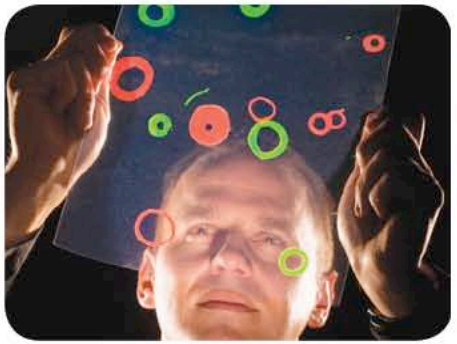
SAND2011-5939C

Exceptional service in the national interest

Sandia National Laboratories


Rad-Hard Enabling Technologies and Trusted ASICs

Richard Dondero

Manager, Rad Hard CMOS

505-284-1457

richard.dondero@sandia.gov

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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

Sandia National Laboratories

AMERICAN TELEPHONE & TELEGRAPH CO. BELL SYSTEM AND ASSOCIATED COMPANIES

THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract [illegible] at Albuquerque, New Mexico. [illegible] atomic [illegible] national defense, and should have the [illegible] national direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an **exceptional service in the national interest.**

I am writing a similar note direct to Dr. C. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

exceptional service in the national interest.

Albuquerque, NM

The Mission Has Evolved for Decades

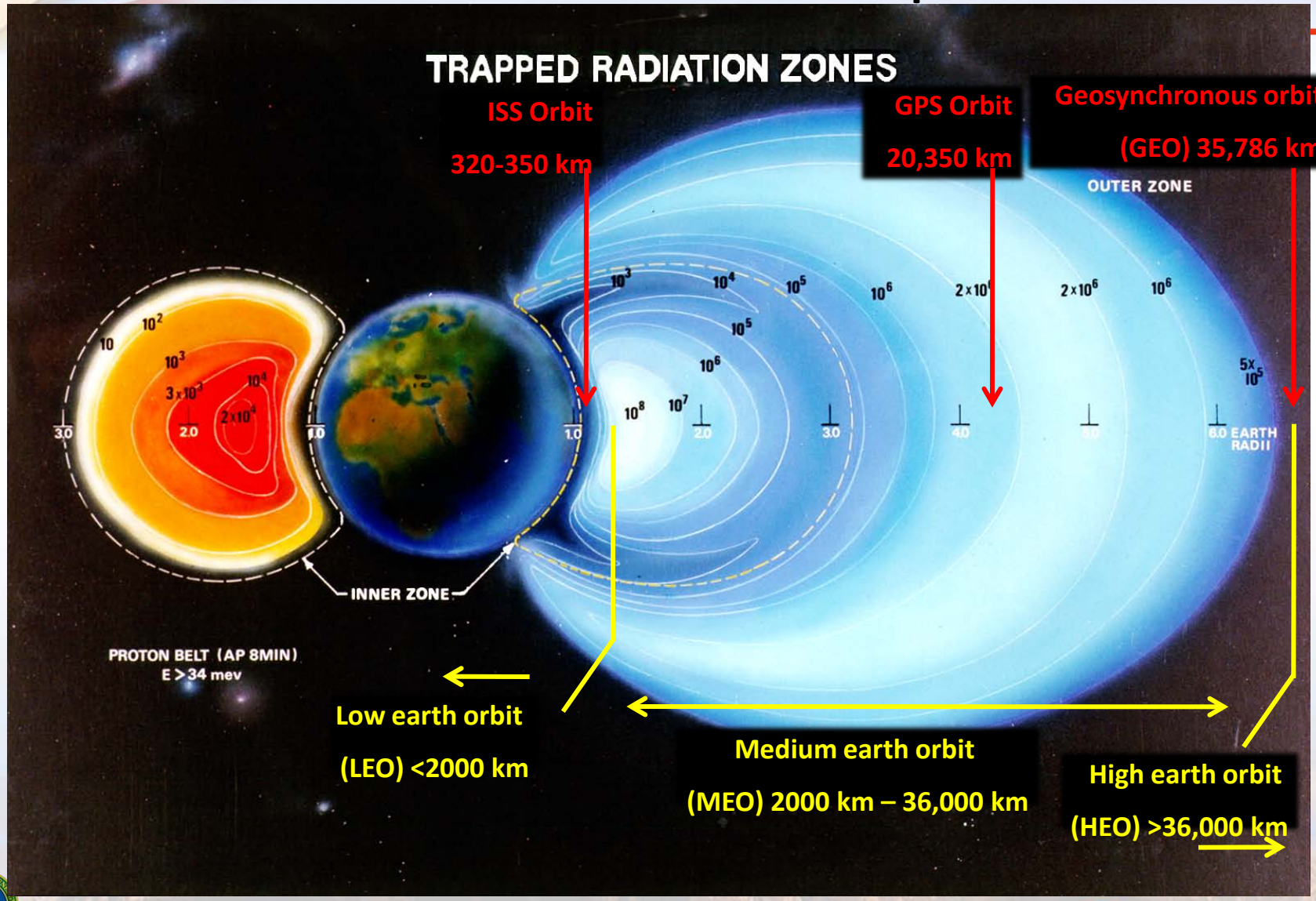
Sandia National Laboratories

1950s	1960s	1970s	1980s	1990s	2000s
Production engineering & manufacturing engineering	Development engineering	Multiprogram laboratory	Research, development and production	Post-Cold War transition	Broader national security challenges

