BRIDGING THE GAP

DARPA

POWERED BY IDEAS

Report Documentation Page

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Who/What is DARPA?

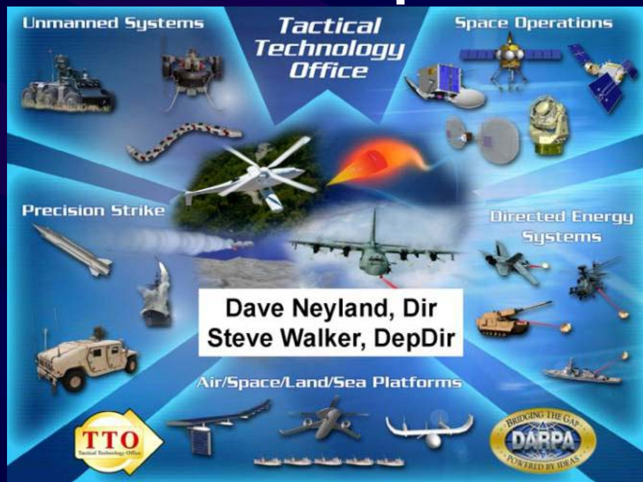
The Advanced Research Projects Agency (ARPA) – which came to be known as DARPA in 1972 when its name changed to the Defense Advanced Research Projects Agency – emerged in 1958 as part of a broad reaction to a singular event – the launching by the Soviet Union of the Sputnik satellite on Oct. 4, 1957.

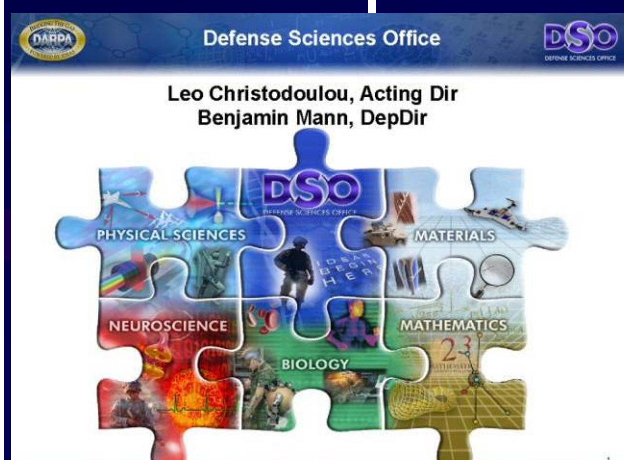
DARPA at a glance

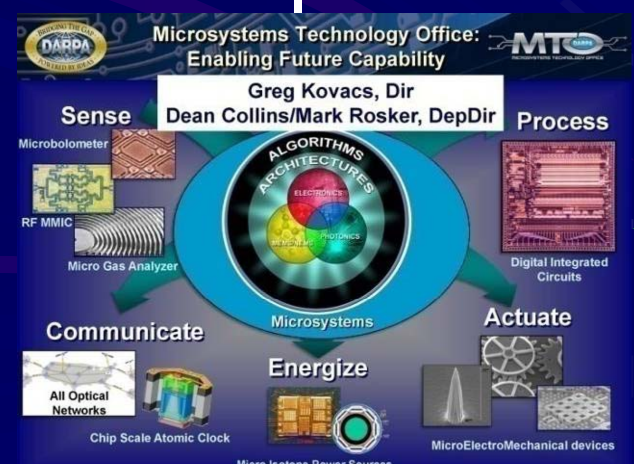
- DARPA's Mission
  – Prevent technological surprise for the United States and to create technological surprise for our adversaries.
- DARPA's Charter
  – Radical innovation
  – Solving hard technical problems
  – Revolutionary capabilities for national security

