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Steady-State Power Operation of a Supercritical Carbon Dioxide Brayton Cycle

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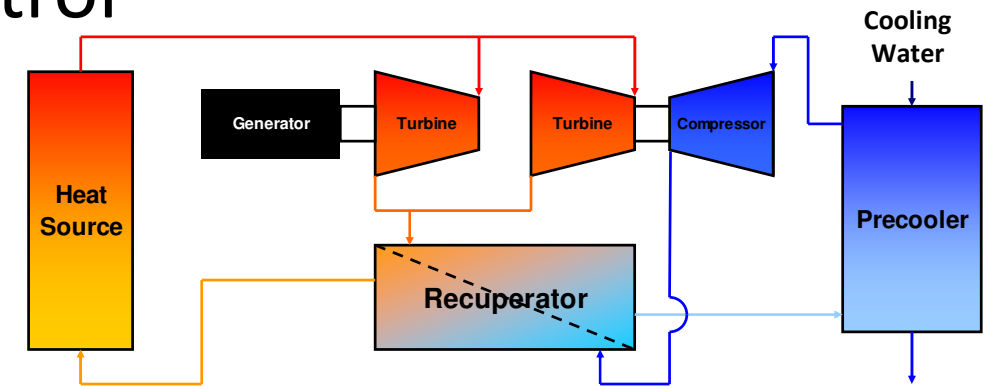
Presentation Summary

