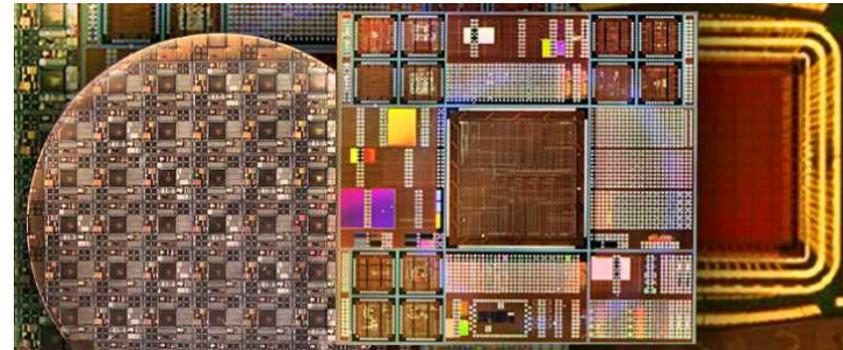
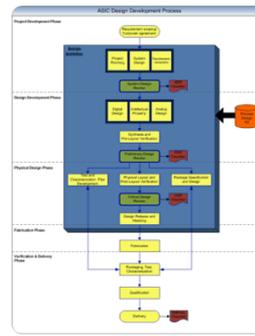