DARPA Technical Offices

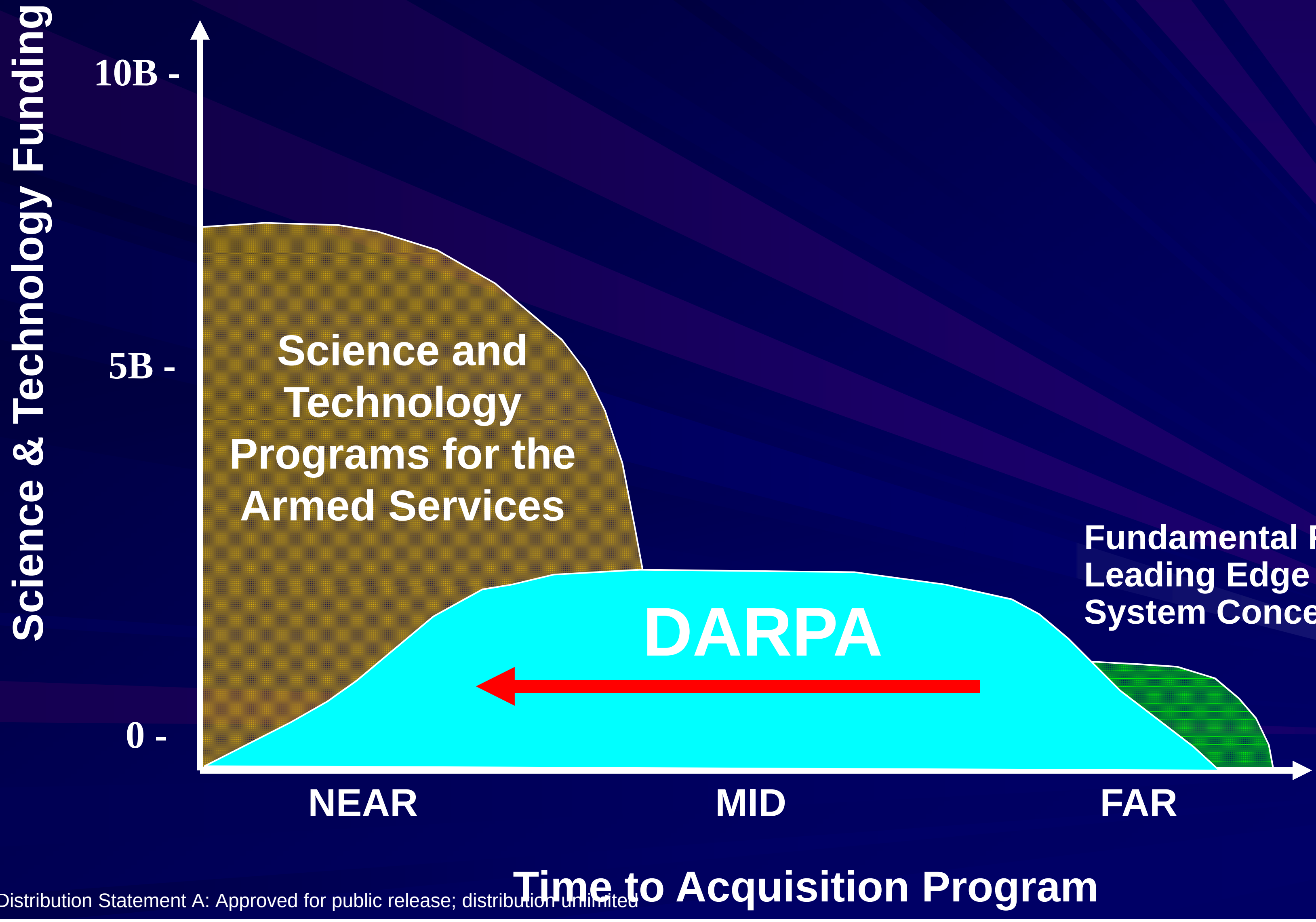
Acting Director, Bob Leheny







DARPA Role in Science and Technology



DARPA's Strategic Thrusts

Investments Today for Future Capabilities

– Robust, Secure, Self-Forming Networks

– Detection, Precision ID, Tracking, & Destruction of Elusive Targets

– Urban Area Operations

– Advanced Manned & Unmanned Systems

– Detection, Characterization, & Assessment of Underground Structures

– Space

– Increasing the Tooth to Tail Ratio

– Bio-Revolution

– Core Technologies (Materials/Electronics/Information Technology)

References for DARPA Projects

Secretary of Defense

Quadrennial Defense Review

Strategic Planning Guidance 2008 – 2013

Combatant Commanders Integrated Priority Lists

USSOCOM CONPLAN 7500-02 – Global War on Terrorism

Joint Program Decision Memorandums

Meetings and Briefs throughout DoD

Operational Liaisons – Transition Agents

Special Assistant / Tech Transition

- **Mr. Chris Earl**

Liaison to Special Operations Command

- **Ms. Kathy MacDonald**

Operational Liaisons

- Col TC Moore, USMC
- COL Valerie Jacocks, USA
- CAPT John Murphy, USN
- Col Will Reese, USAF
- Mr. Fred Schnarre, NGA

Rapid Reaction Support

Bar Armor - Counter RPG

Boomerang

WASP

Tactical Iraqi Language Training

Command Post of the Future

Hand-Held Translator

Broadcast Translation

Cooling Glove

Sniper Rifle

Water Disinfection Pen

TIGR

Current DARPA Programs

That support EUCOM/AFRICOM needs

- Operating in GPS-denied environment
  - Chip-Scale Atomic Clock (CSAC)
  - Robust Surface Navigation/Sub Surface Navigation (RSN/SSN)
  - Micro Inertial Navigation Technology (MINT)
- Long endurance, persistent surveillance
  - Integrated Sensor is the Structure (ISIS)
- Networking/SA for Distributed Operations
  - UltraVis