Overview

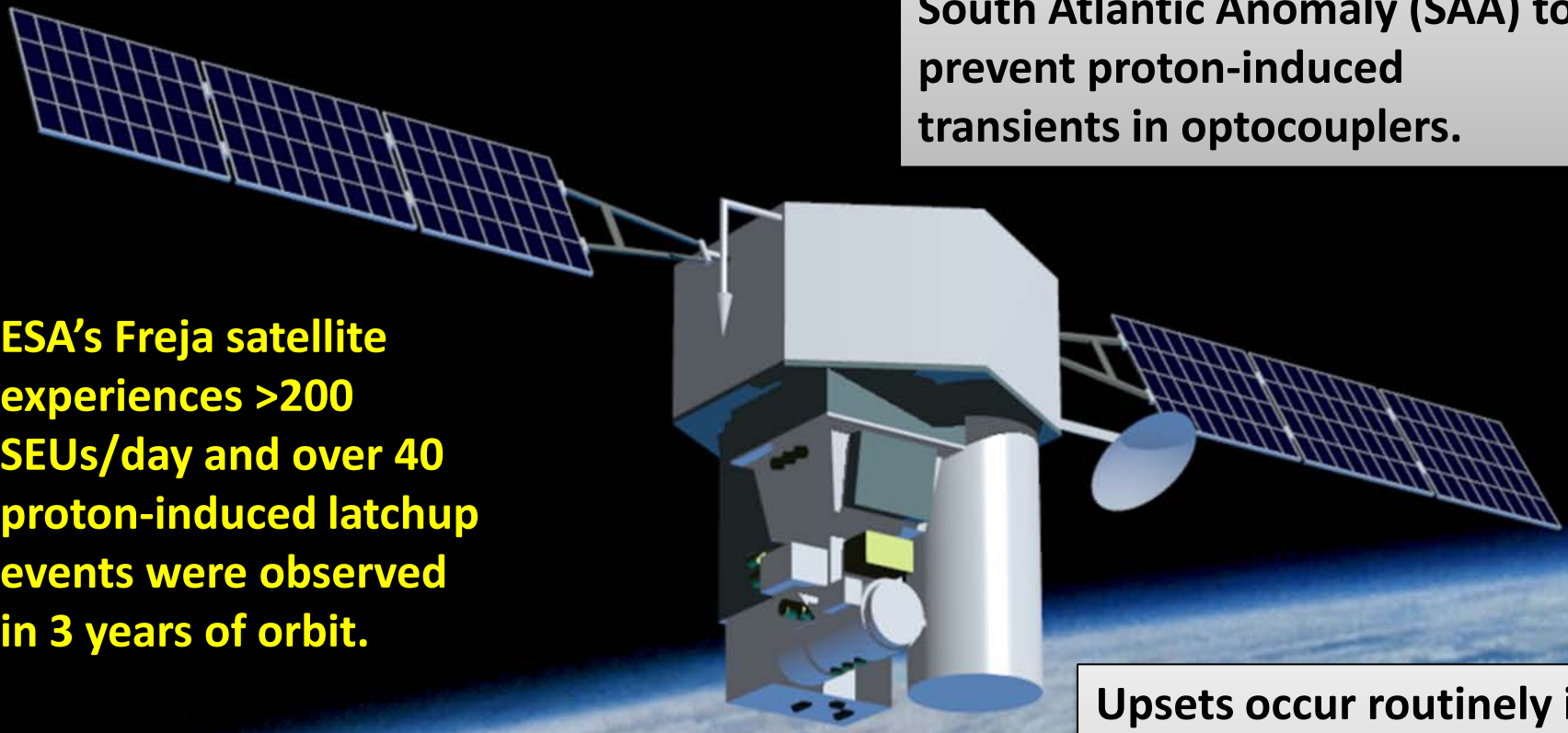
- Sandia National Labs
- The need for radiation-hardened microelectronics
- Rad hard technology
- The need for trustworthy microelectronics
- Trusted services at Sandia
- The Trusted Foundry and the Trusted Suppliers program

Altitude Determines the Nature and Magnitude of Natural Space Radiation Effects



Mission Impact

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



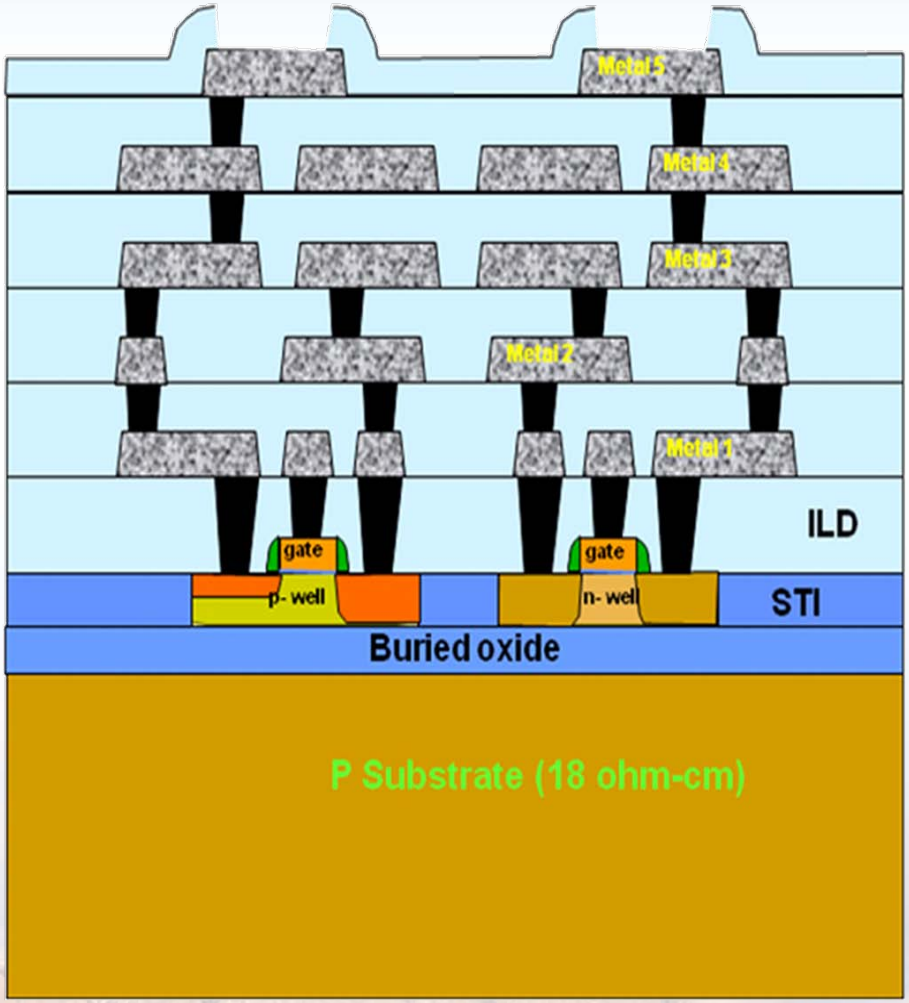
ESA's Freja satellite experiences >200 SEUs/day and over 40 proton-induced latchup events were observed in 3 years of orbit.

