



# Micro Space Propulsion (MSP) Industry Day

John D. Evans  
September 21, 2007





# Overview



- (1) DARPA/MEMS/MTO Background
- (2) Propulsion Primer - **Removed**
- (3) Previous Program: Micro Electric Propulsion - **Removed**
- (4) Micro Space Propulsion Program - **Removed**
- (5) MSP Solicitation Process
- (6) Preemptive Q&A
- (7) Agenda - **Removed**

Removed sections available to qualified individuals and organizations under a different distribution statement. Contact [John.Evans@DARPA.mil](mailto:John.Evans@DARPA.mil) for more information.



# DARPA/MEMS/MTO Background

**MSP Industry Day**  
**John D. Evans**  
**September 21, 2007**





4 October 1957



"All the News  
That's Fit to Print"

# The New York Times.

LATE CITY EDITION

U. S. Weather Bureau Report (Page 2) forecasts:  
Cloudy and cool today and tonight.  
Mostly fair tomorrow.  
Temp. range: 65-55. Yesterday: 62.6-49.2.

VOL. CXXII...No. 36,414.

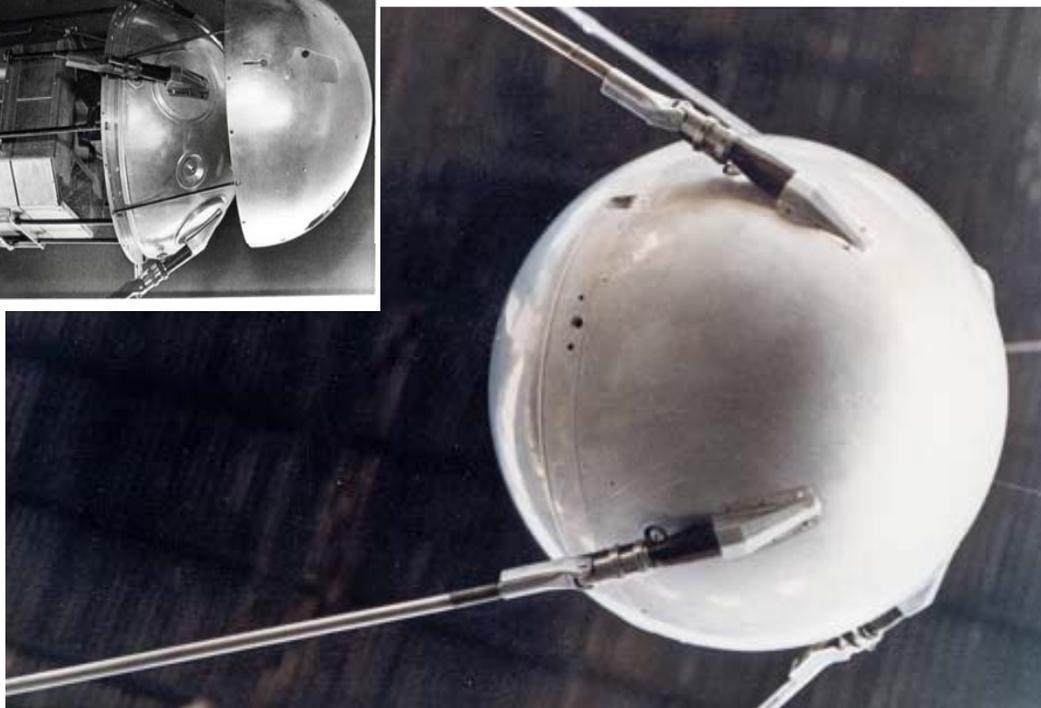
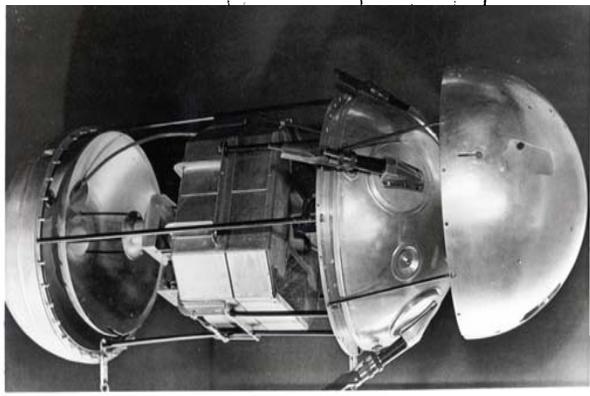
Published by The New York Times Company.

NEW YORK, SATURDAY, OCTOBER 5, 1957.

Printed in the U. S. A.

FIVE CENTS

## SOVIET FIRES EARTH SATELLITE INTO SPACE; IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.; SPHERE TRACKED IN 4 CROSSINGS OVER U. S.



—Dallas News Staff Photo.

### SIGNALS FROM THE SATELLITE

Ham operator Roy Welch of Dallas, seated, plays a tape-recorded signal from the Russian space satellite for fellow hams at the State Fair of Texas. Welch recorded the signals on a receiver at his home.



# DARPA Mission



## Department of Defense DIRECTIVE

NUMBER 5134.10  
February 17, 1995

*Certified Current as of November 21, 2003*

*Incorporating Through Change 2, July 16, 2001*

DA&M

SUBJECT: Defense Advanced Research Projects Agency (DARPA)

- References: (a) Title 10, United States Code  
(b) DoD Directive 5105.41, "Defense Advanced Research Projects Agency," January 25, 1989 (hereby canceled)  
(c) Federal Acquisition Regulation, Subpart 2.1, April 1, 1984, supplemented by Defense FAR Supplement, Subpart 202.1  
(d) [DoD Directive 8910.1](#), "Management and Control of Information Requirements," June 11, 1993

### 1. PURPOSE

Under the authority vested in the Secretary of Defense by Section 113 of reference (a), this Directive establishes the DARPA as an agency of the Department of Defense with the responsibilities, functions, relationships, and authorities as prescribed herein; and replaces reference (b).

