MicroTalon
Networked, Semi-Autonomous Microsystems-based Sensor Systems for National Security Applications

Weapons MicroSecurity

Transportation Security

Border Security

Physical Security

Force/Facility Protection

SDAC

Networked

Small

Comm

Sensor

Power

µProc

Low Cost

Low power

Surveillance

Nanosats
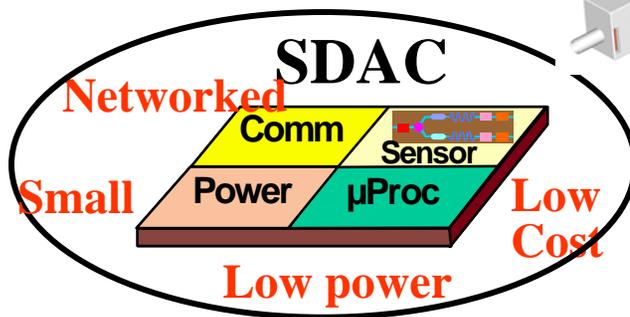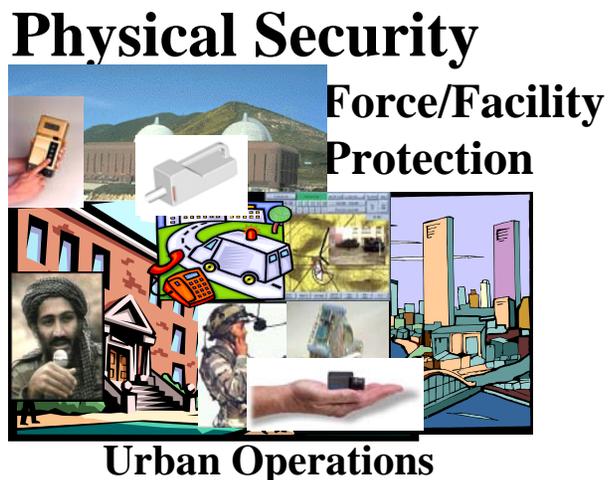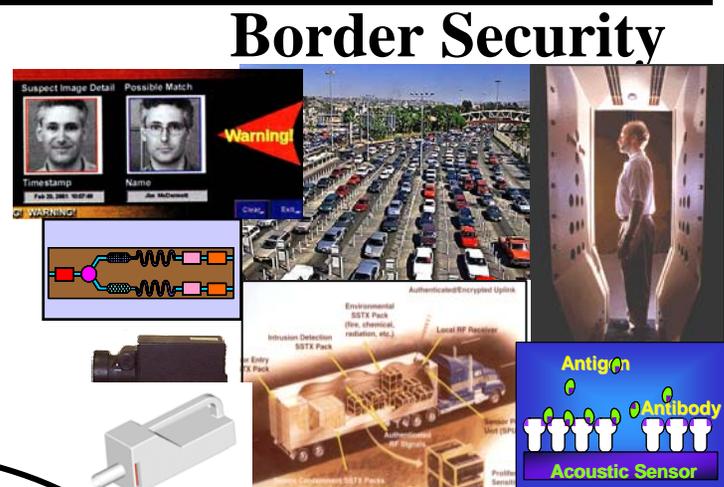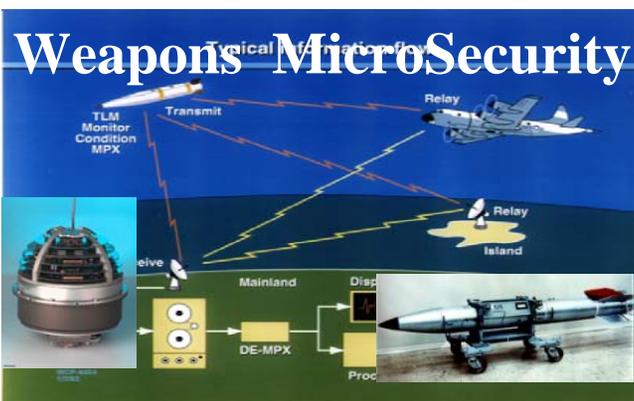
Sense/Decide/Act/Communicate