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

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

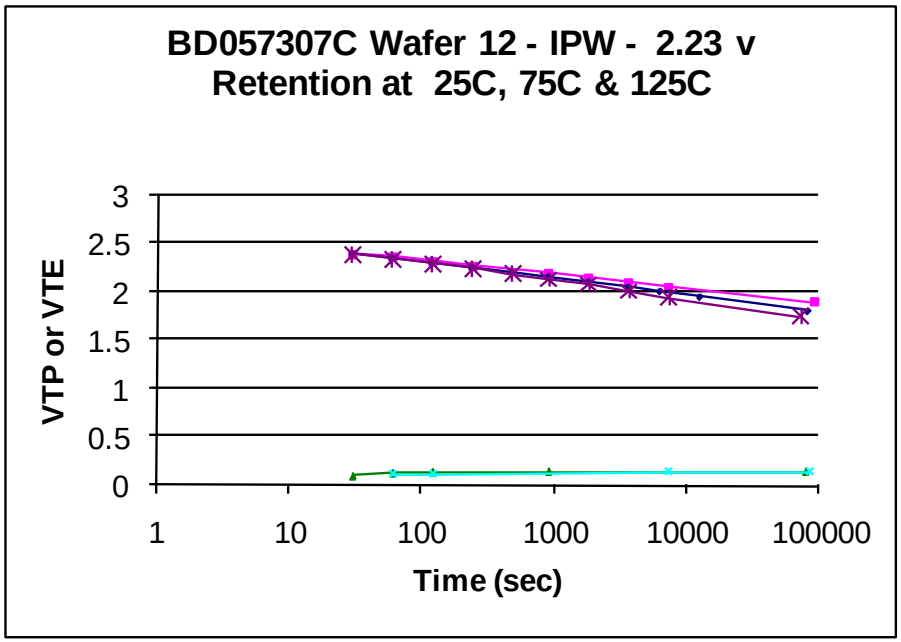
Strategic Radiation-Hardened SOI CMOS

- 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



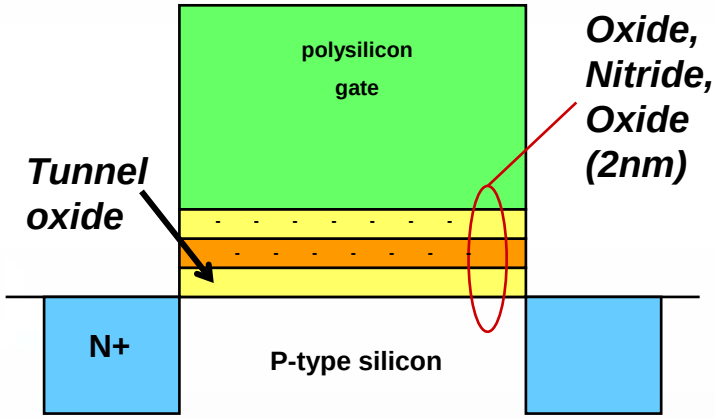
Read/Write Non-Volatile Memory

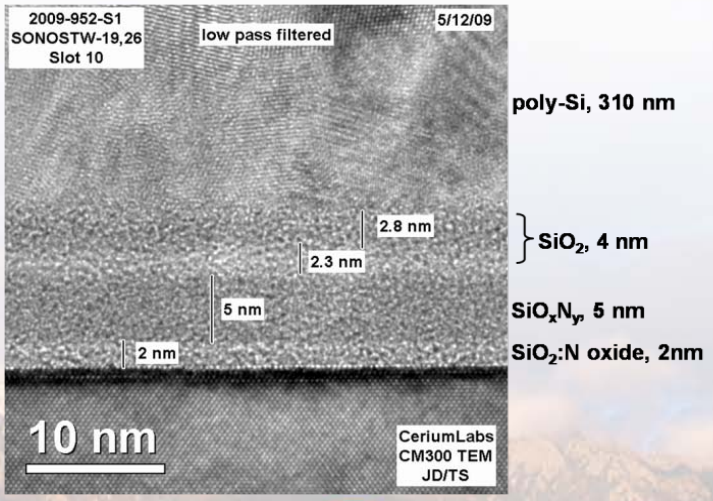
- **Radiation tolerant embedded and stand alone R/W memory**