### 2. APPLICABILITY

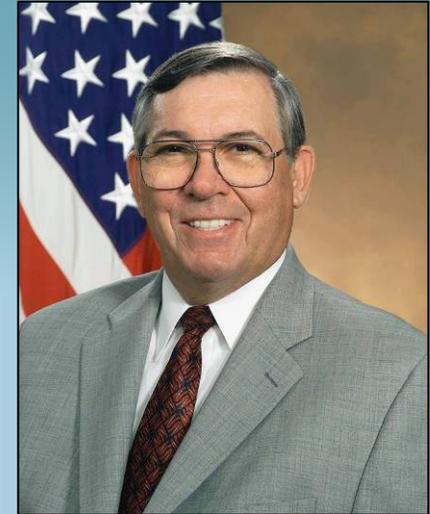
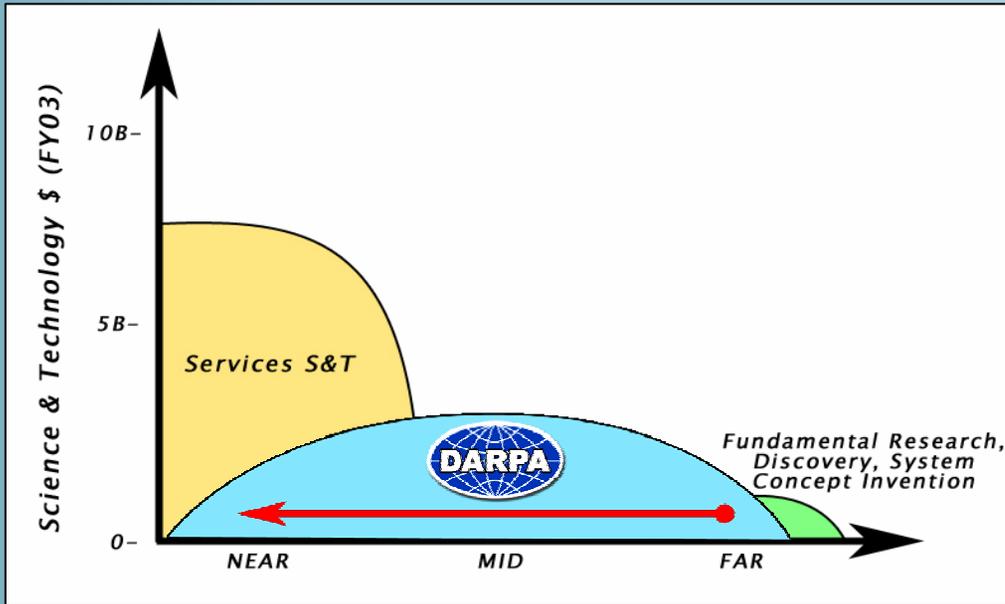
This Directive applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, and the DoD Field Activities (hereafter referred to collectively as "the DoD Components").

The DARPA shall serve as the central research and development organization of the Department of Defense with a primary responsibility to maintain U.S. technological superiority over potential adversaries.

