The University of Texas at Austin
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ELECTRICAL AND THERMAL SYSTEM CONSIDERATIONS FOR MVDC SUPERCONDUCTING DISTRIBUTION ON NAVY SHIPS

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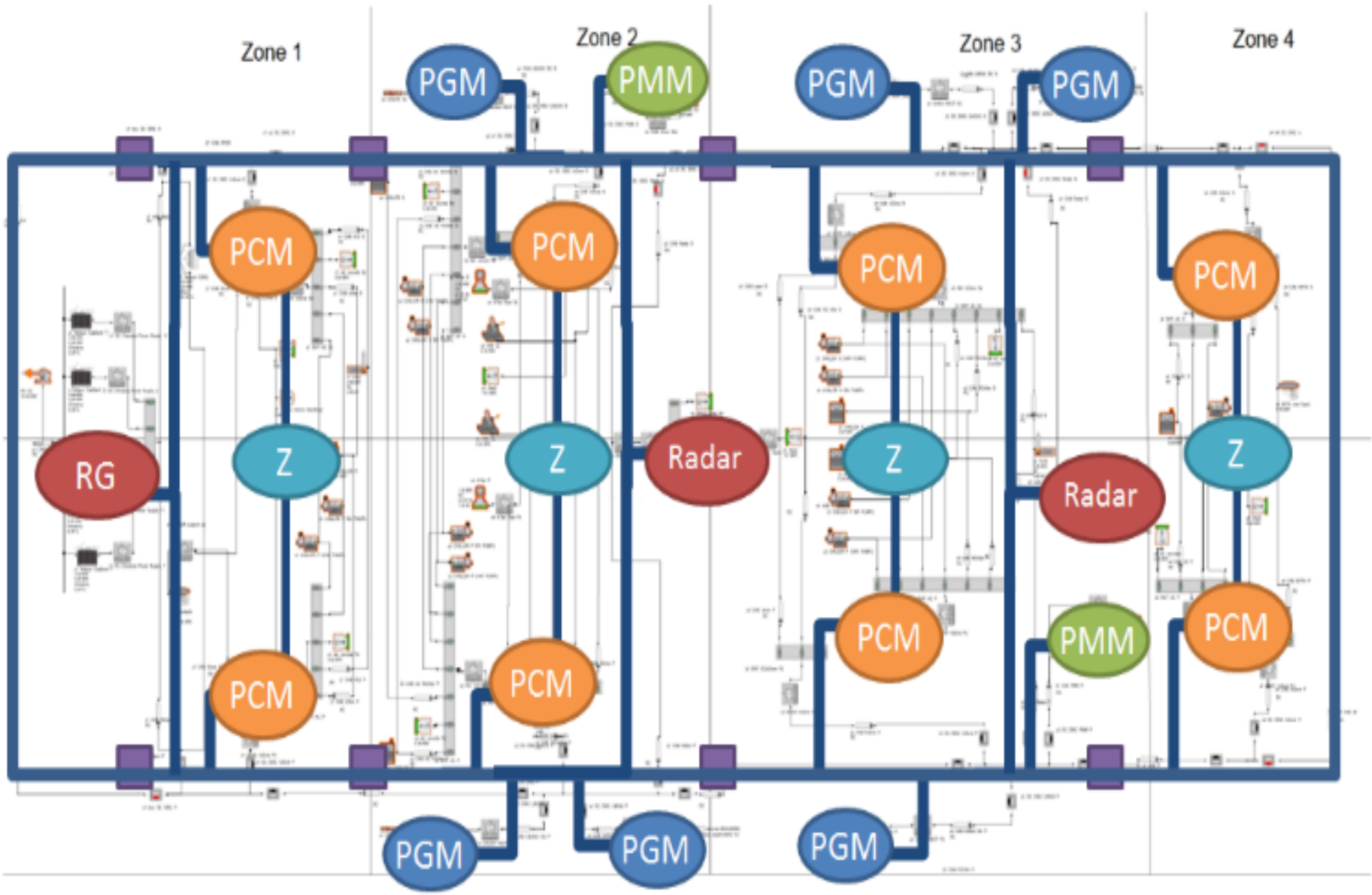
Challenge

- Set appropriate metrics that are research targets for the adoption of superconducting power cables for ships
- For motors and generators the key metric is generally recognized
  - >> 1 T air gap magnetic field
- Metrics for cables in general
  - Smaller
  - Lighter
  - Traditional reliability
    - But not a particular metric for superconducting cables vs. conventional

Generic Ship Power System



S3D Cable Sizing

	S3D	New DC Bus
Rated voltage of cable bundle, kV	10	12
Rated current of cable bundle, kA	10	8.3
Total bus length, m	138	138
Number of cable bundle sections	3	3
Average cable bundle length, m	46	46
OD of each cable, mm	57.9	57.9
Number of cables per bundle	6	5
Resistance per unit length, mΩ/m	0.030	0.036
Weight per unit length, kg/m	50.8	42.3
Number of connections to dc bus	11	11

Potential Comparison

- Losses based on generalized mission profile
  - Analogous to vehicle drive cycles

Mission Segment	Days	Electrical Power MW
Peacetime Cruise	90	23
Sprint to Station	1	43.5
On Station	7	23.7

- Room temperature: 6.2 kW
- Superconductors: 9.4 kW

But neither seem to be near the limits of the technology

Weight

- Weight is an area in which superconductivity appears to have a potential advantage
  - For a point design based on notional circuit
    - Conventional: 4,800 kg
    - Superconducting: 480 kg
- The advantage achieved by superconductors is due to maintaining a fixed temperature.
  - Analysis is needed to see how much the apparent benefit is reduced if copper or aluminum is cooled

Cable Reliability - I

- Reduce size and weight without reducing reliability
  - NAVAIR cable failure is largely due to vibration-induced abrasion.
    - Serious abrasion less likely in ships due to need for magnetic field cancelling leading to a metal shield
    - Vibration can still be an issue
  - Utility cable failure largely at splices and terminations
    - Short ship runs mean that splices can be avoided
    - Terminations are numerous and potentially problematic

Cable Reliability - II

- Insulation thickness is driven by mechanical not electrical limits.
  - Electrically, a thin varnish coating would likely be good enough
    - But risk would be unacceptable due to mechanical strength
      - Polymers, ceramics, or superconductors
- Lack of relevant engineering data on reliability is an impediment
  - Sparse for conventional cable
  - Nearly non-existent for superconducting cable

External Factors

- Without major breakthroughs, superconductivity is unlikely to be brought on ships by other than a cable application.
  - Motors and generators
    - Limited achievable benefit
  - Storage
    - SMES works
      - But smaller, lighter options are available

Conclusions

- Process developed to compare superconducting and advanced cables.
- Challenges in dc ship power system
  - Multiple taps
  - Lack of reliability data
- Conventional cable technology does not have the common courtesy to stop getting better
- So, primary emphasis on data for improved conventional cables