Current DARPA Programs
That support EUCOM/AFRICOM needs

- Operating in GPS-denied environment
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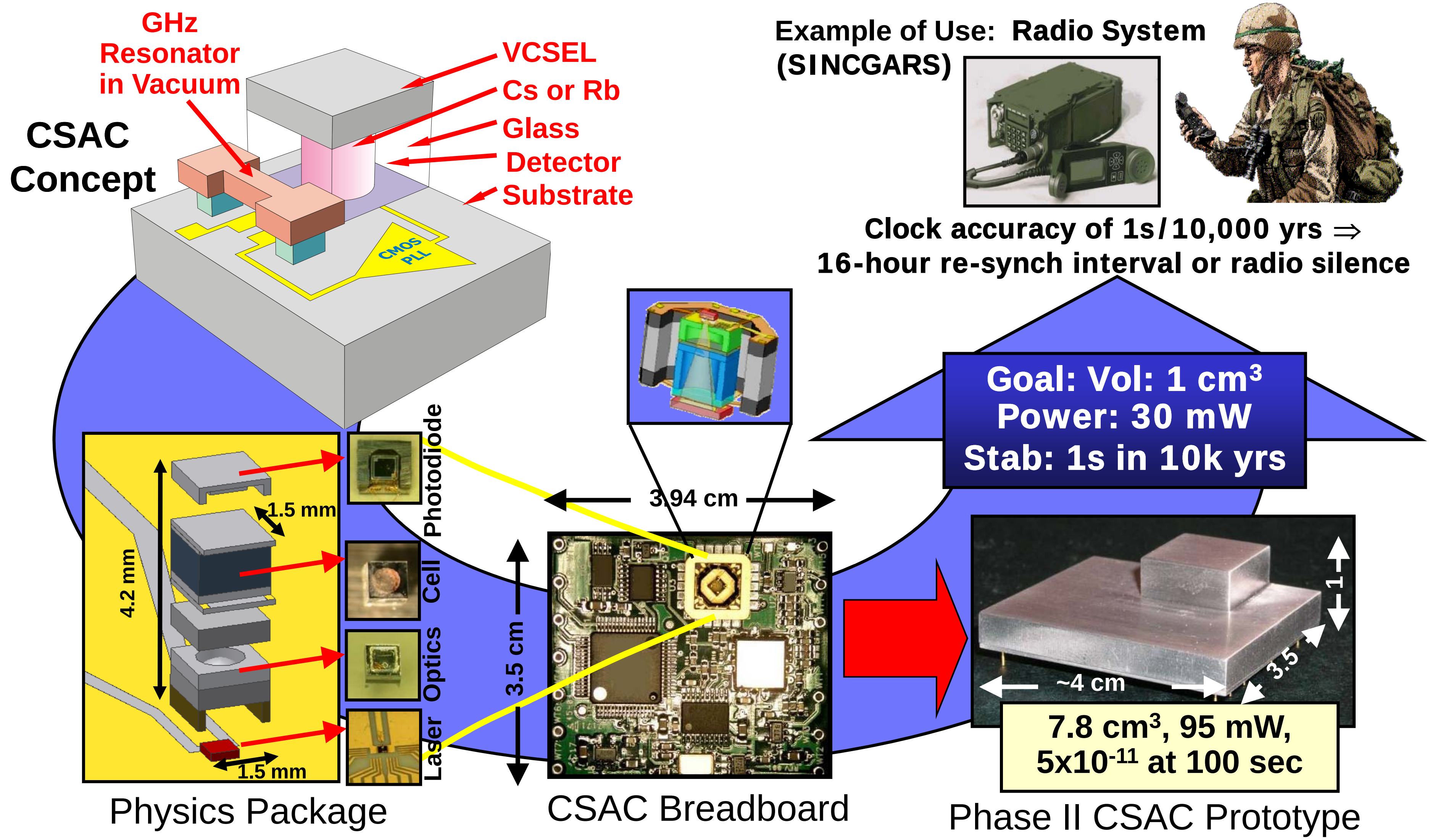
  - Robust Surface Navigation/Sub Surface Navigation (RSN/SSN)
  - Micro Inertial Navigation Technology (MINT)

Integrated Microsystem: Chip Scale Atomic Clock



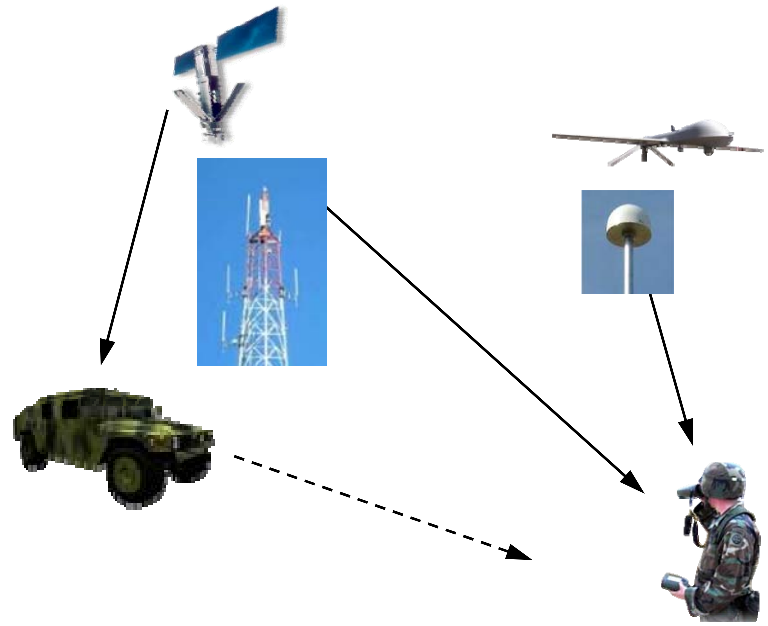
Precision Time for Every Radio and Network Node

Robust Surface Navigation (RSN)

Strategic Technology Office

Why RSN?