*Exceptional service in the national interest*



# SANDIA NATIONAL LABORATORIES MICROELECTRONICS OVERVIEW

September 15, 2016

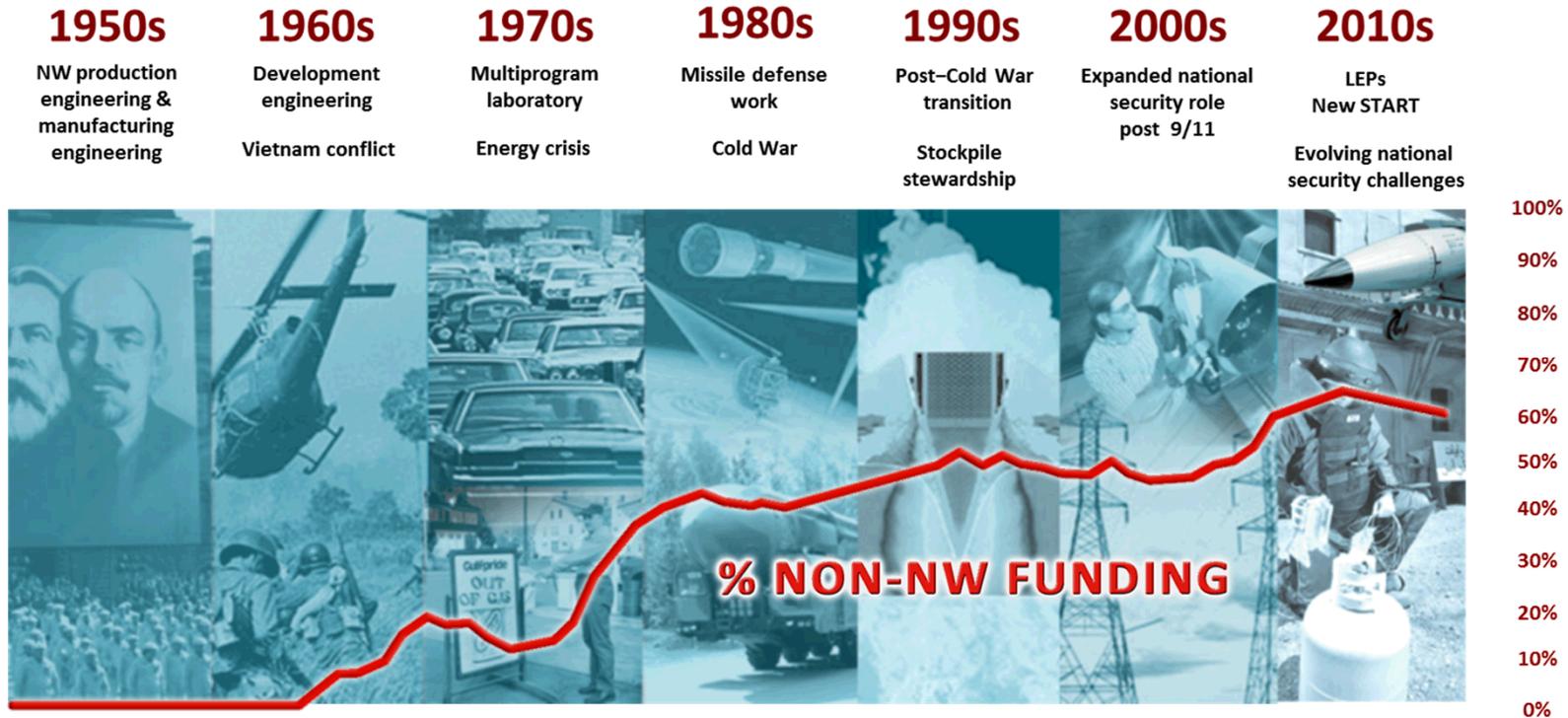
Reno Sanchez & Perry Molley

1700 Microsystems Science and Technology



Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# Sandia National Laboratories: “exceptional service in the national interest”

