NEPP ETW Packaging Overview

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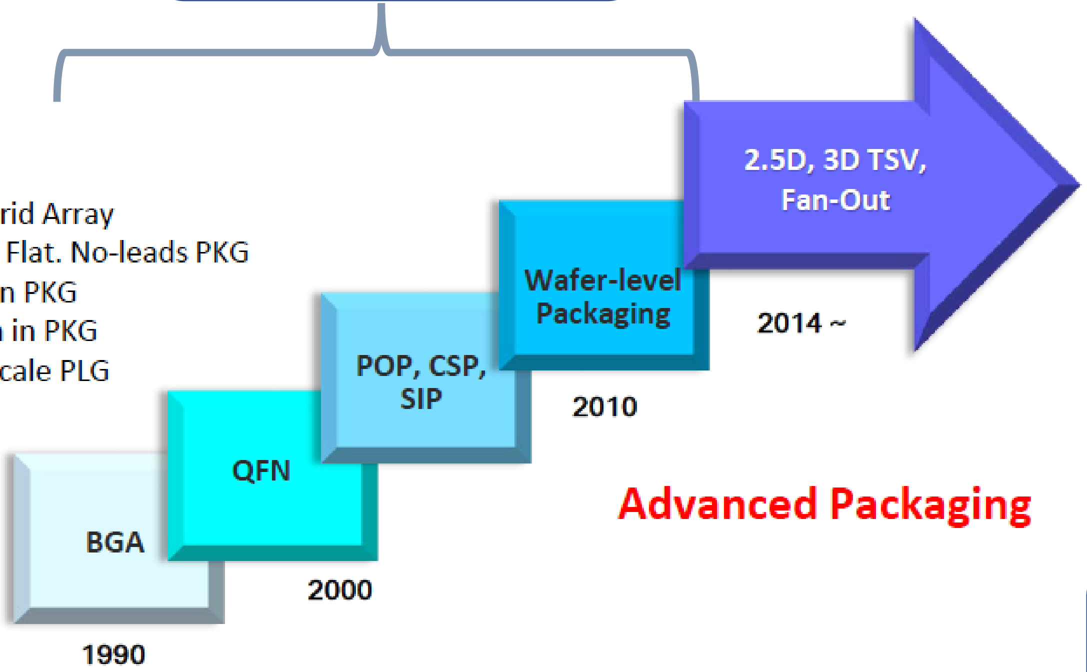
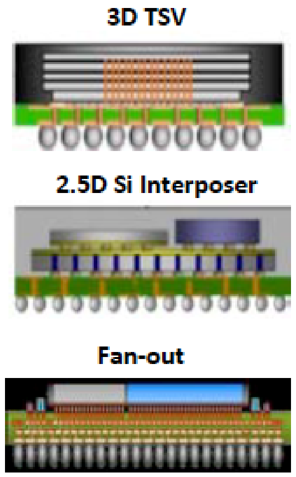
Package evolution – where does NASA fit in?

Not designed for space. Upscreening partial solution sometimes

The space "standard"

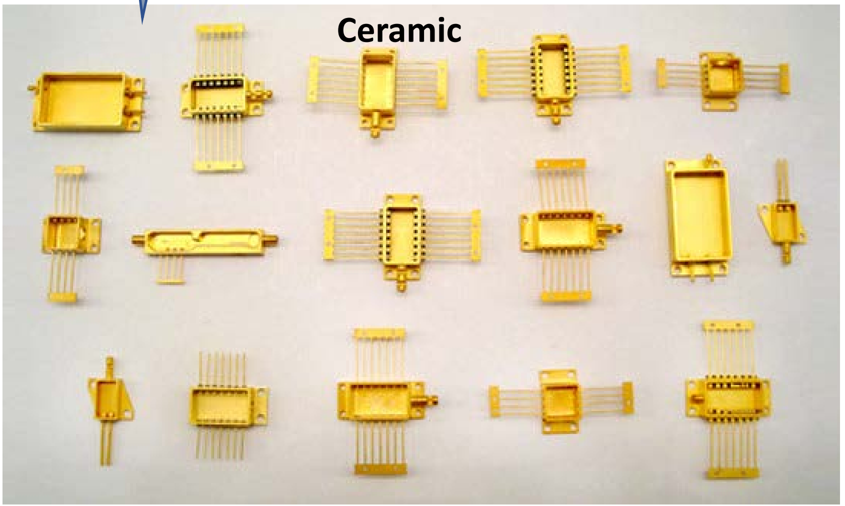
BGA - Ball-grid Array
QFN - Quad Flat. No-leads PKG
PoP - PKG on PKG
SIP - System in PKG
CSP - Chip Scale PLG





