



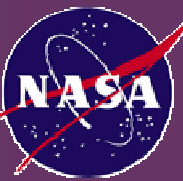
Joint Council on Aging Aircraft/
Joint Group on Pollution Prevention



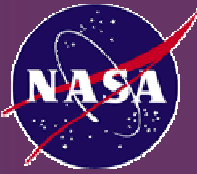
JCAA/JG-PP Lead-Free Solder Project

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IPC APEX2007 Conference
Reliability Summit
Los Angeles, CA
February 23, 2007



Lead-Free Solder JG-PP Participants



U.S. Government

Army

- AMCOM
- Research Development & Engineering Center-Redstone Army Arsenal
- U.S. Army Communications Electronic Command (CECOM)
- U.S. Army Tank-Automotive and Armaments Command (TACOM)

Navy/Marine Corps

- Naval Air Systems Command (NAVAIR)
- NAVSEA
- Potomac Hudson Engineering/U.S. Marine Corps
- TRW/Marine Corp.

Air Force

- F-15 Program/Robins Air Force Base
- Hanscom Air Force Base
- Hill Air Force Base
- ICBM
- Tinker Air Force Base
- Wright Patterson Air Force Base

NASA

- NASA-Goddard Space Flight Center
- NASA-Jet Propulsion Lab
- NASA-Kennedy Space Center
- NASA-Marshall Space Flight Center
- United Space Alliance/Solid Rocket Boosters

Dept. of Energy

- Sandia Labs

U.S. Manufacturers

- Alliant Tech Systems
- The Boeing Company
- Goodrich
- Harris
- Honeywell
- ITT
- Lockheed Martin
- Lucent Technologies
- Motorola
- Northrop Grumman
- Raytheon
- Rockwell-Collins
- Texas Instruments

U.S. Industry and Academic Associations

- American Competitiveness Institute
- IPC
- National Center for Manufacturing Sciences
- NIST
- University of Tennessee

Vendors

- Intersil
- Mitsui Comtek/Senju Metals Co.

