **Allow for quick setting of technology levels**
  - Polytropic efficiency levels versus year??
  - Cooling flow metal temps
- **Check built-in error**
  - Max map efficiency
  - Others coming
- **Use NPSS cycle model only**
  - Not linked to other high-fidelity tools (OTAC)
    - Can be done
  - Eg T4 max is input, not turbine life

Quick Multi-Design Point (MDP)

- **NPSS calling NPSS**
- **Outer NPSS shell drives the MDP**
  - Writes out MDP balance variables into scratch input file
  - Variables that are dependent on true design variables that span several operating points



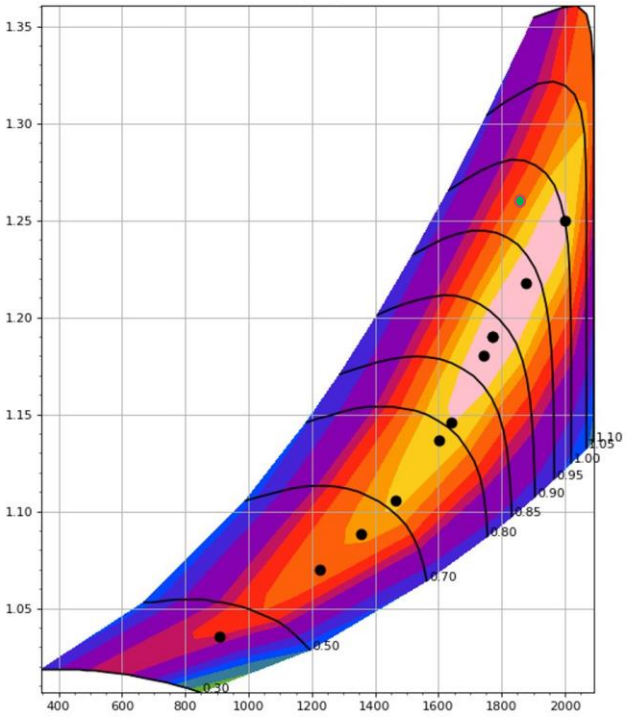
- **Model still runs when not using MDP at final point**
  - Last scratch file is persistent
- **Glenn also does MDP through multiple assemblies**
  - Love to get feedback!

MDP Balances

- **MDP Variables (Independents) assuming cruise point is "design" point**
  - Cruise Compressor HPC PR
  - Cruise Inlet weight flow at cruise
  - Cruise Splitter BPR at cruise
  - Cruise Bleed flow fractions
  - Cruise T4
- **Demand Variables (Dependents)**
  - SLS Pressure Ratio
  - SLS Thrust
  - SLS T4
  - RTO Jet Velocity Ratio
  - RTO COOLIT Cooling errors
- **Additional Design Inputs**
  - Fan Pressure Ratio
  - T4max
  - OPR
  - Can add more, but model must respond to them
    - LPC PR

Peak Efficiency Map

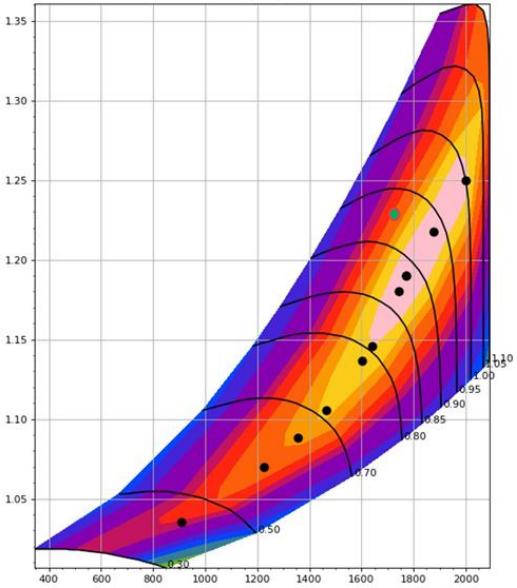
- **If not careful design point efficiency can scale map effs too high**
  - Worst case, scaled efficiencies above 1 are possible



- **Set green design point to a high value**
  - Black points can be way too high if cycle converges there

Make Cruise Point Max Eff Point

- **Additional variables and values in map tabular data**
  - Each has these values defined
    - peakEffNc
    - peakEffRline
    - Identify location of maximum efficiency
  - Set your design point cruise to this condition?
    - This is map specific decision
  - At least make scaled value an output
- **Need to change Max Power schedule**
  - Need to set full power point
  - Design point now controls the map speed set-up
  - Scale map power code map
    - PercentPower.s_rtn = CmpFSec.S_map.NcMap/.9;
- **Did this for HPC and Fan**
  - LPC is way out there…
    - Never modelled correctly
      - 1-D assumptions break down here
- **What to do with the turbines?**



Technology Levels

- **Schedule polytropic effs**
  - Higher polytropic efficiencies with increased technology
  - Add tip clearance losses?
- **Cooling flow metal temps**
  - COOLIT
  - Add in COOLIT efficiency adjustments?
- **What else in a subsonic engine?**

Future Work

- **Automate WATE++ code to respond to design changes**
  - Automate process for a particular model
    - Increase stage count based on stage loading
    - Geometry needs to be re-aligned based on turbine work levels
      - Want reasonable s-ducts
    - Compressor maximum tip speeds
    - …and on and on
  - Done it in the past for subsonic engine
    - TOMAS, SANDIE, AST
      - Was it done it right? (no)
  - Problem is very choppy
    - Materials change resulting in step changes in density
    - Stage counts and blade counts
  - Geared versus ungeared is higher decision not for one model

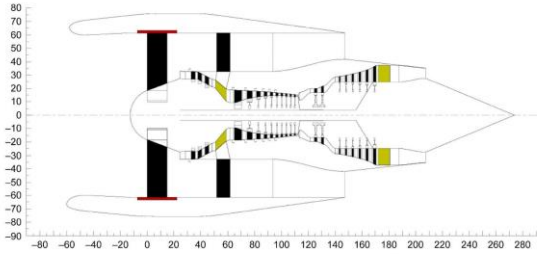


Figure 3.—300-passenger engine flowpath model generated by WATE++.

Proposal to Include Sample Model in Engines Models and Interfaces (EMI)

- **Might be valuable to people who are learning modeling and people doing simplified models in trade spaces**
  - Outside the model, MDP framework may be of interest
    - General capability applicable to any level model of any type
    - Find out in San Antonio
- **Simple MDP**
  - EMI based components
  - No additional tool linkage required
- **No WATE++ module option pack**
  - WATE++ is restricted

Demo