- GPS does not work well indoors or in urban canyons
- GPS can be jammed
- Multiple path propagation corrupts positioning accuracy



Goals

- GPS-equivalent capability in GPS-denied environments
- Navigation using signals-of-opportunity
  - Space and terrestrial communications, broadcast, and navigational signaling systems
- Development of beacons for improved versatility when SoOP are limited or non-existent
- Seamless adaptation of receiver to any available signals (GPS, Beacons, or SoOP)

Technical Challenges

- Mitigation and/or exploitation of multipath
- Ability to operate when line-of-sight (LOS) propagation is not available
- Characterization of and synchronization with available SoOP/beacons

RSN Provides Robust Geolocation and Navigation in GPS-Denied Environments

Slide 14

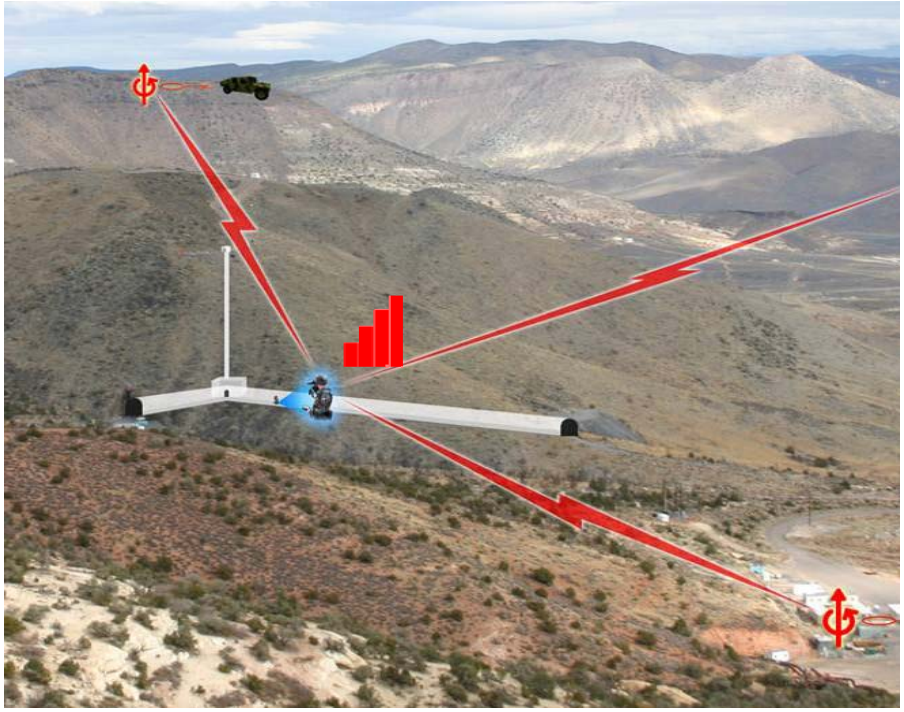
SMU2 Slides 12 & 13 DISTAR case # 10389

Stephen M Urban, 5/26/2009

Sub-Surface Navigation (SsN)

Program Objectives

- Provide the U.S. war fighter with the ability to geo-locate and navigate in environments below the surface of the Earth, where GPS is not available.



