US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Utilizing Ball Grid Arrays in High- G Environments

Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Fuze Development Center

US Army RDECOM ARDEC Fuze Division
Picatinny Arsenal, NJ

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Ball Grid Arrays in High-G Environments

- INTRODUCTION
  - The Fuze Development Center
  - New paradigm for development
- The Fuze Reliability Problem
- Variables Involved
- A Methodology for Evaluation
- Guidance / Mitigation Strategies
- Summary

US ARMY RDECOM

The Fuze Development Center
Picatinny NJ, Building 1530

Fuze Development Center Mission:
Accelerate New technology to the Field

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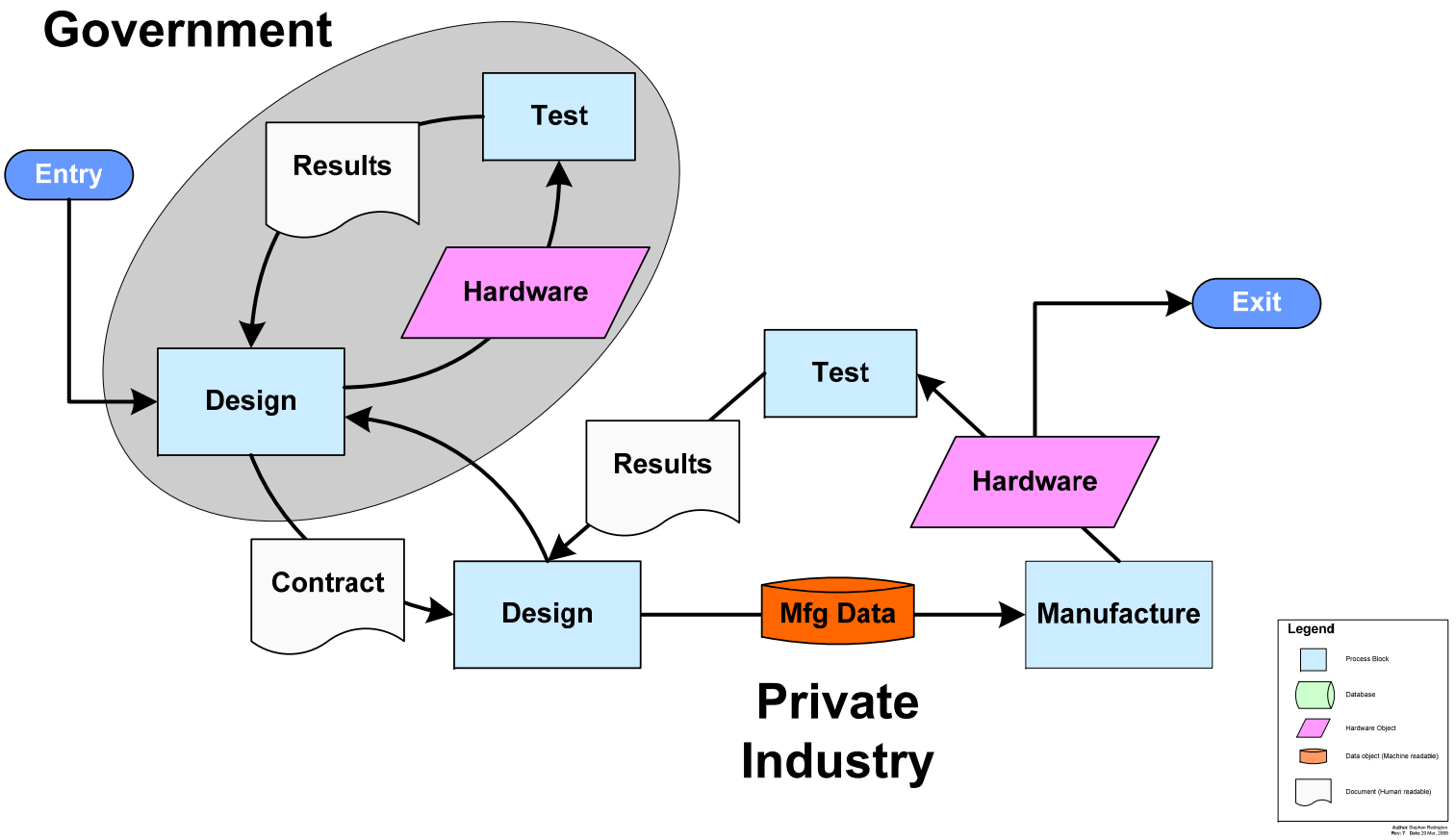
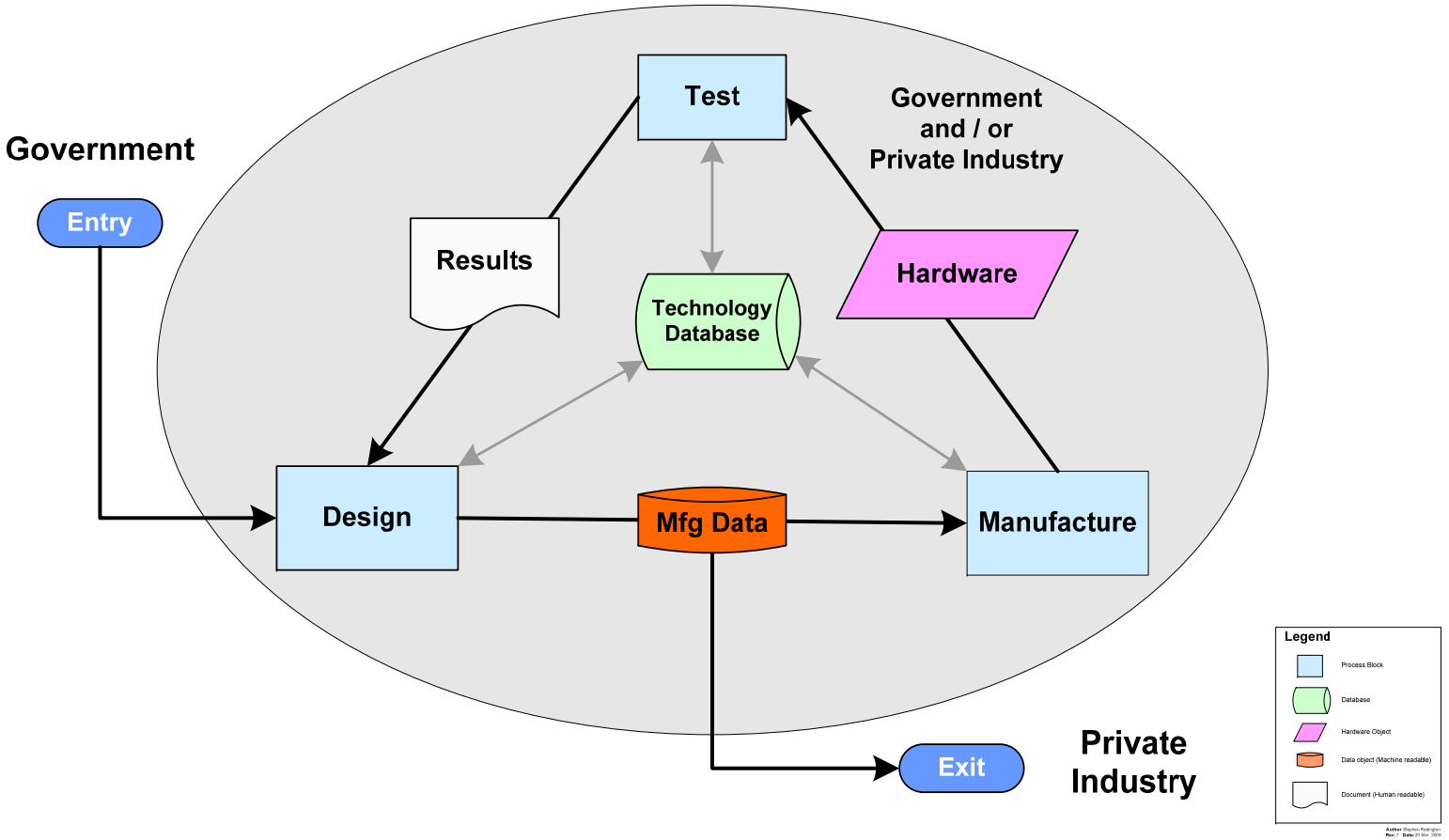
Concept Prototyping

