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Integra Technologies Update

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Analytical Solutions LLC
Albuquerque, NM

800-622-2382
www.integra-tech.com
Integra Technologies History – 33 Years of History

- 1983: Founded by NCR
- 1983: Components Evaluation Technology Center (CETC)
- 1992: AT&T buys NCR/CETC (part of Bell Labs)
- 1996: AT&T Trivestiture
- 1998: Integra spun off from Lucent
- 2000: Amkor buys Integra Technologies
- 2005: Integra Technologies spun off from Amkor
- 2008: Integra becomes an Employee Owned Company
- 2008: ESOP
- 2013: Integra acquires Analytical Solutions, LLC
- 2016: Integra purchases a 40% stake in Aurora Semiconductor

www.Integra-tech.com 1-800-622-2382
### Integra Supports a Variety of Programs

<table>
<thead>
<tr>
<th>Historical Programs</th>
<th>Customers Supported</th>
<th>Services Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boeing/Airbus commercial aircraft</td>
<td>BAE, Crane, HW</td>
<td>Upscreening, parts procurement, CF authentication</td>
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<tr>
<td>Various missile programs (THAAD, PAC3, EKV, HARMS, ATACMS, etc)</td>
<td>LMC, Raytheon, BAE, UTAS, HW, L3, Boeing</td>
<td>Qualification testing, upscreening, FA, DPA, CF authentication, parts procurement</td>
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<tr>
<td>Various space level programs (Orion, MSL Rover, MAVEN, etc)</td>
<td>NASA, JPL, Ball Aerospace, LMC, BAE, SEAKR, NG, Boeing, APL</td>
<td>Screening, qualification, parts procurement, FA, DPA</td>
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<tr>
<td>Missile Defense Agency (MDA)</td>
<td>MDA</td>
<td>FPGA characterization</td>
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<tr>
<td>DoE programs</td>
<td>HW NSC, Sandia</td>
<td>Qualification testing, FA, DPA</td>
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<tr>
<td>Other DoD programs</td>
<td>HW, BAE, LMC, Raytheon, UTAS, Rockwell, L3, NG,</td>
<td>Upscreening, qualification testing, parts procurement, obsolescence solutions, FA, DPA, CF authentication</td>
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</table>

- Practically; every major Space and Military program uses Integra’s value added
- services directly or indirectly.
  - We perform almost 70% of all PEM quals
  - We perform almost 100% of cu bond wire quals
Integra Highlights

 **Stability**
  - 33+ year history
  - Now the largest value added services provider by considerable margin
  - Diversified customer base with 400+ active customers from avionics, military, aerospace, medical, automotive, commercial and industrial sectors
    - No single customer is more than 5% of our business
    - 20-30 year relationships with many of our customers
  - 250+ total employees
    - Experienced management team with average tenure of 20 years

 **Domain**
  - Now all EEE devices as defined by NASA (Microcircuits; Discrete; Passives; Magnetics; Connectors etc.)

 **Performance**
  - Delivery performance and Customer satisfaction rating of 97%
  - Delivery performance of 100% for inventory mgt. services
Broad Scope of Customers Served
Total Solutions Provider  

More Than a Test House

Our core strength of electrical test becomes the foundation for added value beyond test
Integra is More than a Test Facility….

- Procurement of Parts
- Receiving Inspection
- Supplier Management
  - AVL & Site Audit
  - Scheduling
- Qualifications
- Screening
- Solder Tinning
- Tape & Reel
- DPA
- Failure Analysis
- SCD Creation
- Engineering Data Review

- Obsolescence Management
  - End of Life Notifications
  - Life Time Buy
  - Alternate Part Solutions

- Engineering Data Review

- Inventory Locations
  - OMS capability to manage inventory
  - Security
  - Environmental conditions

- Kitting
Analytical Solutions Acquisition – A Full Mil Std 1580

- An Integra Company since 2013
- Located in Albuquerque, NM
- 30 year history as a value added service provider