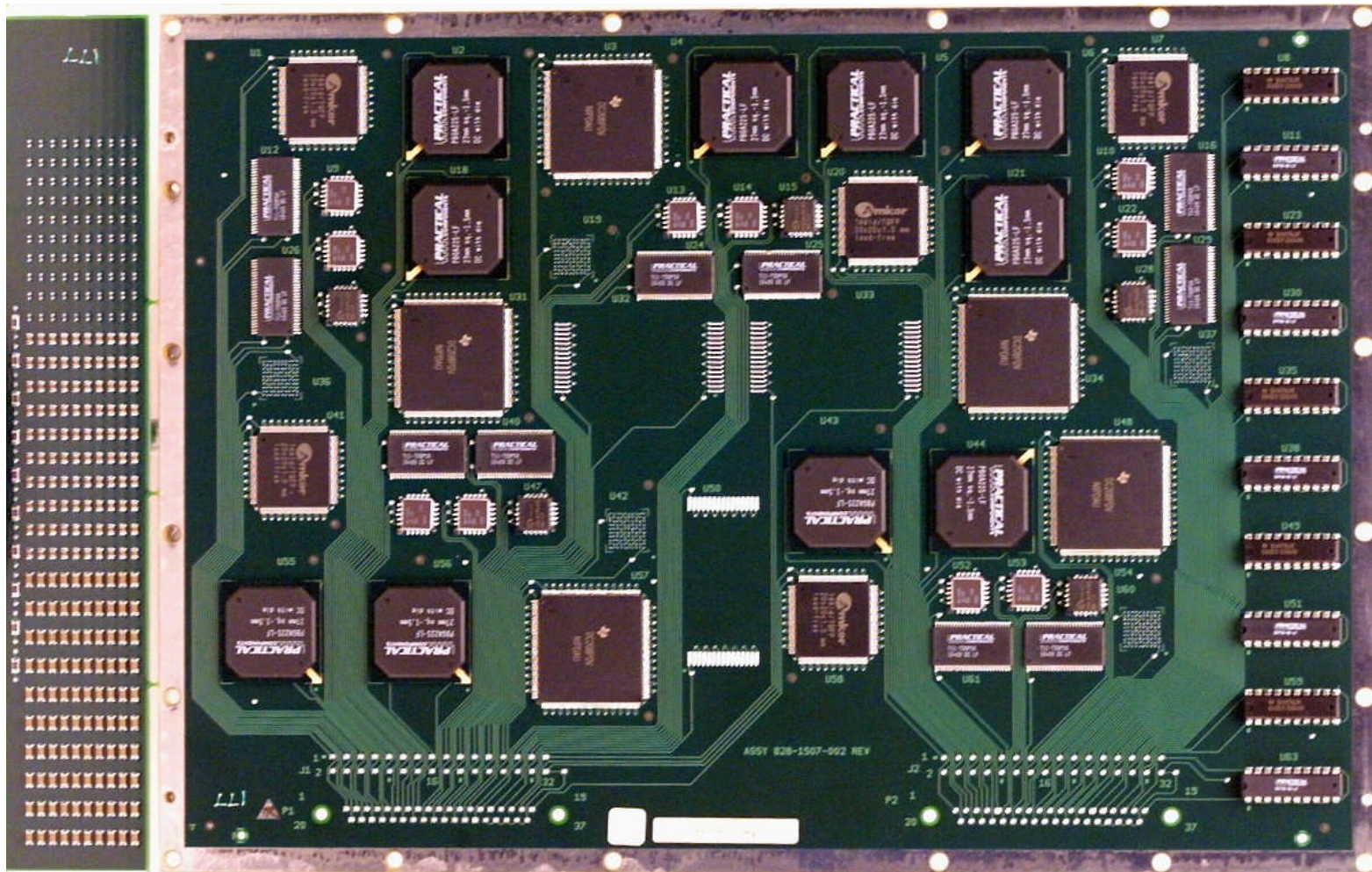
Non U.S. Organizations

- Astrium (UK)
- British Aerospace Systems (UK)
- Institute of Welding and Quality (Portugal)
- MBDA (UK)



JCAA/JG-PP Lead-Free Solder Project

- **Objective:** Formed to determine reliability of lead-free solders for military/aerospace. Effects of rework were also examined.
- **Testing status**
 - ✓ Thermal Shock (-55 to +125°C) **Completed**
 - ✓ Vibration (up to 20 grms) **Completed**
 - ✓ Mechanical Shock **Completed**
 - ✓ Thermal Cycle (-55 to +125°C) **Completed**
 - ✓ Thermal Cycle (-20 to +80°C) **In-work**
 - ✓ Combined Vibration/Thermal Cycle **Completed**
 - ✓ Electromigration* **Completed**
 - ✓ Humidity, Salt Fog **Completed**
- **Joint Test Report** (<http://acqp2.nasa.gov/JTR.htm>)