-- DoD Directive 5134.10  
February, 18, 1995



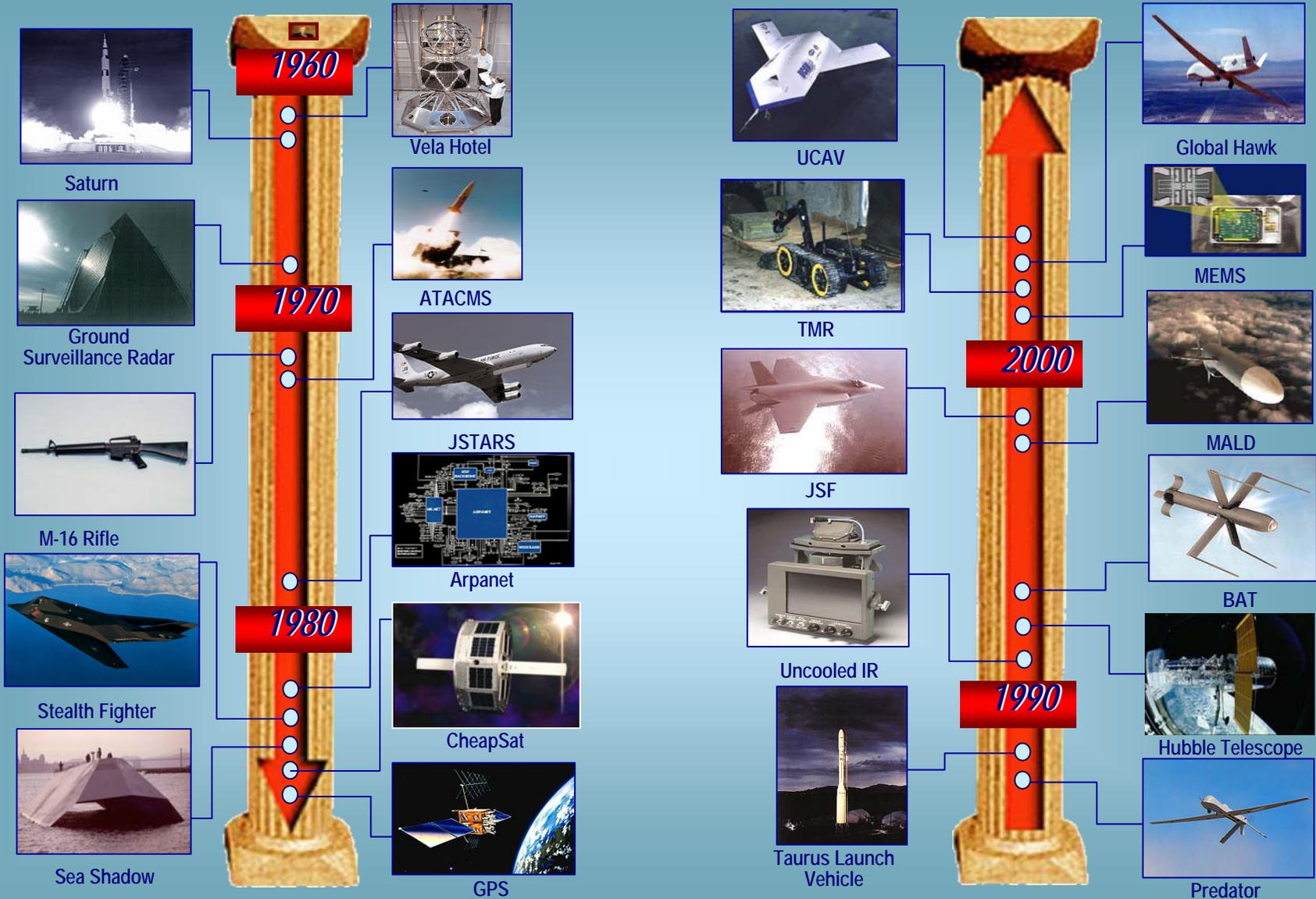
# DARPA Role in Science and Technology



Director, Tony Tether



# DARPA Accomplishments





# DARPA Organization



**Director, Tony Tether**  
**Deputy Director, Bob Leheny**

Distribution Statement "A" (Approved for Public Release, Distribution Unlimited).  
DARPA Case 10295, 9/24/2007

## Tactical Technology

Steve Welby  
Gary Graham/Steve Walker

Air/Space/Land Platforms  
Unmanned Systems  
Space Operations  
Laser Systems  
Precision Strike  
Planning/Logistics

## Information Exploitation

Bob Tenney

Sensors  
Exploitation Systems  
Command & Control

## Strategic Technology

Dave Honey  
Larry Stotts/Brian Pierce

Space Sensors/Structures  
Strategic & Tactical Networks  
Information Assurance  
Underground Facility Detection  
& Characterization  
Chem/Bio Defense  
Maritime Operations

## Defense Sciences

Barbara McQuiston (Acting)  
Valerie Browning (Acting)

Bio Warfare Defense  
Technologies  
Biology  
Materials & Devices  
Mathematics

## Information Processing Technology

Charlie Holland

Cognitive Systems  
Computational – Perception  
Representation & Reasoning  
Learning  
Natural Communication