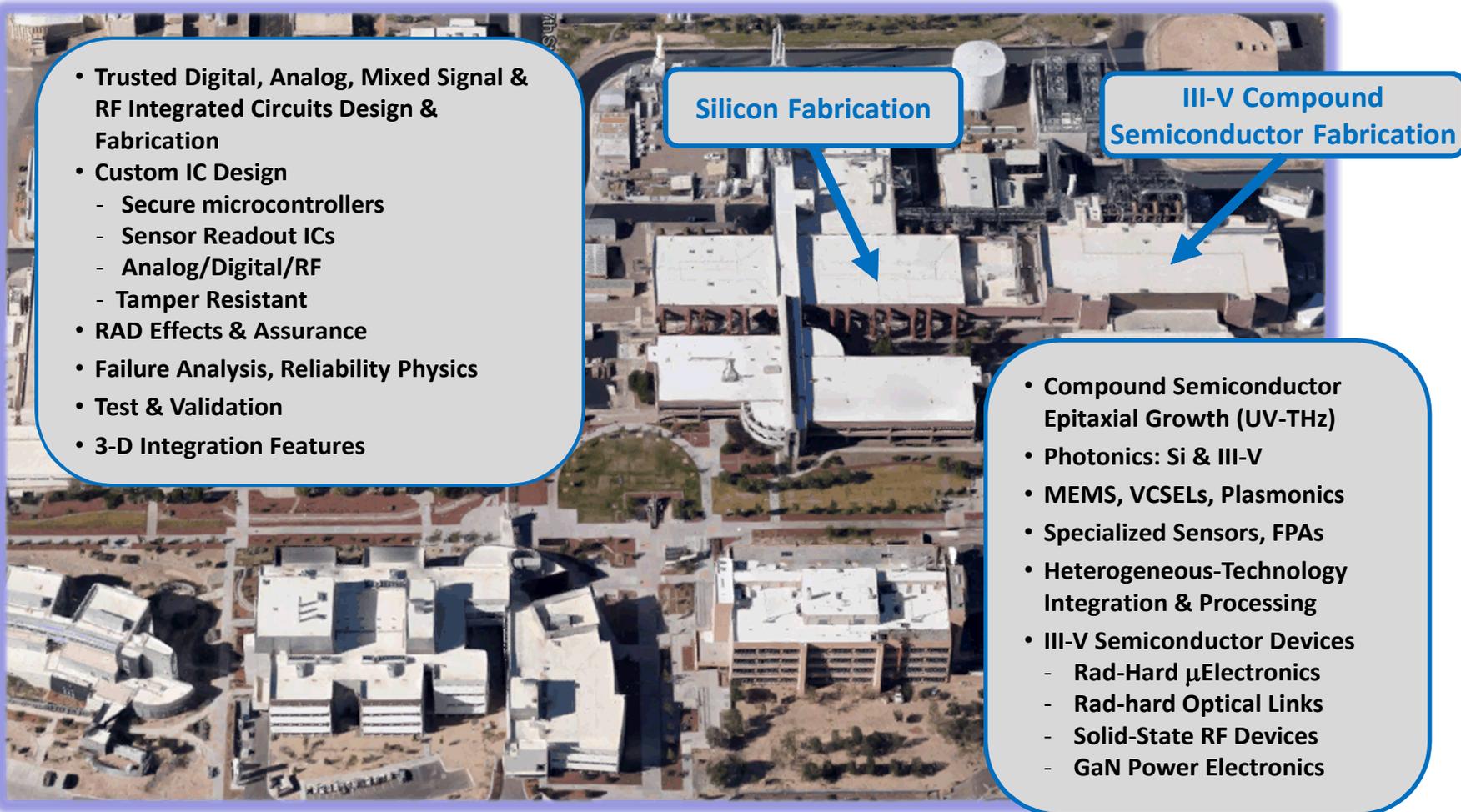


- DOE FFRDC: Initially Z-division of Manhattan Project (Non-nuclear Components, Weaponization of NEP)
- DOE supports our “Strategic Partnership Projects” (with industry & other gov’t agencies (OGAs))
- Our Big 3: **Non-compete with Industry, Fairness of Opportunity, No Organizational Conflict of Interest**
- **CRADAs with many Defense Contractors, Many STTRs & SBIRs, BAA response teaming**
- **Experience handling sensitive & proprietary information**

**Sandia has evolved from solely a Nuclear Weapons (NW) Lab to include broader mission areas that support other **national security** needs.**

# Microsystems & Engineering Sciences Applications (MESA)

400,000 Sq-ft Complex with >650 Employees in Secure Facility



The image shows an aerial view of the MESA facility, a large industrial complex with multiple white buildings and parking lots. Two callout boxes with blue arrows point to specific buildings: 'Silicon Fabrication' points to a large white building in the center, and 'III-V Compound Semiconductor Fabrication' points to a building on the right. A large callout box on the left lists various services, and another on the right lists specific fabrication capabilities.

- Trusted Digital, Analog, Mixed Signal & RF Integrated Circuits Design & Fabrication
- Custom IC Design
  - Secure microcontrollers
  - Sensor Readout ICs
  - Analog/Digital/RF
  - Tamper Resistant
- RAD Effects & Assurance
- Failure Analysis, Reliability Physics
- Test & Validation
- 3-D Integration Features