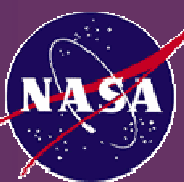


JG-PP Test Vehicle with Break-Off Coupon Attached



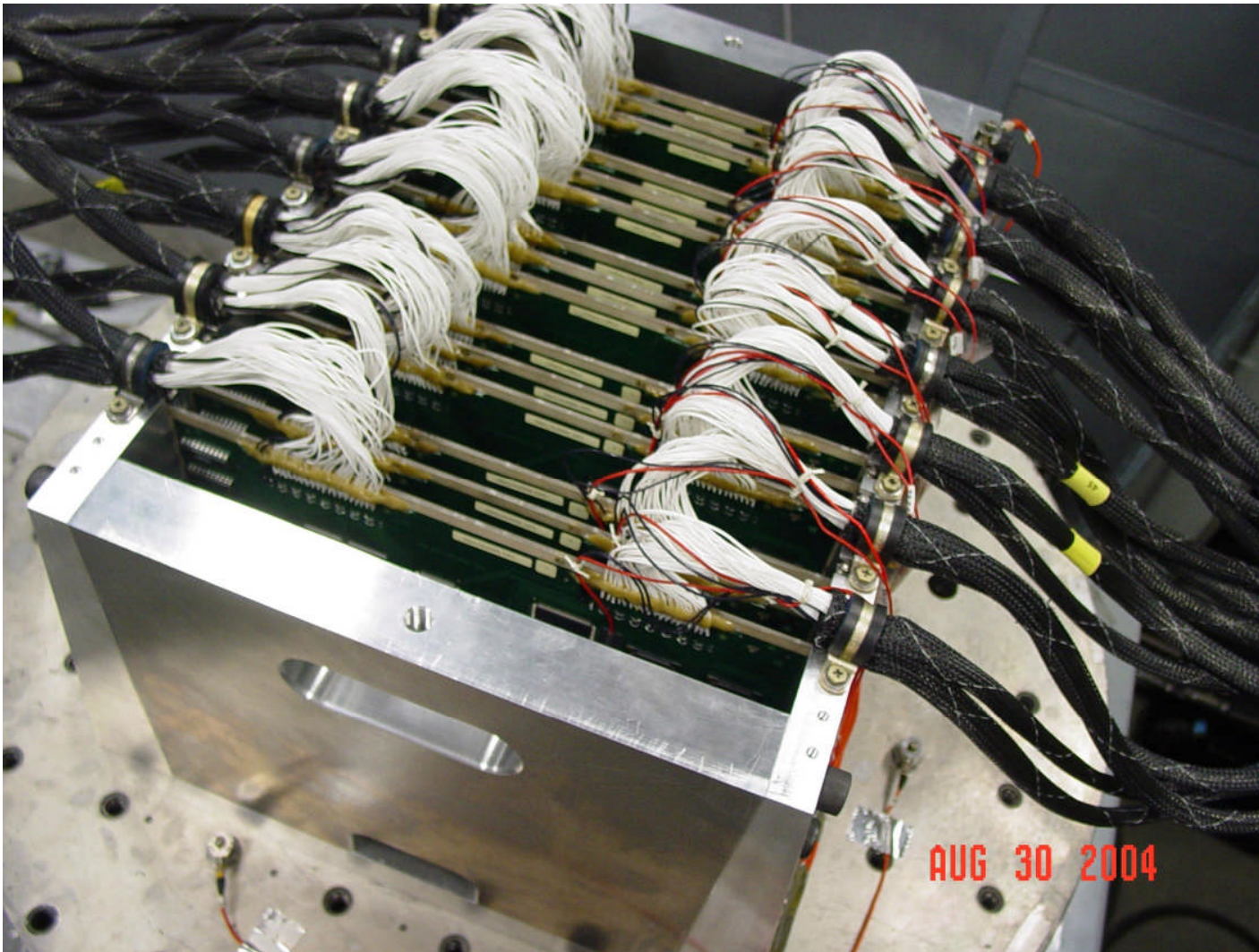
JCAA/JG-PP Lead-Free Solder Project

- Accelerated test data can be of limited usefulness (you really want field lifetimes)
- Modeling will be required to convert accelerated test data to field lifetimes
- The JG-PP data can be used to validate models and is one of the best data sets in the public domain
- **Current specs offer little guidance regarding effective models**

