



Smaller, Smarter C4ISR

**Presentation to
Defense Science & Technology Seminar
December 8, 2000**

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Information Domain

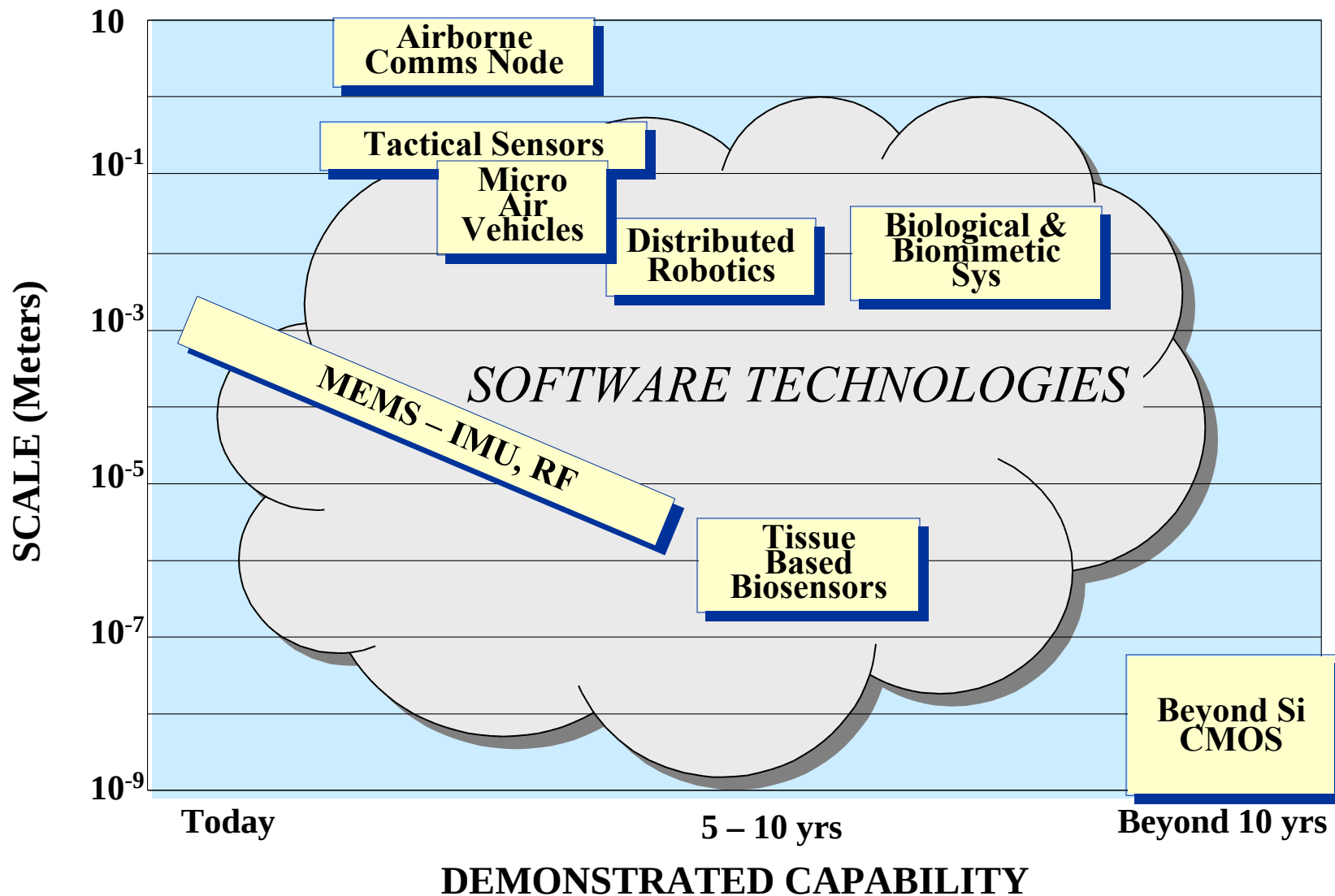
“The transformation of the joint force to reach full spectrum dominance rests upon information superiority as a key enabler and [on] our capacity for innovation.”

*** * * ***

“Information superiority is fundamental to the transformation of the operational capabilities of the joint force.”