**Silicon Fabrication**

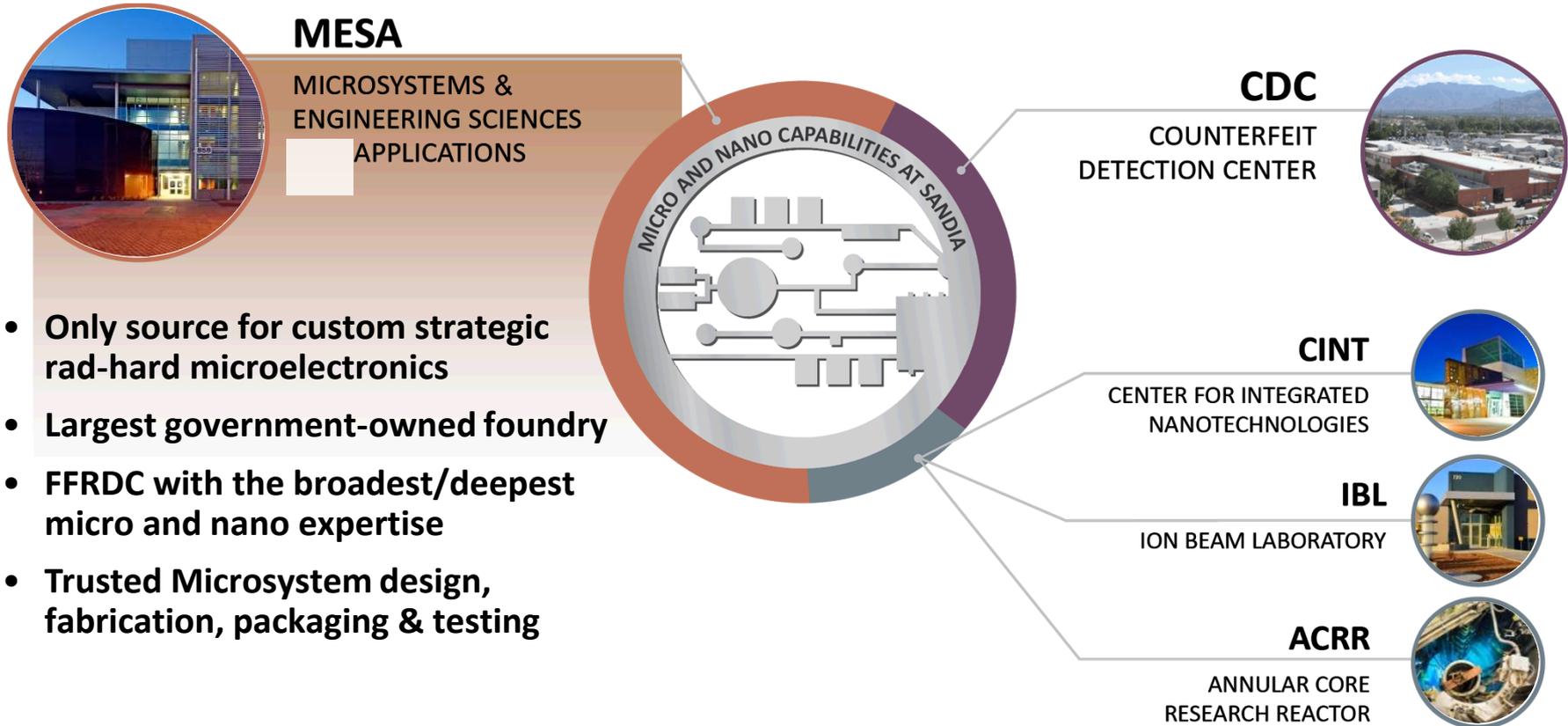
**III-V Compound Semiconductor Fabrication**

- Compound Semiconductor Epitaxial Growth (UV-THz)
- Photonics: Si & III-V
- MEMS, VCSELs, Plasmonics
- Specialized Sensors, FPAs
- Heterogeneous-Technology Integration & Processing
- III-V Semiconductor Devices
  - Rad-Hard  $\mu$ Electronics
  - Rad-hard Optical Links
  - Solid-State RF Devices
  - GaN Power Electronics

DOE/NNSA has established MESA as an *essential & enduring* facility to fulfill its Nuclear Weapon mission for parts that cannot be obtained commercially

# MESA IS A STRATEGIC NATIONAL RESOURCE

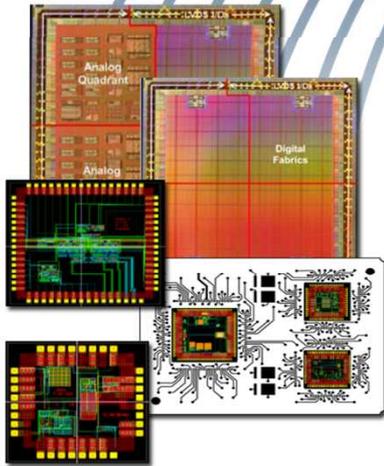
## Microsystems & Engineering Sciences Applications



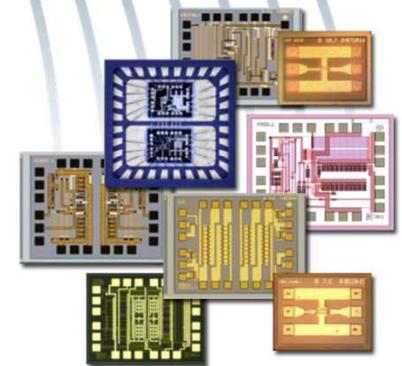
In conjunction with other unique, world-class facilities, MESA provides a complete **suite of capabilities** required for TRUSTED microsystem products.