New Portfolio of Services
- Failure Analysis (FA)
- Construction Analysis (CA)
- Destructive Physical Analysis (DPA)
- Laser Ablation Decap (for Cu wire)
- Cross Section
- Real Time/3-D X-Ray
- Scanning Acoustic Microscopy (SAM)
- Bond Pull / Die Shear
- FIB Editing
- SEM Inspection
- Optical Inspection
- PIND
- Fine & Gross Leak (Krypton 85)
Full DPA, Failure and Construction Analysis Support

- **Types of Analysis**
  - Construction Analysis
    - New Designs, Products and Processes
      - Wafer Fabrication
      - Packaging
      - Assemblies
    - Competitor Bench-Marking
  - Qualification Failures
  - Low Yield Analysis
  - Field Failures / Returns / System Failures
  - Counterfeit Detection

- **Fully Compliant DPA**
  - Per Mil-Std-1580 DPA (B and S Level)
  - Per NASA SSQ25000

- **Packages Covered**
  - Packaged ICs, Discretes, Passives
  - Connectors, Cables, Wires
  - PCBs
  - Sub-assemblies

Drilled-Hole (A) Allowing for End-Point Analysis To Determine When Metal Layer is Reached and Filling With W To Create Vias (B, C) and Jumper Wire (D)
Aurora Semiconductor Partnership

Valuable Partnership
- Larger role in Trusted supply chain (testing)
- iUHD MCM Test & Qualification support
- Draper R&D relationship for existing and future products

Aurora Offerings
- iUHD MCM (Integrated Ultra High Density Multi-Chip Module)
  - Worlds Most Advanced MCM Technology
- Custom Back End Wafer Processing
  - Wafer/Die Thinning
  - RDL
- Die Harvesting
- Cleanroom space available for Customer-owned tooling
  - Possibilities: Bump Fab, Plasma Dicing tool, Assembly
Aurora MCM – Complete System Solution

**Aurora**
- Small to Medium volume Manufacturing
- Accessible, US – based, Trusted facilities
- Specialty Processes geared to performance-driven customers
- Transfer of existing customer proprietary processes
- Customization of process steps
- Quality Assurance System

**Integra Technologies**
- Die level and MCM Level final Testing
- Reliability Testing
- Qualification
- Analytical FA Service

**DRAPER**
- R & D
- Design
- System Modeling
- Physical Design/ Layout

“Bridging the Gap” in Wafer Foundry Services™
Established, proven full turnkey solution – From Silicon Foundry to Assembly to Test
Integra will buy the parts
- Buy product from franchised distributors
- Inventory management and kitting
- Forecast management

Integra will procure and bank wafers / die
- Assembly and test of die as needed
- Full device level qualification as needed

Integra will manage your BOM by supporting all required Value Added Services with a single PO
- Write SCD / SIDs / VIDs
- Incoming Inspection
- DPA
- CSAM
- Assemble die
- Upscreening
- Qualification
- Failure Analysis
- Solder Dip
- Tape / Reel
- Dry Pack Bake
- Out-going Inspection
Experience and History of Success

- Started managing parts buys in 1991
- Currently manage parts BOM and procurement programs for many customers, including: BAE, Honeywell, Crane Aerospace, Moog, Plexus, Celestica, Benchmark, Hamilton UTC, MDA, Orbital

MRP system in place to inventory and manage volume orders

- Integra procured components on ~1,100 orders in 2015
- Currently tracking ~ 4,000 finished good inventory locations
- Currently tracking ~ 6,000 WIP and raw material inventory locations
- All inventory tracked by part, date code, processing flow, PO, DPAS, etc

Example of Customer Inventory Status Report downloaded from Oracle DB
Dedication to the Quality standards that our industry demands