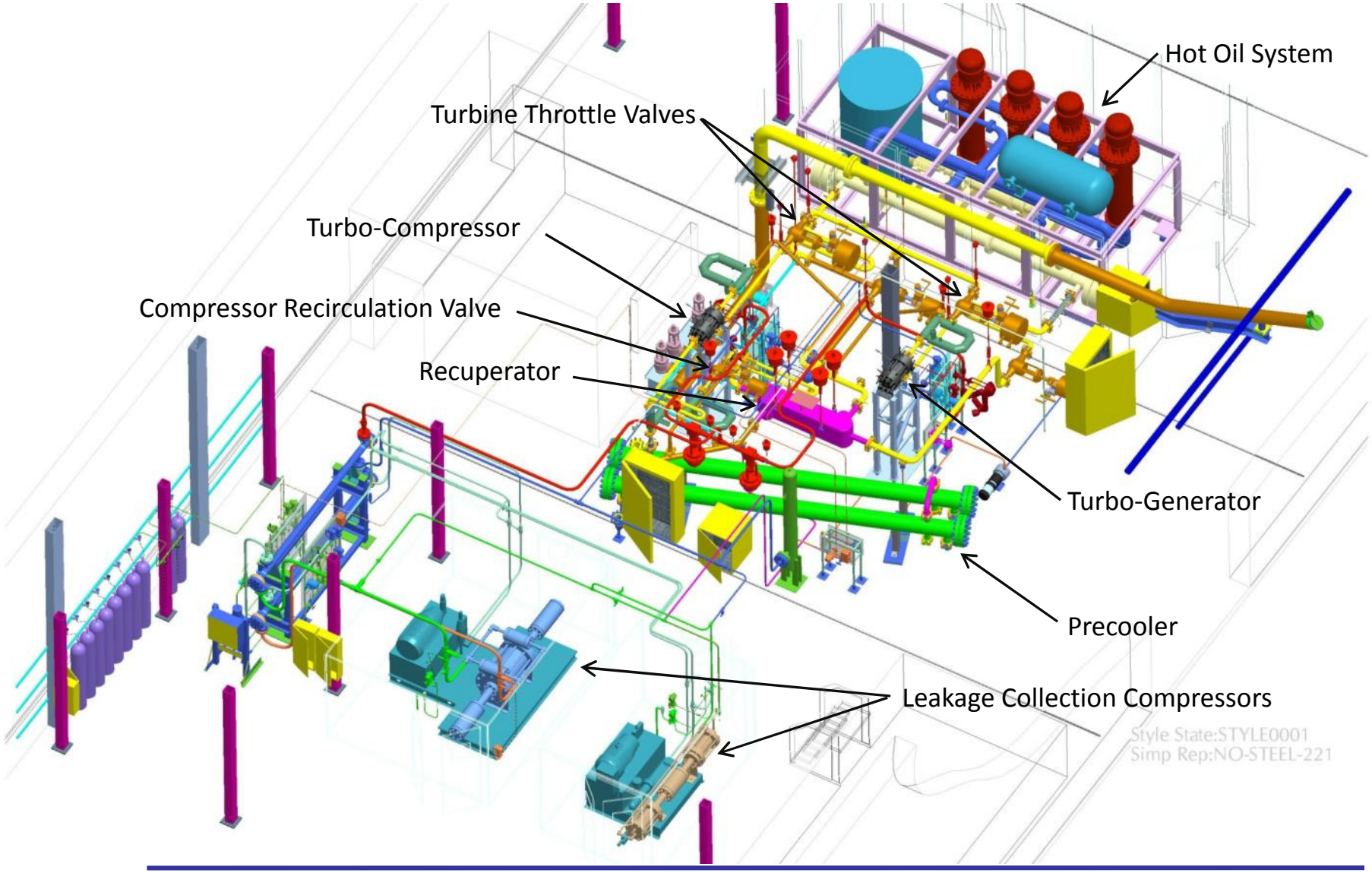
- S-CO_2 Brayton Cycle Integrated Systems Test (IST) Overview
- System Operational Overview
  - Loop startup
  - Normal Operating Conditions
- Operational Test Results
  - Normal Power Generation
  - Maximum Power Operation