# MESA manufactures strategically radiation-hardened trusted components for Nuclear Weapons

Radiation Hardened ASICs  
>30,000 deliveries



Rad-Hard III-V  $\mu$ Electronics  
>150,000 deliveries



**TRUST environment (NW, DMEA)**

**Strong Failure Analysis/Reliability**

MESA has a **proven reputation** for delivering TRUSTED, rad hard microsystem products to NNSA, Navy & USAF systems

# MESA FACILITY AND TOOL STATUS

- **MESA Silicon Fab**
  - 6” PD-SOI 350 nm Rad Hard by process CMOS (Digital & Mixed Signal-CMOS7); ViArray (Via-configurable Structured Gates)
    - ASIC and MPWs; 1,000 wafer starts/yr.
    - 8” PD-SOI CMOS7b at 350nm 2018 transition date
    - 180nm Rad Hard CMOS (CMOS8) in development
- **MicroFab**
  - III-V Compound Semiconductor Fab with MEMs post processing and advanced R&D flexible capability
  - Heterogeneous integration
  - HBT production
  - Versatile microfabrication environment
- **National Center for Trusted Microelectronics (NCTM)**
  - Microfabrication capability beyond 2025
  - 90 nm technology and 12” tools under consideration

The MESA facility has a planned **evolutionary path** to remain relevant for evolving national security needs.

# BROAD IMPACT & EXTERNAL ENGAGEMENT

- MESA has the capability & capacity to meet the needs of other agencies requiring TRUSTED microsystem products
- Sandia has great interest in teaming with other government agencies & contractors to design, develop and fabricate custom rad hard products:
  - Technology development & maturation is already occurring for: embedded processors, FPGAs, non-volatile SRAM, MEMS accels/gyros, photonics
- External engagement & industrial partners
  - Sandia has experience in design and building microelectronics in fabs around the country and in the most advanced technologies available



As the number of US-owned foundries continue to shrink, MESA will work with external partners to maintain the supply of necessary **trusted microelectronics**.

# SUMMARY

- **MESA Makes It Real**

The Microsystems & Engineering Sciences Applications (MESA) Complex represents the essential & enduring facilities and equipment to design, develop, manufacture, integrate, and qualify microsystems for national security needs that cannot or should not be made in industry.

- **Collaboration with other national security programs is essential**

MESA has the mission, capability & capacity to meet the needs of other agencies requiring TRUSTED microsystem products.

- **DOE/NNSA's enduring mission ensures long-term MESA fab viability**

Sandia's proven ability to deliver microsystems can help protect other national security programs from the loss of trusted US foundries.