- ITAR Registered
- DLA Lab Suitability
  - MIL-STD-883
  - MIL-STD-750
  - MIL-PRF-19500P
- ANSI/ESD S20.20-2007
  - Class 1 Product Handling
- DMEA Category 1A “Trusted”
- Flows
  - Customer specific, Source Control Drawing (SCD)
  - ITAR Process
  - JEDEC Standards for Plastic

QUALITY MATTERS

When every part has lives on the line, customers choose Integra
Leader in Advanced Technology Testing

- **High Frequency RF Testing**
  - Multiple 20GHz to 40GHz testing projects
  - Membrane probe at 40GHz / Cantilever RF Probe at 20GHz
  - S Parameters/Gain, P1dB/Phase Noise, Noise Figure, IP3, ACPR, Vtune, Frequency Range

- **14-24 Bit ADC/DAC**
  - Integra has tested 24 bit ADC at temp for NASA

- **High Voltage testing and burn in expanded (experience up to 10KV)**

- **SERDES**
  - Developed capabilities to test high speed SERDES with BERT and Sub-Pico second Jitter measurements (183 femto seconds)

- **Advanced Memories (NAND Flash, NOR Flash, DDR3, MRAM, etc)**
  - First test facility to test 128G NAND Flash & DDR3 at full speed

- **Microprocessors, Microcontrollers, FPGAs, CPLD**
  - Full uP development from scratch
  - Wide breadth of FPGA development expertise (Xilinx, Microsemi, Altera, etc)

- **ASICS**
  - Testing up to 2,000 I/Os and 1 GHz+ Digital / 50 GHz RF
Missile Defense Agency Selects Integra for Counterfeit FPGA Evaluation

- **MDA project requirements**
  - Research a robust set of advanced electrical tests for counterfeit parts screening
  - Using the research, rigorously test and analysis many different types of FPGAs to evaluate the effectiveness of the developed tests
  - The end product for this research is a new set of advanced electrical tests that will authenticate FPGAs at a high confidence level

- **Integra was selected because**
  - We have the largest number of test engineers, so projects happen in parallel
  - The broadest range of equipment – can match tester to device specs
  - The largest existing FPGA test library – over 250 existing FPGA test programs
  - We have the experience and capacity to execute a project this large

- **MDA project is ~2 years long and consists of 3 phases**
  - Phase 1 – Establish test capability for initial list of devices that are important to MDA programs and are likely targets for counterfeiters
  - Phase 2 – Research electrical test techniques that are effective in screening out counterfeit types expected to be encountered in the aftermarket
  - Phase 3 – Develop advanced and/or nontraditional electrical test techniques that target counterfeits not able to be screened by Phase 2 techniques
Device Types
- General purpose Diodes, Transistors, Power FET, MOSFET, J-FET, TVS, Rectifier, Zener, TRIAC, SCR, Opto-Coupler, Microwave Diode

Full Electrical Testing at Extended Temps
- -150°C to +200°C

Tester Platforms
- ASL-3000 / ASL-1000
- Scientific Test 5300HX- Automated Tester: Programmable; 0.1na Resolution
- RFT Custom Test System for RF Testing

Dedicated Test and Reliability Engineers for Discrete Products

MIL-PRF19500/MIL-STD-750 DLA Suitability for 62 Different Test Methods

Full MIL-STD-1580 DPA for Military and Space Grade Products

DMEA Approved Trusted Processing
Recognized as an Industry leader in testing for passive units in both the Aerospace & Military sectors

- MIL-PRF-55342 (Caps)
- MIL-PRF-27 (Resistors)
- MIL-PRF-28861 (Filters)
- MIL-STD 1344 (Connectors)
- MIL-O-55310 (Crystals)
- MIL-C-55361 (Inductors)
- MIL-T-27 (Transformers)
- MIL-R-39016 (Relays)

Burn in capacity in place for capacitors in many package styles

High/Low Temp Testing to MIL-STD 202, TM301, 302, 303, 304 & 309

Custom designed processing trays for many package styles
Connectors – Comprehensive Suite of Testing