IST Overview

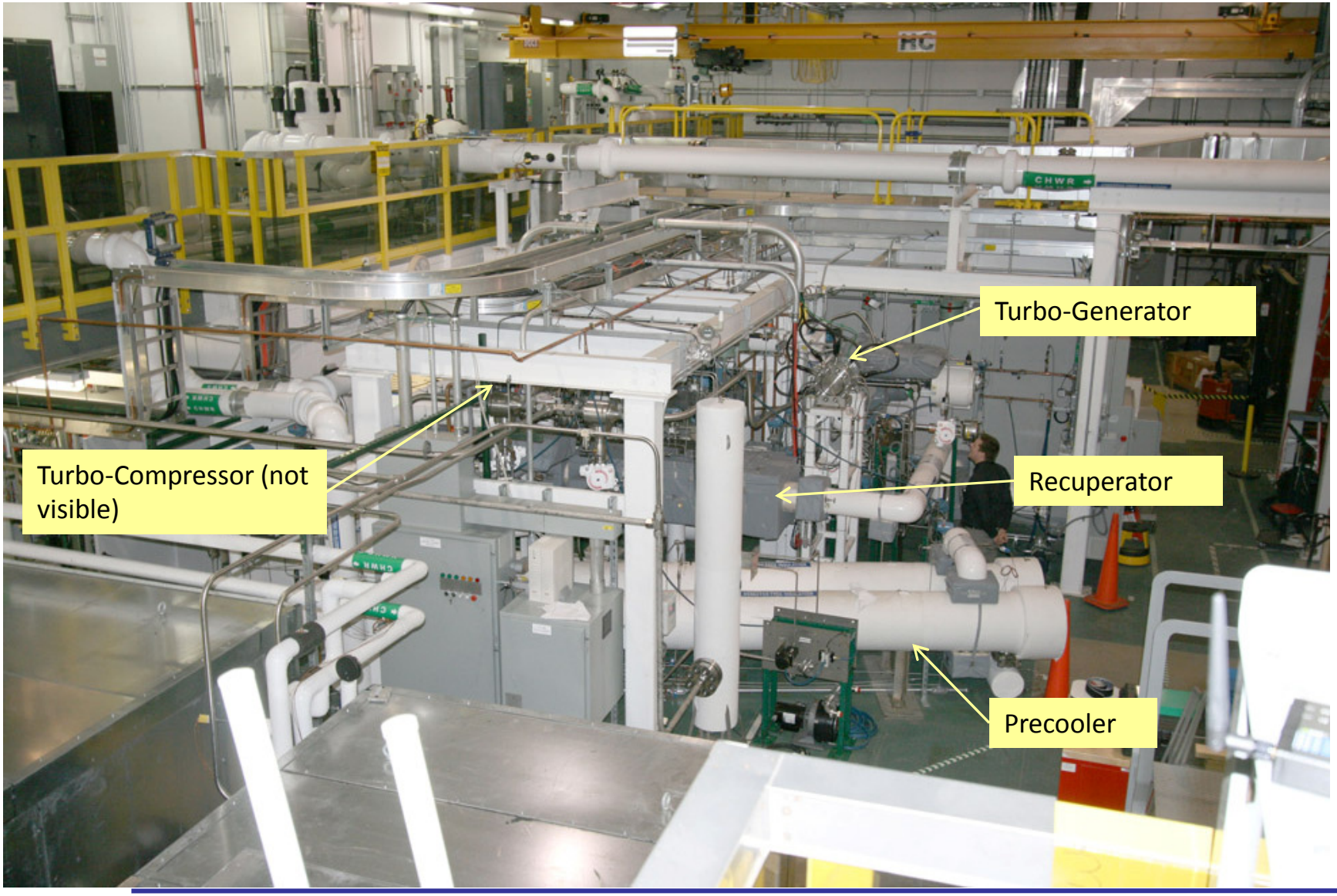
- 100 kWe IST has been main S-CO_2 development focus of BMPC
- Simple Brayton cycle
  - Single variable speed turbine-compressor
  - Single constant speed turbine-generator
  - Single recuperator
- Focus on system control
  - Rapid startup
  - Power changes
  - Shutdown



