



NASA Conceptual Design Toolchain Workshop for eVTOL Aircraft: August 22-26, 2022
Topic: **Numerical Propulsion System Simulation (NPSS) Power Systems Library**
Presenter: **George Thomas – NASA Glenn Research Center**

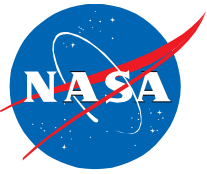
- Introduction
- Numerical Propulsion System Simulation (NPSS)
- NPSS Power Systems Library
- Workflow
- Input/Output
- Future work

- eVTOL design process complicated by lack of integrated multiphysics systems analysis tools
 - NASA investing in modeling and tool development to help address this weakness
 - One tool is the NPSS Power System Library / NPSS Electric Port
- Numerical Propulsion System Simulation (NPSS) is a key industry propulsion system modeling tool
 - Inherently multiphysics capable, but no existing built-in interfaces and models for electrical power systems
- NPSS used in RVLT toolchain to develop propulsion system data for vehicle models
 - Ongoing effort to build power system models for RVLT concepts with NPSS Power System Library
 - Effort will be first time NPSS Power System Library is integrated directly in RVLT toolchain

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- npss**
- NUMERICAL PROPULSION
SYSTEM SIMULATION**
- A Consortium of **SwRI**

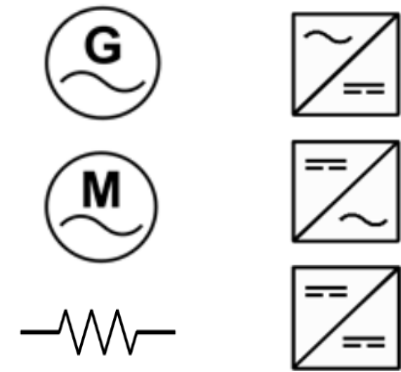


NPSS Power System Library

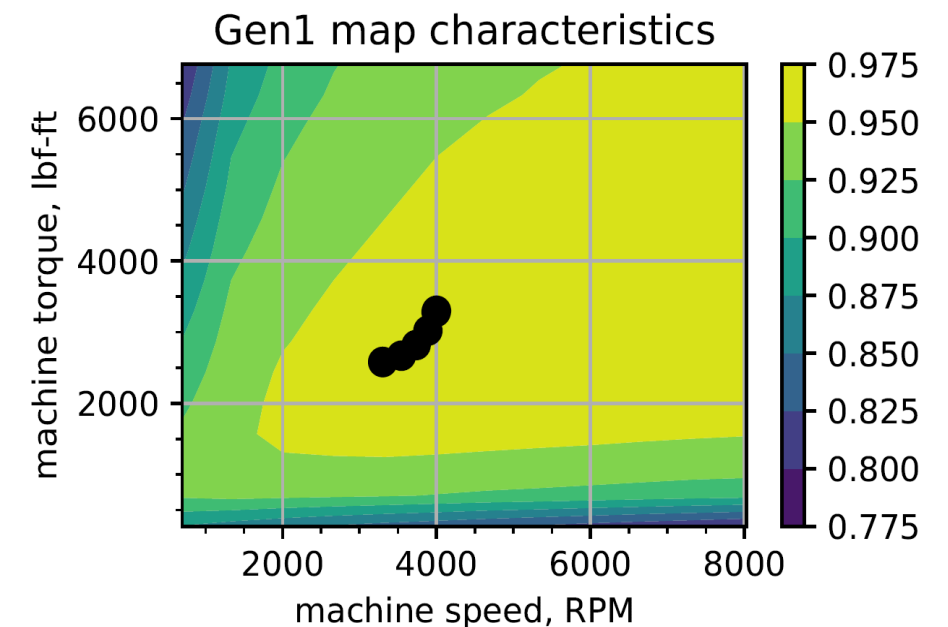


- NPSS Consortium to add electrical port into next official NPSS release
- NASA developing open source library of power components for port
 - <https://github.com/nasa/NPSS-Power-System-Library>

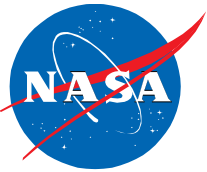
ELEMENT	MAP	MDP	DC	AC, 1-PHASE	AC, 3-PHASE
CABLE			X	X	X
MOTOR	X	X			X
GENERATOR	X				X
RECTIFIER	X		X		X
INVERTER	X		X		X
DC-DC CONVERTER	X		X		
BREAKER			X	X	X
LOAD			X	X	X
SOURCE		X	X	X	X
BATTERY	X		X		
RESISTOR			X	X	
CAPACITOR			X	X	
INDUCTOR			X	X	