## Microsystems Technology

John Zolper  
Dean Collins

Electronics  
Photonics  
MEMS  
Algorithms  
Integrated Microsystems

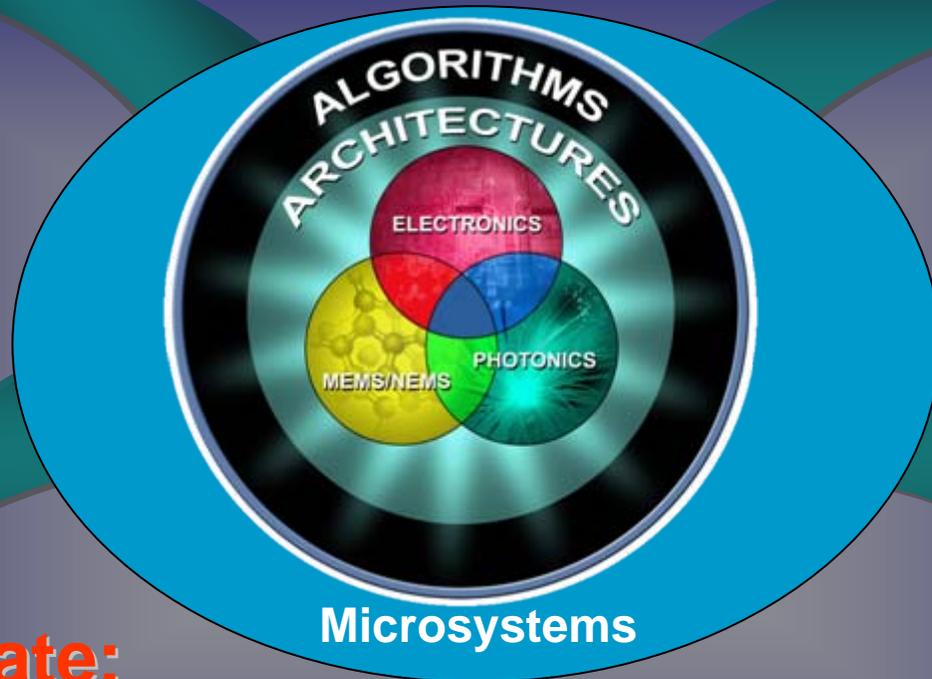


# Microsystems Enabling Future System Capability



**Sense:**  
EO/IR/Visible/UV  
RF/mm-wave/THz  
Chemical  
Biological  
Trust/Protect

**Process:**  
Digital  
Analog  
Memory  
Quantum  
Biological  
Trust/Protect



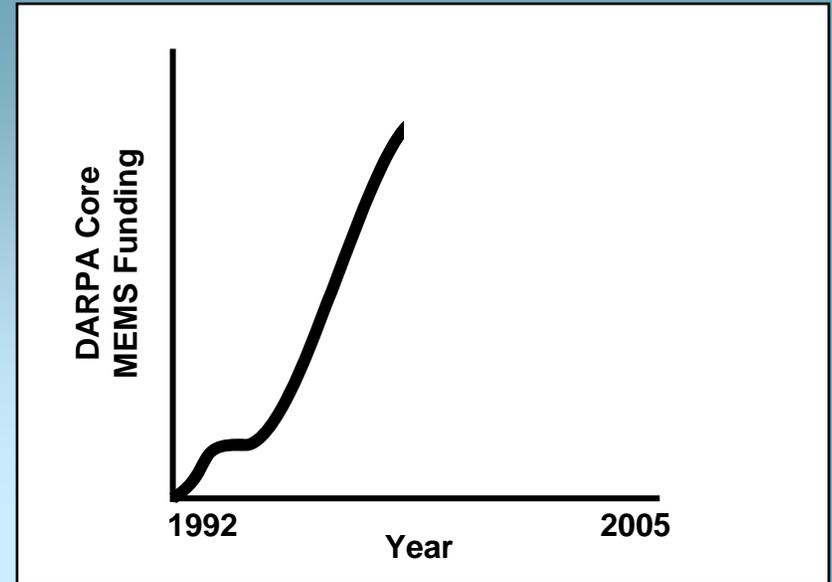
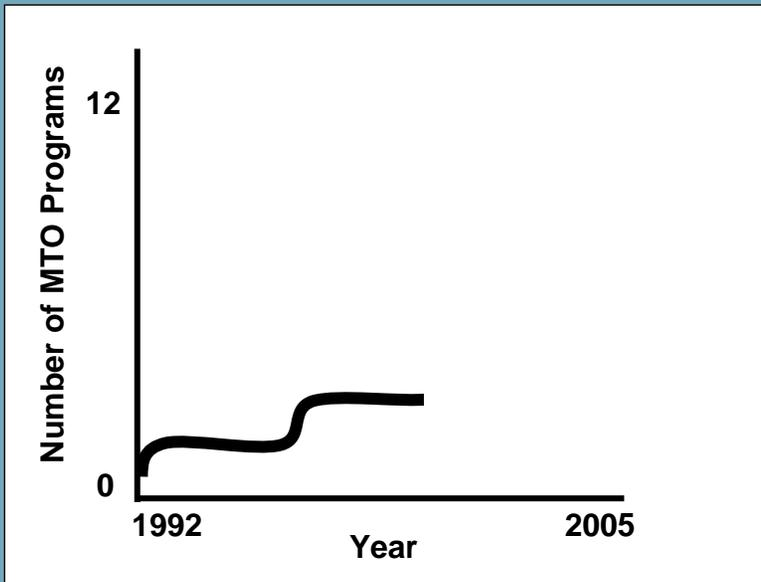
**Communicate:**  
Optical  
Analog/digital  
Wireless RF/mm-wave

**Energize:**  
Convert  
Generate  
Directed

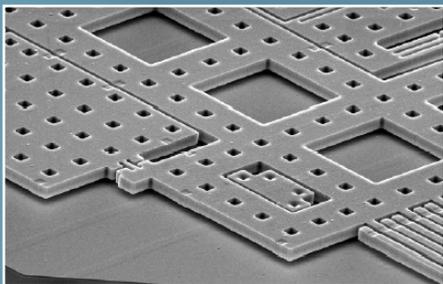
**Actuate:**  
Mechanical  
Electrical  
Optical  
Chemical