Urban Operations

Logistics

Interdiction/Tracking

battlefield

Enigmas Facilities

Sandia National Laboratories
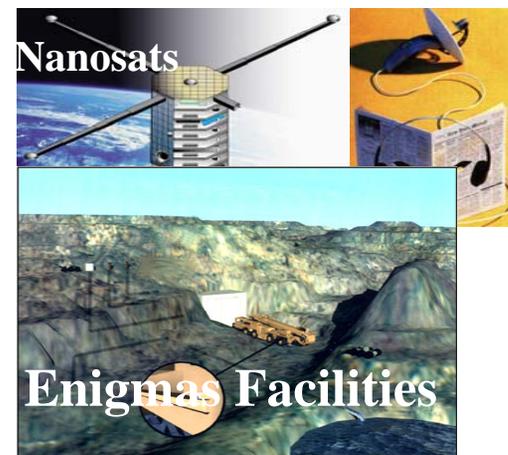
SDACs: A solution for many problems

They will have some or all of these parts:

Selected Examples:

Wireless (RF, IR, Acoustic, etc.) or Hardwire / Fiber Optic Network Comm Link

Embedded Intelligence & Decision Capability

Multi-Modal Sensor Suite

GPS

Communications Layer

Network Protocol Layer

Geolocation and / or Navigation (GPS / INS)

Response Action Capability

Memory

Systems Algorithms

Data Processing

Data Interp.

System Control

Sensor Systems Interface

Clock, Time Sync, & Time Stamp

Zap!

Power

SDAC Platform

"See" — Magnetic, RF, µwave, IR, Visible, Imaging, Ionizing Radiation, Spectroscopy

"Hear" — Acoustic

"Smell" "Taste" — Chemical, Biological

"Feel" — Seismic, Proximity, Temperature

Sandia Steel Eagle UGS

NASA/JPL Sensor Pod

UC/Berkeley Smart Dust

Commercial MIDS Gear

Fixed
Land, Sea

or Mobile
Land, Air, Sea

Elements of an Integrated SDAC System Package

Mobile SDAC Platforms

24/7 virtual presence with low cost and low risk to personnel

Who are the customers for SDACs?

Sandia's focus is National Security Customers:

- **DOE – NW and E&CI - security & transp – DP, Nuc Engy, Rad Waste**
  - need semi-autonomous, heterogeneous sensor systems for 24/7 physical security
  - *early adopter of MicroSentinels*, Sandia does systems integration and prototyping
- **Intelligence community – CIA, NSA, DIA, …**
  - need covert, semi-autonomous, long life, sensor systems w/no maintenance
  - issues: data exfiltration, LPI/LPD, power, emplacement
  - need rapid availability, custom devices, affordable in small quantity
  - *early adopter of MicroSentinels* – Sandia is system integrator and fabricator
- **Military community – SOCOM, OSD, FCS, …**
  - need covert, long life, semi-autonomous sensor systems w/little maintenance
  - mission-specific sensing capabilities, simple human interface
  - small, light systems, low cost (<$2k) for airdrop or hand emplacement
  - defense contractors integrate/fabricate, Sandia provides new tech, prototypes
- **Homeland Security – DHS, FBI, DTRA, FEMA, EPA, …**
  - need long life, low cost sensor systems w/little maintenance
  - mission-specific sensing capabilities, semi-autonomous operation
  - need millions of very low cost sensors, risk averse, social issues important
 - COTS systems, Sandia prototyping reduces risk, enables industry capability

If Everyone Wants Them, Why Are There No SDACS?

- Creation of an SDAC system requires broad technical expertise, systems integration, and 3 years for first field-qualified systems

    - Several formidable systems issues: cost, info fusion, low false positives, …

- Individual customers and programs don't have the time horizon or budget to do the system development and integration needed

- Universities provide innovation but lack integration & development capability

- Industry sees small markets, prohibitive financial/technical risk

- Start with a relatively simple application and show the value

SDACs will take time and require the foresight to create a platform to enable us to take advantage of opportunities

Why microsystems? Why Sandia?