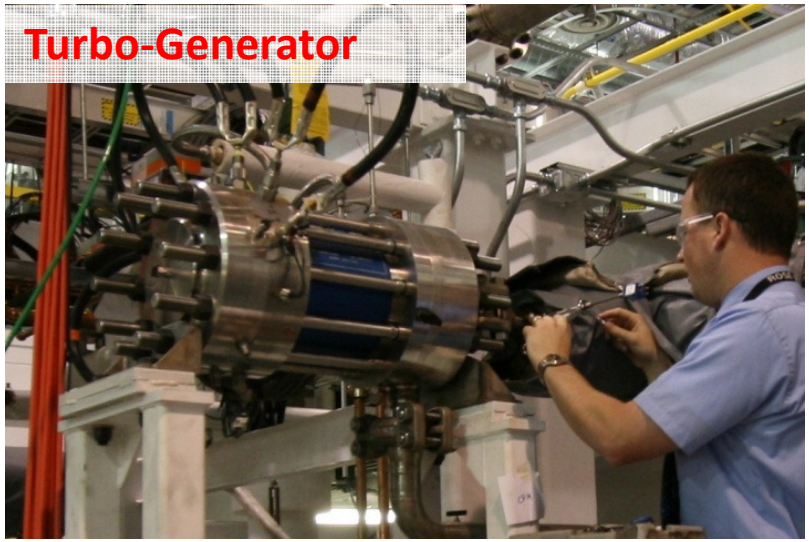
IST Physical Layout



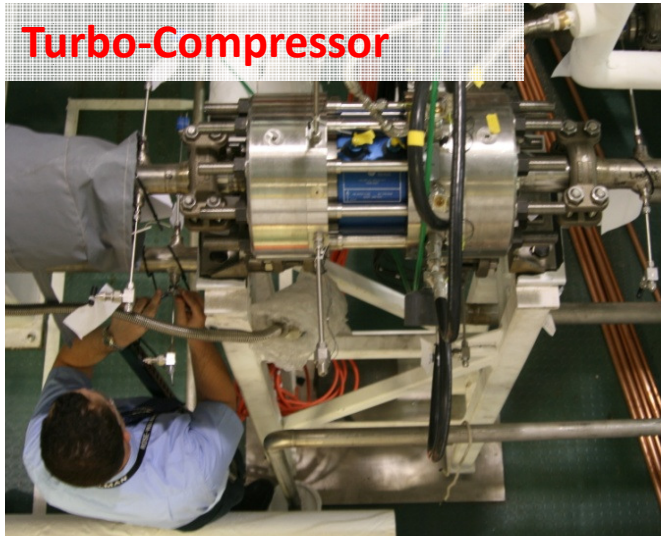
IST Physical Layout

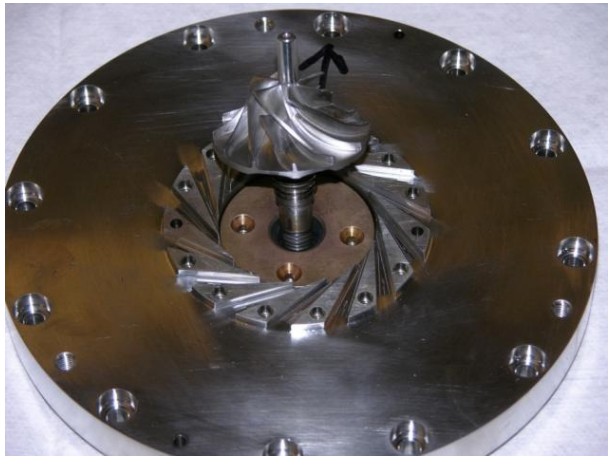


IST Turbomachinery

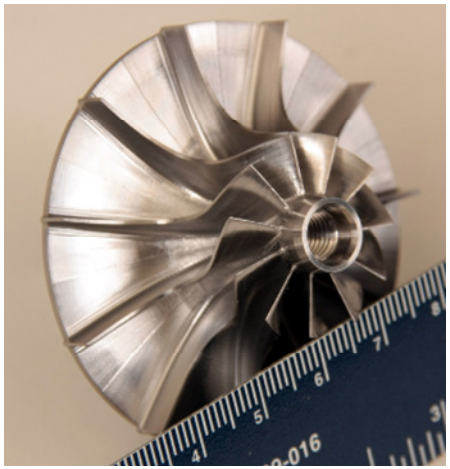


Thrust Bearing





Compressor/Diffuser



Turbine

Loop Startup

- Heat up system to supercritical conditions and achieve normal system mass
- Start up both turbomachines to 37,500 rpm
- Heat up system to normal turbine inlet temperature
  - Transition TG from motoring to generating
- Establish normal compressor inlet conditions

