Agenda

1. TCS Background & Services
2. Surface mount devices
3. Advanced Packaging
4. Questions
A distinguished history of serving both domestic and international aerospace customer for nearly 40 years.

1976
TRW Components International (TRWCI) was formed by TRW, Inc., to supply parts management, engineering services and custom packaging solutions to the international space and military communities.

1999
TRWCI merged with Cubic Memory to form Vertical Circuits, Inc. (VCI).

2007
The space and military arm of VCI became Trident Space & Defense.

2011
Trident Space & Defense is acquired by TeleCommunication Systems, Inc, to become TCS Space & Component Technology.

“Same people, different names... TRW heritage and structure has been maintained since 1976.”
Quality Assurance for all your Space System Needs

Component Engineering
- Design Assistance
- Parts Selection & Qualification
- Radiation Support
- Obsolescence Management
- Counterfeit Parts Detection
- Up-screening

Supply Chain
- Manufacturer Selection
- Supply all EEE Part Types
- Supply of Hardware & Materials
- Procurement Consolidation
- Die Procurement & Qualification

Manufacturing Support
- Materials Review
- Customer Source Inspection
- Product Assurance Testing
- Die Banking
- Unique Device and Obsolete Part Manufacturing

Quality Assurance
- Visual & Mechanical Inspection
- Quality Data Review
- Prohibited Materials Analysis (XRF)
- DPA
- GIDEP & ESCC Alert Tracking

Export Compliance
- Review of Regulation & Policies prior to contract
- Nearly 40 Years Experience with US regulations and all major jurisdictions

After Delivery Services
- Long term storage
- Assembly, Integration & Test Support
- Warranty Management
- Kit to BOM

Complete Supply Chain Solution to Ensure Mission Success
TCS has developed a broad network of US and European suppliers, laboratories and test facilities for all of your EEE parts and management needs.
As the need for smaller, more complex systems arise, designers may look to utilize higher density microelectronic packaging solutions.

Today we will discuss current microelectronic design and packaging techniques to help reduce size and weight of space systems, including surface mount, BGA & CGA packages, MCM technology and stacking.
Typical Space Requirements

It’s expensive to launch into space. It can cost >$10,000 per pound, even for LEO mission. Typical requirements include:

- High reliability (repairs not possible)
- Long life: 5 – 15 years with no maintenance
- Operating range of -55°C to +125°C
- Radiation-tolerant/hardened: requirements vary considerably by application
- Low power consumption
- Reduced size and weight

Special consideration must be taken to meet these needs
Many designs for space continue to utilize through-hole technology.

**Advantages**
- Heritage designs that are proven to work
- Offers greater strength and support – more rugged
- May be advantageous for high power applications
- Easier for prototyping

**Disadvantages**
- Larger, bulkier package
- Limit available routing because they must pass through the opposite side – limits ability for double sided boards
- Lower pin count
- Newer, more complex devices not available in through-hole technology
Benefits of Surface Mount

• Savings in space using smaller components
• Weight savings
• Double sided board – higher circuit densities
• Reduced material handling – pick and place
• Automated and controlled manufacturing process – solder reflow oven
• Higher pin count for more complex devices

Disadvantages

• Prototyping may be more difficult
• Finer pitch devices may be more difficult to properly mount
• Heat dissipation may be an issue for high power devices
Case Study: Conversion of 8 Lead DIP to 10 Lead Class S Flatpack

- Heritage design utilized 8 lead DIP
- Conversion to 10 Lead Class S flatpack to save space and weight
- Significant savings in board space, which allowed for use of both sides of board. Part is ~50% smaller
- Significant savings in weight. From 1.05 grams down to .36 grams
- Allowed utilization of board level kitting, supporting automated manufacturing
Ball Grid Array

• Consists of an array of solder ball connections across the underside of the component.
• Increased complexity and higher density designs
• Move from quad flat pack to Ball Grid Array (BGA) with greater I/O count ~300 + I/O
• Lower thermal resistance
• Lower inductance

Disadvantages
• Difficult to inspect
• Subject to mechanical stress and CTE mismatch
• Can be difficult for design prototypes
Column Grid Array

- Evolution of BGA technology – More Robust.
- Balls are replaced with ductile columns to absorb stress from CTE mismatch between the PWB and ceramic package.
- Higher standoff distance – allows for easier inspection + reduced stressed.
- Increased thermal cycle reliability >5x can be achieved.