Advanced Packaging

K. Lee IRPS 2019

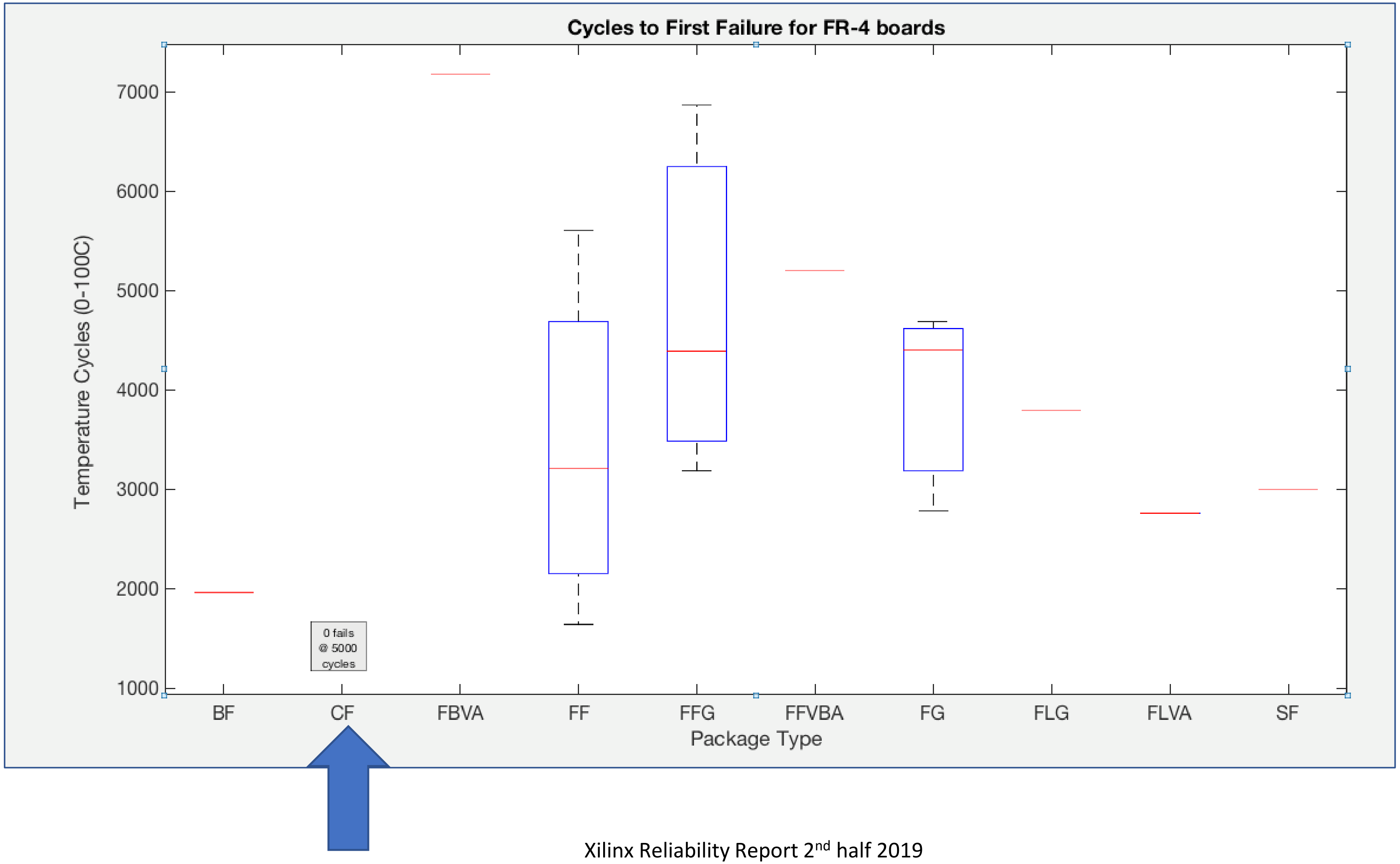


www.completehermetics.com

SWaP revolution possible but upscreening becomes much more challenging

What about a custom 2.5/3D space package?

Reliability of Commercial BGAs – 1000 cyc TC limit



- All capable of 1,000 0-100C cycles, but significant variation in actual response
- Physics/materials science difference drive actual failures
- Interdependences w/ solder type, geometry, bump pitch, etc.
- How to extrapolate / interpolate stress conditions to mission requirements?
- Complexity of design and materials use of 2.5/3D packages compound applicability assessments

Xilinx Reliability Report 2nd half 2019

IEEE Heterogeneous Integration Roadmap

HETEROGENEOUS INTEGRATION ROADMAP

Market Drivers

- High Performance Computing and Data Centers
- Medical, Health and Wearables
- Autonomous Automotive
- Mobile
- Aerospace and Defense
- IoT

Building Blocks

- Single Chip and Multi Chip Integration (including substrates)
- Integrated Photonics
- Integrated Power Electronics
- MEMS and Sensor integration
- 5G and Analog and Mixed Signal

Technical Areas

- Materials and Emerging Research Materials
- Emerging Research Devices
- Test
- Supply Chain
- Security
- Thermal Management
- Co-Design
- Simulation

Technology Areas for HI

- SiP
- 3D & 2D Interconnects
- Wafer-Level Packaging – WLP (fan in and fan out)

- Emphasis on DARPA CHIP HI and IP reuse program
- Doesn't specifically address reliability, #1 space concern