--Joint Vision 2020

DARPA Programs Aimed at Smaller, Smarter C4ISR



Tactical Sensors

- **Goal: Develop new sensor systems that can detect, track and classify mobile tactical targets and characterize fixed, man-made structures**
- **Challenges:**
 - **Computationally efficient algorithms to organize sensor field, detect, track, fuse, classify**
 - **Low-power, miniature sensor hardware & innovative deployment methods**
- ***Smarter & Smaller***
 - **Order of magnitude smaller volume**
 - **Low false alarm rate & small, low-power imaging systems**
 - **Use of collaborative signal processing across a sensor network**
- **Milestones**
 - **Visible camera launched from 40mm launcher to attach to concrete**
 - **Demonstrated 6 brassboard sensors performing precision targeting**
 - **End of this year: Increasing numbers of sensors in demos; launching IR and acoustic sensors from 40mm launcher**

Micro Air Vehicles

- **Smallest military UAV – 45-in. wing-span**
- **DARPA has flown four families of proof-of-concept vehicles less 15 cm in size**
 - 0.25 horsepower engine running on JP-8
 - 82 gram vehicle, 30 min. flight w/ color video sensor
- **Plans are now to demonstrate an organic air vehicle for FCS in 15-75 cm size-range**
 - Including sensor
 - Capable of autonomous flight, hover plus forward flight speeds of 50 mph



Distributed Robotics

- **Push robotics even smaller – less than 5 cm**
- **Use collective behaviors to optimize performance of robots with limited individual capabilities**
- **Develop software to allow swarms (100s!) of robots to operated collaboratively**
 - **Energy efficient communications among robots**
 - **Human robot interface to allow human to interact with robots collectively**
- **Milestones**
 - **Have 12 different robot efforts – roll, hop, swim, fly, reconfigure**
 - **Future: Demo sensors, actuators, comms to robots; Demo collaborative software**

MEMS for Inertial Navigation

- **Ring laser and fiber optic gyros = ~ 30 cu in**
- **MEMS Inertial Measurement Unit = 10 cu in**
 - **Accuracy of <0.5 mg accelerometer bias and 1.0°/hr gyro drift rate**
 - **Temperature Range: -54 to 85°C**
 - **Low Power: 1.0 Watt**
 - **Low Cost: \$1,200**
- **Milestones**
 - **Demonstrated gyro operation at 1-100 °/hr**
 - **This year: Conduct brassboard testing with Wind Corrected Munitions Dispenser program office**
 - **Next year: Field test IMUs from three contractors**

RF MEMS

- **RF MEMS offers**
 - High performance, low bias power consumption
 - Potentially low-cost manufacturing into a variety of substrates
- **Size Reduction**
 - x 53 in UltraComm Communication receiver; x 33 in weight
- **Applications**
 - Reconfigurable arrays, filters, tunable antennas, wearable antennas
- **MEM-tenna: Very large electronically scanned radar antenna using MEMS phase shifters**
 - 6 mo. – Demonstrate phase shifters
 - 30 mo. – Build array using 10,000 phase shifters

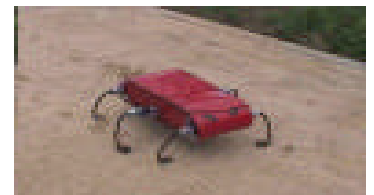
Airborne Comms Node

ACN is making our RF systems smarter – by combining communications and SIGINT into one modular package

- **Phase I (3 teams) started in FY98**
 - Demonstrated narrowband, comms-only proof of concept
- **Down selected to 2 teams for Phase II comms/SIGINT tech development and system design**
- **System design review - Jan. 02; Readiness review - Aug. 02**
- **Transition to Service with CDR-level design**

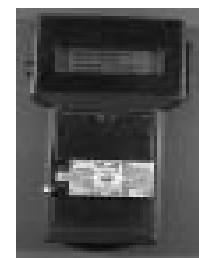
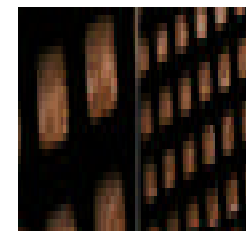
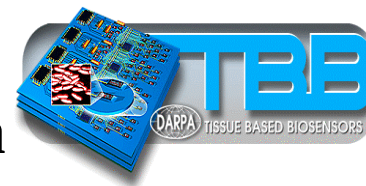
Biological & Biomimetic Systems

- **Goal:** Explore unique capabilities of biological systems for defense – locomotion, sensory fusion, target location
- **Thrusts:** Living Systems as Sentinels --- Biohybrid Devices --- Biomimetics
- **Accomplishments:**
 - Collected biological signals from living systems; used signals for animal sentinels, biohybrid devices, biomimetic platforms
 - Moving to field experiments; ideas taking hold in defense technology community
 - Demonstrated bees capturing BW simulant microbe
 - Trained and used living systems to ‘smell’ and detect UXO, BW
 - Used understanding of winged flight, legged locomotion, visual guidance/control to build robots