- **The <u>batch processing</u> approach used for microelectronics and microsystems production <u>is the key</u> to low cost production**

- **Microfabrication technology also enables multi-component integration and small/light/low power subsystems needed for many national security applications.**

- **The nation has provided unique microsystems fabrication facilities and expertise, located at Sandia, that are capable and available for system prototyping.**

  - The $1B capital investment required precludes similar commercial facilities from being used for R&D and prototyping.
  - Broad expertise in all relevant areas is in place
  - Sandia's NW investment enables this work at marginal cost

- **Government, university and industry partnership is crucial**

Sandia's Role Must Center on Its Unique Capabilities

Development Path →

Sniffer Star

Autonomous
Nerve Agent
Sensing

Specific DoD Application	Broader Platform or Operational Environment	Any Sensor Anywhere Anytime	Any Number Any Combination Any Budget
Functional Small Light	Adaptable comm LPI anti-jam, low power, smart network	Expanded sensor suite, PnP architecture long op. life	Millions of low cost, custom, SDAC systems
Micro Chem Lab, adv pkg, smart	RF MEMS for impedance matching, directionality	Adv Pkg Microsensors Micropower, Scalable process	Commercial Production

MESA-specific capabilities, including →

prototyping of integrated systems

Potential Killer Applications
## Identified by MicroTalon

- <u>Physical Security</u> – DTRA, AF, Navy, SOF (but no R&D)
  - Perimeter/Area security with baseball size, $600 multi-sensor SDAC systems - Rondeau/Glaser - can sell this to DoD if it is real. Cost is important. This capability also supports NW, MTA, ECR.
  - DHS also needs this but not yet organized to support it directly.

- <u>Battle Damage Assessment</u> – DARPA
  - Detachable sensor system on weapons to monitor impact, effect on target, and post-blast activity – Rondeau/Walker

- <u>Logistics</u> – DoD, AF, LM
  - Autonomic Logistics, Prognostics and Health Mgt – Cranwell – need test system now!
  - Monitor vibration and sound from gearboxes on aircraft for pending failure, save and report results autonomously – this is the new approach to gov systems, crucial to LM

- <u>Weapons MicroSecurity</u> – NW
  - Self-aware weapons that are aware of their environment and can react appropriately

- <u>Non Proliferation – Intelligence</u>
  - Specific projects like SE or room monitoring, but must be a complete system solution including comms/exfiltration, power/life, and emplacement. Cost is not the issue.

Lots of room for a new <u>solution</u>, but must demonstrate it is real.
Some customer funding possible, but may need to demonstrate some capability on our own nickel to establish credibility. Mesaworks?

Mission Req & Specs – Logistics

- Mission definition – Health and Prognostics (broader later)
  - Applications: Military or other high value equipment, esp F-16 and JSF
  - One of the simplest first applications
- Special Requirements
  - Golf ball size, hand locate, no service, auto-insert
- Power
  - Possibly self-powered, batteries, energy mining from vibration?, turn off subsystems
- Sensing modes and specs
  - Acoustic and Vibration (10-5000 Hz?), direct contact, tag recog
  - Maybe other sensors later
- Comms/Networking Requirements
  - 100 m to hanger receiver post-flight, 50kb/s bursts
- Local Processing Needs
  - .1-20 MIPS controller, 400 MIPS DSP for FFTs w/ 10s latency
- Operational Life and Cost
  - 5 years at few % duty factor, $2k in quantities of 1000

Implementation of SDAC Systems Requires
Hardware, Software, Integration, and Fabrication