# DARPA's First Decade of MEMS

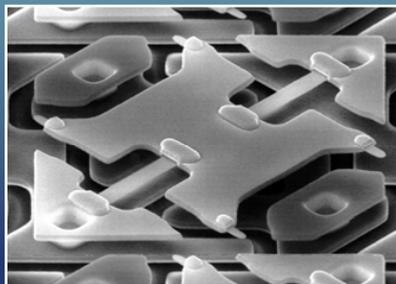


First decade convincingly demonstrated that ***“Smaller is Better”***



**Accelerometers**

Analog Devices



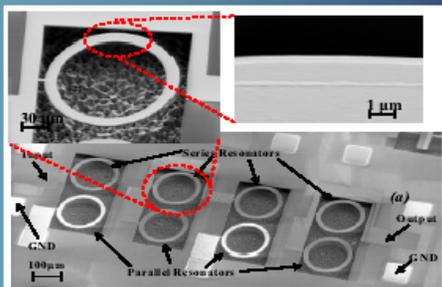
**Displays**

Texas Instruments



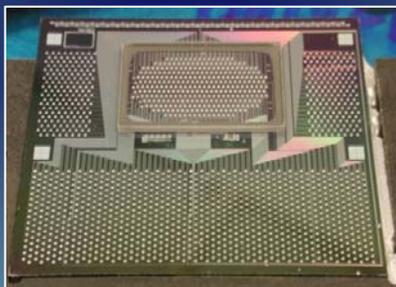
**RF Switches**

Radant



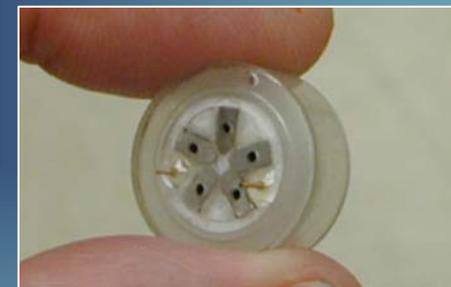
**RF Resonators**

Pisano, Berkeley



**Optical switches**

Calient



**Fuel Cells**

Honeywell

Performance

Power

Form Factor

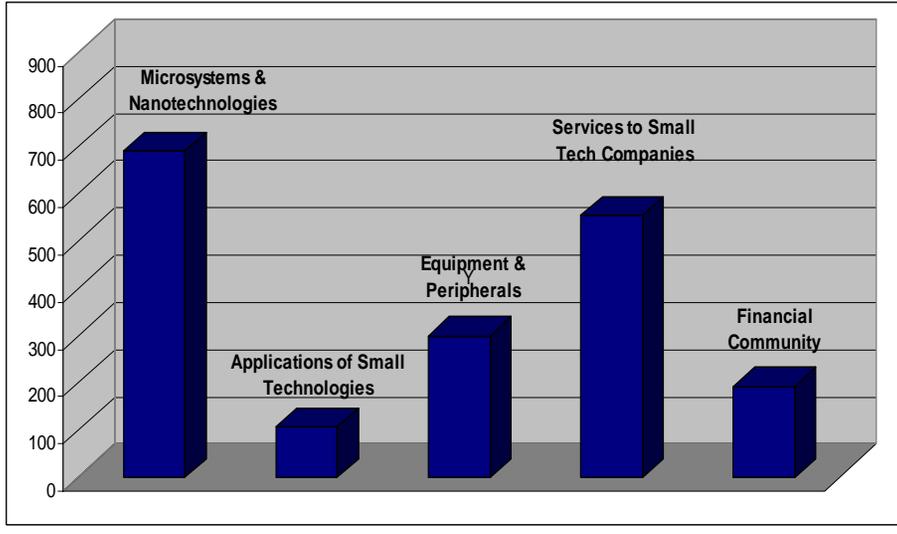
Reliability



# DARPA MEMS Spawned Significant Commercial Activity

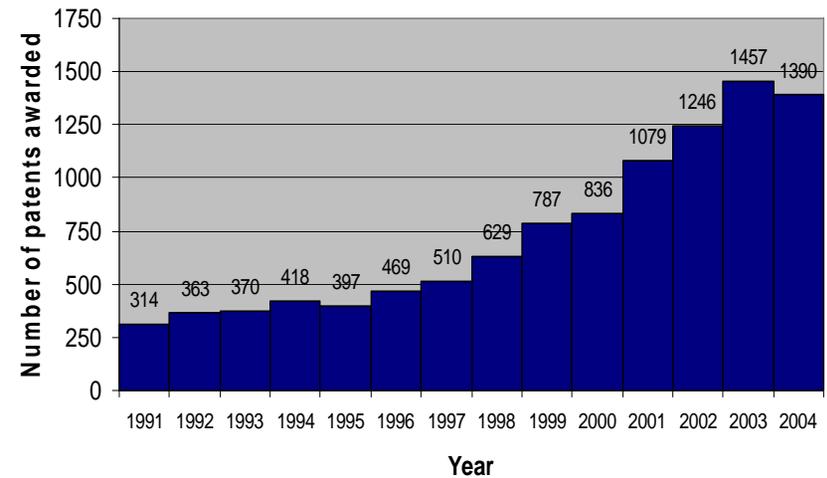


### MEMS / Microsystems Companies by Category



Small Times Media, 2005

### MEMS / Microsystems Patents Awarded by Year



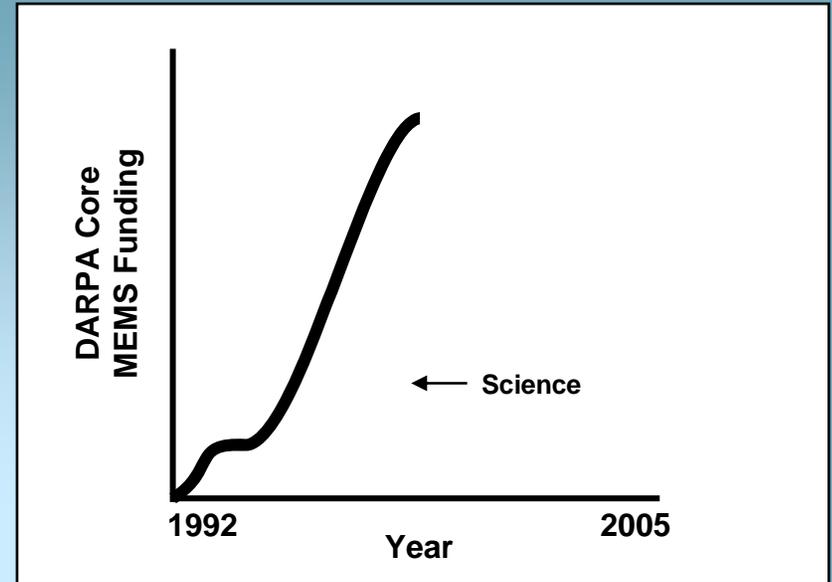
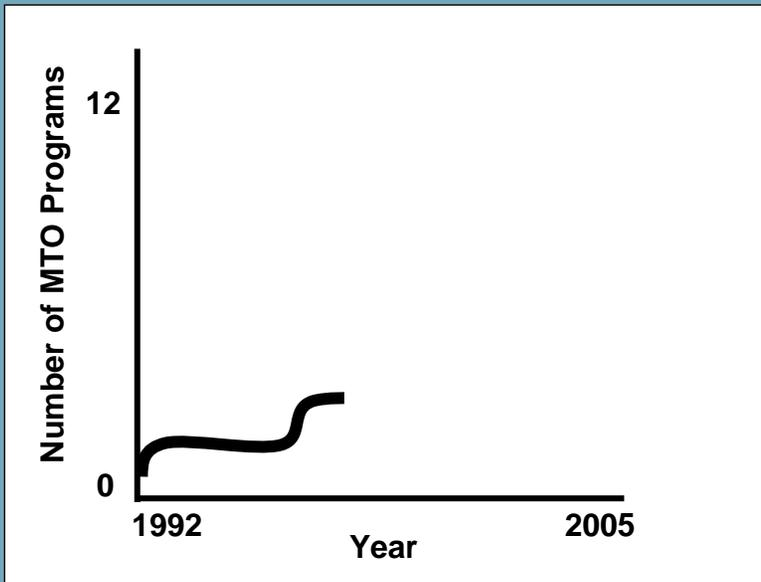
Small Times Media, 2005

