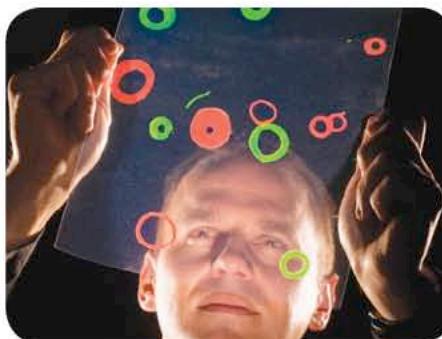


*Exceptional service in the national interest*



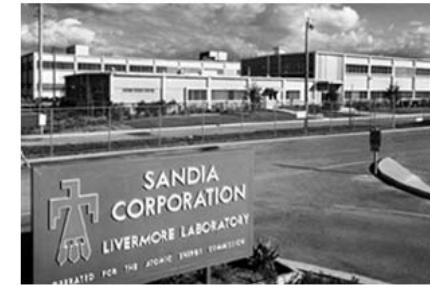
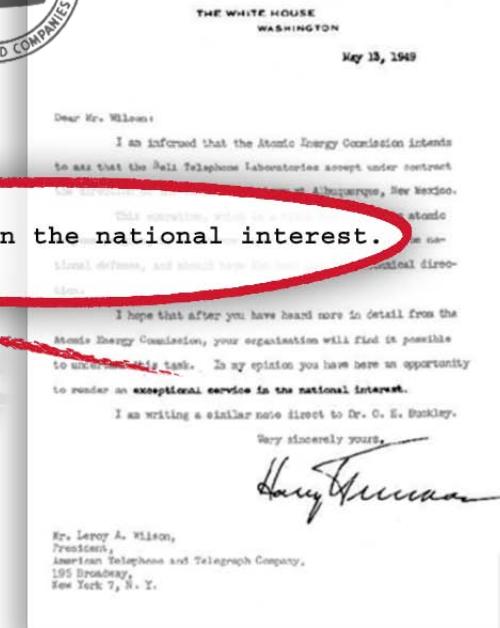
# Rad-Hard Enabling Technologies and Trusted ASICs

**Richard Dondero**  
Manager, Rad Hard CMOS  
505-284-1457  
richard.dondero@sandia.gov



Sandia National Laboratories is a multi-program 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. SAND2011-0439P