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

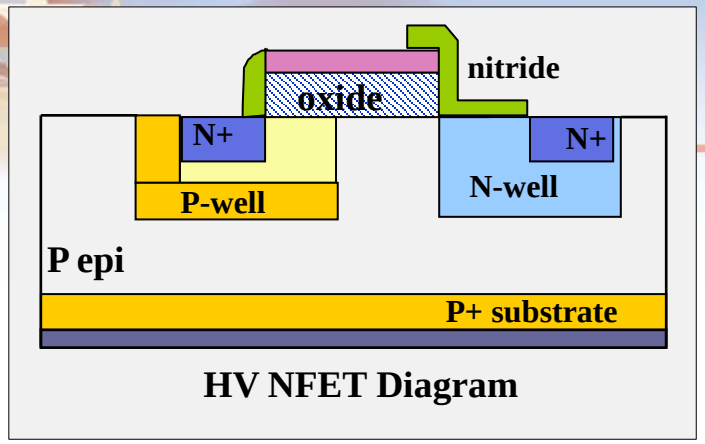
SONOS





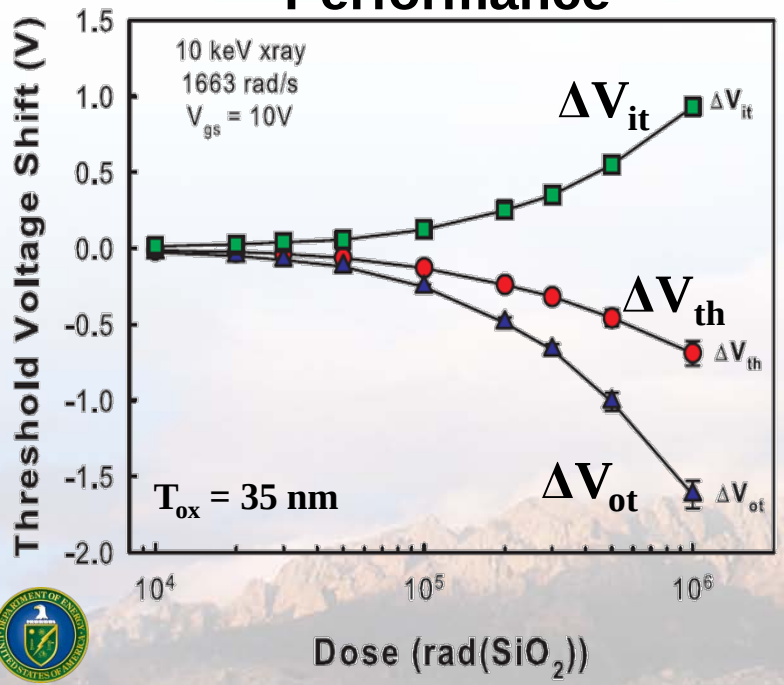
Sandia National Laboratories

High Voltage CMOS for Point-of-Load Power

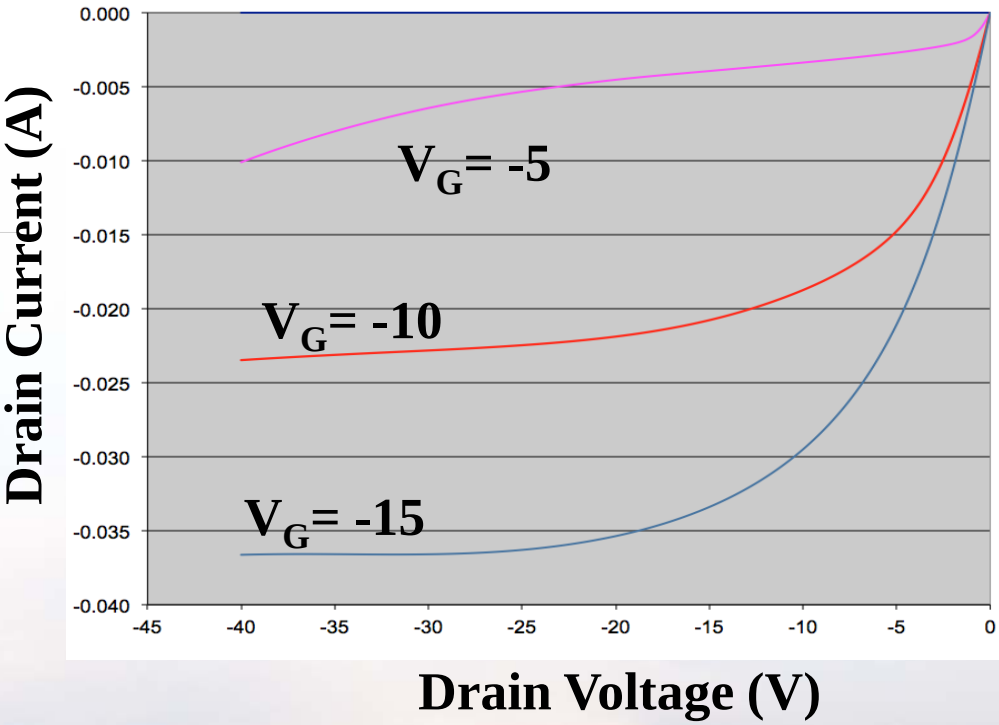


HV NFET Diagram

Power NMOS: Total Dose Performance



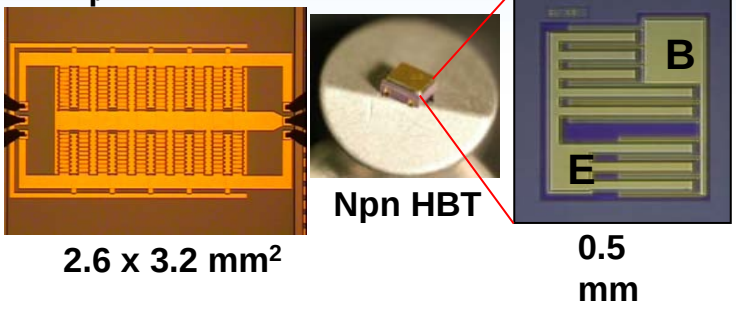
Power PMOS: IDVG curve



Sandia National Laboratories

Discrete Rad-Hard NPN HBTs

200 finger 10x100 μm^2 HBT



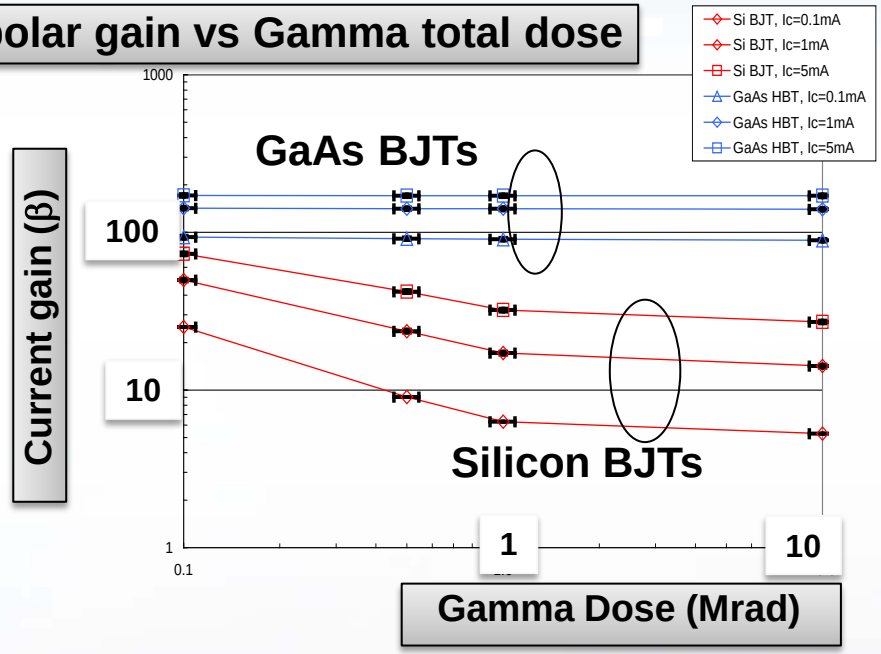
2.6 x 3.2 mm^2

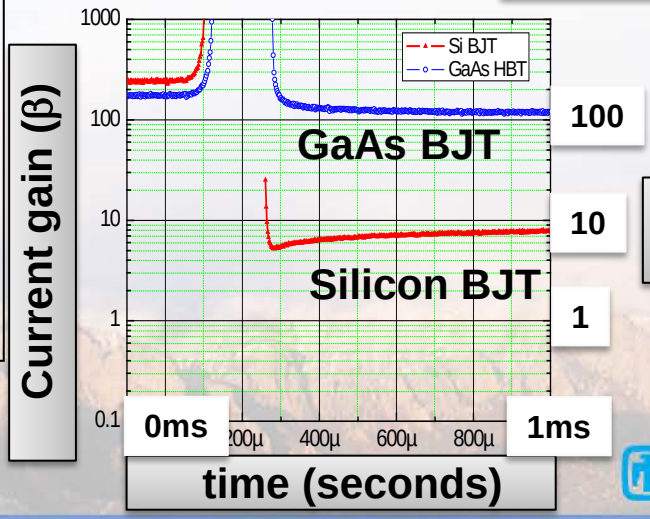
Npn HBT

0.5 mm

- **Identified applications**
  - High-voltage blocking
  - High-current switching
- **Demonstrated radiation hardness in**
  - Mixed neutron/gamma
  - Total dose and dose rate
- **Performance Characteristics**
  - >300V BVcbo
  - > 3A current handling with low on-resistance
- **Built to customer specification**

Bipolar gain vs Gamma total dose



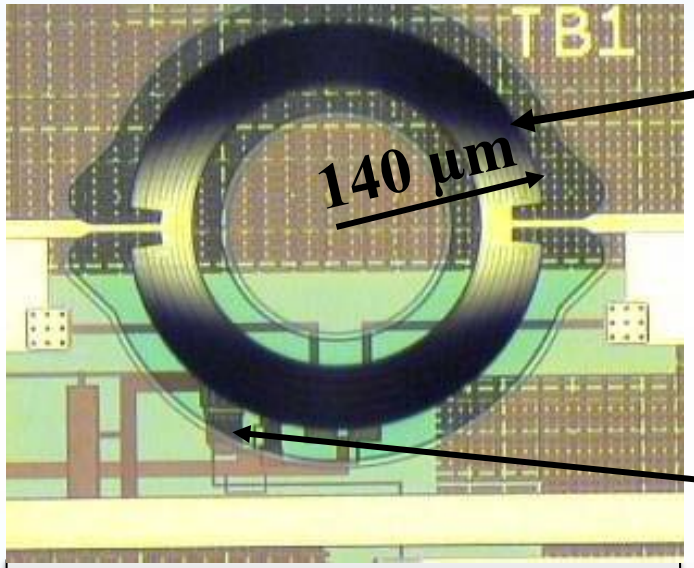


Gain post neutron fluence

Sandia National Laboratories

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



532 MHz AlN Oscillator Integrated on CMOS

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