Goals

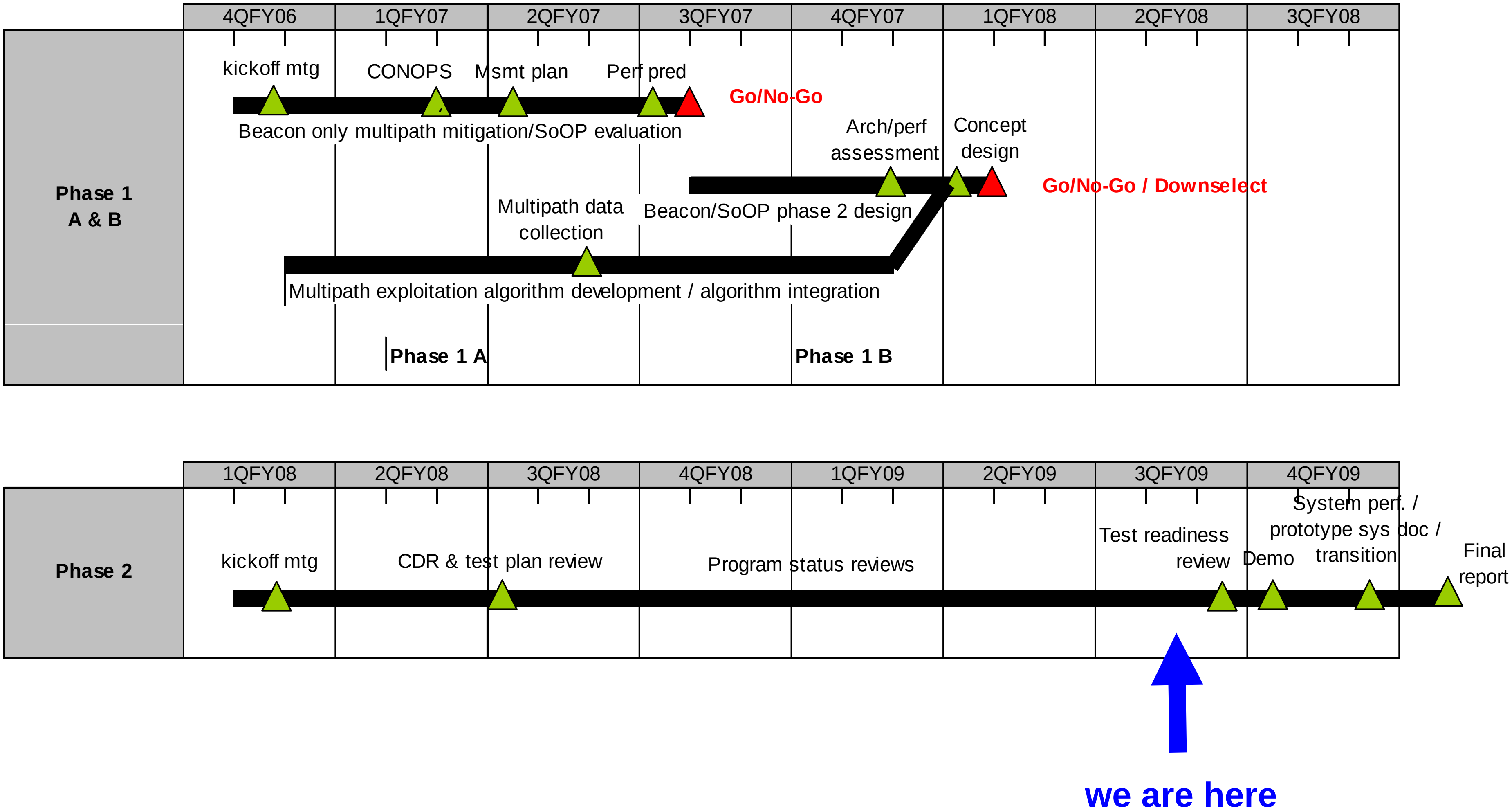
- Provide navigation capability in underground environment, where GPS is not available
- Evaluate the use of signals-of-opportunity (SoOP) for navigation
- Develop beacons for improved versatility when SoOP are limited or non-existent

Technical Challenges

- Signal penetration into underground environment limits operational range
- Signal distortion through non-homogeneous ground limits accuracy and robustness
- Seamless operation above- and below-ground requires additional complexity
- Development of readily deployable receivers and through-the-earth transmitters that do not burden the warfighter

Seamless Underground Navigation and Geo-Location for the War Fighter

RSN Schedule



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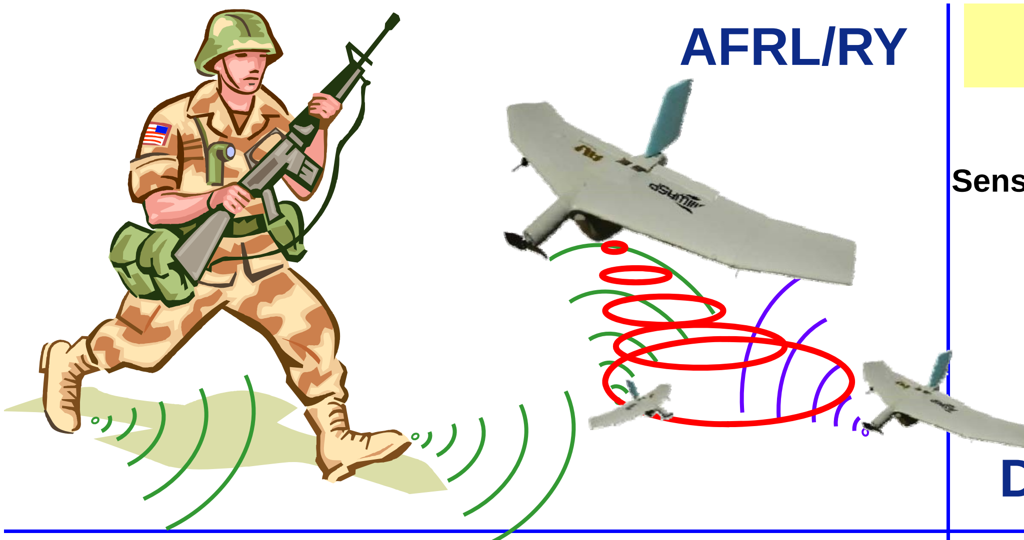
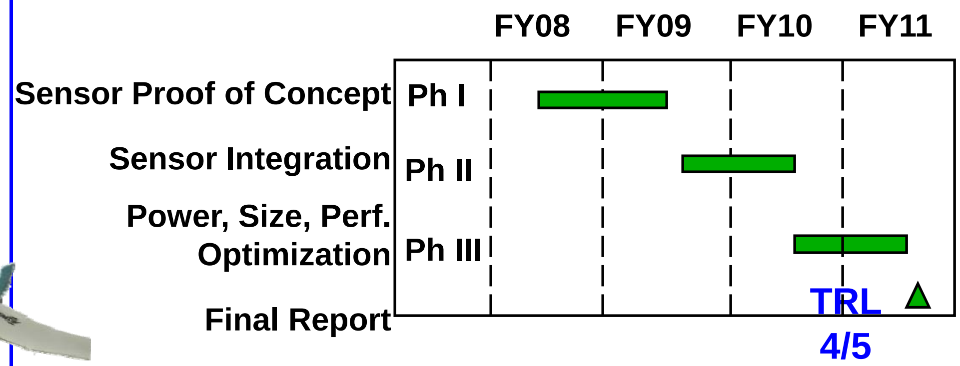
SMU1