- Full Range of Qualification, Design Verification and Reliability Testing
  - Space and Military
  - Rugged and Harsh Environment

  - Vibration / Shock
  - Temperature Cycling / Thermal Shock
  - Contact Retention, Stability and Engagement
  - Separation, Mating and Un-mating Force
  - High Temperature Exposure and Humidity
  - Insert Bond Strength and Insert Retention
  - Coupling Torque
  - Shell-to-Shell Conductivity
  - Working Voltage, Dielectric Withstanding Voltage

- Dedicated Test and Reliability Engineers for Connectors
- Full MIL-STD-1580 DPA for Military and Space Grade Products
Cost Effective Equipment for Every Technology

Test Platforms
High End Mixed Signal & Digital
- Verigy 93K & 83K
- Credence Quartet
- Credence Diamond

Digital Testers
- Verigy 93K & 83K
- Credence Diamond
- Teradyne J750
- Nextest Maverick (PT/GT)
- Trillium Micromaster
- MCT 2020

Linear & Mixed Signal
- Credence ASL-1000
- LTX TS88 DX90

Memory Testing
- Verigy 93K & 83K
- Teradyne J937
- Nextest Maverick (PT/GT)

Discrete Testing
- Credence ASL-1000
- STI 5300 HX
- Custom Set-Up

RF Testing
- ASL-3000
- RFT (custom eq set)

Auto Handlers
- SEIKO NS6040 (Parallel Test)
- SYNAX 1211 (Dual Site)
- MULTITEST 9510 (Tri Temp)
- MULTITEST 8704
- MCT 3608
- AETRIUM V6
- PROBERS (3” to 12”)

www.Integra-tech.com
Extensive Wafer Probe Experience

Began Probing in 1995

- 3” to 12” capability
- Probe card design, fab and verification
- Bumped probe
- Al, Au pads and Pb, Pb free bumps
- Vertical, Cantilever & Membrane probe
- High pin count, fine pitch

- N2 and vacuum wafer storage
- Elevated probing up to 200C
- Data analysis capability
- Handle wafers back grind to 6 mils

20 Million Die Per year
Diced Bare Die Probe - Xilinx Virtex 7 Example

Interposer brings the pad geometries out from the die to the ATE

Diced bare die probe on 8000+ pads @ -55C to +125C with 1GHz test rate

Advantest 93000 Test Head
Probe Card
V7 Interposer (MLC)
Removable Probe Head
V7 Die

Test Stack Up

Sectioned Side View of Probe Head Assembly

Probe Head Assembly

10-15µm Typical Scrub Mark
Largest Engineering Test Development Organization

- Over 300 man-years of combined experience
- Low Turnover
- >17000 test programs developed
- Over 25 other degreed technical personnel
- Engineering mgmt team of 4 with over 100 years combined experience

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<th>Engineer</th>
<th>Years</th>
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<th>Quartet</th>
<th>JT50</th>
<th>Mav</th>
<th>STE</th>
<th>Trillium</th>
<th>Sentry</th>
<th>J937</th>
<th>Xincom</th>
<th>LTX88/90</th>
<th>MCT2020</th>
<th>ASL-1000</th>
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<td>X</td>
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<tr>
<td>Engineer 25</td>
<td>2</td>
<td>Mixed Signal</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Engineer 26</td>
<td>1</td>
<td>Digital/Memory</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

Total: 26
Enhanced Burn-In and Life Test Capabilities

- High max temp of 260°C for static and dynamic burn-in
- Small, non-interrupt custom burn-in ovens, 8 power supplies per board
- Up to 192 digital channels per board - expandable to multiples of 192 digital channels
- Extremely high pattern depth (supporting loops, repeats and subroutines) to support most complex FPGA, Microprocessors and Microcontrollers
- Customizable FPGA logic in oven for flexibility
- Extensive real time monitoring for voltage, current & temperature including dynamic output stimulus on a device by device basis
- Analog instrumentation ports for easy interface of any programmable GPIB equipment
- Extremely high frequency burn-in and life test for complex ASICs, FPGA, Microprocessors and Microcontrollers; both RF and Digital
- Very high power air cooled burn-in achieving 200W per device to a 0.1 sq inch device pad
New Equipment/Capability Additions