# Backup Slides

# Radiation Hardening (RH) Capabilities

<b>Mission Statement</b>	To provide strategic radiation hardened advanced microelectronic, photonic, and micro-electromechanical technologies and qualification testing to high consequence, high reliability systems by maintaining leading capabilities in basic mechanisms, modeling, design, manufacture, and test.
<b>Personnel</b>	Multiple departments in advanced technologies including CMOS, III-V systems, photonics, COTs, RF Ics, advanced digital and analog design, layout, manufacturing, test, modeling, packaging, assembly, and radiation effects. Supported by 100's of staff across SNL.
<b>Capabilities/ Infrastructure</b>	<p><b>Design:</b> Maintains complete suites of industry standard analog and digital design tools including UVM, timing analysis, power analysis, simulation, layout verification, design for manufacturability, design for test, formal methods, library generation, design kit development and compact modeling. Executes designs across multiple technologies down to 14 nm CMOS, including III-V GaAs HBT SSICs and Transistors, Memristor, Wide-Band-Gap, photonic and MEMS components.</p> <p><b>Manufacture.</b> MESA SiFab and Micro-Fab builds 0.35um CMOS and III-V GaAs devices and IC's, with capabilities to integrate other non-CMOS "beyond-Moore" elements, including Memristors, Wide-Band Gap, photonic, and MEMS components. 3D integration techniques are also being employed. We're developing a 180nm CMOS manufacturing technology.</p> <p><b>Test:</b> Maintains commercial IC test systems for ASIC qualification, including burn-in systems and advanced failure analysis capabilities, including Power-Spectral Monitoring for counterfeit analysis. Maintains multiple portable test systems and capabilities for radiation effects testing at remote heavy ion and dose-rate (LINAC and Flash x-ray sites). Maintains on-site Co-60 and Cs-137 TID test systems, Aracor X-ray test systems, as well as other nuclear-environments simulators, HERMES, Saturn, and ACRR. On-site ion-beam/microbeam capabilities are also available.</p> <p><b>Modeling:</b> Maintains 1D, 2D, 3D TCAD modeling capabilities using both commercial (Silvaco) and internal codes (Xyce/Charon), executable in massively parallel computing environments. Maintains nuclear transport codes to understand local environments to components. Develops "radiation-aware" compact models to account for degraded parameters, photocurrent, and neutron effects in devices and circuits.</p> <p><b>Radiation Effects:</b> Maintains expertise in TID, SEE, Dose-Rate, and Neutron effects on microelectronic, photonic, and materials systems. Executes qualification plans for components in hostile and natural nuclear and space environments.</p> <p><b>Facilities:</b> MESA, Gammacell irradiator, HERMES, Saturn ACRR</p>

# Electromagnetic (EM) Capabilities



<b>Mission Statement</b>	Our primary mission is to advance and apply electrical sciences in support of the design, qualification, and lifecycle of nuclear weapons in normal, abnormal, and hostile electromagnetic and radiation environments. This foundation also enables support of other mission spaces including synergistic defense products, secure and sustainable energy futures, cyberspace, and national security space innovations.
<b>Personnel</b>	45 technical staff, 15 technicians, 5 managers with expertise in engineering, physics, mathematics, computer and circuits sciences and conduct of experiments.
<b>Capabilities/ Infrastructure</b>	<p><b>Linear electromagnetics:</b> Modeling, simulation, analysis and testing involving EM coupling and interactions in complex geometries supporting design, qualification and surveillance in normal, abnormal, and hostile environments.</p> <p><b>Plasma physics:</b> Electromagnetic kinetic (Monte-Carlo and Particle-In-Cell) modeling and simulation of pulsed-power, EMP, and gas and vacuum discharge physics supporting Nuclear Weapon design, experiments, and qualification in hostile environments.</p> <p><b>High voltage sciences:</b> Physics of high voltage electrical breakdown, Lightning burn/blast through, electrostatic discharge supporting engineering design, qualification and surveillance in normal and abnormal environments.</p> <p><b>Circuit and device simulation, device model development:</b> Analog, digital and RF circuit simulation as well as TCAD device simulation supporting Nuclear Weapon electrical systems design, qualification and surveillance. Physics based device model (radiation, temperature, aging) development; device specific model extraction, V&amp;V and calibration; supporting life cycle Nuclear Weapon electrical systems</p> <p><b>Power systems and electronics:</b> Design, development and modeling/simulation of power systems/microgrids, power electronics, advanced solid state switching and advanced control and optimization.</p> <p><b>Facilities:</b></p> <ul style="list-style-type: none"><li>• Full threat, multi-pulse lightning simulator</li><li>• Large scale GTEM chamber</li><li>• Large scale TEM chamber for CW and EMP simulation (&gt;30kV/m pulse testing)</li><li>• Large scale, high-Q Mode-stir chamber</li><li>• High power RF amplifier inventory from 10 KHz to 40 GHz.</li></ul>