# Sandia's History



Albuquerque, NM

# The Mission Has Evolved for Decades

**1950s**

Production  
engineering &  
manufacturing  
engineering

**1960s**

Development  
engineering

**1970s**

Multiprogram  
laboratory

**1980s**

Research,  
development and  
production

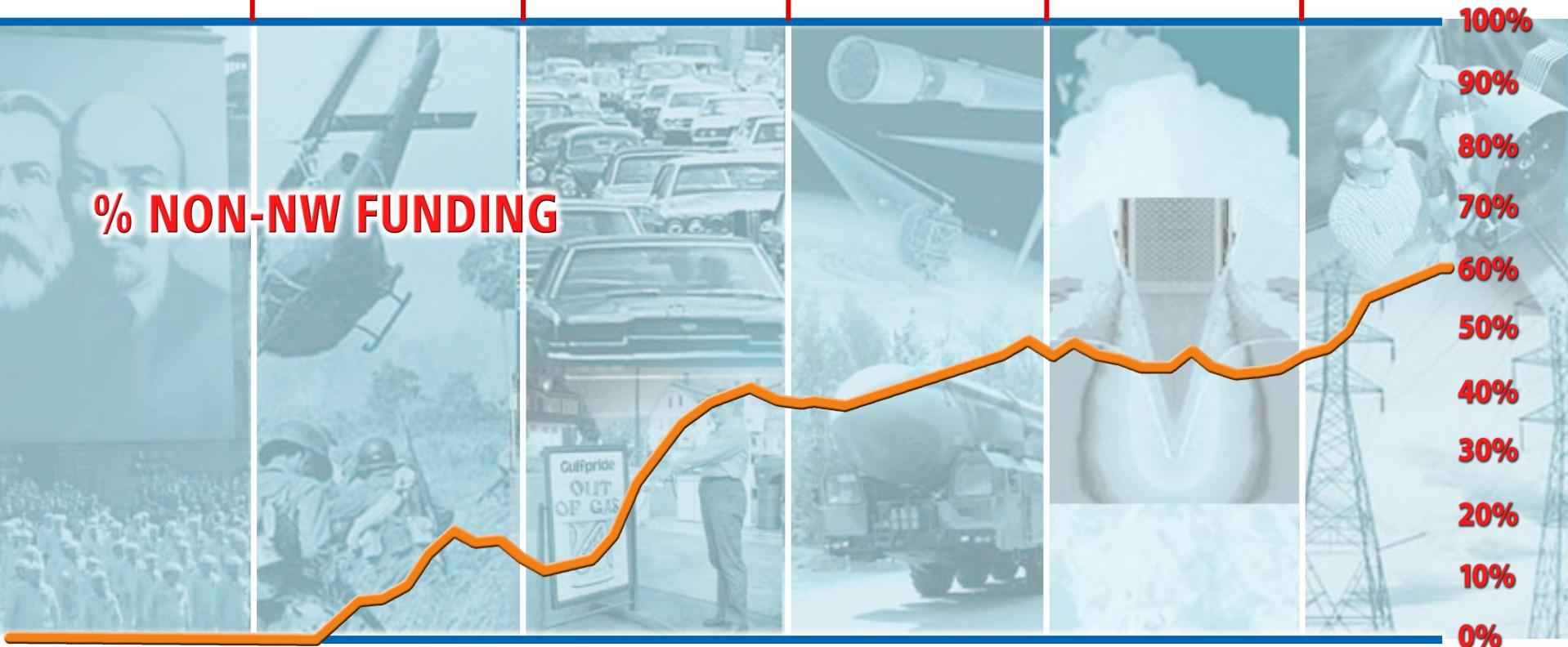
**1990s**

Post-Cold War  
transition

**2000s**

Broader national  
security challenges

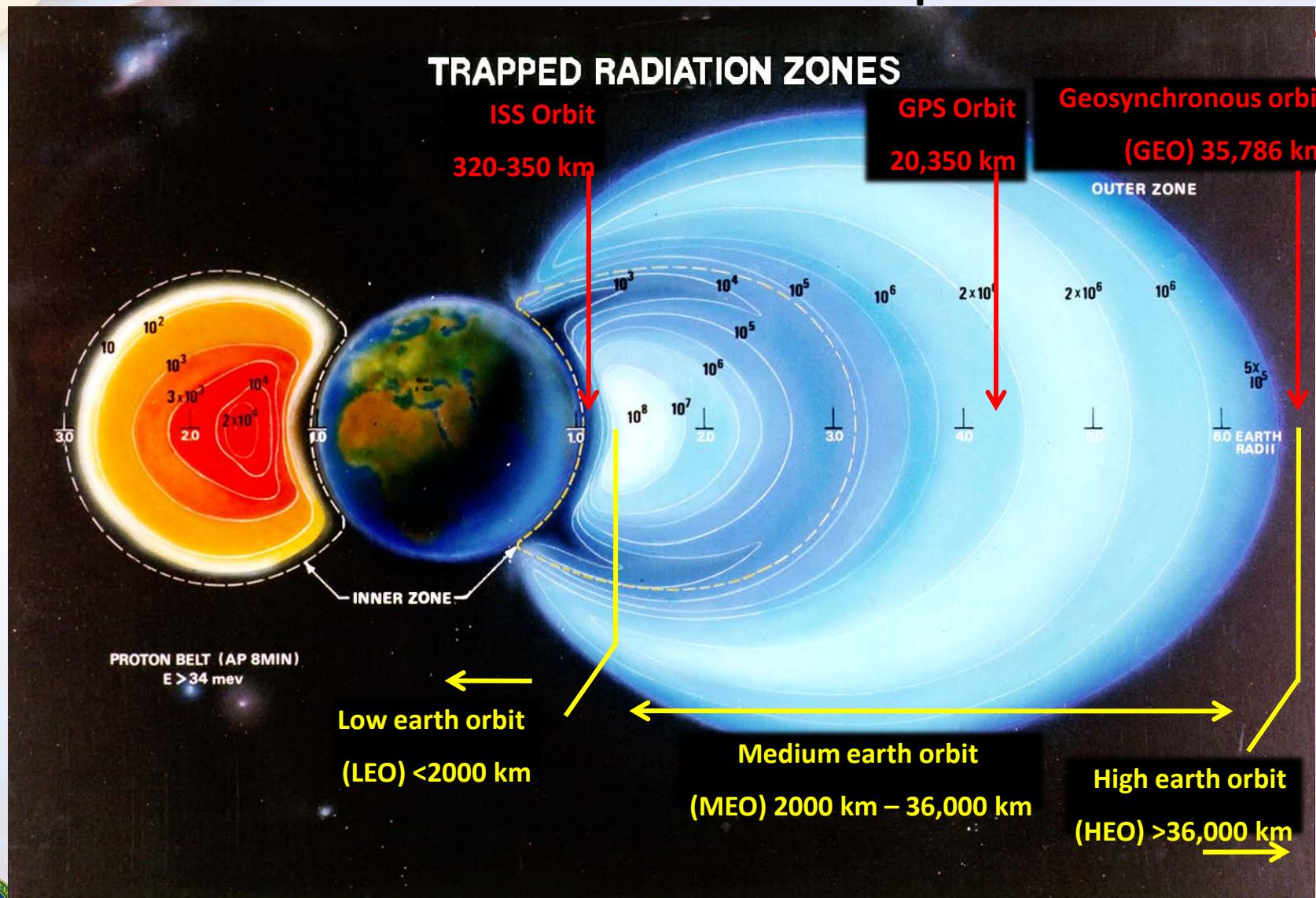
**% NON-NW FUNDING**



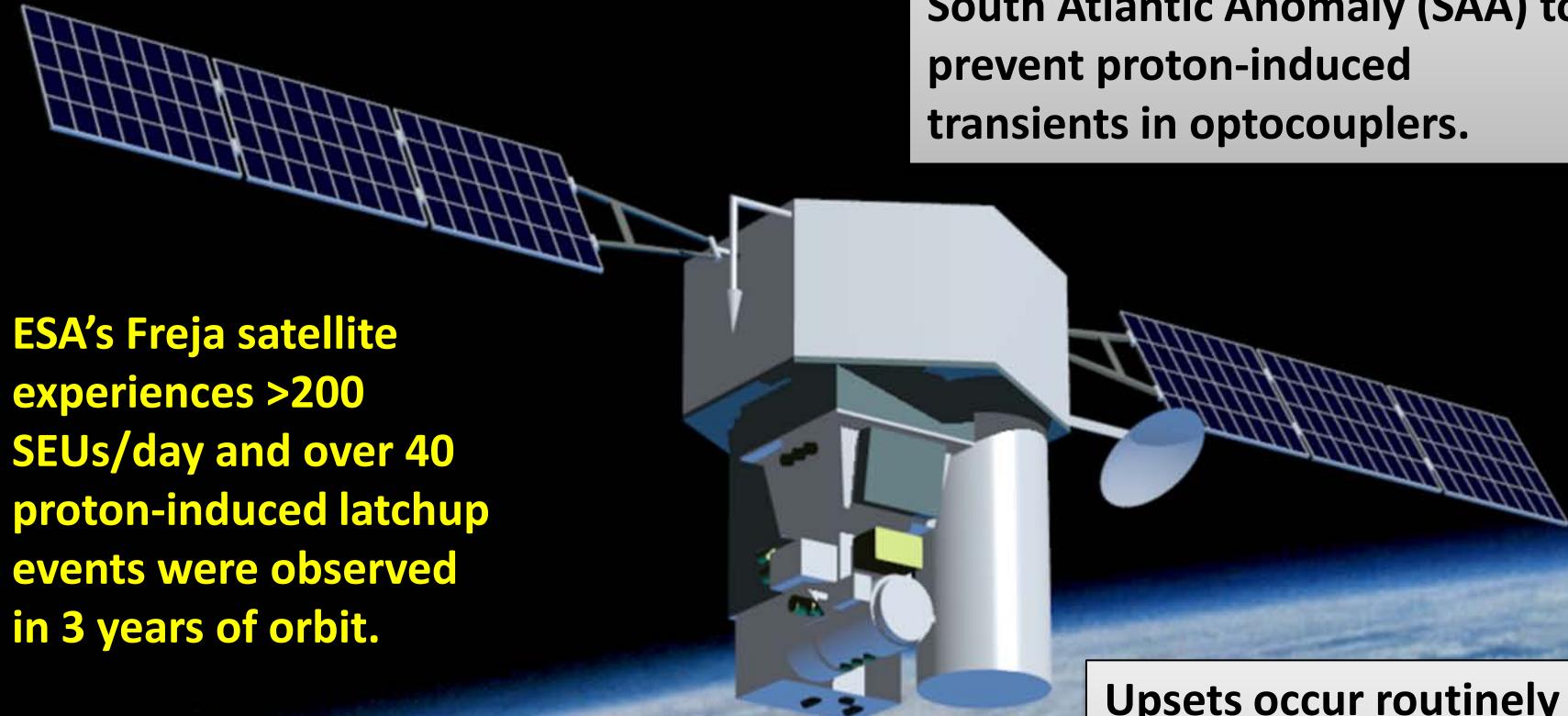
- **Sandia National Labs**
- **The need for radiation-hardened microelectronics**
- **Rad hard technology**
- **The need for trustworthy microelectronics**
- **Trusted services at Sandia**
- **The Trusted Foundry and the Trusted Suppliers program**



# Altitude Determines the Nature and Magnitude of Natural Space Radiation Effects



# Mission Impact



**ESA's Freja satellite experiences >200 SEUs/day and over 40 proton-induced latchup events were observed in 3 years of orbit.**

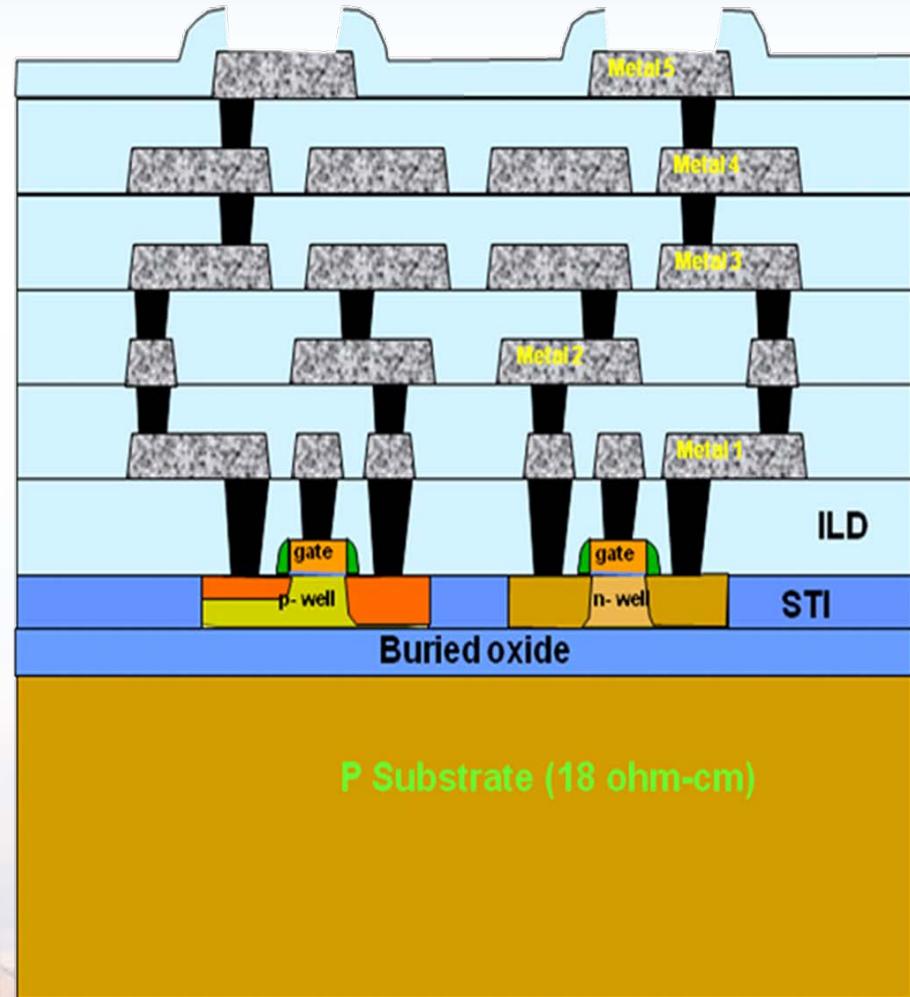
**Instruments onboard Hubble Space Telescope are powered down during traverses of the South Atlantic Anomaly (SAA) to prevent proton-induced transients in optocouplers.**