Normal Power Operation

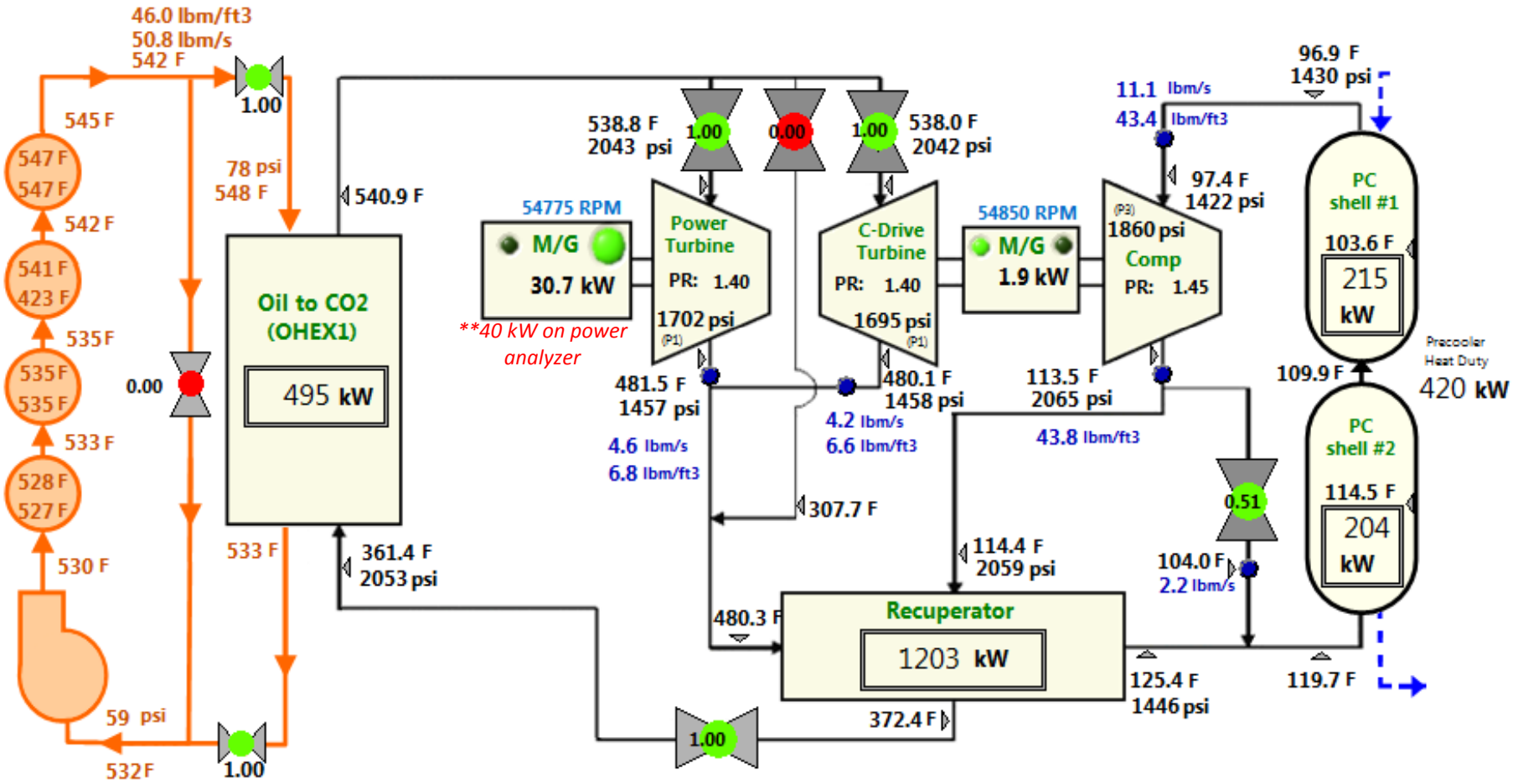
- Turbine-generator operates at fixed speed with load regulated to maintain speed
- Turbine-compressor thermal-hydraulically balanced
  - Turbine power = compressor power + losses
- Power level changed by position of compressor recirculation valve
  - Valve nearly full closed at maximum system power