Micro Inertial Navigation Technology (MINT)

AFRL/RY



Carnegie Mellon University



DARPA/MTO funded

As of 2 Apr 09

OBJECTIVES/PAYOFF

- **Enable long term (hours to days) GPS denied precise navigation for dismounted soldiers & rel. nav. for swarms of UAVs:**
  - Sensor placement in small compartments, such as the shoe sole or small UAVs
  - Low power - compatible with energy harvesting & reduced weight of batteries
  - Wide temperature range & shock environment
  - Goals of navigation accuracy during walking of **1 m position error after 10 hours** and **size of 1 cc and power of 5 mW**, not including the IMU

APPROACH

- **Develop & Demonstrate Micro- and Nano-scale navigation sensors that use secondary inertial variables, e.g. relative velocity measurements (Radio Frequency, etc)**

- **Integrate and Demonstrate System: Nav sensors with MEMS Inertial Measurement Unit/Magnetometer using Zero Velocity Updates and Kalman Filter**

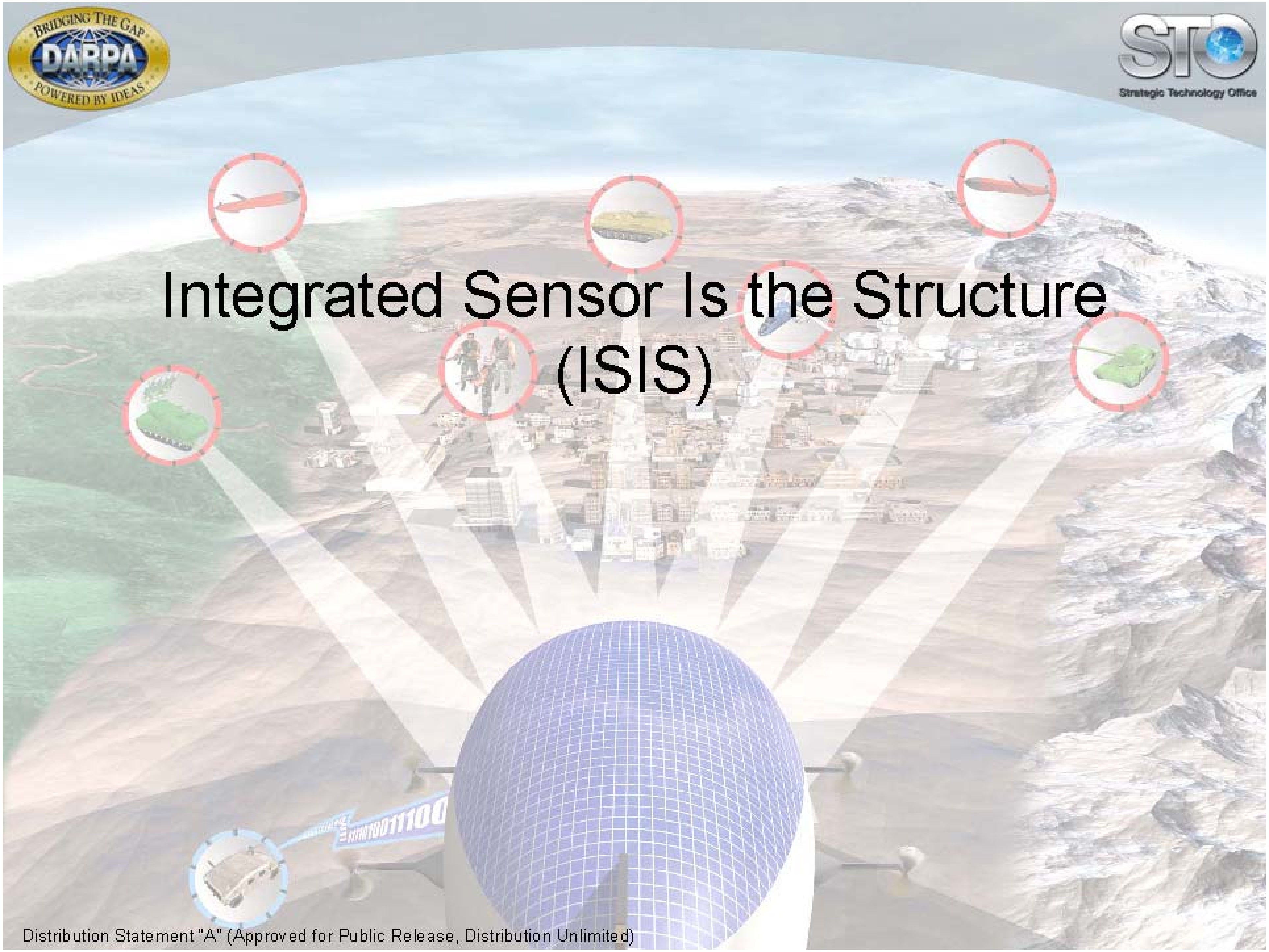
SMU1 DISTAR case # 13418

Stephen M Urban, 5/26/2009

Current DARPA Programs
That support EUCOM/AFRICOM needs

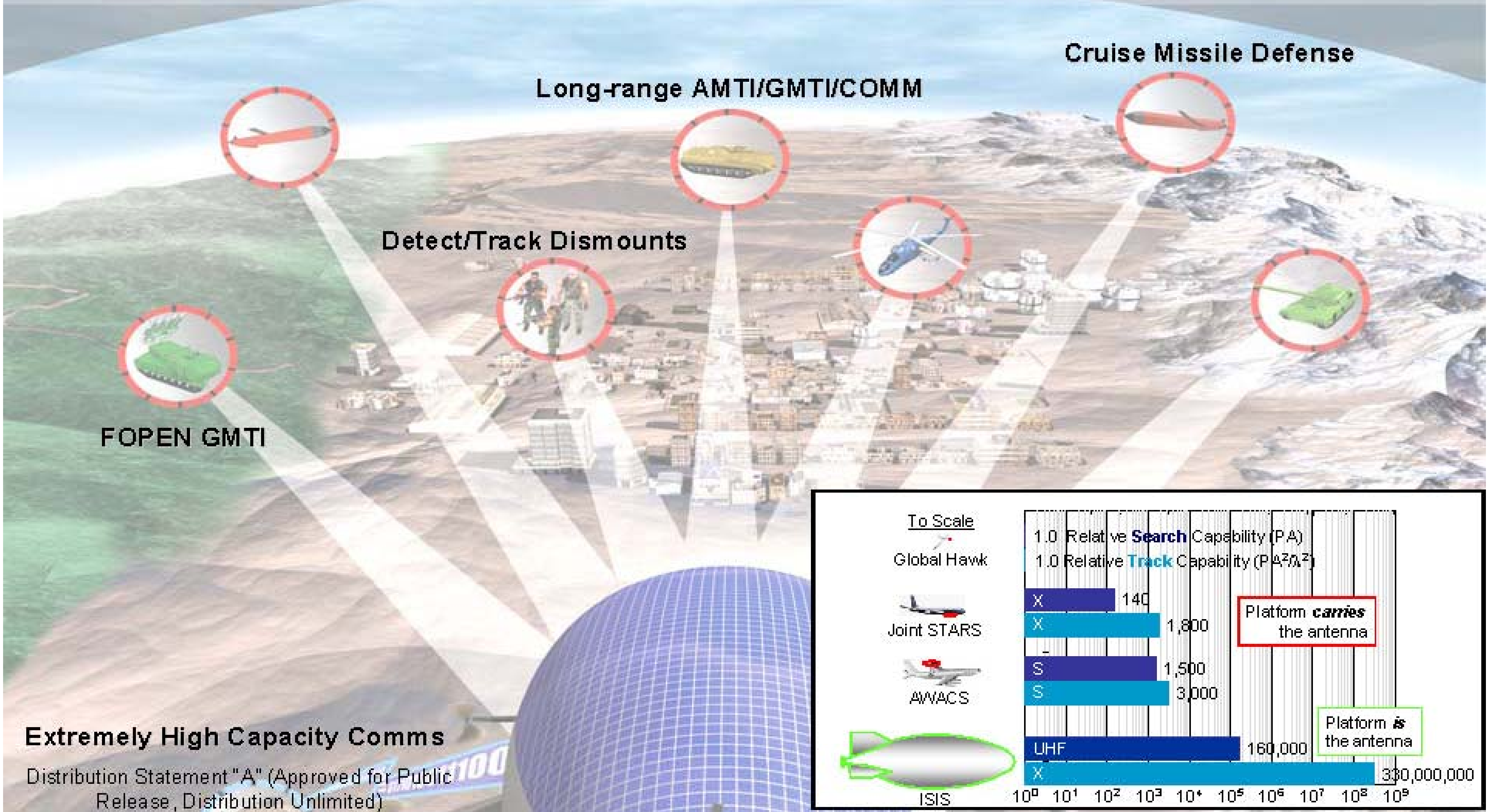
- Long endurance, persistent surveillance
  – Integrated Sensor is the Structure (ISIS)
  – Vulture
  – Rapid Eye

Integrated Sensor Is the Structure (ISIS)



Integrated Sensor Is the Structure (ISIS)