A model for experimentation and development



Integrated Producability

An integrated model for experimentation and product development



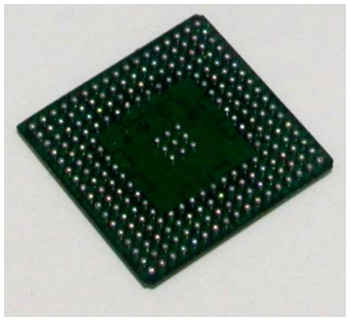
- The Fuze Electronics Reliability Problem
  - Military markets have little or no influence over electronics technology
  - Advanced features of new fuzes require electronics packaging technology developed for commercial markets
    - Cell phones
    - Computers / TV / VCR / Digital cameras & recorders
    - Personal GPS navigation
    - Games / Toys
  - Commercial technology has no long term reliability requirement

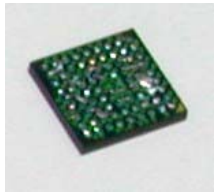
- The Problem (continued)
  - Ball Grid Array packaging is new to the fuze community
    - Very little historical data for long term reliability
    - The technology has known shock survivability issues
  - Use of Ball Grid Array (BGA) technology is unavoidable in fuze applications
    - High level of integration / small footprint
    - Preferred over fine pitch leaded components for manufacturing
    - Guided munitions require BGA technology

Reliability: What's the difference?

- Commercial environments
  - Short product life cycle (a few years in most cases)
  - Benign storage / operating environment
  - Short storage life / Long service life (2-10 years)
- Fuze environments
  - Long product life cycle (20 years or more expected)
  - Not so benign storage (can be controlled to a degree)
  - Harsh operating environment (thermal & shock)
  - Long storage life / Very short service life (minutes)