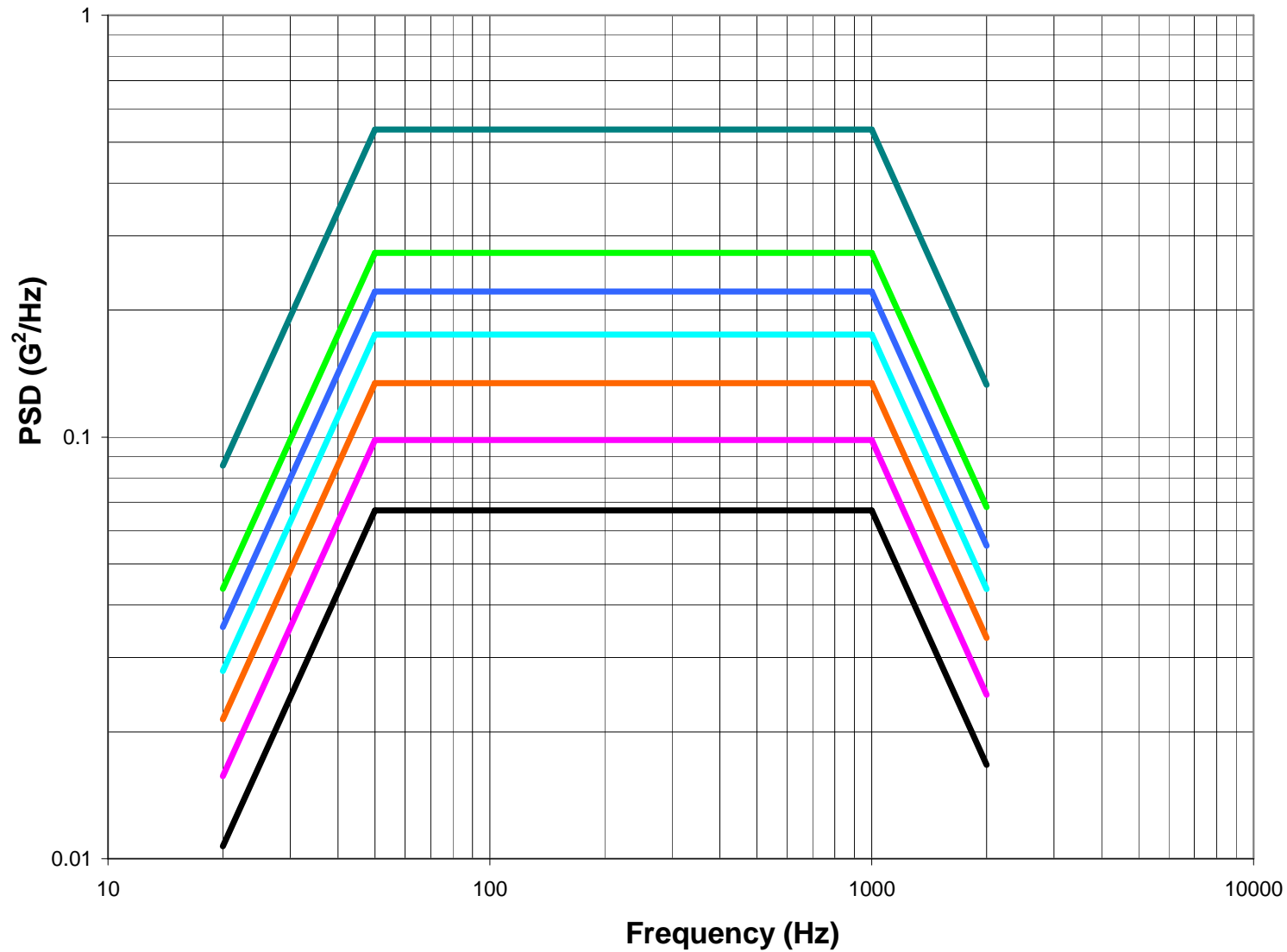


JCAA/JG-PP Lead-Free Solder Project Vibration Test

- **Except for the JG-PP data, very little vibration test data exists for lead-free solders (in the public domain)**
- **No vibration test spec exists that is specific for circuit assemblies?**
- **Test conditions must mimic use conditions (e.g., fixturing must be realistic, PSD input must excite the major resonances)**