The Threat: $$ or Conspiracy

Counterfeit Routers: eGlobe Solutions Inc.

May 2003 – July 2005

- $788,000 counterfeit equipment

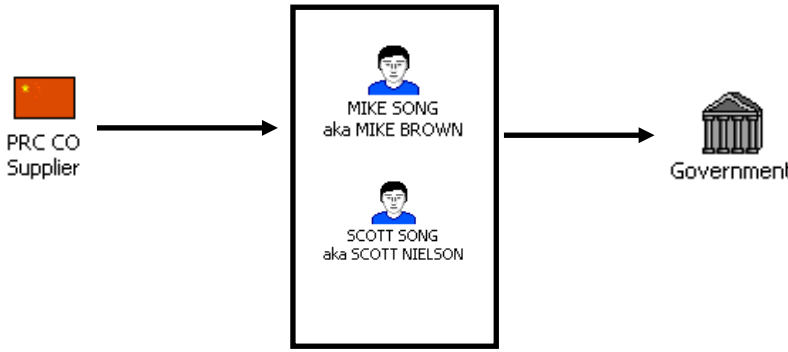
November 2006 Indictment

- 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 (Spangdahelm, 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

“Typical” ASIC Product Flow

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

Syd Pope (ODUSD/IP), GOMAC 2009

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

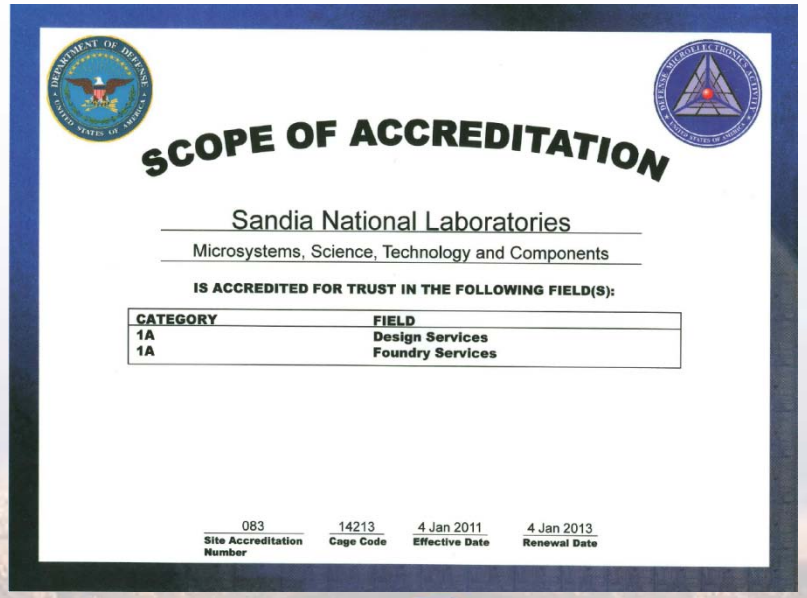
Government has improved buying practices for all microelectronics and implemented a Trusted Foundry and Trusted Supplier program

Sandia National Laboratories

Sandia Trusted Foundry

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

- **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



SCOPE OF ACCREDITATION

Sandia National Laboratories

Microsystems, Science, Technology and Components

IS ACCREDITED FOR TRUST IN THE FOLLOWING FIELD(S):

CATEGORY	FIELD
1A	Design Services
1A	Foundry Services

083	14213	4 Jan 2011	4 Jan 2013
Site Accreditation Number	Cage Code	Effective Date	Renewal Date