BGA Technology is unavoidable in new Fuzes



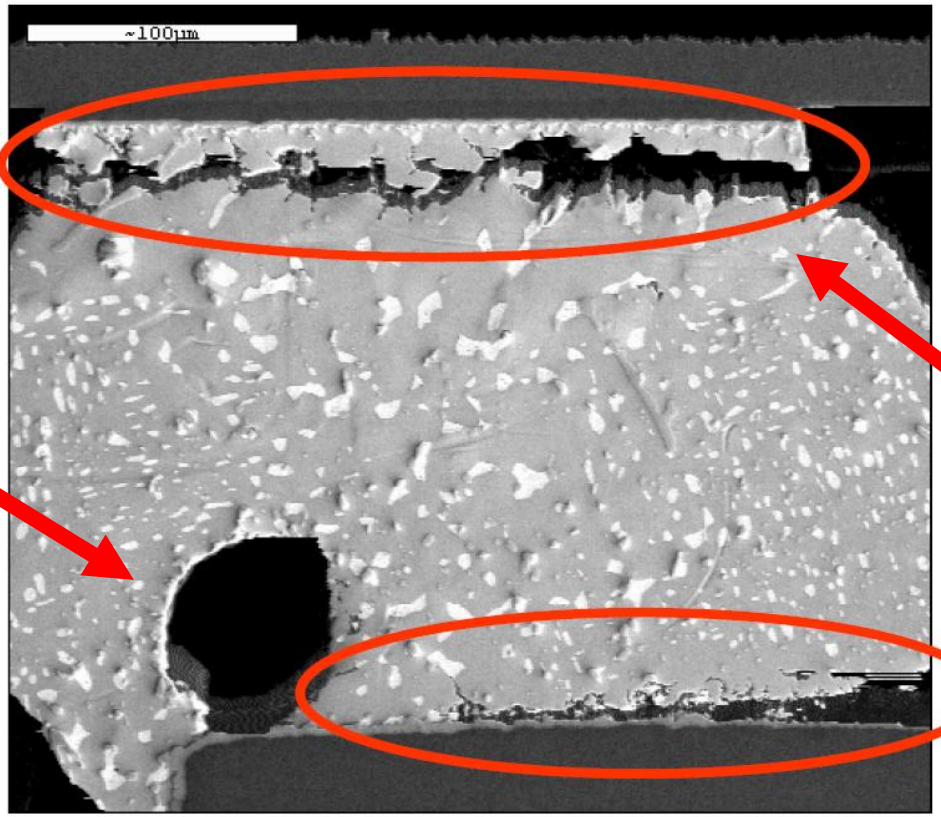


What does this mean for fuze reliability?

BGAs in High-G Environments
Failed solder joint

Stress failure of a lead free BGA in a tin/lead solder process

VOID
(acceptable)



Stress induced failure

Photo courtesy of iNEMI/Sanmina-SCI, Dr Robert Kinyanjui

BGAs in High-G Environments

- Many variables contribute to fuze reliability
  - Solder process / void allowance
  - Axial load orientation
  - BGA package size
  - BGA ball pitch
  - Thermal coefficients (package to board)
  - Thermal environment / Cycling
  - Local power density / Package heat dissipation
  - Potting compounds / Under-fill materials
  - PCB flexing under load

BGAs in High-G Environments Test Methodology

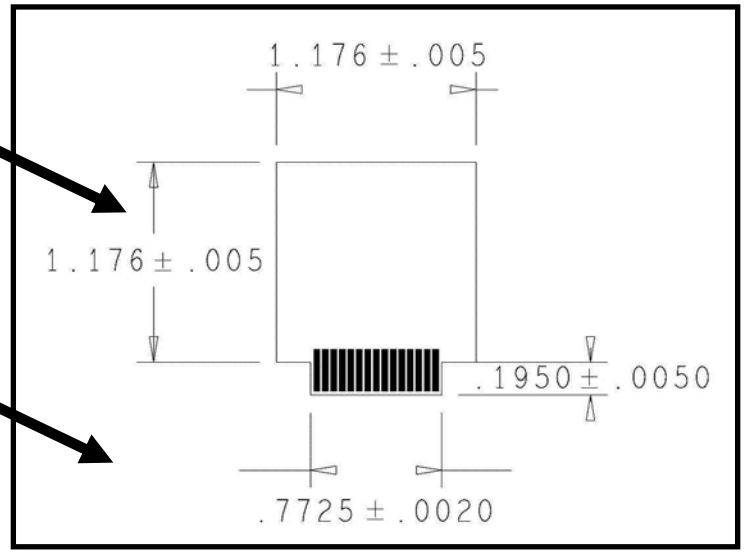
- Industry is investigating several issues
  - Results applicable to fuzing tend to be proprietary
- Fuze Development Center is addressing the problem
  - Test method and vehicle have been developed
  - No hard data to date
  - FDC will pursue remedies in FY10
    - A design guide is the target deliverable
  - More funding / Participants are desired
    - Anybody have some money / time ??