**>1,800 U.S. Microsystems Companies**

**~1,400 patents issued per year**



# DARPA's Second Decade of MEMS



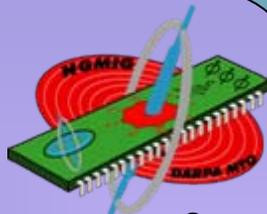
**2005 was the best year yet for MEMS,  
both in terms of dollars, and number  
of programs**



# DARPA MTO MEMS Portfolio: Diverse and Robust



Clocks



Gyro

Navigation



Basic R&D



Computation



Power



Gyro  
Switches

Filters &  
Passives

RF/MMW

Switches & Filters



Cooling



Hybrid Microwave  
Integrated Circuits



Manufacturing



Aerospace



Sensing





# MEMS Program Managers



John Evans, Ph.D, MBA

Dr. Dennis Polla

Dr. Amit Lal

Dr. Tom Kenny



# John D. Evans



## Biography:

- DARPA Program Manager
- Work History
  - *Start-up*: CTO, MEMGen, Inc.
  - *Fortune 500*: Scientist, Becton Dickinson, Inc.
  - *Congress*: Research Consultant, United States Congress Office of Technology Assessment (OTA).
- Education
  - B.A., Physics, Carleton College
  - M.S. Civil Engineering, UC Berkeley
  - Ph.D., Mechanical Engineering, U.C. Berkeley
  - MBA, Duke University
- Key interests
  - Microsystem technology, including RF/MMW systems, isotope power systems, propulsion systems, etc.
  - Aerospace systems, including satellites and NAVs
  - Economics of transition and commercialization.
  - R&D strategic planning.
  - Innovation.





# John D. Evans



Program	Goal
3-D MERFS	Enable dramatic reduction in size (30x) and cost (100x) for MMW systems by demonstrating a new air-core-coax "printed circuit board" technology for MMW.
Analog Spectral Processors	Enable dramatic decreases in radio size and power by simultaneously trading advances in new radio architectures and new MEMS filters.
Disruptive Manufacturing Technologies	Exploit opportunities to dramatically decrease manufacturing costs for existing military systems.
Micro Space Propulsion	Demonstrate thrusters with wide Isp dynamic range, enabling spacecraft to flexibly respond to changing national needs.
Micro Isotope Power Sources	Demonstrate high-energy-density isotope batteries.





# MSP Solicitation Process

MSP Industry Day  
John D. Evans  
September 21, 2007





# BAA Timeline



## September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

9/12/07  
BAA  
Released

9/21/07  
Industry  
Day

## October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

10/3/07 4:00  
White  
Papers Due

10/12/07  
Feedback  
on White  
Papers

## November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

11/14/07  
Full Proposals  
Due



# TFIMS Registration Requirement



- Both abstracts and proposals may be submitted electronically to the Technical Financial Information Management System (TFIMS) proposal submission system.
- All material submitted electronically must be UNCLASSIFIED.
- Organizations planning to submit proposals and/or abstracts via T-FIMS must register at: <http://www.tfims.darpa.mil/baa>.
  - Only the lead or prime organization should register.
  - One registration per proposal should be submitted.
  - Proposer makes no commitment to submit by registering.
  - **Proposers should register on TFIMS at least a week prior to the submission deadline** to allow sufficient time for completing registration process and uploading submission.
  - Proposers will receive a confirmation e-mail generated from the T-FIMS electronic system as receipt that their proposal has been received.



# White Paper Requirements



- 3 elements:
  - (1) a single Penta Chart
  - (2) a cover sheet
  - (3) a proposal summary up to 5 pages
- Cover sheet and proposal summary may be combined in one single file
- Abstracts should be submitted through TFIMS (<https://www.tfims.darpa.mil/baa>)
- Per BAA: “DARPA will respond to proposal abstracts with a recommendation to propose or not propose and the time and date for submission of a full proposal. Regardless of the recommendation, the decision to propose is the responsibility of the proposer.”



# MSP Penta-chart Template Prime Contractor



## Team

LOGO (PRIME CONTRACTOR)

LOGO (SUB #1)

LOGO (SUB #2)

LOGO (SUB #3)

LOGO (SUB #4)

- Prime Contractor (City, State) ← LEAD
- Subcontractor #1 (City, State)
- Subcontractor #2 (City, State)
- Subcontractor #3 (City, State)
- Subcontractor #4 (City, State)
- ...

## Technical Approach

Title of Technical Approach:

- Description of key innovation #1
- Description of key innovation #2
- Description of key innovation #3
- ...

INSERT GRAPHIC(S)

## Performance Metrics

INSERT TABLE OR GRAPHIC

## Transition Path

- Description of transition plans

## Budget/Schedule

**Total: ? months (\$?K)**

**Phase 1: ? months (\$?K)**

- *Description of Phase 1*
- Deliverable #1 for Phase 1
- Deliverable #2 for Phase 1
- ...

**Phase 2: ? months (\$?K)**

- *Description of Phase 2*
- Deliverable #1 for Phase 2
- Deliverable #2 for Phase 2
- ...