- Capabilities
 - Performance (efficiency) maps
 - Sizing logic (multi design-point (MDP), cable)
 - Integration with thermal/propulsion
 - Transients (thermal and shaft dynamics)

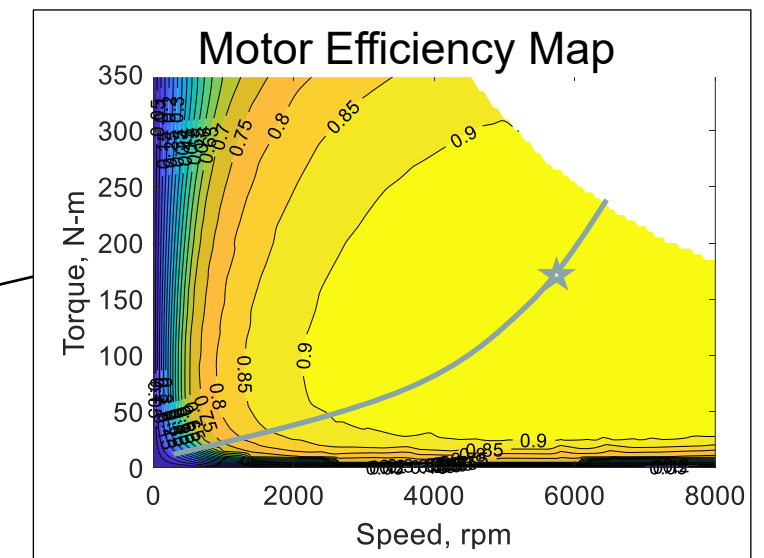
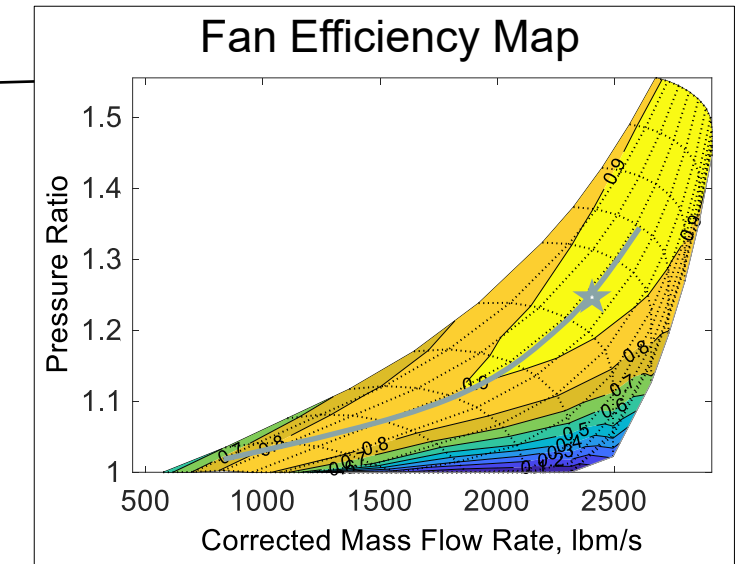
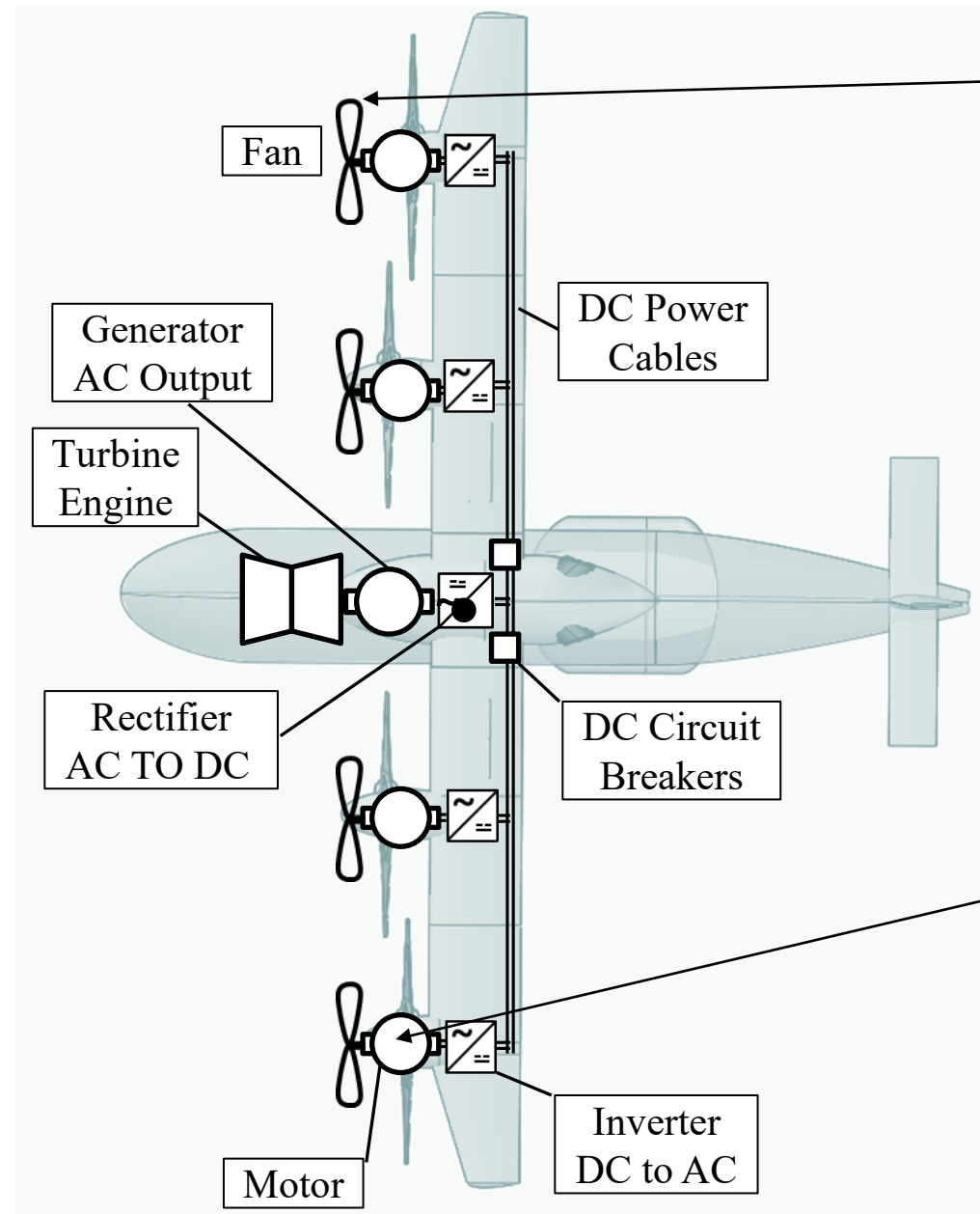
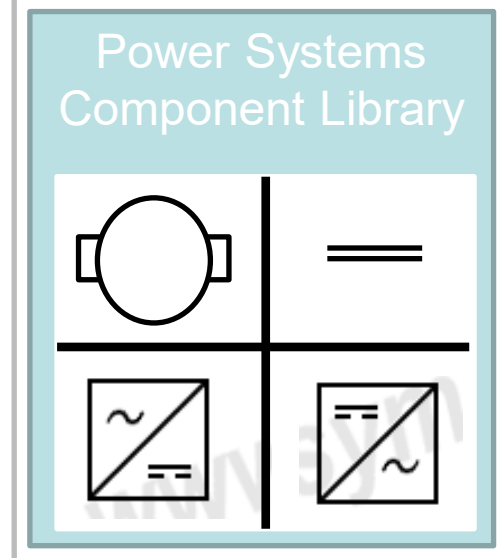
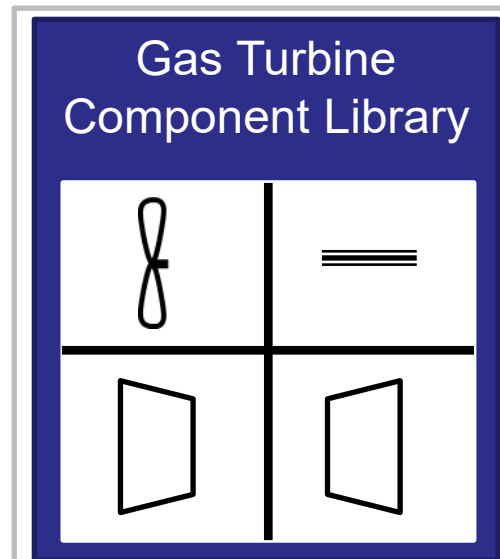