IST Power Limitations

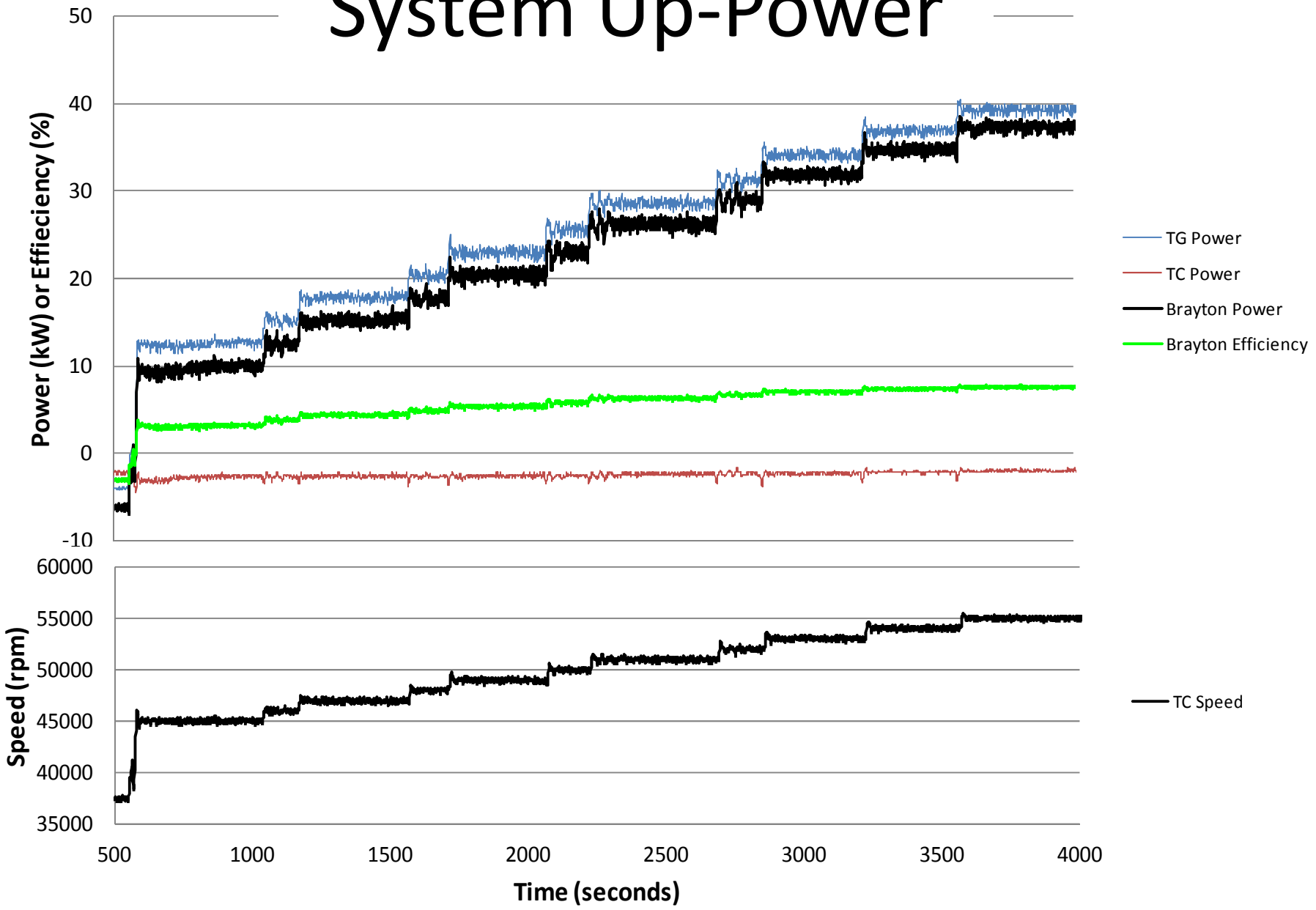
- TG output voltage droops as power is increased
- Voltage droop affects speed and rotor position algorithm causing delay in firing of IGBTs and degradation of power factor
  - Limited to 24 kWe DC (~30 kWe AC) @ 55,000 rpm
- Permanent magnet rotor remagnetized to increase output voltage
  - Resulted in higher power capability
  - New target ~50 kWe AC @ 60,000-65,000 rpm

