Applications of Flexible Hybrid Electronics (FHE) in Harsh/Extreme Environments

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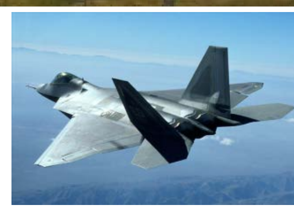
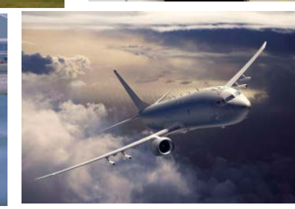
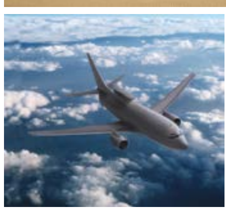
What is Boeing?

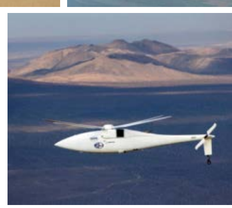
1925: Boeing Air Transport enables cargo transport in the emerging Air industry

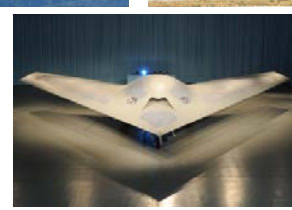
2017: Boeing is World's Largest Aerospace Company

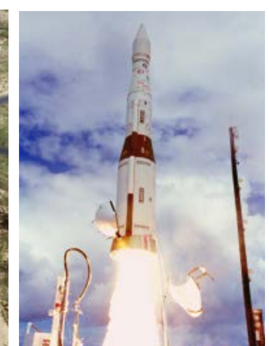


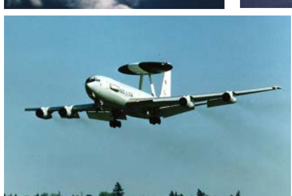


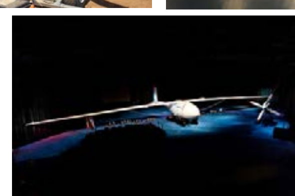


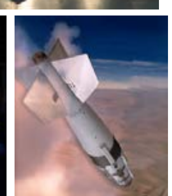












Potential Applications For Electronics In Harsh Environments

- Aircraft Engine Control Electronics (300-600°C)
- Environment control systems
- Aircraft braking systems (~250°C)
- Embedded Sensors
- Hypersonic Vehicles
- Rocket Engines
- Space Based Radar Applications
- High Voltage Air/Spacecraft Bus Electronics
- Control Electronics For Harsh Environment Power Converters
- Terrestrial Vehicles Operating In Desert Environments
- Long Duration Space and CisLunar Missions
- Industrial Applications in the Factory (Autoclaves, etc..)

What Are Harsh/Extreme Environments?

Definition of Harsh Environments for Avionics

- Temperatures over 200°C
- High Radiation Flux Density > Mrad
- High Operating Voltages 10V – 1000V
- Mechanical vibrations

Flight Altitudes:
Drops 2°C per 1000 ft, However, speed creates compressibility that raises temp,
Rain, Lightning, Winds, etc…

Transition Time to
Altitude: 10 to 20 minutes

Take-off/Landing

Cold Desert Climate:
-50°C to 10°C, Very Dry, High Pressure, Dynamic Fronts

MidWest Climate:
-20°C to 40°C, Rain, Fog, Snow, Varying Pressure

Hot Desert Climate:
0°C to 50°C, Very Dry, High Pressure, Dynamic Fronts

Temperature range:
-40°C to 85°C versus 0°C to 70°C for most commercially available solutions

Variations for Military Applications

For Rotorcraft: The considered harsh environments are humidity, sand/dust, and salt spray fog mixed with various temperature levels

For Missiles: A harsh environments are humidity with various temperature levels and degradation of propellants

When systems are operating in these environments the removal of heat from electrical systems can be important

For Space Exploration

Missions in the central (equatorial) regions of the Moon:
Limitations:

- Daylight temperatures at lunar “noon” 380K = 107°C
- Temperatures at lunar “midnight” 120K = -150°C

An Extreme Environment for rockets includes instrumentation that can operate at cryogenic temperatures, down to 35K (-238°C)

An Extreme Environment for Space Travel includes temperatures swings from 120°C to -150°C depending on sun exposure

Boeing Technology/Material Needs

Some of the Things Boeing is Seeking to Enhance with FHE:

- Knowledge of Corrosion Status in Materials
- High Conductivity Materials
- Fabrication of Large FHE Arrays/Systems
- Robust Interconnects
- Substrate Materials
- Component Integration

Boeing's Interest in FHE

Lighter Weight

- 1% weight reductions can equate to *billions* in operating cost savings to carriers.

Less Complexity, Improved Maintenance, Higher Reliability

Added Capability

Printed electronics is an enabler