**Phase 3: ? months (\$?K)**

- *Description of Phase 3*
- Deliverable #1 for Phase 3
- Deliverable #2 for Phase 3



# Full Proposal Requirements



- Full proposals should consist of 3 files:
  - (1) A single Penta chart. (PowerPoint format)
  - (2) Volume I: Technical and Management Proposal (Word or PDF format). 50 Page Limit
  - (3) Volume II: Cost Proposal (Word or PDF format)
- Penta-chart template provided on FedBizOpps
- Full proposals may be submitted through either TFIMS (<https://www.tfims.darpa.mil/baa>) or Grants.gov (<http://www.grants.gov/>)
- Per BAA: “All submitted proposals will be fully reviewed regardless of the disposition of the proposal abstract.”

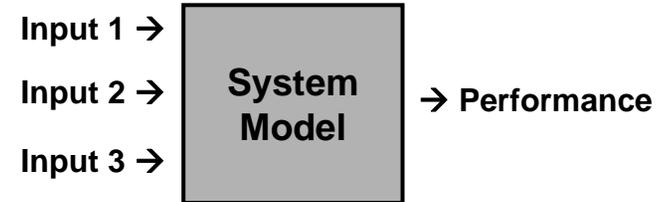


# How John Thinks About R&D

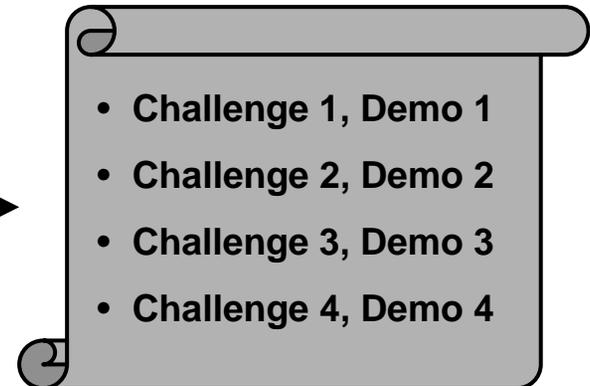


- Goal of R&D is to develop actionable information about the difficulty and likely success of future R&D and product development efforts.
- The R&D plan serves as a decision tree. Working this decision tree develops/confirms your understanding of the problem, and directs / motivates future research.
- The fundamental building block of a plan is a demonstration.
  - A demonstration is a collection of activities designed to yield a specific technical result (i.e. a thruster with 1 W output)
  - Success or failure at a demonstration generates actionable information about how (or whether) R&D program should proceed.

- Create a model for the objective device
- Identify specific objective values for inputs that will enable the system to achieve phase / program requirements.
- Identify specific challenges / risk elements that must be overcome to realize those values.
- For each challenge, specify a demonstration with specific metrics that unambiguously define success or failure at overcoming the challenge.



Parameter	Now	Objective	Delta
Input1	$X_1$	$X_2$	$\Delta X$
Input2	$Y_1$	$Y_3$	$\Delta Y$
Input3	$Z_1$	$Z_4$	$\Delta Z$

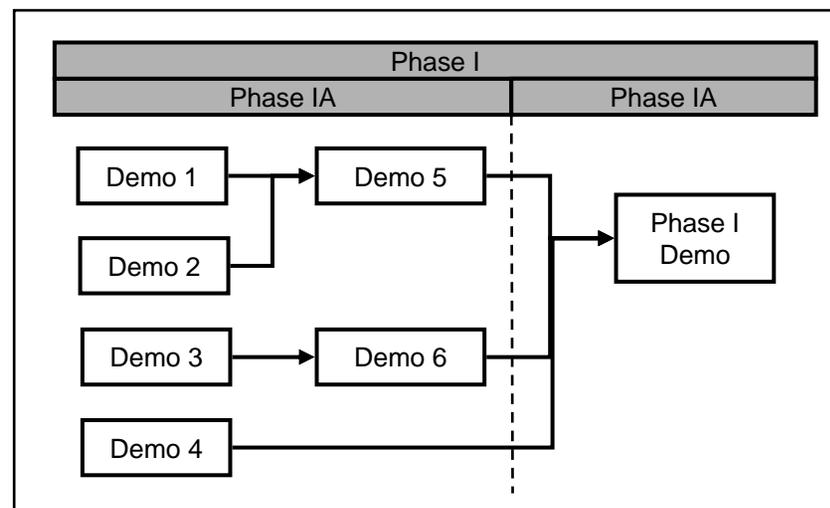
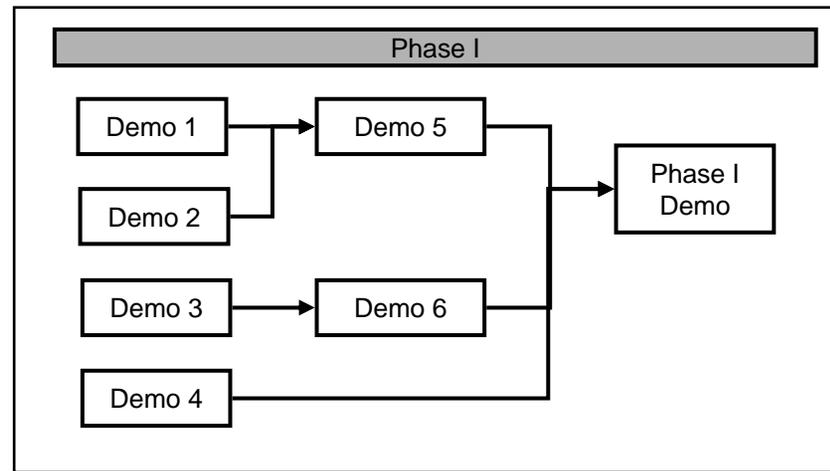