Provide systems for National Security needs

Reduce risk for commercial production

Fabrication
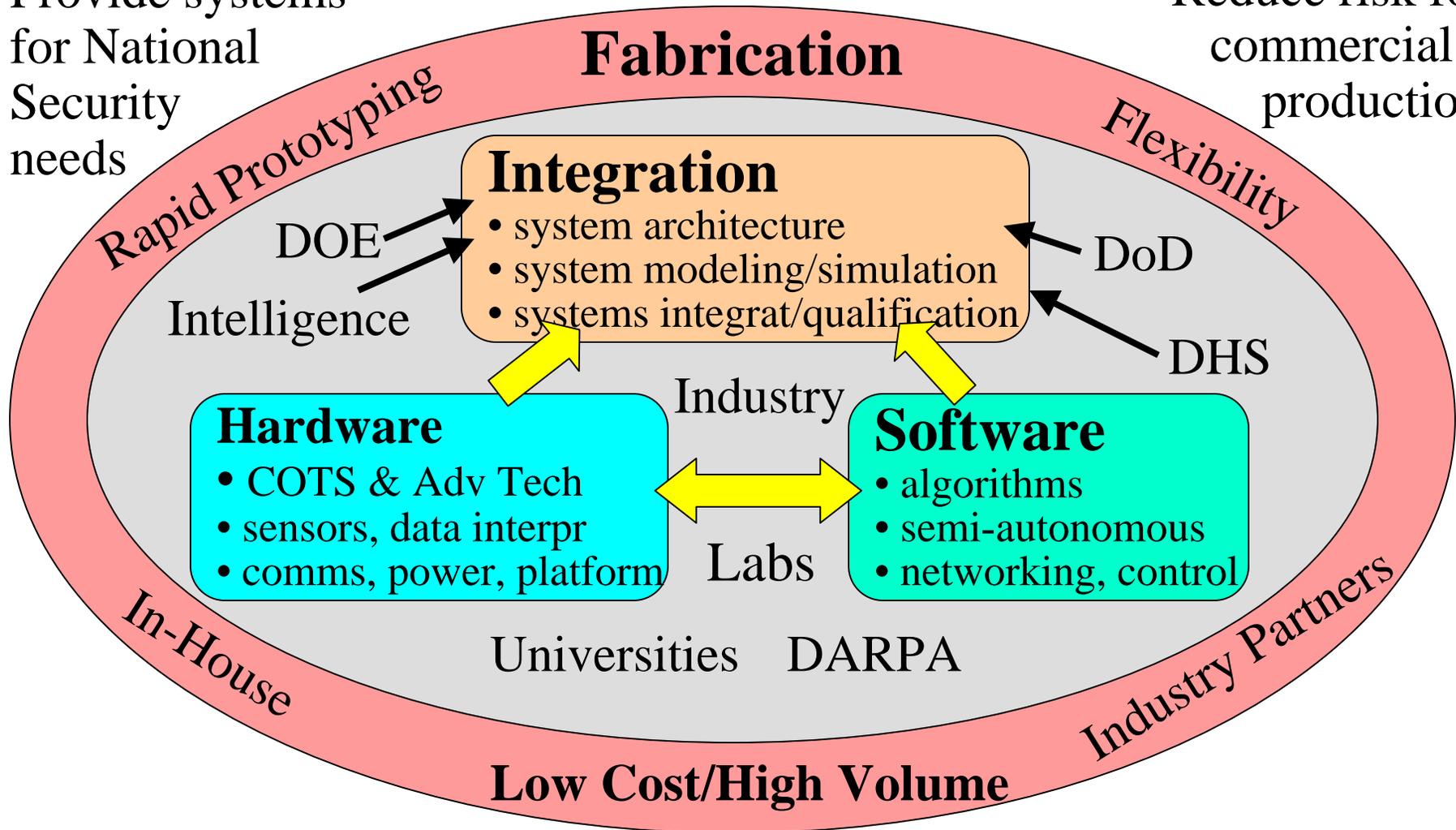
Rapid Prototyping

Flexibility

Integration
- system architecture
- system modeling/simulation
- systems integrat/qualification

DOE

Intelligence

DoD

DHS

Industry

Hardware
- COTS & Adv Tech
- sensors, data interpr
- comms, power, platform

Software
- algorithms
- semi-autonomous
- networking, control

Labs

In-House

Universities

DARPA

Industry Partners

Low Cost/High Volume

Sandia's MESA Program Represents a $1 Billion National Investment in Integrated Microsystems over 5 years