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

IBM

TAPO

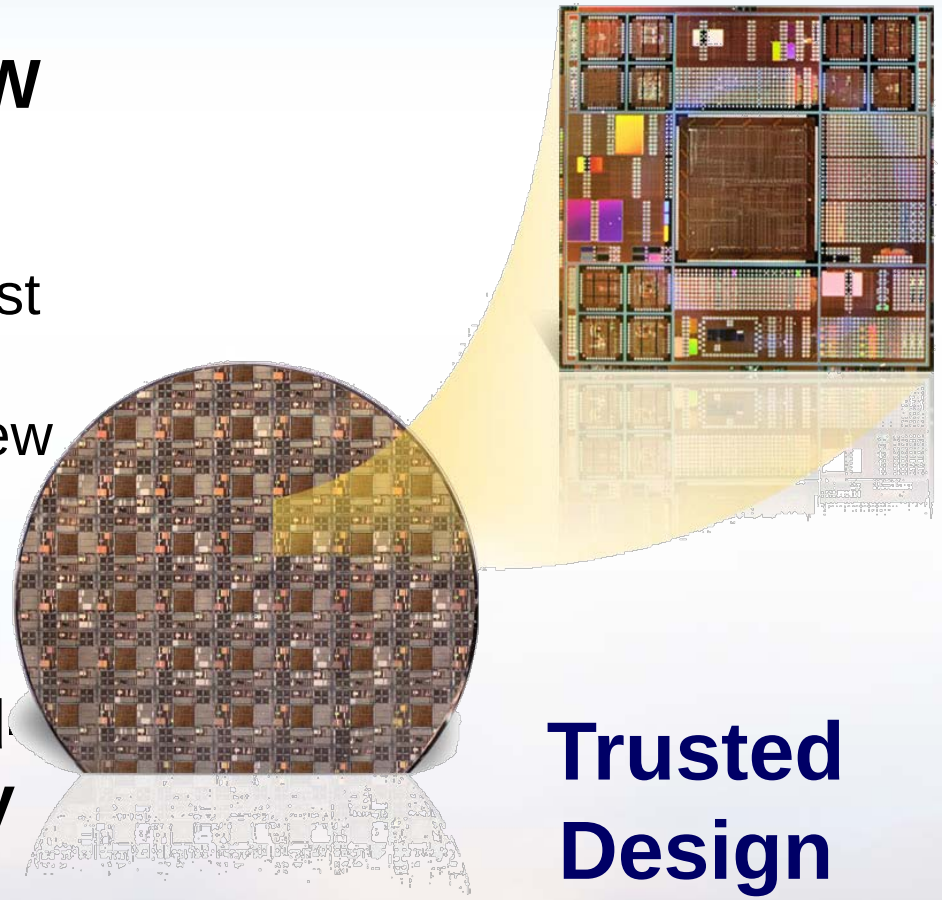
National Semiconductor

Honeywell

NORTHROP GRUMMAN

Sandia's MPW Program

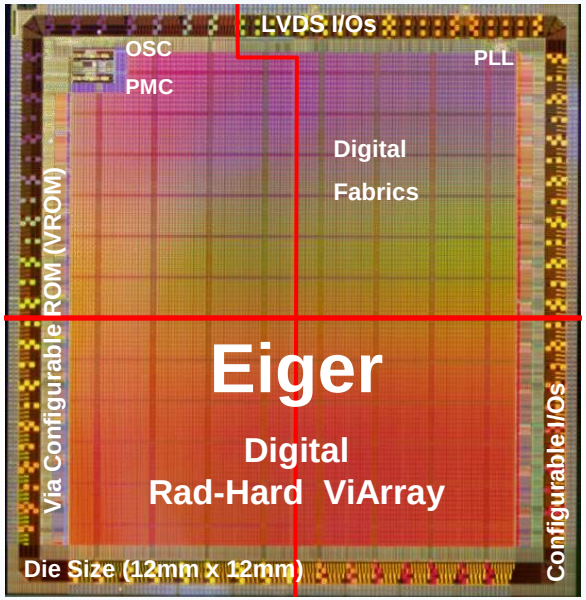
- **Multi-Project Wafer: MPW**
  - Several IC designs and customers share masks and wafer resources reducing cost per chip
  - Effective way to prototype new designs or produce low quantity ICs



- **CMOS7 Rad-hard, mixed-signal CMOS technology**
  - 0.35um, 3.3V core, 3.3V I/O