Maximum Power Operation

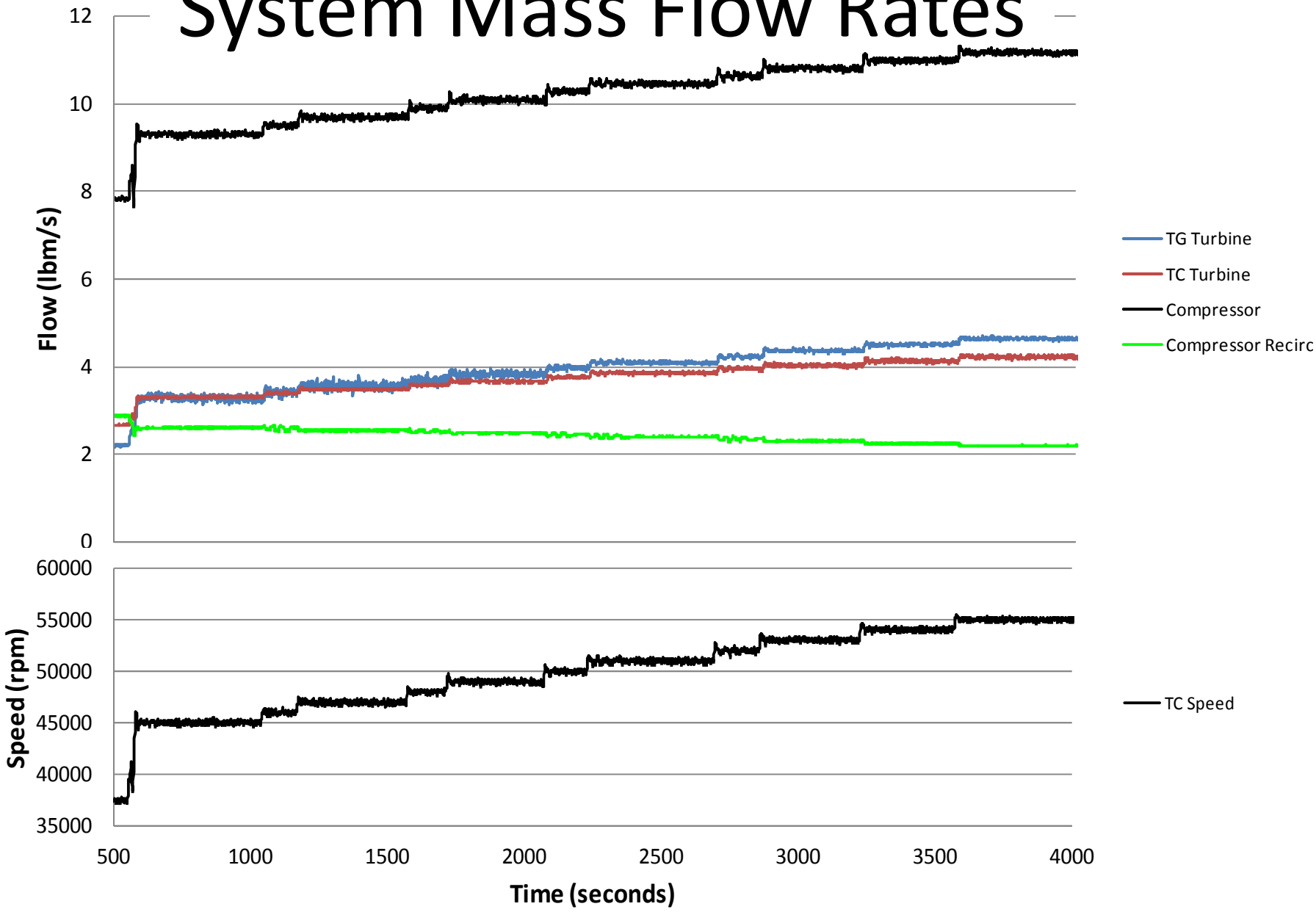
November 2013



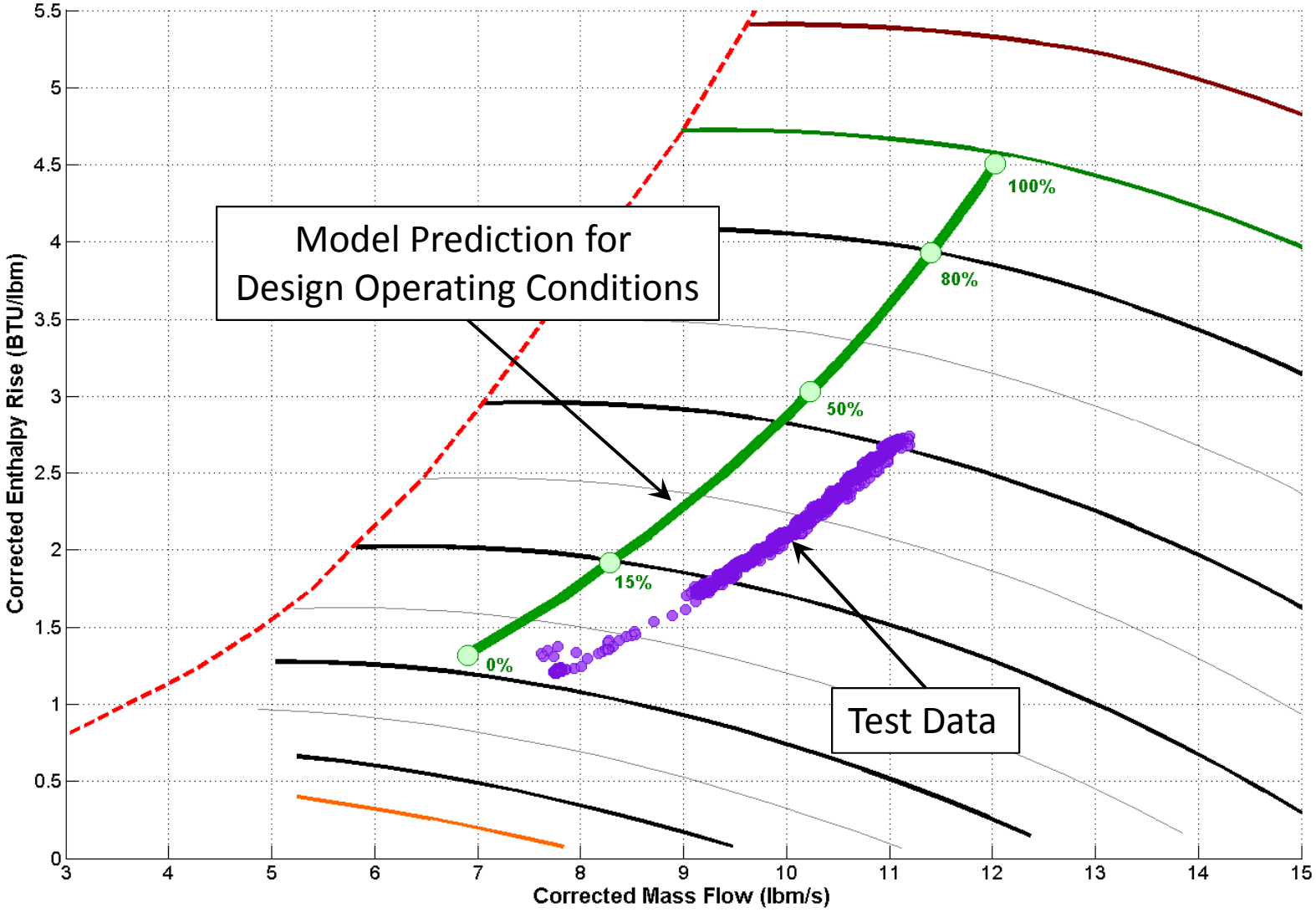
System Up-Power



System Mass Flow Rates



Compressor Map



Summary

- IST continuing to make progress towards the purpose of demonstrating controllability of the S-CO2 Brayton cycle
- System operation up to 40 kWe AC has been demonstrated with good agreement with model predictions
- Normal power operation over range of power levels up to ~50 kWe planned

Acknowledgements

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