Disadvantage
- Finished CCGA packages may be more difficult to handle, in order to avoid damaged or bent columns.
- Columns still not as compliant as properly formed leads.
Adding even more density

- Multi chip module
- Stacked die
- Custom ASIC
Multi-Chip Modules (MCM)

- Multiple discrete components in a single package to reduce footprint.
- Hybrids may remove need to external passives
- Simplify board design

Example: Honeywell 64Mb MRAM
- Next generation from QMLV qualified 16Mb MRAM to 64Mb MRAM
- Dramatic reduction in space:
  - 16Mb package 29.5mmx29.5mm.
  - 64Mb MCM package 40.7mmx34.7mm
- MCM technology to create a larger memory configuration for FPGA boot applications
- Successful demonstration of Honeywell MRAM boot device for Xilinx V5 FPGA
- Key specifications:
  - Radiation hardened: >1M Rad(Si)
  - Magnetically-shield Ceramic package
  - Retention > 15 years
  - Endurance – unlimited write and read cycles
  - -40°C to +125°C Temp Range

Proof of concept with 4 discrete 16Mb MRAM Utilized as XILINX FPGA boot loader
Die Stacking

- Achieves even more density in the same footprint
- Pads can routed to edge of die with insulating layer between die or through use of interposer
- Through silicon via (TSV) can be incorporated for higher density interconnects

Example: Honeywell 64Mb SRAM
- 86 Lead Flatpack 31.25mm x 24.5mm
- 4 high stack of 16Mb SRAM Die
  - 512K x 32 SRAM Die
  - Configured as 2M x32
- Rad Hard
- QMLV Qualified
Application Specific Integrated Circuit (ASIC)

- Implementations for specific function or functions
- Combine multiple IC’s into a single component
- Smaller, Faster, lower power
- NRE can be more expensive than FPGA, but with lower unit costs

Example: Honeywell HX5000 with SERDES Macrocell for high speed point to point communication.

ASIC Macrocell
SERDES Embedded in an ASIC
HX5000 ASIC Family

Developing macrocell for use in Honeywell structured array for cost and schedule advantage.

Serial Bus Equivalent To Ethernet (1Gb/s to 3Gb/s)

Ideal for RAD Hard Routers and switches, computing and storage
Conclusion

- The move to surface mount has achieved significant savings in space and weight.
- Complex digital devices may require higher pin count packages, such as the CCGA.
- Advanced packaging techniques and custom ASICs can achieve even greater densities.
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SCT Value Proposition

COMPLETE SUPPLY CHAIN SOLUTIONS

- Consolidated procurement and long term storage
- Quality assurance
- Supplier qualification and management
- Pre-cap and final source inspection
- Dedicated program management
- Bill of material kitting
- Customer inventory management
- FAR compliance
- Order expediting and status reporting
- End-to-end parts project management

ENGINEERING SERVICES

- Component/RF/Mechanical Engineering
- Qualification testing
- Specification preparation
- Thermal and Stress analysis
- Source inspections
- Failure analysis
- BOM review/Obsolescence management
- Counterfeit parts detection
A Single Point of Contact

Customer

Program Manager works with full range of staff to meet any needs required

Our Goal: To Exceed Expectations

Program Management Team

Engineering

Purchasing

Quality Assurance

Production Control

Shipping Receiving

Oracle/CPMS

Document Control

Finance

Marketing

Our Goal: To Exceed Expectations
Senior-Level Component Engineering, Quality Assurance and Procurement Staff

- Specializing in difficult part procurements, qualification and testing
- Technical expertise in most all part technologies
- Development of all drawing types: custom procurement specs, upscreen documents and special procedures to meet specific customer quality and reliability requirements
- Significant experience working with most high-rel manufacturers
- Expertise to solve manufacturing, test and quality problems
- Space and MIL parts knowledge
- Significant experience with PEMs selection, screening and test
- Library of over 1000 SCDs and more than 1700 upscreen documents to meet high reliability requirements
- Parts also procured to customer SCDs, US MIL specs, ESCC specs and customer drawings
- Independent qualification testing
- Performance of DPA by independent laboratories, with reports reviewed and approved by TCS Component Engineering
TCS performs all types of electrical and environmental testing