**Scientific instruments aboard the Polar Earth Resources Satellite (ERS-1) permanently failed following proton-induced latchup.**

**Upsets occur routinely in SRAMs and DRAMs used in the SAMPEX and HST solid-state data recorders.**

# Strategic Radiation-Hardened SOI CMOS

- **CMOS7 Radiation-Hard Technology**
  - 0.35um Technology
  - SOI Substrate
  - 5 Metal Layers
  - 3.3V VDD, 3.3V I/O
- **Mixed Signal Components**
  - MIM capacitor
  - N+ Poly resistor
- **Additional Extensions**
  - SONOS NVM
  - High Voltage CMOS
  - Anti-Fuse for OTP-NVM

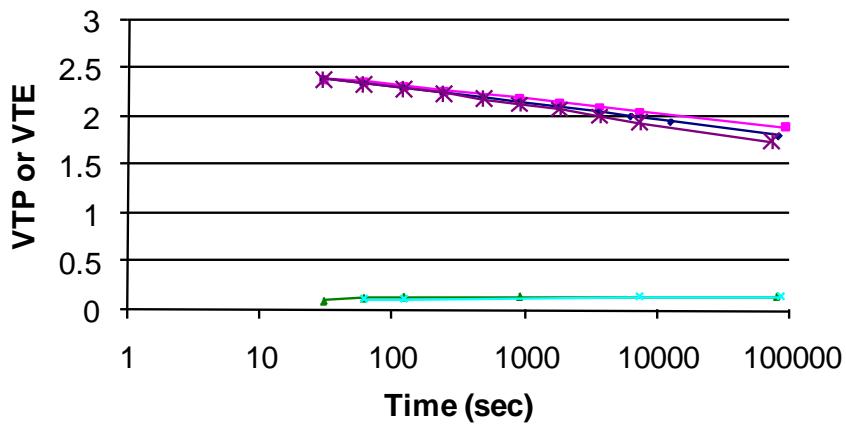


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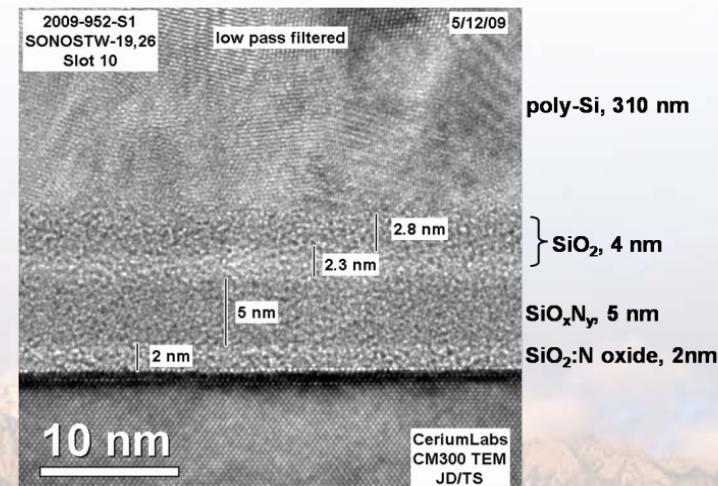
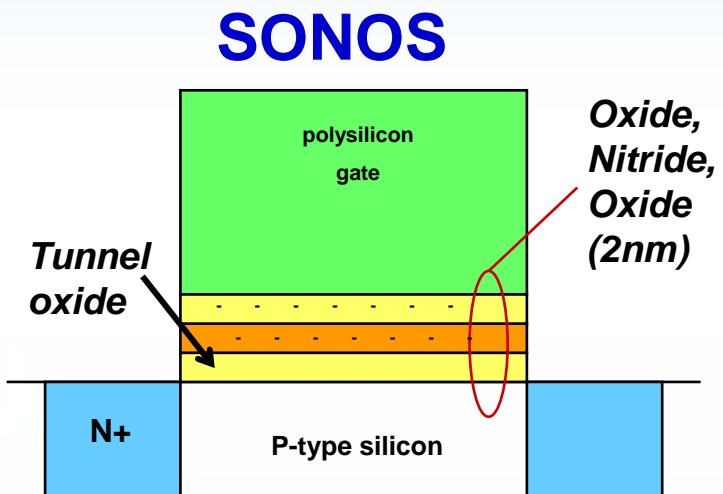
# Read/Write Non-Volatile Memory

- Radiation tolerant embedded and stand alone R/W memory

BD057307C Wafer 12 - IPW - 2.23 v  
Retention at 25C, 75C & 125C

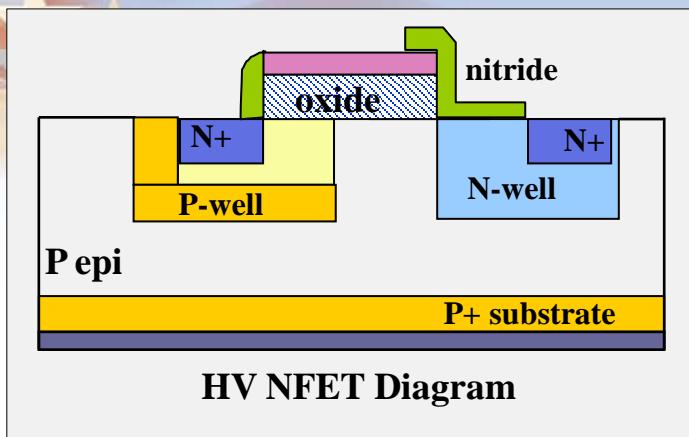


Extrapolated program windows at 10y:  
1.2 v (25C), 1.0 v (75C), 0.85 v (125C)