Workflow

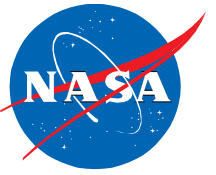


NPSS Workflow with Propulsion and Power

Model and size power and propulsion subsystems together



Input/Output



Presenting I/O for team's RVLT Quad6 Model

- Inputs

- Modeling assumptions/constants file
- Model definition file(s)
 - Define architecture in terms of modular assemblies
- Run file
 - Instantiate a model
 - Define input parameters
 - Define solver variables and Ics

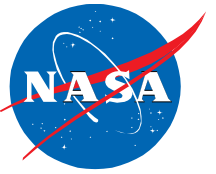
- Outputs

- Viewer Output files (NPSS Standard)
- CSV files (import to Excel)

```
▼ npss-rvlt-quad
  ▼ include
    ⚙ Acp_4001_NPSS.map
    ⚙ axi-3_2.map
    ⚙ hpt1269.map
    ⚙ lpt9013.map
    ⚙ techAssumptions.int
  > map_plotting
  ▼ model
    ▼ DC_Hyb_Model
      ⚙ DC_Hyb_Engine.mdl
      ⚙ DC_Hyb_LoadAssembly.mdl
      ⚙ DC_Hyb_Model.mdl
      ⚙ DC_Hyb_SourceAssembly.mdl
    ▼ TE_Model
      ⚙ TE_Engine.mdl
      ⚙ TE_LoadAssembly.mdl
      ⚙ TE_Model.mdl
      ⚙ TE_SourceAssembly.mdl
    ⚙ AC_Model.mdl
    ⚙ DC_Model.mdl
    ⚙ TS_1S.mdl
```

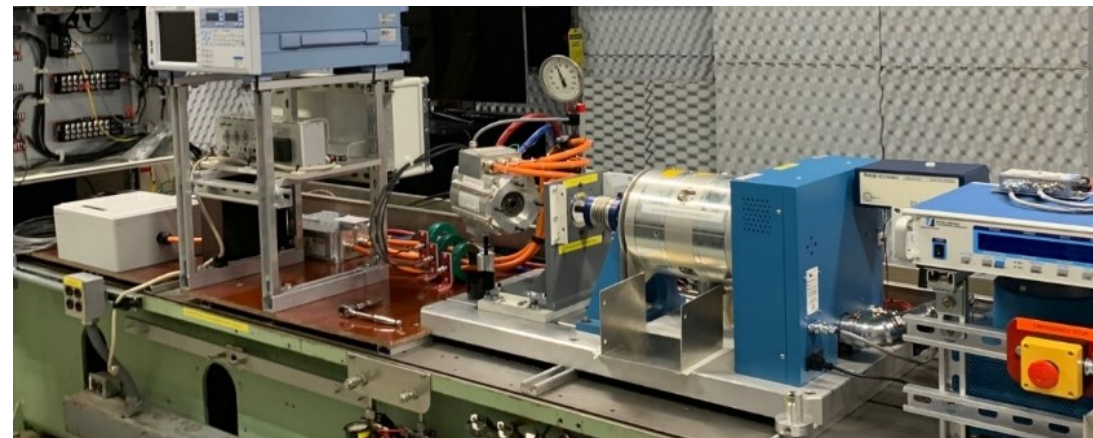
```
▼ run
  ⚙ AC_Model.run
  ⚙ DC_Hyb_Model.run
  ⚙ DC_Model.run
  ⚙ TE_Model.run
```

Future Work



- Continue developing electrical component models in NPSS
- Model remaining RVLT concept power systems with NPSS Power Systems Library
 - Use these to produce higher fidelity power system metamodels for NDARC, other tools in toolchain
- Creating standard electrified propulsion demo model with NPSS Consortium
 - To be included in the official NPSS elements, models, and interfaces (EMI) package
 - Expected to inform SAE recommended practice on electrified propulsion modeling conventions
- Develop NASA test cells to produce data for NPSS power model validation/refinement
 - Scaled/lower power (up to 9 kW) testbed for controls testing
 - Higher power & voltage (up to 200 kW, 1000 V) testbed for efficiency, power quality, fault, thermal testing

Photo of NASA's Scaled
Power Electrified Drivetrain
(SPEED) Testbed



Demo