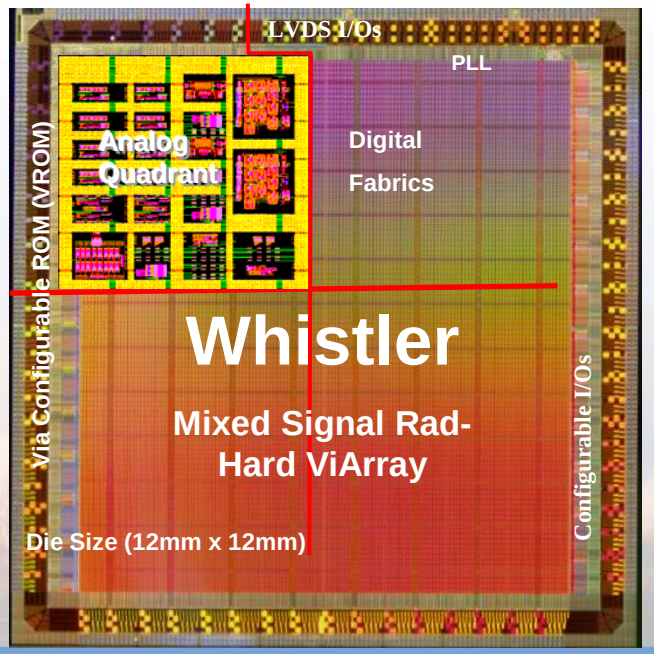
Trusted Design

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

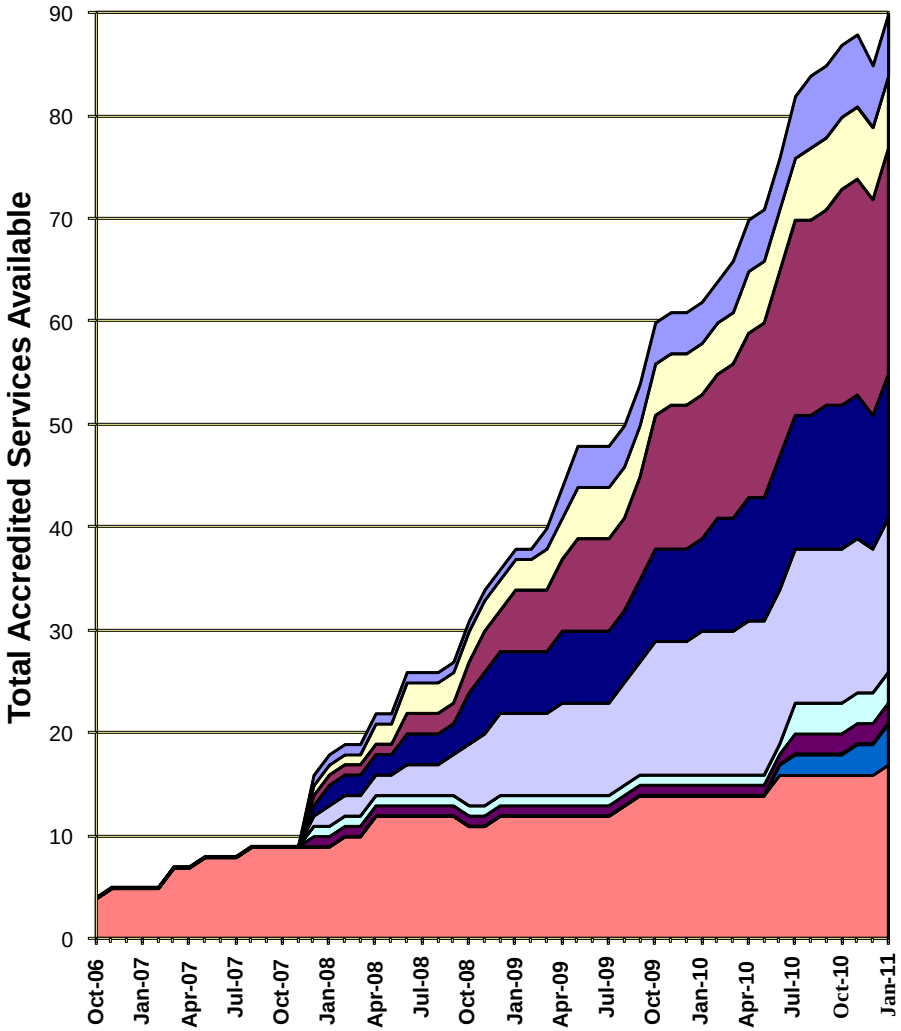
INFORMATION TECHNOLOGY AND SYSTEMS DIVISION

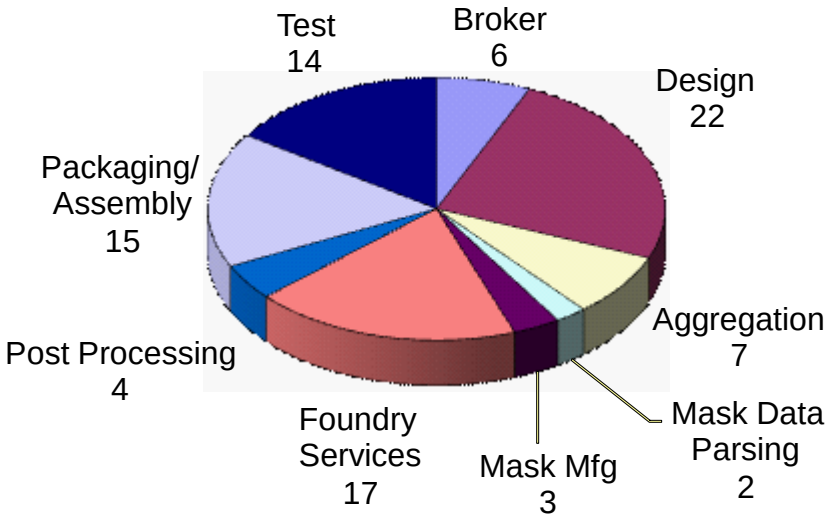
Accredited Suppliers with Foundry capabilities

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

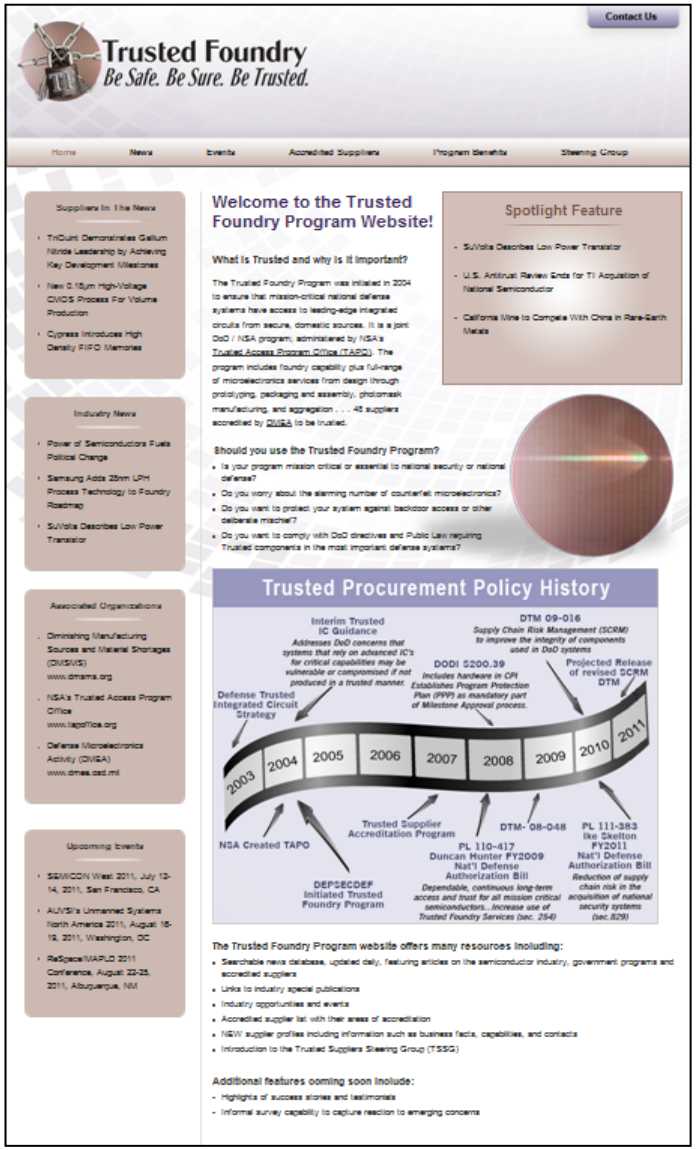
- **All Trusted Suppliers**
- NSA/TAPO Access to IBM
- DMEA Accreditation
- Even upcoming DMSMS