MESA-Integrated Microsystems for NW applications

Micro Fab
Robotics
Micro Lab/science
Si and III-V
Systems Engineering
Sensors
Materials
Computation
Southwest Aerial

TEC: $453M, >50% equipment and clean rooms
Micro Fab and Micro Lab: >$250M

+ SNL/CA LIGA & KCP packaging
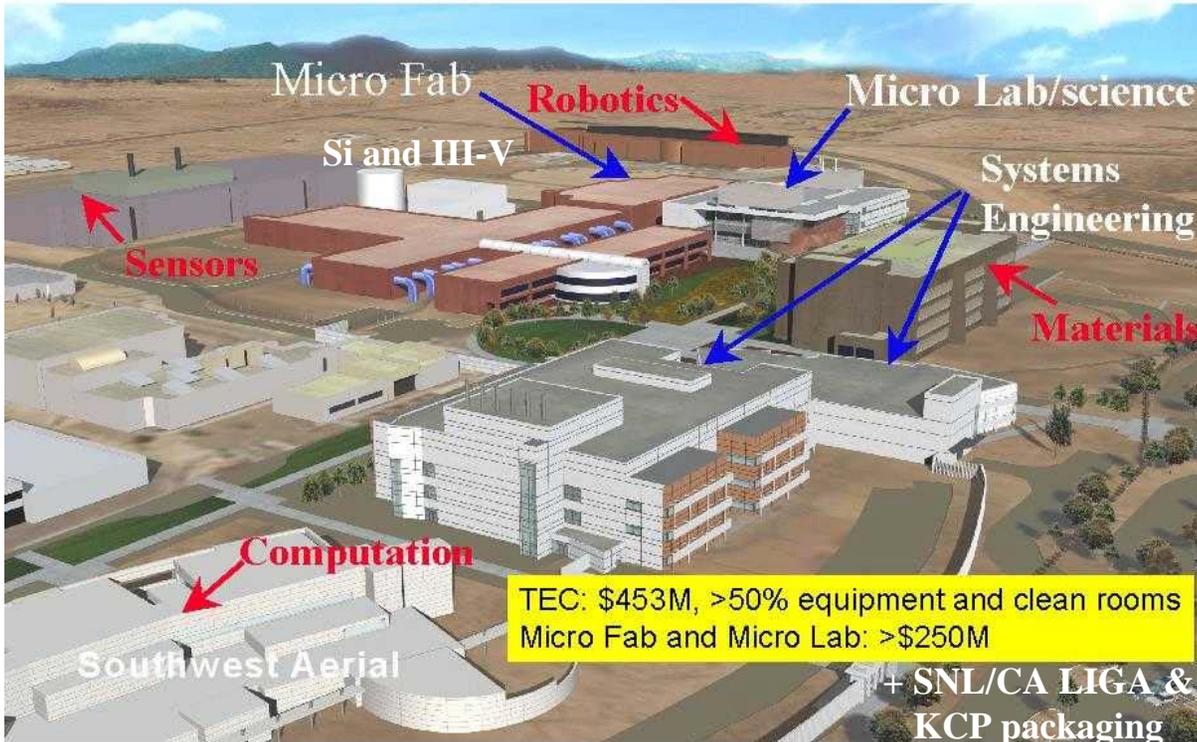
'02 Operating Budget

CMOS	$37M
III-V	$15M
Sensors	$16M
MEMS	$ 9M
µ-elect	$17M
COTS	$ 7M
Packaging &Reliability	$16M
Total	$117M

MESA's µFab Provides the capability to fabricate Integrated, Mixed Technology Microsystems

Think
Integrated Microsystems
Sense
Silicon Lab (CMOS- Existing MDL)
Transition (New)
Flexible Lab (III-V - CSRL)
Act
Communicate

MESA can uniquely leverage acceleration of Microsensor System/SDAC development

- enables new solutions and designs
- prototypes and qualification
- modeling & simul - virtual prototyping

Wafer Level Integration
Sensors
Optical
RF Circuits
Memories
CMOS
Sensors
- Thin Wafers
- Bond Wafers
Saw Into
Single Chips