- **Krypton 85 Fine/Gross Leak capability**
  - Supports preferred method for characterizing small leak rates
  - Supports the proposed tightened Hermeticity tests limits

- **Laser Ablation for Cleaner Plastic Device Decapsulation**
  - Cleanly remove mold compound using laser technology (primarily) with secondary shorter acid etch
  - Expose to secondary wire bonds without measurable damage

- **Failure mode analysis & understanding of physics behind potential Cu wire failures**
  - IMC failure mode analysis
  - Bond wire / pad splash phenomenon
  - Break mode understanding
  - Implications of pad lifting
  - Hidden micro-crack damages
  - Die cracks & corrosion
Upscreening

The definition of up-screening is testing a device to a wider temperature range than the original manufacturer specified. The only way to assure commercial temperature range devices can operate at the extended temperature ranges is to perform full AC/DC/Functional testing to “Upscreen” them for these harsher environments.

Electrical Testing at Temperature Ranges of -75C to 225C
- Up-Rating Commercial Devices to Military and Industrial Grade
- Up-Rating Industrial grade to Military Grade
- Speed sorting for memory devices
- Burn in

Back end processing to complete your value add requirements
- Part marking to uniquely identify up rated devices
- Solder dip
- Bake, dry pack and tape/reel
- Parts procurement and Inventory Management
  - Stock tested inventory to fulfill your JIT inventory needs
Volume Production Support & In Depth Technical Support

➢ Production capacity to support all your test & qualification needs
  ▪ Volume production test experience (wafer probe & package test)
    • Tested 55,000,000+ units in 2014/15
    • 147,000,000 insertions in 2015 alone
  ▪ Leader in PEM qualification testing (medical, military and aerospace focus)
    • Completed 1100+ qualifications in 2014/15
    • Co-Chair of G12 PEM Task Force Meeting
  ▪ 24 x 7 operation with on site equipment maintenance support
    • Off shift maintenance and engineering support
  ▪ Redundancy on all test equipment

➢ Technical Expertise
  ▪ 26 engineers & 4 management and 55+ total technical staff with over 300 years combined experience
    ▪ Test, Product, Reliability & Failure Analysis Engineers
  ▪ Support all technologies – digital, RF, memory, linear, discretes, passives, capacitors, resistors, microprocessors, magnetics, connectors, etc.
  ▪ Multiple engineers in each technology
  ▪ Expertise in developing test plans that meet your requirements and are cost effective
  ▪ Written over 17,000 test programs
  ▪ Recognized worldwide as industry leader in test expertise
Upscreening

- Integra has been upscreening devices for commercial aircraft and military programs since 1985.
  - Key customers are: Boeing, Honeywell, BAE, Crane Aerospace, LMC
- Integra has upscreened over 15 million units since beginning the program in 1985
  - 35 million+ test insertions
  - 1,800+ part numbers
  - 30+ manufacturers
  - Every device technology
- Integra has extensive data on fail rates by technologies and supplier
- All test programs were written in house to the customer’s device specification
- Automated handlers and temp forcing units to maximize throughput
Integra Advantage for PEM Qualification

➢ **Capabilities**
  - Electrical test @ temp
  - Construction Analysis
  - DPA/FA
  - Bond pull & Bond Shear
  - HTOL, HAST, THB
  - Temp Cycle
  - Copper Wire Evaluation

➢ **Experience**
  - Performed 1,000+ quals on:
    - 110,000 devices
    - 165 package types
    - 425 device types
    - 75 manufacturers
  - Knowledge of all EEE products
    - Discrettes, Passives, Linears, Memory, FPGA, SERDES, Microcontrollers, A/D, D/A, Inductors, Magnetics & more