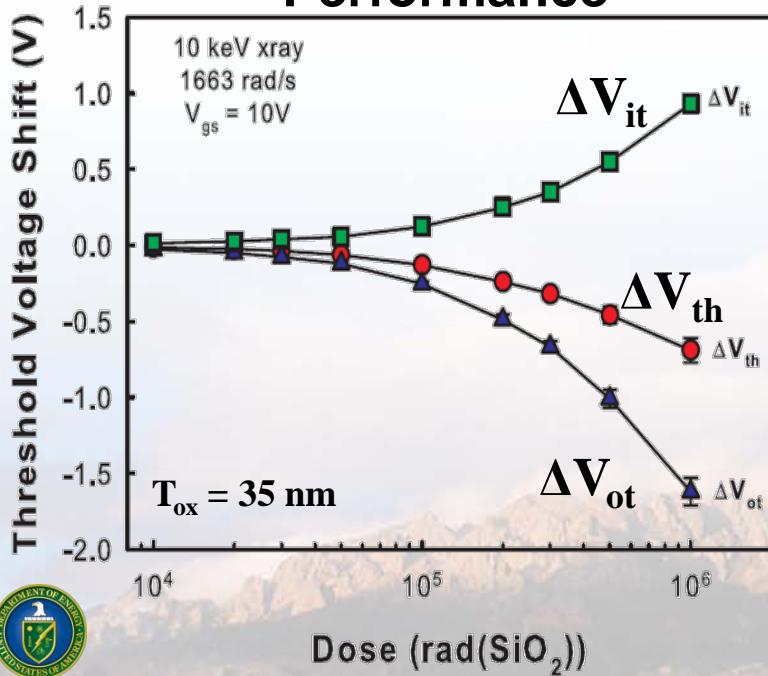


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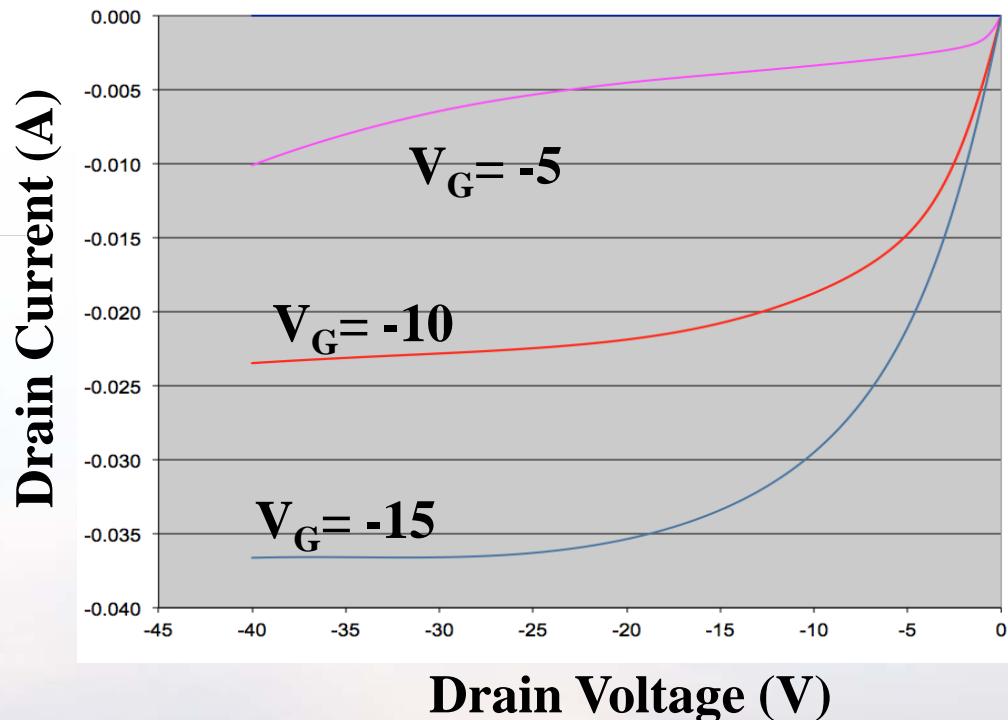
# High Voltage CMOS for Point-of-Load Power



**Power NMOS: Total Dose Performance**

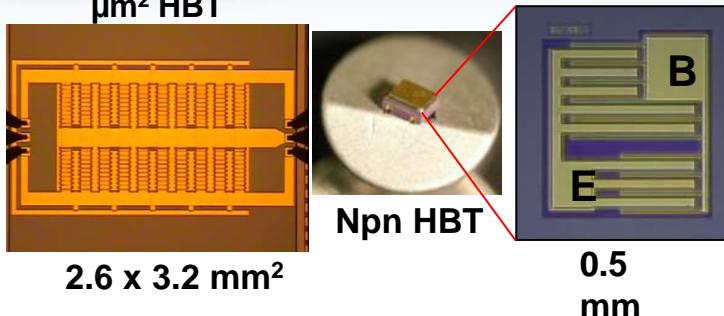


**Power PMOS: IDVG curve**



# Discrete Rad-Hard NPN HBTs

200 finger 10x100  $\mu\text{m}^2$  HBT



## Identified applications

- High-voltage blocking
- High-current switching

## Demonstrated radiation hardness in

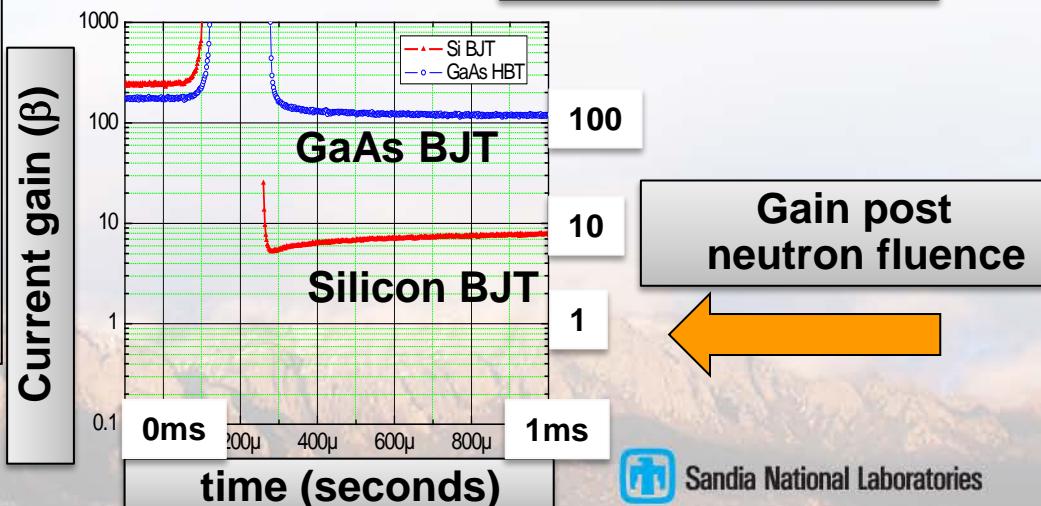
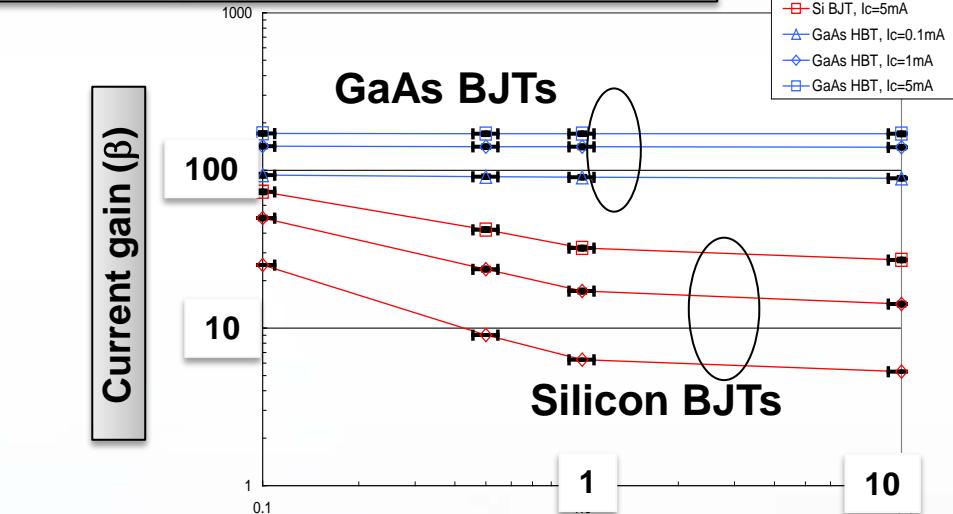
- Mixed neutron/gamma
- Total dose and dose rate

