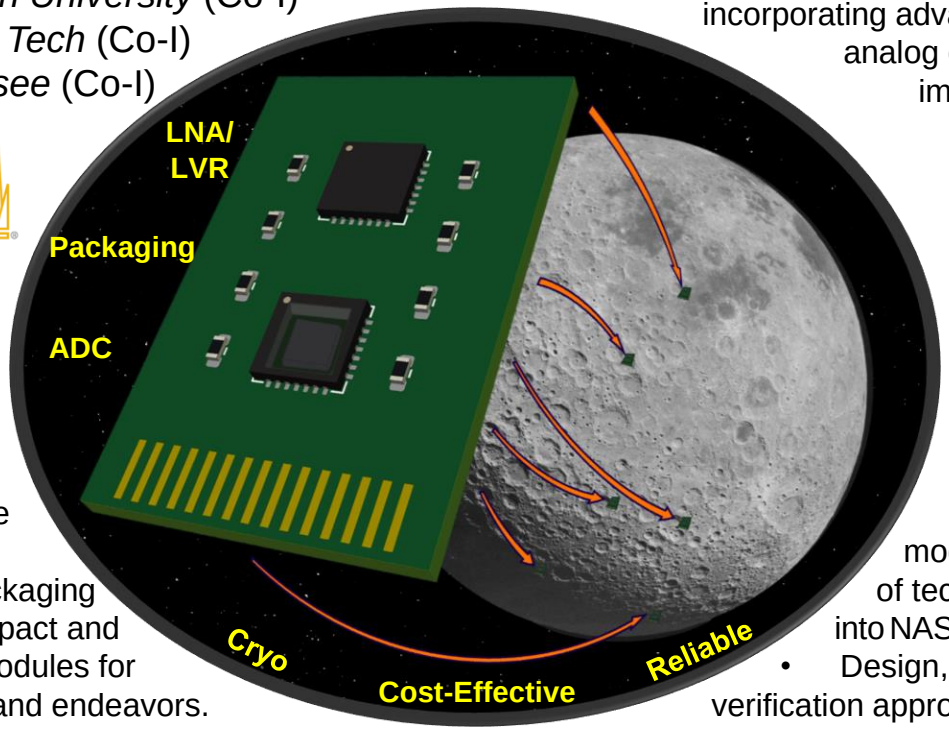
"Cold-Tolerant Electronics and Packaging for Lunar Surface Exploration" ('CTE-PLuS')

For: NASA SpaceTech-REDDI-2021 – LuSTR Topic 3

Michael C. Hamilton, *Auburn University* (PI)
Guofu Niu, *Auburn University* (Co-I)
Foster Dai, *Auburn University* (Co-I)
R. Wayne Johnson, *Auburn University* (Co-I)
John D. Cressler, *Georgia Tech* (Co-I)
Ben J. Blalock, *U. Tennessee* (Co-I)

Development Objectives

- Realize small, light, robust packaged analog electronics modules for future lunar missions in extreme environments.
- Challenges: cryo electronic devices and thermo-mechanical packaging reliability (CTE-related) for extreme environment electronics modules that is *commercial & cost-effective*.
- Advancing over SOA by eliminating *warm electronics box*, incorporating advanced technology nodes, new analog circuit concepts and providing improved electrical and thermo-mechanical reliability.
  - Advance **TRL** from 2/3 to 5/6 by designing/building hardware then operating in simulated relevant extreme environment.



Approach

- Use commercially-available, Si (GF 22-nm FDX) and SiGe (GF 9HP) multi-project wafer fabrication & commercial packaging to realize *cost-effective*, compact and reliable analog electronics modules for future NASA lunar missions and endeavors.
- Use *physics-based models* of electronic devices and finite-element thermo-mechanical packaging performance & reliability modeling for extreme/cryogenic environments.
- Test fabricated and assembled hardware in challenging lunar-relevant *extreme* environmental operating conditions (25 K to 400 K + thermal-cycling) to explore performance and reliability of advanced analog electronics modules.
- Verify & validate modeling and predictive capabilities by designing, fabricating and testing flight-like hardware.

Impact and Infusion

- Reliability, performance and SWAP-C of electronics modules will allow *timely* adoption of technology, approach & lessons into NASA lunar system/mission designs.
- Design, fabrication, assembly, test and verification approaches and knowledge gained in this LuSTR effort will be *infused* into and are relevant to other NASA extreme environment electronics systems.
- Outcomes of electronic device cryogenic model extraction, ADC/analog/power regulation electronics circuit designs, and packaging materials studies results will be useful for adoption of advanced electronics & packaging approaches for NASA, other space agency and non-space applications.
- Multiple graduate/undergrad. students educated & trained.
- Data/results will be widely disseminated via publications.