Tissue Based Biosensors

- **Program Goal:** Build an activity-based system able to detect known & unknown chem/bio agents
- **Current sensors can only detect & identify known agents**
- **Technical Approach:** Use the response of cells/tissues to detect the presence and toxicity level of threats
- **Milestones:**
 - Extracted robust signatures of response for ‘state change’
 - Improved operationally relevant stability of cells and tissues
 - Built handheld, bench-top prototypes and began field testing
 - Future: Add sample collection/preparation function and work on data acquisition/utilization

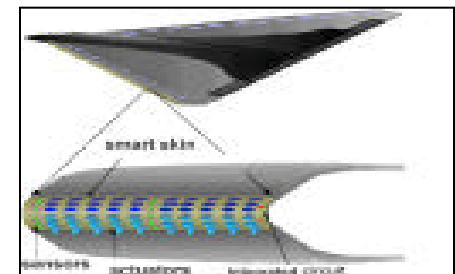


Embedded Software

Advances in processor, MEMS and photonics technology drive the deeper and finer grain integration of computing with physical processes

DARPA's response:

- **Integration of system and software design**
 - Model-based design environments and model-based software generators for large avionics and vetronics applications by 2002 (MoBIES)
 - Automated design verification and validation approaches for hybrid systems by 2004 (SEC, MoBIES)
- **New Composition Technology for embedded systems**
 - Aspect-oriented programming languages and environments by 2003 (PCES)
- **Revolutionary middleware for networked embedded systems**
 - Composable, adaptive middleware for coordinating the operation of 10^2 - 10^5 node MEMS applications by 2005 (NEST)



Beyond Silicon CMOS for the Warfighter

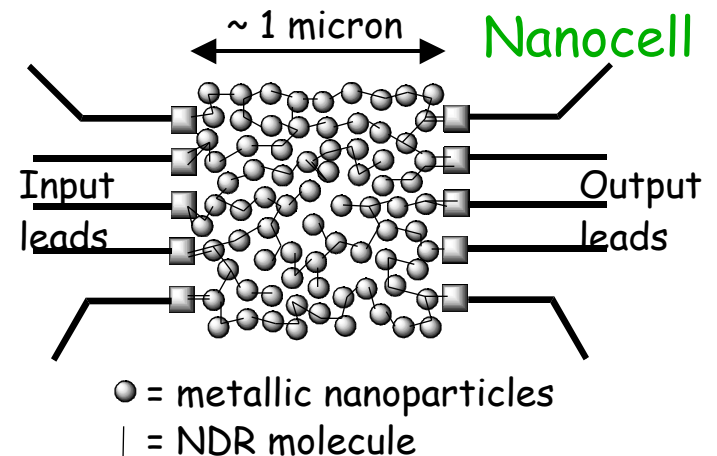
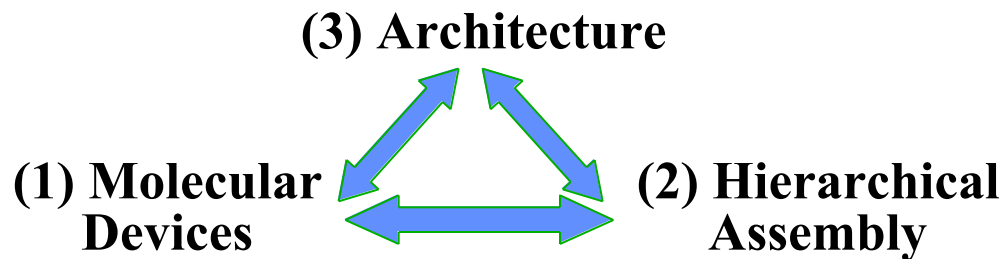
Powerful information technology devices and systems using approaches that extend beyond traditional CMOS scaling

- **New design capabilities for information processing components leading to new ways of computing, sensing and actuation**
- **Examples: computational fabric, smart matter, quantum effects, bio-computing (DNA, molecular electronics, microbial robotics), spin effects**

Substantial reductions in size, weight, and power for reliable, fast and secure computing, communications, data storage

Example: Molecular Electronics

- **Goal:** Create miniaturized computational engines and ultra-dense memory using self-assembled, functional molecules with connections to real world
- **Accomplishments:**
 - Demonstrated *room temperature* logic gates and scaleable 16-bit memories
 - Demonstrating initial attributes of scalability, gain, reversibility, interconnects, switching, multi-bit storage
 - Future: Demonstrate functional, scaleable computation *connected to outside world*



Summary

- **Information superiority is a key pillar of Joint Vision 2020**
- **DARPA programs are providing innovative smaller, smarter C4ISR technologies**

**Today's S&T in C4ISR
will help enable
*Full Spectrum Dominance***