➢ **Qualification performed to:**
  - NASA’s PEM-INST-001
  - Marshall Space MSFC-STD-3012
  - Class Y & N per Mil-PRF-38535
  - JEDEC
  - Other industry standards
# Integra PEM Qual Data Overview

Time Period Covered: 1998 through August of 2013

<table>
<thead>
<tr>
<th>Total Number of Parts Processed:</th>
<th>111,183</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Lots:</td>
<td>791</td>
</tr>
<tr>
<td>Total Number of Passing Lots:</td>
<td>496</td>
</tr>
<tr>
<td>Passing Lot Percentage:</td>
<td>63%</td>
</tr>
<tr>
<td>Total Number of Failing Lots:</td>
<td>295</td>
</tr>
<tr>
<td>Failing Lot Percentage:</td>
<td>37%</td>
</tr>
<tr>
<td>Total Customer Part Numbers:</td>
<td>455</td>
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<tr>
<td>Total Manufacturer Part Numbers:</td>
<td>410</td>
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<tr>
<td>Total Number of Manufacturers:</td>
<td>73</td>
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<tr>
<td>Total Number of Customers:</td>
<td>42</td>
</tr>
<tr>
<td>Unique Pin/Package Combinations:</td>
<td>165</td>
</tr>
</tbody>
</table>

Notes:
- No qualifications conducted by semiconductor manufacturers are included.
- Plastic packaged semiconductor devices only - no passives.
- Predominant test temperatures are -40, 25 85 and -55, 25 125.
- Testing temperature order is usually room, cold, hot.
- Once a qual fails it is usually stopped.
- Failures are for electric test only (no mechanical failures).
- Vast majority of testing performed to manufacturers datasheet limits.
- Virtually all electrical test programs written by Integra Technologies.
There is not a great deal of sensitivity to technology, with the exception of memory. It should be noted that the memory devices we evaluated tended to more often come in packages that were previously shown to be less reliable.
Summary

- Over 30 years in business
- Employee Owned Company
- Dedication to Quality
- Stable & Experienced Management Team
- Capacity Model Supports Significant Growth
- ERP System second to none
- Largest and most experienced engineering team
- More than Just a Test House
  - Parts Procurement
  - BOM Management
  - Failure Analysis/DPA
  - Obsolescence Solutions
  - Inventory Management
  - PEM Qualification
### Integra Supports a Variety of Programs

<table>
<thead>
<tr>
<th>Historical Programs</th>
<th>Customers Supported</th>
<th>Services Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boeing/Airbus commercial aircraft</td>
<td>BAE, Crane, HW</td>
<td>Upscreening, parts procurement, CF authentication</td>
</tr>
<tr>
<td>Various missile programs (THAAD, PAC3, EKV, HARMS, ATACMS, etc)</td>
<td>LMC, Raytheon, BAE, UTAS, HW, L3, Boeing</td>
<td>Qualification testing, upscreening, FA, DPA, CF authentication, parts procurement</td>
</tr>
<tr>
<td>Various space level programs (Orion, MSL Rover, MAVEN, etc)</td>
<td>NASA, JPL, Ball Aerospace, LMC, BAE, SEAKR, NG, Boeing, APL</td>
<td>Screening, qualification, parts procurement, FA, DPA</td>
</tr>
<tr>
<td>Missile Defense Agency (MDA)</td>
<td>MDA</td>
<td>FPGA characterization</td>
</tr>
<tr>
<td>DoE programs</td>
<td>HW, NSC, Sandia</td>
<td>Qualification testing, FA, DPA</td>
</tr>
<tr>
<td>Other DoD programs</td>
<td>HW, BAE, LMC, Raytheon, UTAS, Rockwell, L3, NG</td>
<td>Upscreening, qualification testing, parts procurement, obsolescence solutions, FA, DPA, CF authentication</td>
</tr>
</tbody>
</table>