## Performance Characteristics

- >300V BV<sub>cbo</sub>
- > 3A current handling with low on-resistance

## Built to customer specification

### Bipolar gain vs Gamma total dose

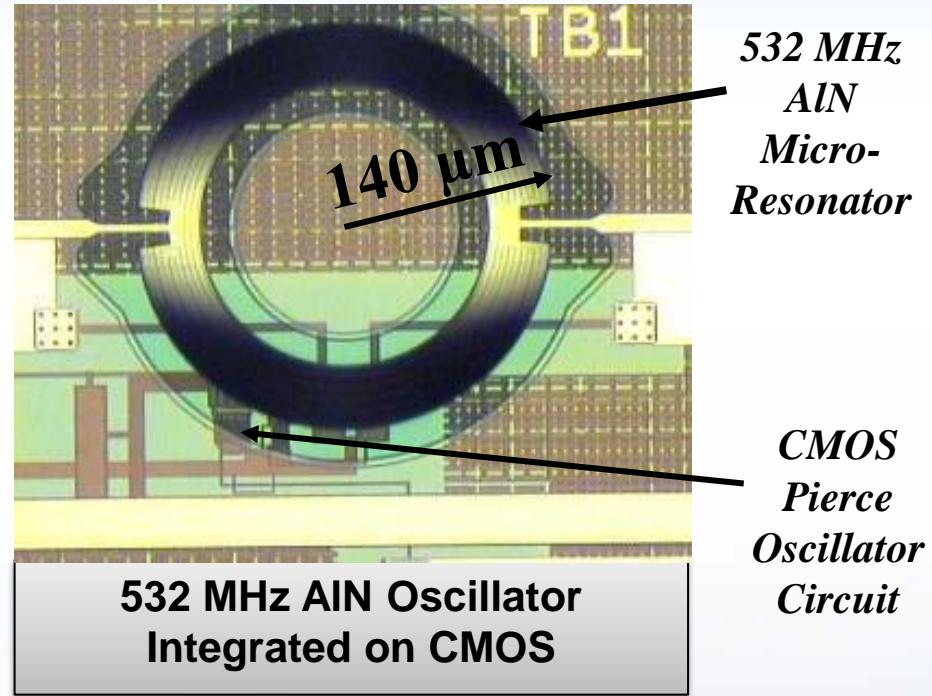


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# Microresonators

- For miniature high-selectivity filters and filter banks not available in commodity driven wireless market

- RF Filters in non-commercial bands
- Miniature SAW IF filter replacement
- Filter banks for spectrum analysis and spectrally aware radios
- Miniature super-high Frequency Acoustic Filters with previously unachievable selectivity



- Rad Hard
- High stability
- Low noise
- Low power



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# The Threat: \$\$ or Conspiracy



INFORMATION TECHNOLOGY AND SYSTEMS DIVISION

## Counterfeit Routers: eGlobe Solutions Inc.

May 2003 – July 2005

- \$788,000 counterfeit equipment

November 2006 Indictment

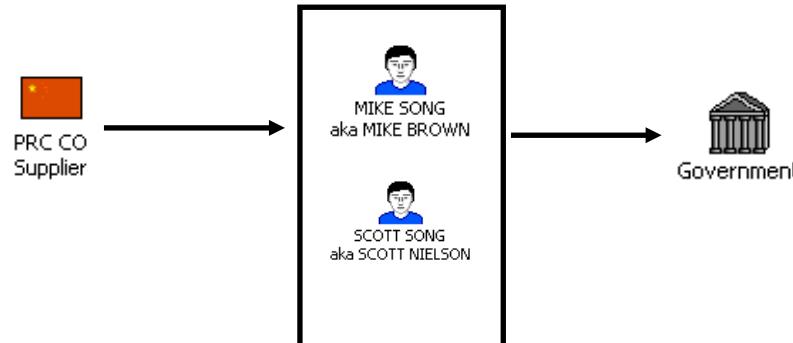
- Conspiracy, Mail Fraud, and Counterfeit Trademark

Sold to

- U.S. Naval Academy
- U.S. Naval Air Warfare Center
- U.S. Naval Undersea Warfare Center
- U.S. Air Base (Spangdahlem, Germany)
- Bonneville Power Administration
- General Services Administration
- Raytheon (Defense Contractor)



eGlobe Solutions



<http://www.abovetopsecret.com/forum/thread350381/pg1>

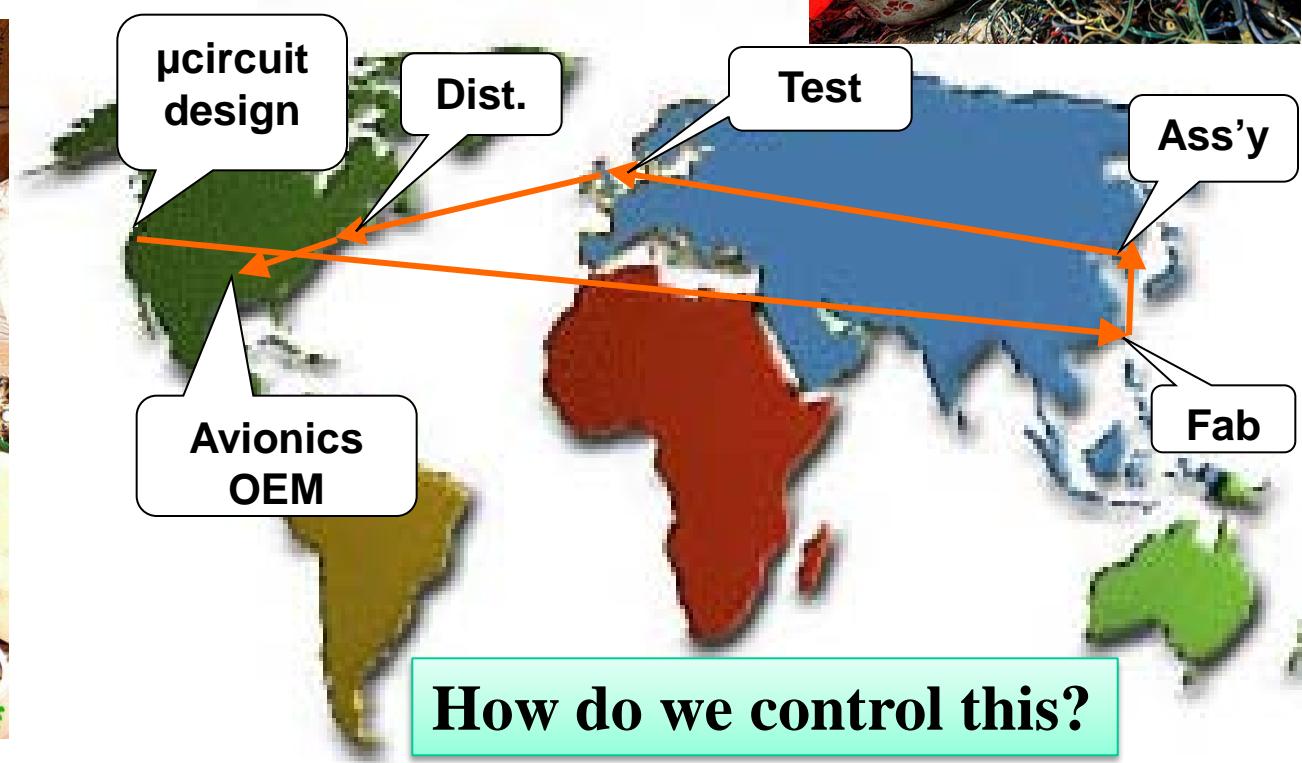
<http://www.donkeyonawaffle.org/OMB%20briefing%202008%2001%2011%20a.ppt>

[http://www.usedcisco.com/press-my-esm\\_used\\_cisco\\_identifying\\_fake\\_chisco.aspx](http://www.usedcisco.com/press-my-esm_used_cisco_identifying_fake_chisco.aspx)



# “Typical” ASIC Product Flow

The microcircuit chain is....circuitous. The number of potential combinations of links is large, and growing. Ability to “control” shrinking.





# Some Options for Trusted ASICs

- Ignore the problem
- Economic incentives to keep CONUS foundries
- Captive government fab
  - How advanced? Cost? Yield?
  - Increased risk with sole source?
- Co-process model
  - Keep backend metallization steps on CONUS and use advanced foundries overseas
  - What about test and packaging
- Government and commercial partnership(s)

The model

Government has improved buying practices for all microelectronics and implemented a Trusted Foundry and Trusted Supplier program