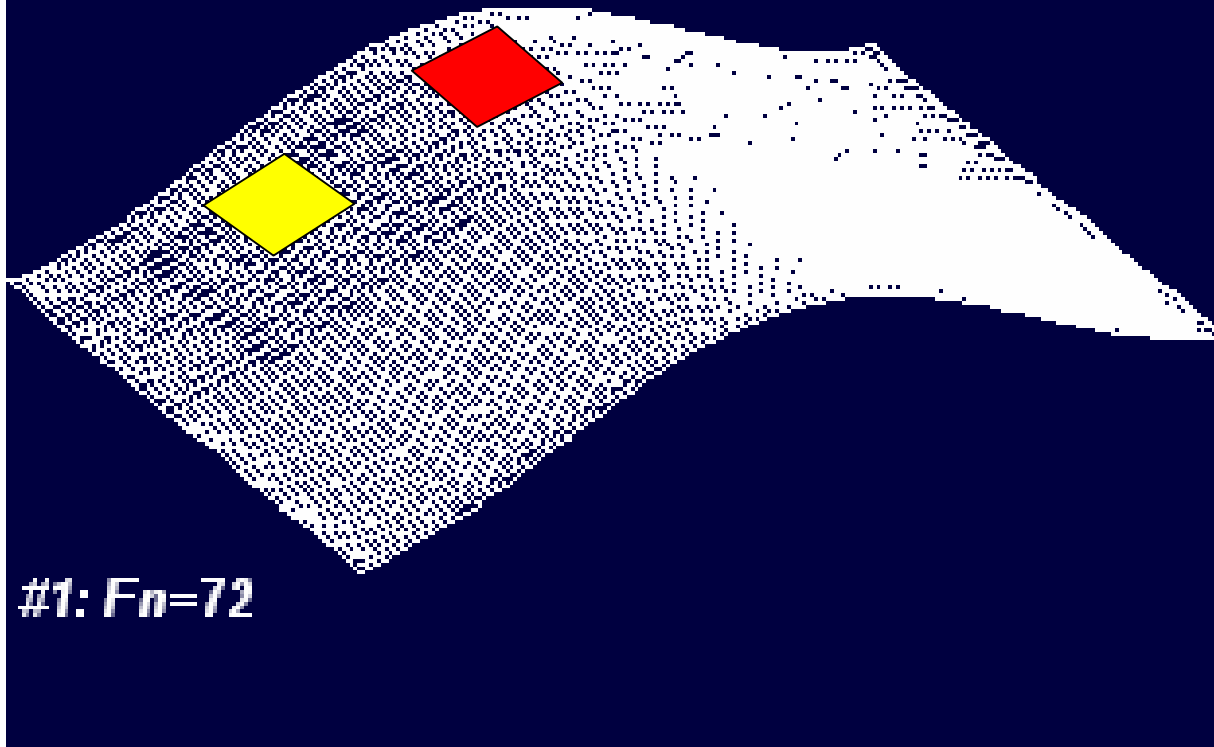


JG-PP Test Vehicles in Vibration Test Fixture

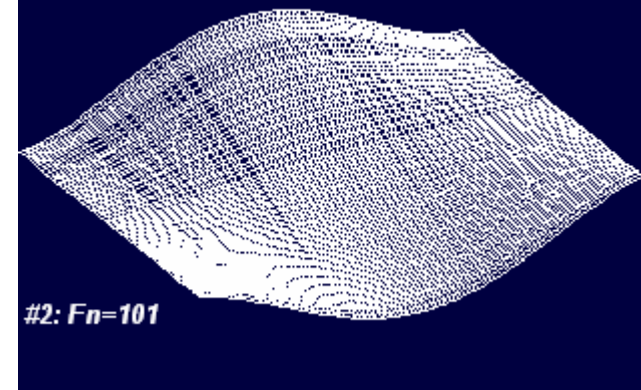


Vibration Step Stress Test Levels (9.9 Grms to 28 Grms)

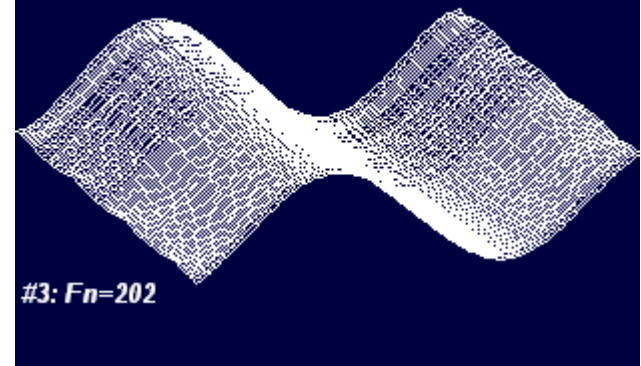
First Bending Mode of the JG-PP Test Vehicle



Second Bending Mode



Third Bending Mode



The **yellow BGA** will last 500 times longer than the **red BGA** simply due to position on the board (at a constant test level).