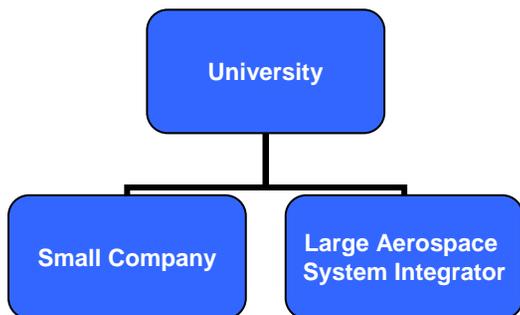
# Demo-Based Proposal Structure



- Arrange in network diagram according to dependency.
- Remove all demos that do not contribute to final demo.
- In general, move all non-dependent demos that involve significant uncertainty/risk as left as possible.
- BAA requires that all phases longer than one year be broken into sub-phases, with specific metrics for each sub-phase.
- Use demo metrics as sub-phase metrics.



How to team and organize a proposal is at the sole discretion of the proposer

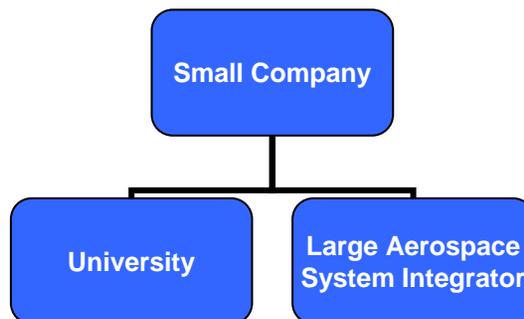


Advantages:

- Basic science/physics takes a front seat.
- Maximizes range of technical exploration.
- Maximizes potential for breakthrough results.

Disadvantages:

- Inexperience or insufficient commitment to project management.
- Inexperienced researchers slows research.
- Poor choice when effort requires strong coordination between team members to achieve program goals.

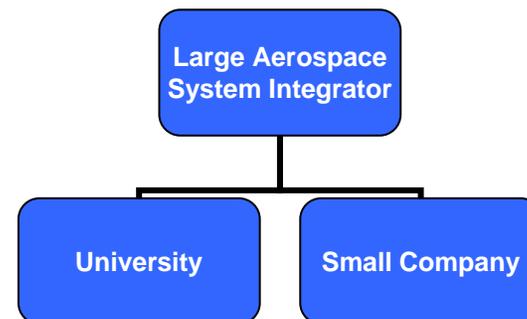


Advantages:

- Experienced researchers enable performer to address more sophisticated challenges than universities.
- Less expensive, quicker, and more dynamic than large firm.

Disadvantages:

- Inexperience or insufficient commitment to project management.
- Poorer choice when effort requires strong coordination between team members to achieve program goals.



Advantages:

- Expertise in project design and project management.
- Integrator lends credibility to technical approach.
- Integrator participation lends credibility to transition plan.
- Development likely to be directed towards identified military applications.

Disadvantages:

- Higher overhead costs
- Less likely to achieve surprising, breakthrough results.
- Less dynamic.



# Teaming Website



- Collaborative efforts are encouraged.
- Website available:  
<http://www.davincinetbook.com/teams>
- **Specific content, communications, networking, and team formation are the sole responsibility of the participants.**
- DARPA/DoD does not specifically endorse the teaming website or any information posted on the teaming website.



# Review Criteria



Evaluation of proposals will be accomplished through a scientific/technical review of each proposal using the following criteria:

- a) Overall Scientific and Technical Merit
- b) Potential Contribution and Relevance to the DARPA Mission
- c) Plans and Capability to Accomplish Technology Transition
- d) Offeror's Capabilities and Related Experience
- e) Realism of the Proposed Schedule
- f) Cost Realism



# Preemptive Q&A

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## Q&A



- **Does the proposed technology have to be FEEP or Colloid?**
  - No. However, system must use a single fuel across all Isp ranges, and form a compact integrated thruster system.
  - Contact PM immediately if not proposing FEEP or Colloid.
- **Does the prime contractor have to be a major defense contractor?**
  - No. Team composition and organization is at the digression of the proposer. However, composition and organization do influence proposal review.



# Q&A



- **How important is schedule vs. cost?**
  - Both schedule and cost are important. Schedule is particularly important.
  - Teams should NOT propose efforts with numerous redundant parallel paths designed to increase chances of success. Teams should propose lean plans that put forth their best strategy for overcoming each technical risk element.



# Q&A



- Will information generated under the program be export controlled?
  - DARPA believes that it is highly likely that information generated under the program will be subject to export controls.
  - Contractors and subcontractors are individually responsible for making determinations about whether information they generate is export controlled.
  - Bidders are responsible for identifying whether they believe information they will generate is export controlled. If export controlled, they must outline how they will prevent dissemination of that information to foreign nationals.
  - Individuals are likely to be found personally and criminally liable if they allow export controlled information to be disseminated to foreign nationals.



# Q&A



- **Can Universities participate in the program?**
  - Yes. However universities should pay special attention to export laws governing information to be generated on the program. DARPA believes that it is highly likely that such information is export controlled.
  - If universities are to participate, the proposal must explicitly outline whether the team believes any information generated under the contract will be export controlled, whether that information will be shared with the University, and if so, how the university will prevent dissemination to foreign nationals.



## Q&A



- Can Non-US Citizens (and permanent residents) participate in the program?
  - Yes. However teams are responsible for identifying those individuals and outlining their plans to prevent export controlled information from being disseminated to those individuals.



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