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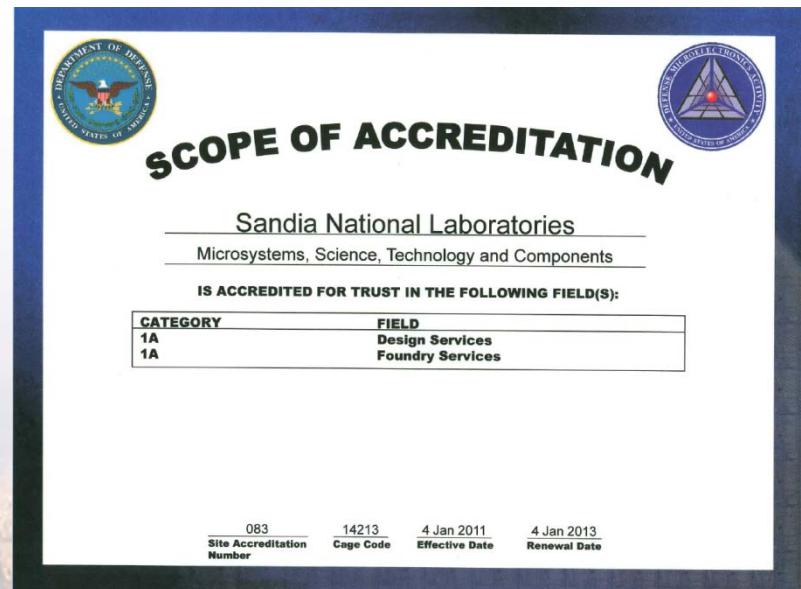


# Sandia Trusted Foundry



- ISO 9001 Certified ASIC Process
  - Disciplined and controlled design process
  - Technology model files and support for custom design
  - Standard Cell and I/O Libraries
  - Analog Intellectual Property

- CMOS7 Rad-Hard Foundry Engagement
  - Low Cost Multi-Project Wafer
  - Quick Turn Structured ASIC
  - Low Volume Production ASICs



Sandia National Laboratories



# *Trusted Design* in Multiple Trusted Foundries Based on Customer Needs

## ■ Delivering ASICs from Sandia Radiation Hardened Trusted Foundry

- Meets the needs for strategic radiation hardened programs
- Flexible to accommodate research activities



## ■ One of the heaviest users of the IBM Trusted Foundry

- Helped IBM and TAPO define process for using IBM Trusted Foundry
- Design submission History
  - FY06: 4 Design Submissions (130nm node)
  - FY07: 4 Design Submissions (130nm, 90nm nodes)
  - FY08: 6 Design Submissions (130nm, 90nm nodes)
  - FY09: 9 Design Submissions (130nm, 90nm, 65nm nodes)
  - FY10: 7 Design Submissions (130nm, 90nm, 65nm, 45nm nodes)
- Currently pursuing Micro-resonator technology development



## ■ History and experience with other Trusted Suppliers

- National Semiconductor Corporation Foundry
- Honeywell Aerospace Foundry
- Partnerships with Northrop Grumman



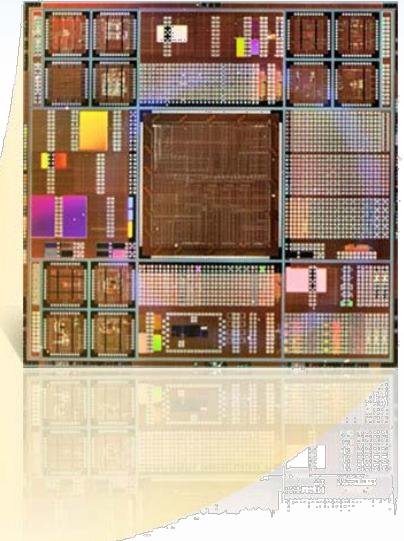
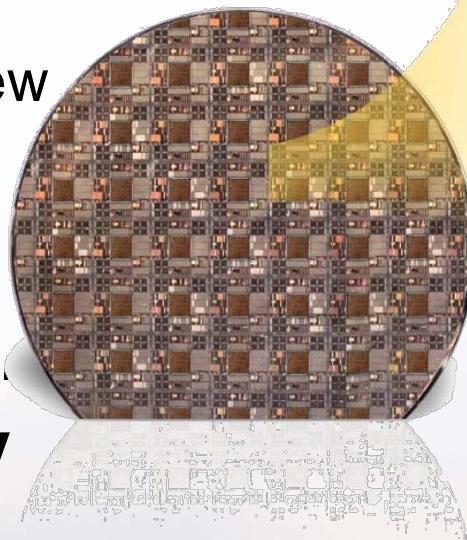
Sandia National Laboratories



# Sandia's MPW Program

## ■ Multi-Project Wafer: MPW

- Several IC designs and customers share masks and wafer resources reducing cost per chip
- Effective way to prototype new designs or produce low quantity ICs



Trusted  
Design

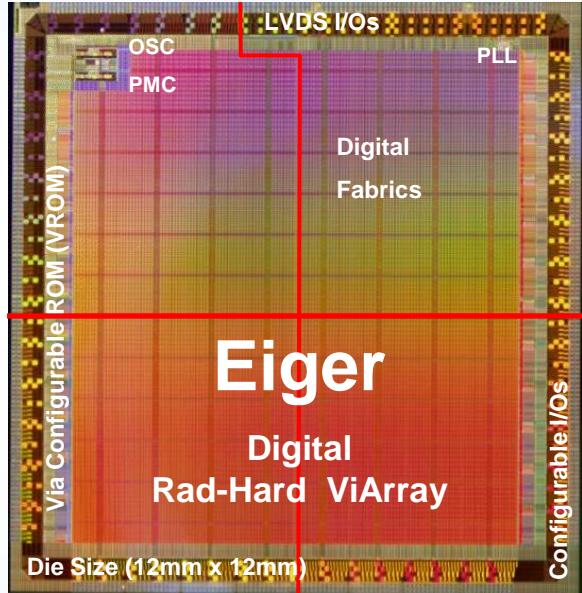
## ■ CMOS7 Rad-hard, mixed-signal CMOS technology

- 0.35um, 3.3V core, 3.3V I/O



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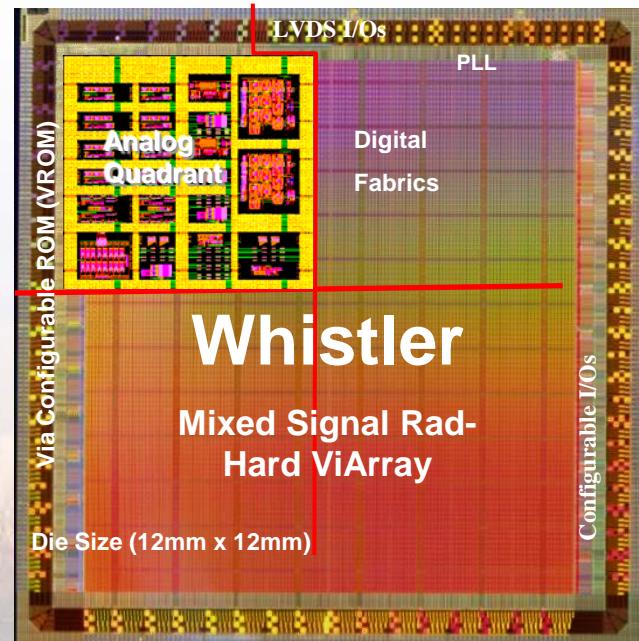
# Fast-turn, Low NRE, Via-Configurable Structured ASIC Platform



- The sASIC enables rapid turn-around, lower non-recurring engineering and development costs
- Pre-qualified base arrays reduce risk
- ASIC-like performance
- Regular, fabric-like structure enhances verification of trusted parts

## ■ Special Features

- Metal-via configurable using ViASIC® Via-Mask Technology
- Four Power-Quadrants allowing up to four independent power supplies for power sequencing
- Unused transistors and circuits are isolated from power and ground to minimize power consumption