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/



TAPO Access to IBM Trusted Foundry

IDA

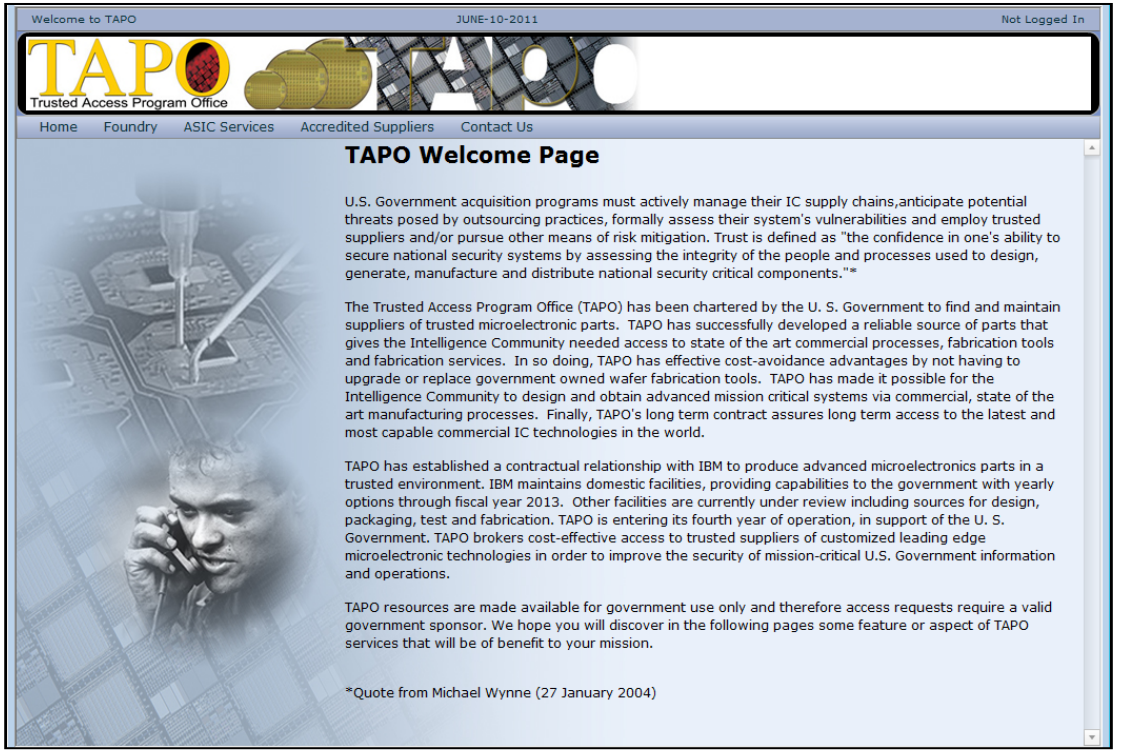
INFORMATION TECHNOLOGY AND SYSTEMS DIVISION

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



https://www.tapoffice.org/

Access to other Trusted Suppliers is direct, not through TAPO

DMEA Accreditation – Online Info

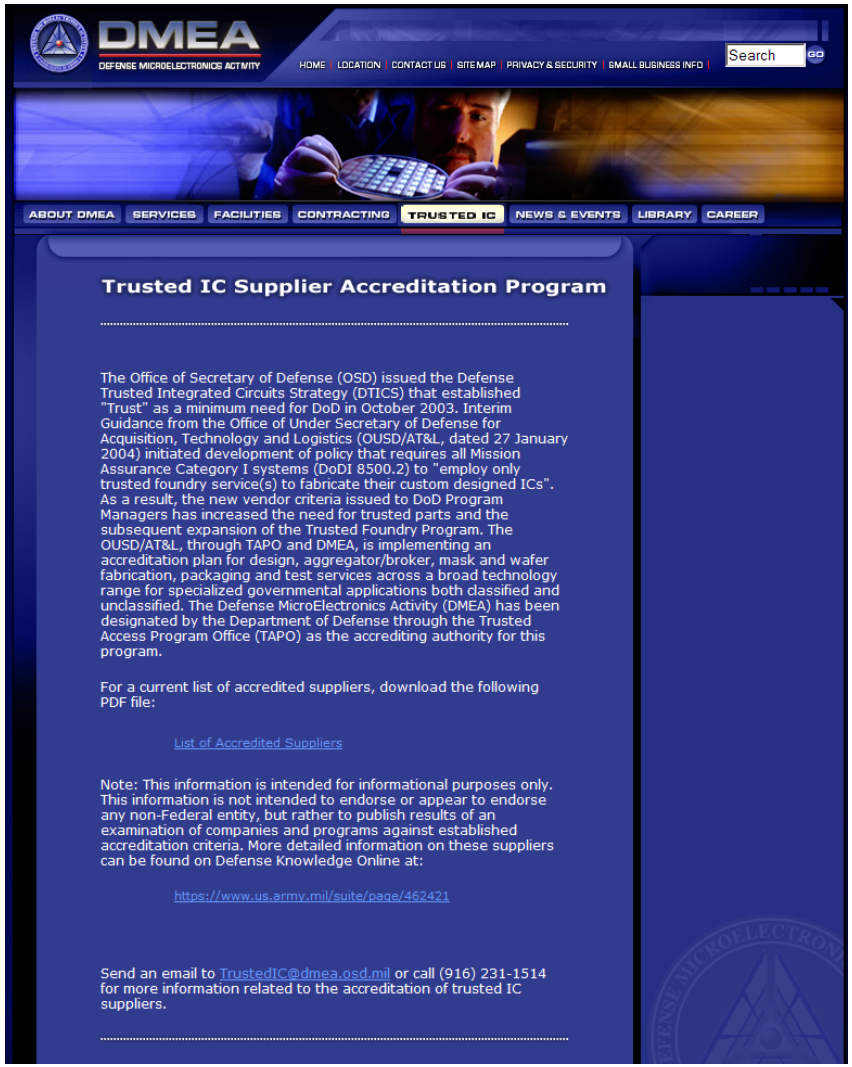
Program Description

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



http://www.dmea.osd.mil/trustedic.html

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**

Thank you for your attention

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

- **Questions**