# Electromagnetic (EM) Capabilities (continued)

<b>Design</b>	Design support for electronics and systems to meet electromagnetic environment compatibility requirements.
<b>T&amp;E</b>	<ul style="list-style-type: none"><li>• EM/RF testing from 10 kHz to 40 GHz</li><li>• EMP testing</li><li>• ESD testing</li><li>• Full threat, multi-pulse lightning simulator</li><li>• Large scale GTEM chamber</li><li>• Large scale TEM chamber for CW and EMP simulation (&gt;30kV/m pulse testing)</li><li>• Large scale, high-Q Mode-stir chamber</li><li>• High power RF amplifier inventory from 10 KHz to 40 GHz</li></ul>
<b>PKG</b>	N/A
<b>M&amp;S</b>	Electromagnetics, EMP, plasma physics modeling and simulation in support of design and qualification of nuclear weapons systems and components in electromagnetics and radiation environments.

# HIGH POWER ELECTROMAGNETIC (HPEM) CAPABILITIES

<b>Name of Laboratory</b>	Sandia National Laboratories, Albuquerque, New Mexico 87185
<b>Mission Statement</b>	Our mission is to provide cutting edge service to the nation in the development and design of High Power Electromagnetic (HPEM) Directed Energy weapons and their effects on electronic systems at fluence levels well above those typically included in EMP/EMI/EMC studies and testing.
<b>Personnel</b>	7 technical staff, 8 technicians with expertise in engineering, physics, mathematics, computer and circuits sciences and conduct of experiments.
<b>Capabilities/ Infrastructure</b>	<p><b>Linear electromagnetics:</b> Modeling, simulation, analysis and testing involving EM coupling and interactions in complex geometries in support of both offensive and defensive capabilities.</p> <p><b>Pulsed Power and High Power Sources.</b> Design, fabrication and test of state of the art HPEM system</p> <p><b>Circuit and device simulation, device and model development:</b> Analog, digital and RF circuit simulation as well as TCAD device simulation including self consistent interaction of the linear EM problem with the non-linear response of the electronics.</p> <ul style="list-style-type: none"> <li>• <b>Various Amplifiers available for testing in the GTEM and Anechoic Chambers</b> <ul style="list-style-type: none"> <li>• 50 W solid state amplifier from 1 – 1000 MHz</li> <li>• 120 W solid state amplifier from 80 – 3000 MHz</li> <li>• 1 kW solid state amplifier from 80 – 1000 MHz</li> <li>• Suite of 200 W TWT amplifiers from 500 MHz to 18 GHz</li> <li>• 100 W CW 94 GHz amplifier (350 MHz 3 dB bandwidth)</li> <li>• S-band (2MW Peak) and x-band (~100kW Peak?) Radars</li> </ul> </li> </ul>

# HIGH POWER ELECTROMAGNETIC (HPEM) CAPABILITIES

<b>Capabilities/ Infrastructure</b>	<ul style="list-style-type: none"> <li>• <b>HPM sources</b> <ul style="list-style-type: none"> <li>• Diehl and Sandia Designed Wideband Transient sources</li> <li>• Stinger/HPM Tubes – CHAMP surrogate (L-band, GW Class)</li> <li>• Nonlinear Transmission line - 500 to 900 MHz, ~1 MW</li> </ul> </li> </ul>	
	<b>Fabrication</b>	Yes
	<b>Design</b>	<ul style="list-style-type: none"> <li>• Design support for electronics and systems to meet electromagnetic environment compatibility requirements.</li> <li>• Design of threat level source test systems</li> </ul>
	<b>T&amp;E</b>	See capabilities above
	<b>PKG</b>	Packaging of weapon, test systems, and protection systems.
	<b>M&amp;S</b>	Electromagnetics, linear and non-linear circuit response of targets