# 48 Accredited Trusted Suppliers



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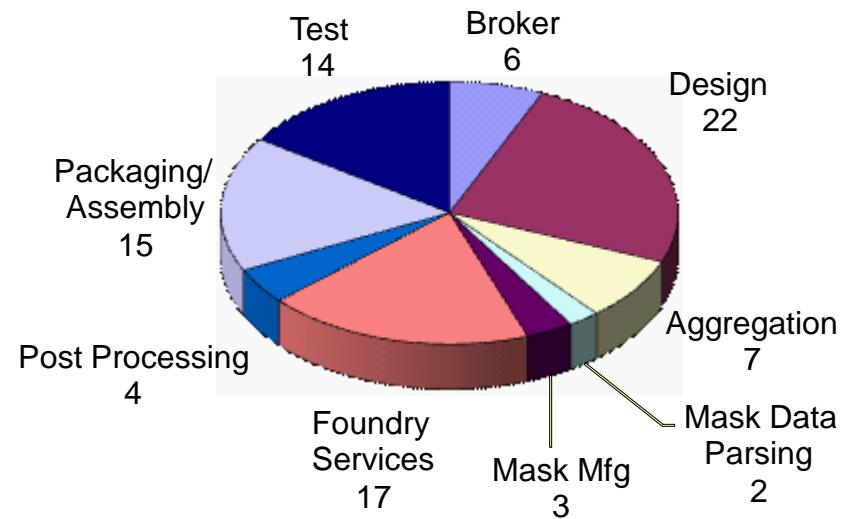
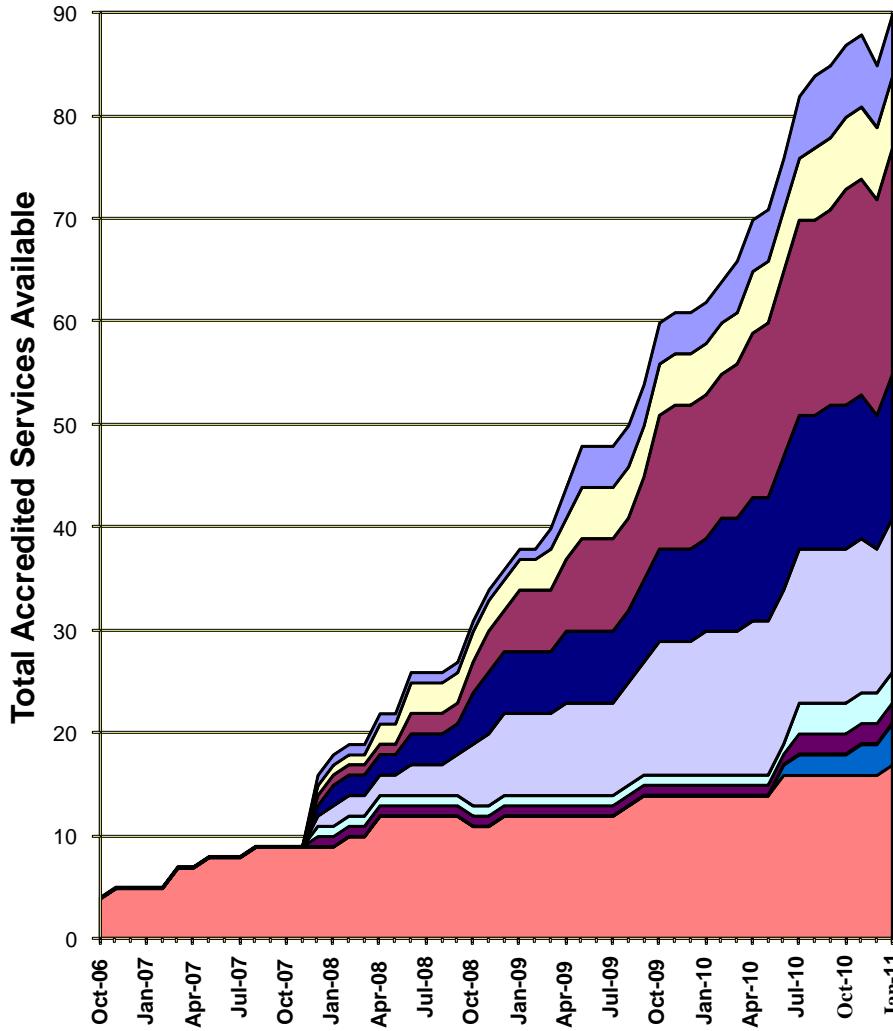
● Accredited Suppliers with Foundry capabilities

Not shown: Silanna Semiconductor, Sydney, Australia

# 90 Accredited Trusted Services



INFORMATION TECHNOLOGY AND SYSTEMS DIVISION



As of 26 Jan 2011

# Trusted Foundry Program

INFORMATION TECHNOLOGY AND SYSTEMS DIVISION



## Describes the Program

## Acts as a Portal

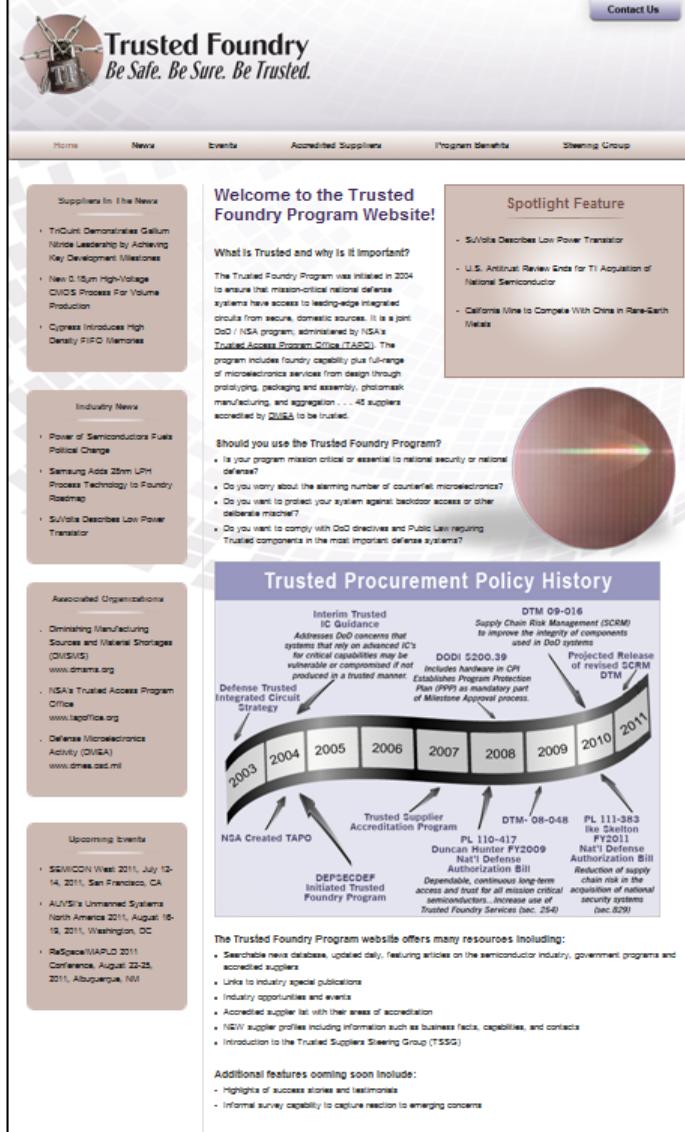
- All Trusted Suppliers
- NSA/TAPO Access to IBM
- DMEA Accreditation
- Even upcoming DMSMS

## News and Events of interest to the community

## And provides information on the Trusted Supplier Steering Group

- Trusted Suppliers Point Paper
- A central place to provide feedback

<http://www.trustedfoundryprogram.org/>



The screenshot shows the homepage of the Trusted Foundry Program website. At the top, there is a navigation bar with links for Home, News, Events, Accredited Suppliers, Program Benefits, and Steering Group. A "Contact Us" button is located in the top right corner. The main content area features a large circular logo with the text "Trusted Foundry" and the tagline "Be Safe. Be Sure. Be Trusted." Below the logo, there are several sections: "Suppliers In The News" (listing TruGuard, New 0.15µm, Cypress), "Industry News" (listing Power of Semiconductors, Samsung, SUVolta), "Associated Organizations" (listing CMMS, NSA, DMEA), and "Upcoming Events" (listing SEMICON West, AUVSIA, ReSpace). To the right, there is a "Welcome to the Trusted Foundry Program Website!" section with a "What is Trusted and why is it important?" paragraph and a "Should you use the Trusted Foundry Program?" list. A "Spotlight Feature" box highlights SUVolta's low-power transistor. At the bottom, there is a "Trusted Procurement Policy History" timeline from 2003 to 2011, showing the evolution of policies like DODI 5200.39, DODI 8000.39, and PL 111-383.