- Testing for space and MIL level qualification
- Manufacture and test of obsolete / heritage devices
- Upscreening, special testing, Quality Conformance Inspection (QCI)
- Complete die lot qualification - including radiation testing as needed
- Integrated circuits, ASICs, memory, hybrids, diodes, transistors, connectors, capacitors, resistors, RF/microwave devices, relays, switches, fuses, filters, thermal control devices, magnetics, oscillators, converters, wire, cable, cable assemblies, and many other device types

- Our network agreements make us uniquely able to apply competent, timely, cost effective and efficient test resources

From basic characterization to full qualification
Destructive Physical Analysis (DPA)

Utilized on high-reliability parts programs
- To discover workmanship or process defects
- Find lot-related problems
- Prevention of latent failures

TCS works with numerous laboratories - selection based on specific device characteristic or special study requirements...TCS manages the analysis

DPA methods used:
- MIL-STD-1580
- SSQ 25000
- GSFC S-311-M-70
- MIL-STD-883 Method 5009
- Customer specific requirements
Failure Analysis Services

Failure analysis capabilities are critical

Need to determine exactly what happened…root cause
- Bad part?
- Overstress or ESD?
- Design / application issue?
- Process issue?

Need to eliminate or minimize risk
- Must understand why part failed
- Must have experience and history with all high-reliability part types
- Must understand appropriate techniques and when to use them…preserve evidence

Good failure analysis skills are critical
- Failure in-orbit can cost millions of dollars in losses
- Mission-critical failures can endanger human lives
- Understanding the failure mechanisms drives corrective measures

TCS engineers have decades of space component engineering experience utilizing a vast network of resources
Radiation Testing

- Multiple radiation test facilities utilized based on our customers needs…TCS manages the testing
- TCS’s test data base contains over 1000 radiation test reports
- Data also obtained from JPL, GSFC, NASA, NGST, ERRIC, Aerospace Corp, Sandia and many manufacturer data bases

**Radiation testing performed:**

- Total Ionizing Dose (TID)
- Enhanced Low Dose Rate (ELDRS)
- Displacement Damage
- Flash X-Ray
- EMP
- SEE-Single Event Effects
  - Heavy Ion testing
  - Proton testing
  - Neutron testing
  - Gamma testing
• TCS performs Prohibited Materials testing with in-house XRF

- Since 2006, the EU’s Restriction of Hazardous Substances (RoHS) directive has restricted lead in metal finishes and solder coatings
  - “Lead-free” designation can mean “pure tin”
  - “Pure-tin” can translate to tin whiskers
  - Counterfeiters re-mark new RoHS parts with older, leaded part numbers
  - Cadmium and zinc can sublimate in a hard vacuum
    - The sublimation products are conductive and can redeposit causing short circuits and whisker growth
Counterfeit Screening Services

Basic Screening Package
• Database Review / Comparison
• External Visual Inspection (100%)
  ▪ Physical Dimensions
  ▪ Marking
  ▪ Package / Lead Conditions
  ▪ Irregularities
• Solvent Testing
• Real-Time X-ray Inspection (100%)

Optional Screening Steps
• Electrical Characterization (100% or sample)
• De-lid and Die Visual Inspection
  ▪ Cross section – Passives
  ▪ Decapsulation – Plastic Devices
• SEM
• Solderability
• Materials Analysis via XRF
• CSAM
Customers

A Sampling of our Domestic and International Customers

Domestic

- BAE Systems
- Honeywell
- Lockheed Martin
- Raytheon
- Pratt & Whitney
- Harris Communications
- DRS Technologies
- Hamilton Sundstrand
- QinetiQ
- Goodrich
- Boeing

International

- Mitsubishi Corporation
- Enertec
- JAXA
- Mitsubishi Electric
- NEC/Toshiba
- Mitsubishi Heavy Industries, Ltd.
- Fuji Heavy Industries Ltd.
- Embraer
- INPE
- GE
- Fanuc
- KARI
- Thales
- Energia
- NEC

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Quality Certifications

- MIL-Q-9858A, MIL-I-45208 and NHB5300.4(1C) compliant
- ISO27001 certified
- DO-254 certification in process
- Fully Documented
  - Policy / Procedures
  - Work Instructions
- Records maintenance