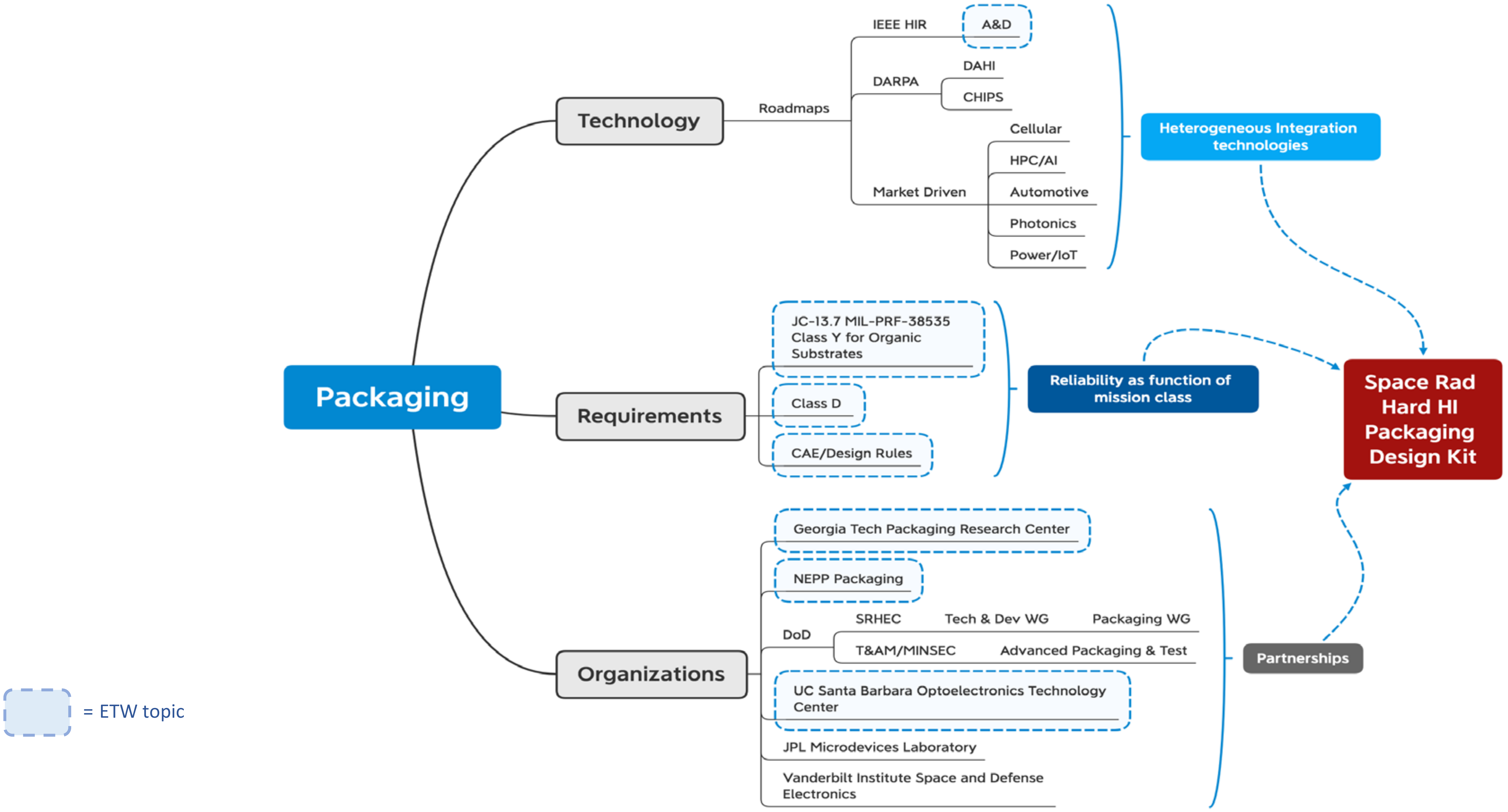
Many areas of interest for NASA, but still mostly commercial focused solutions

NASA focused HI reliability roadmap

NPR 8705.4 Classification	(Class A)	(Class B)	(Class C)	(Class D or unclassified)
Mission Description	Large mission primarily built in house, highly visible, complex in nature, single string spacecraft.	Spacecraft with redundancy, large system contract for spacecraft, or large, highly visible instruments critical to meeting project level 1 requirements.	Spacecraft with shorter life and lower cost, instruments important to meeting project level 1 requirements.	Short life and low cost missions, instruments whose performance is not required to meet project level 1 requirements, and technology demonstrations.
Risk Posture	Very Low	Low	Medium	Med/High
Lifetime	> 7 Years	2 – 7 Years	< 5 Years	< 2 years
Modeling		Increasing model accuracy (1D-2D, FEM), validation starting w/ R&D to Production processes, Statistical robustness (Monte Carlo), integration with CAE tools		
Test devices		Increasing temperature / voltage range coverage and prediction, R&D to production process migration, scaling dimensionality > products, Reliability Proxy PKGs,		
Products	COTS Quals (0/77 1000Hr) to custom BI flows w/ HI specific BIST innovative space materials/design solutions,			

- Specific combinations of modeling, test devices and products for each mission class
- Leverage and extend JC-13.7 Class Y where possible

Evolution and Integration of Space Rad Hard HI Design Kit



Space RH HI Design Kit

- University and Industry CAPEX investments have made small lot, custom developments possible
- University tool sets near-equal some industry tools -> enables real technology transfer
- CAD design rules are physics/materials science based to support space requirements
- Leverage and supports workforce development with modern software experience base
- Begin to leverage development in infrastructure to make unique NASA HI parts – not reliant on COTS systems architectures where you have to qualify many additional part types (support)
- Heterogenous integration - unique to NASA mission requirements
  - Mixture of rad hard and not so rad hard
  - Different power requirements
  - Old and new technologies
  - Electrical and optical
- **Goal moving forward to enable NASA to leverage and benefit from the HI packaging revolution**

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jpl.nasa.gov