# TAPO Access to IBM Trusted Foundry



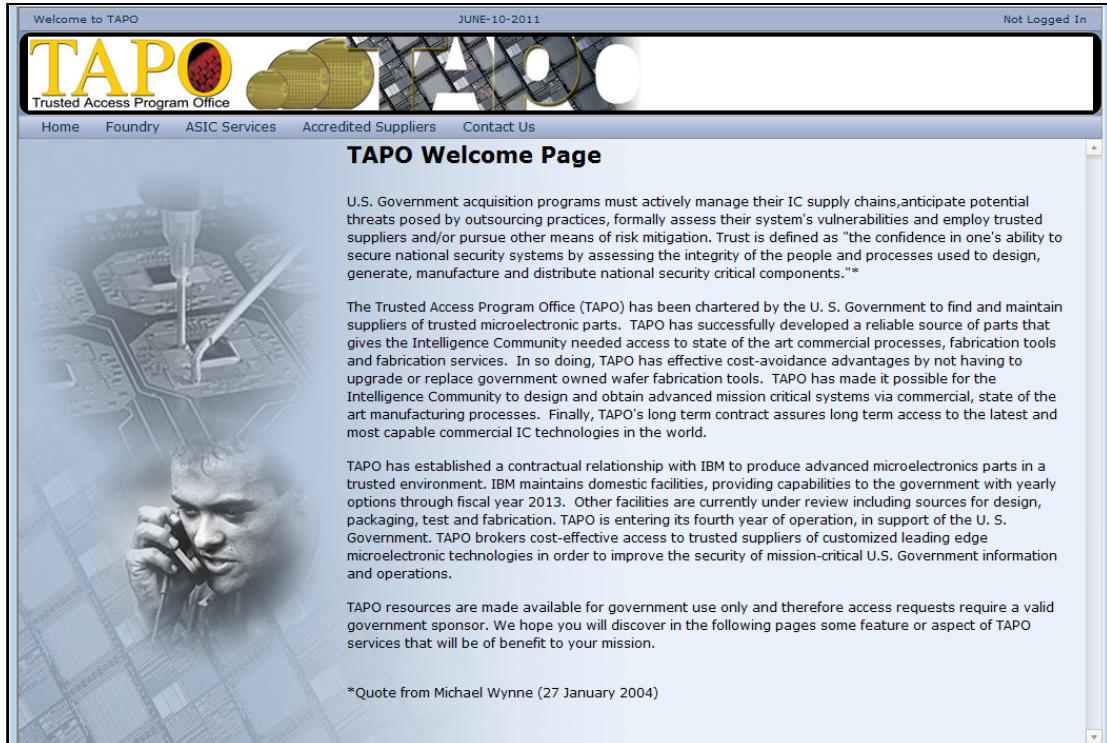
INFORMATION TECHNOLOGY AND SYSTEMS DIVISION

## Trusted Access Program Office (TAPO)

- Portal to access contracted services and products

## Must be enabled with government sponsor

- Open to any sponsored customer
- Some services and/or products are available without charge (i.e. design kits, IP, ...)
- Most customers will pay for services and products obtained



The screenshot shows the TAPO Welcome Page. The header features the TAPO logo and navigation links for Home, Foundry, ASIC Services, Accredited Suppliers, and Contact Us. The date JUNE-10-2011 is displayed in the top right. The main content area has a background image of a circuit board and a technician. The title "TAPO Welcome Page" is centered. A quote from Michael Wynne is present: "U.S. Government acquisition programs must actively manage their IC supply chains, anticipate potential threats posed by outsourcing practices, formally assess their system's vulnerabilities and employ trusted suppliers and/or pursue other means of risk mitigation. Trust is defined as "the confidence in one's ability to secure national security systems by assessing the integrity of the people and processes used to design, generate, manufacture and distribute national security critical components."\*". Another quote states: "The Trusted Access Program Office (TAPO) has been chartered by the U. S. Government to find and maintain suppliers of trusted microelectronic parts. TAPO has successfully developed a reliable source of parts that gives the Intelligence Community needed access to state of the art commercial processes, fabrication tools and fabrication services. In so doing, TAPO has effective cost-avoidance advantages by not having to upgrade or replace government owned wafer fabrication tools. TAPO has made it possible for the Intelligence Community to design and obtain advanced mission critical systems via commercial, state of the art manufacturing processes. Finally, TAPO's long term contract assures long term access to the latest and most capable commercial IC technologies in the world." TAPO has established a contractual relationship with IBM to produce advanced microelectronics parts in a trusted environment. IBM maintains domestic facilities, providing capabilities to the government with yearly options through fiscal year 2013. Other facilities are currently under review including sources for design, packaging, test and fabrication. TAPO is entering its fourth year of operation, in support of the U. S. Government. TAPO brokers cost-effective access to trusted suppliers of customized leading edge microelectronic technologies in order to improve the security of mission-critical U.S. Government information and operations. TAPO resources are made available for government use only and therefore access requests require a valid government sponsor. We hope you will discover in the following pages some feature or aspect of TAPO services that will be of benefit to your mission." A small note at the bottom left indicates the quote is from Michael Wynne (27 January 2004).

<https://www.tapoffice.org/>

Access to other Trusted Suppliers is direct, not through TAPO

# DMEA Accreditation – Online Info



INFORMATION TECHNOLOGY AND SYSTEMS DIVISION

## Program Description

### Links to List of Accredited Suppliers

- Company Name
- Location
- Scope of Accreditation
- Point of Contact
- Email Address
- Phone Number

### DMEA Trusted IC Accreditation Team

- Phone Number
- Email Address



The screenshot shows the DMEA website with a banner featuring a person working on a circuit board. The main menu includes links for About DMEA, Services, Facilities, Contracting, Trusted IC (which is highlighted in red), News & Events, Library, and Career. The Trusted IC page contains a section titled 'Trusted IC Supplier Accreditation Program' with a detailed description of the program's history and purpose. It also includes a link to a PDF of the list of accredited suppliers and a note about the information being for informational purposes only. At the bottom, there is a link to a specific page and a note about contacting TrustedIC@dmea.osd.mil.

**Trusted IC Supplier Accreditation Program**

The Office of Secretary of Defense (OSD) issued the Defense Trusted Integrated Circuits Strategy (DTICS) that established "Trust" as a minimum need for DoD. October 2003. Interim Guidance from the Office of Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD/AT&L, dated 27 January 2004) initiated development of policy that requires all Mission Assurance Category I systems (DoDI 8500.2) to "employ only trusted foundry service(s) to fabricate their custom designed ICs". As a result, the new vendor criteria issued to DoD Program Managers has increased the need for trusted parts and the subsequent expansion of the Trusted Foundry Program. The OUSD/AT&L, through TAPO and DMEA, is implementing an accreditation plan for design, aggregator/broker, mask and wafer fabrication, packaging and test services across a broad technology range for specialized governmental applications both classified and unclassified. The Defense MicroElectronics Activity (DMEA) has been designated by the Department of Defense through the Trusted Access Program Office (TAPO) as the accrediting authority for this program.

For a current list of accredited suppliers, download the following PDF file:

[List of Accredited Suppliers](#)

Note: This information is intended for informational purposes only. This information is not intended to endorse or appear to endorse any non-Federal entity, but rather to publish results of an examination of companies and programs against established accreditation criteria. More detailed information on these suppliers can be found on Defense Knowledge Online at:

<https://www.us.army.mil/suite/page/462421>

Send an email to [TrustedIC@dmea.osd.mil](mailto:TrustedIC@dmea.osd.mil) or call (916) 231-1514 for more information related to the accreditation of trusted IC suppliers.



## In Summary

- Radiation Hardened technologies and products are necessary for certain operating environments
- The threat is real – trustworthy micro-electronics can reduce the risk of subversion and counterfeiting
- Sandia National Labs is one of several entities with the capability to manufacture and deliver rad-hard ASICs and trusted microelectronics



Sandia National Laboratories



# Thank you for your attention

## ■ Acknowledgements:

- IDA – Brian Cohen, Dan Radack
- OSD – Syd Pope
- Sandia
  - Rita Gonzales – Trusted Design ([ragonza@sandia.gov](mailto:ragonza@sandia.gov))
  - Paul Dodd – Radiation Reliability Physics ([pedodd@sandia.gov](mailto:pedodd@sandia.gov))

## ■ Questions