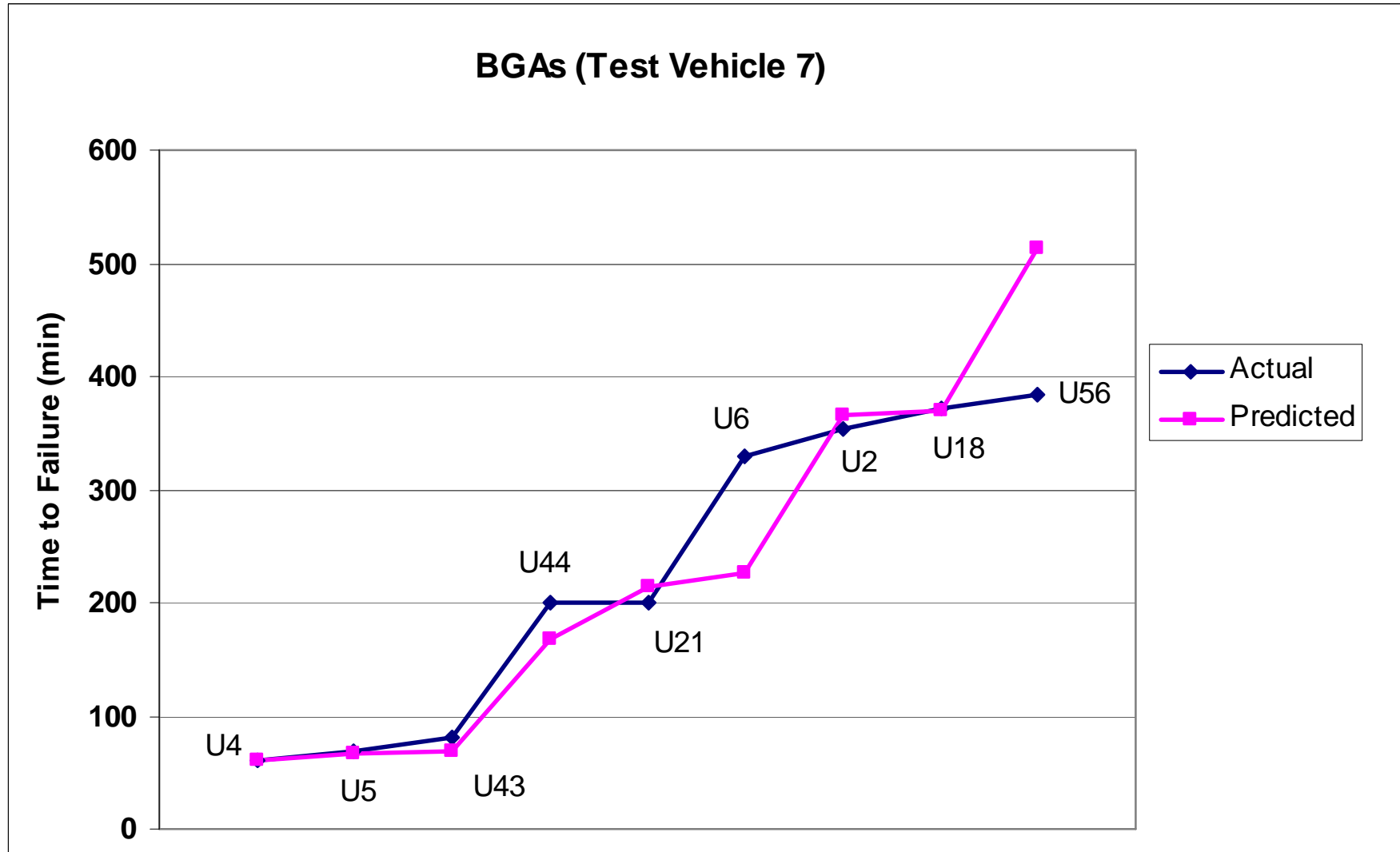


JCAA/JG-PP Lead-Free Solder Project Vibration Test

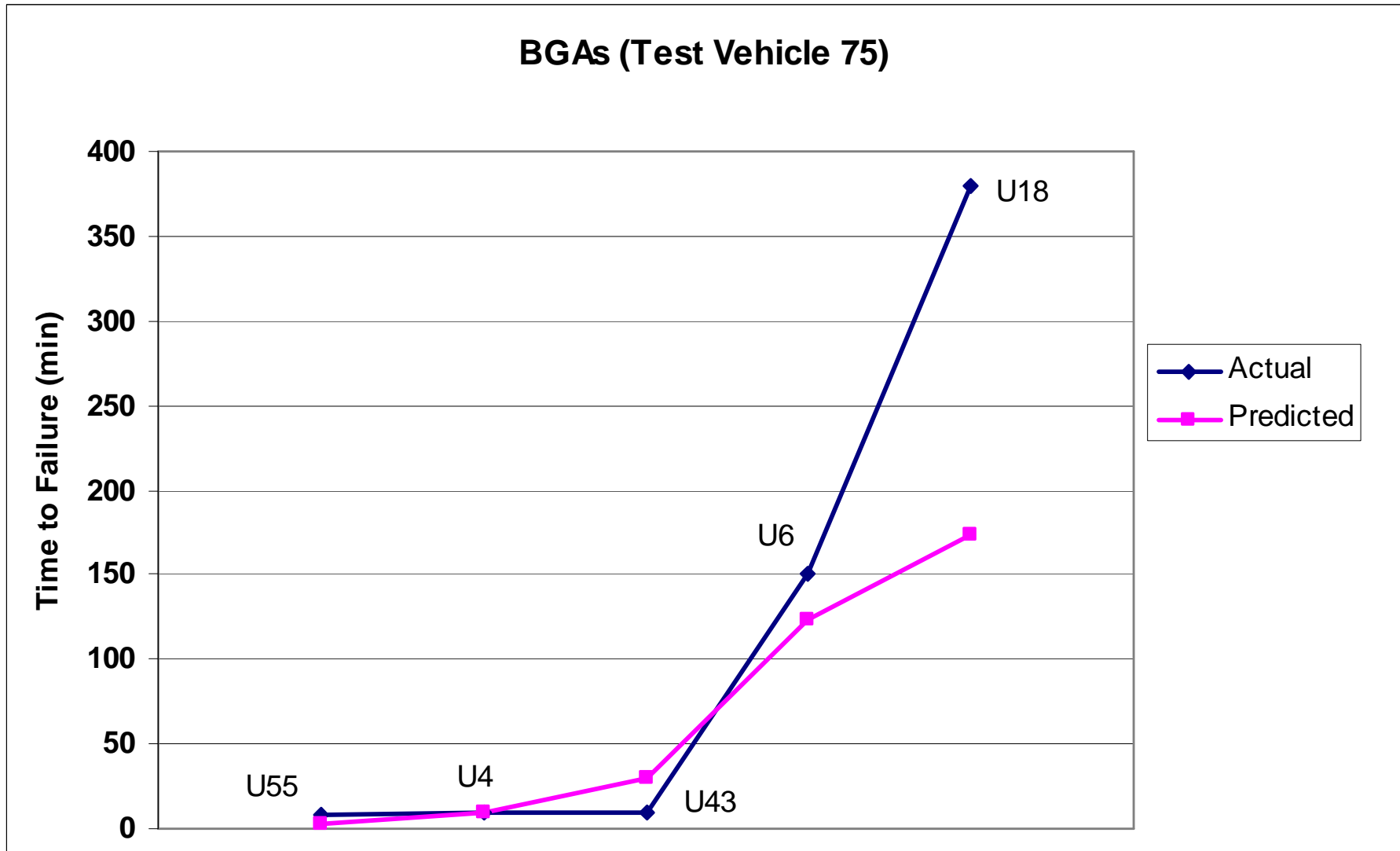
- **Commercially available software (Cirvibe) was used to predict the JG-PP component lifetimes (from test)**
- **Vibration test data was also extrapolated to lifetimes under field conditions**



Prediction of the Times to Failure for **SnPb BGA's** on JG-PP Test Vehicle 7 (Q values at accelerometer for Modes 1, 2 and 3 were 27.4, 2, and 6.7 respectively)



Prediction of the Times to Failure for SAC BGA's on JG-PP Test Vehicle 75 (Q values at accelerometer for Modes 1, 2 and 3 were 22.3, 5, and 4 respectively)



Extrapolation of Test Data for SnPb and SAC BGA's to a Field Condition

Predicted Time to Failure at Constant 3 Grms (0.0062 G ² /Hz) Input (years)					
BGA	Test Vehicle 5, SnPb Solder	Test Vehicle 7, SnPb Solder	Test Vehicle 8, SnPb Solder	Test Vehicle 77, SAC Solder	Test Vehicle 79, SAC Solder
U4	14.3	19.2	40	0.6	0.8
U6	297	7010	330	13.3	1.6
U18	4145	23800	35850+	102	228

- **SnPb BGA's will outlast SAC BGA's by a factor of 20x (or more) using a 3 Grms JG-PP PSD spectrum (0.0062 G²/Hz under first resonance)**
- Potentially a big problem for high reliability electronics?
- Below some threshold, all SAC BGA's will survive more than 20 years
- More testing and modeling required before SAC can be widely used in high reliability electronics