Test Methodology

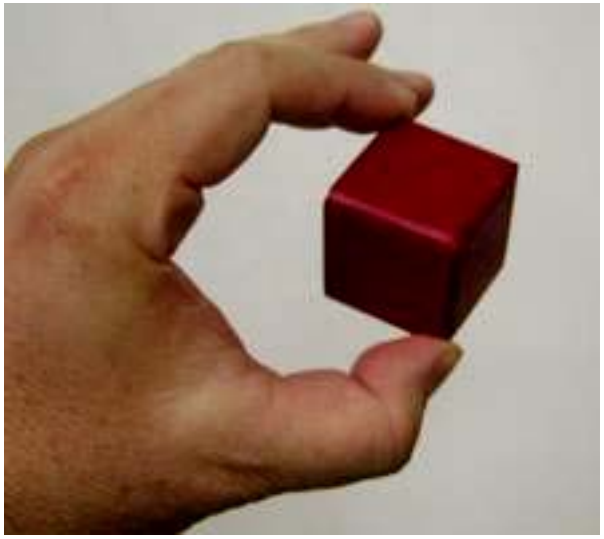
- Test individual technology samples
  - Test programmable BGA packages by daisy chaining I/O to create a simple continuity test
  - Isolate and test one sample at a time be it a package or a process

Standard Test Tile
One sample per tile

Edge connector keeps
PCB cost low

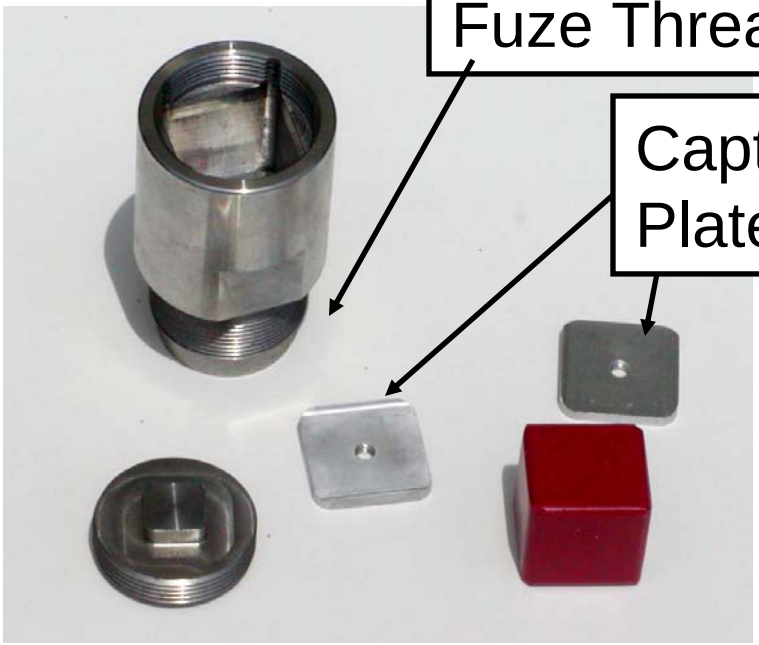


BGAs in High-G Environments Test Methodology



Cubes are gun launched in any axial orientation any number of times. Each sample is individually tested.

Test samples are cast into testable cubes. Up to 3 samples per cube



- No hard data but evidence suggests the following guidance
  - Use leaded packages where possible
  - Choose larger ball pitches over smaller ones
    - Smaller ball size results in higher stress from thermal or shock load
  - Choose smaller packages over larger ones
    - Larger area results in higher stress from thermal or shock load

- Guidance (continued)
  - Use an appropriate under fill
    - Shock hardness improvement has been demonstrated
    - Bad thermal matches will make reliability worse
  - Shock hardness is likely better in compression over sheer (need more data here)
  - Avoid lead free BGAs if at all possible. Explore re-balling to keep in a traditional tin / lead solder process
    - **Do NOT use RoHS BGAs in a tin / lead solder process without changing the oven profile**
  - Control all process variables
    - Oven profile, paste formula, under fill, etc…

Conclusions

- Electronics technology is rapidly evolving and resultant long term reliability issues need to be addressed
- RoHS initiatives are creating new reliability concerns before existing tin / lead BGA issues can be answered

Questions

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