Simultaneous AMTI/GMTI Operation via Dual Band (UHF/X-Band) Aperture



Global Relocation <10 days – 600km Sensor Radius – No In-Theater Ground Support

10+ year Operational Lifetime – 99% Availability for 1 year

Integrated Airship-Radar

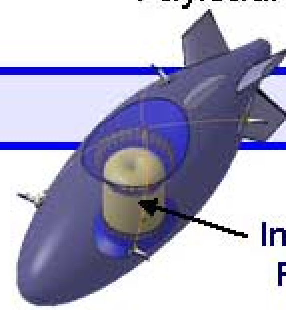
Conventional

Payload: 2-3% of system mass

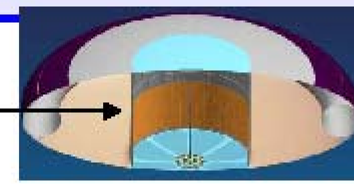
Payload bay

ISIS New Paradigm

Payload: >30% of system mass



Integrated Payload



Enabling Technologies	DARPA ISIS Accomplishments
Hull Material	• Improved lifetime by 10x while reducing fabric mass 4x over state-of-the-art
Active-Array Antenna	• Performance from size, not power • Removed heavy high power electronics, cooling • Removed structure: Flexible panels bonded onto pressure vessel • Low-power Transmit/Receive modules based on low-cost "cell phone" technology
Power System	• Solar-regenerative power with fuel cells instead of batteries • Airspeed: 60 knot sustained, 100 knot sprint

FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13

System Study

Technology Development

Scaled Prototype System Demonstration

SDD...

TRL 5
MRL 2

TRL 7
MRL 6

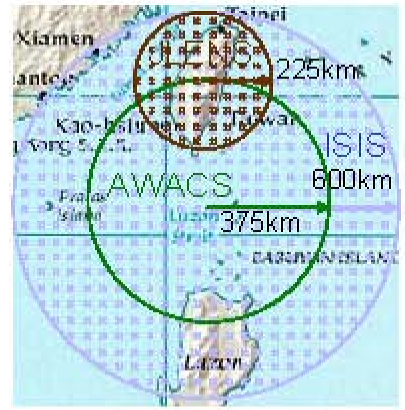
ISIS Critical Technologies

Addressing critical hardware technology needs	Achieved	
• Low areal-density advanced hull material		Mass
– Areal density $\leq$100 g/m^2	90.6 g/m^2	Mass
– Matrix glass transition temperature (T_G) $\leq$ -90°C	-101°C	Mass
– Fiber strength-to-weight $\geq$ 1000 kN·m/kg	1274 kN-m/kg	Mass
– Fiber retains >85% strength at 5 years	>85% at 22 years	Mass
• Lightweight, low-power density AESA		Mass
– Areal density $\leq$ 2 kg/m^2	1.8 kg/m^2	Mass
– Power consumption $\leq$ 5.0 W/m^2 on receive	4.7 W/m^2	Mass
– Bonded to hull material	Passed	Mass
• Extremely low-power Transmit-Receive modules		Power
– FOM $\geq 1\text{x}10^4$ W^{-2}	1.1 x 10^4 W^{-2}	Power
– Demonstrated TRL5 (MTTF >10^6 Hours)	MTTF >1.98x10^6 Hours	Power
• Novel power systems for stratospheric airships		Power
– Demonstrate 400 W-hr/kg regenerative system	779 W-hr/kg	Power

Single Integrated Picture

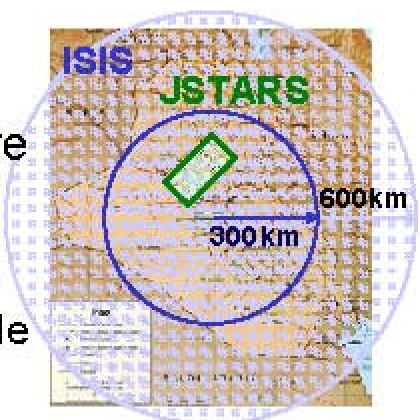
Complete Air Picture

- AWACS (70's) and E-2 (60's) – designed for hard targets of their day
- ISIS is designed for the theoretical limit at the radar horizon
  - Single-platform search, track, and fire-control



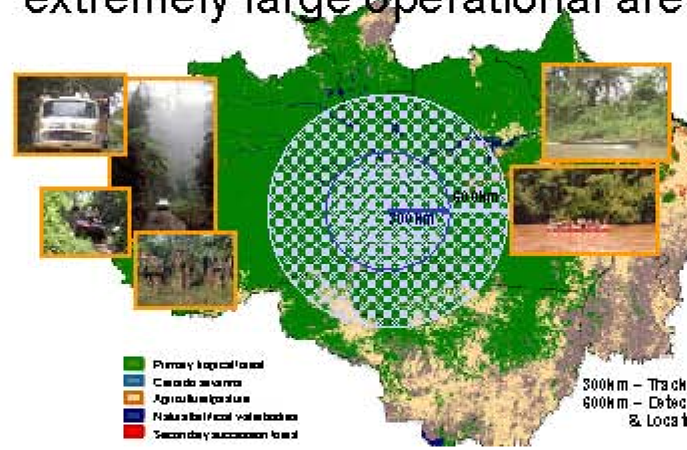
Unobscured Surface Target

- Joint STARS (70's) designed for tanks in the Fulda Gap
- ISIS is designed for dismounts across the entire Line-of-Sight
  - LSRS-like resolution
  - 300km @ 3° grazing angle
  - 600km line-of-sight



Wide-Area Foliage Penetration GMTI

- Joint STARS precision across an extremely large operational area



Distribution Statement "A" (Approved for Public Release, Distribution Unlimited)

No Forward-Based Logistics

- Forward-deployed aircraft-based ISR
  - Local air base
  - Multiple aircraft for single orbit
  - Air crews
  - Ground crews
  - Fuel supplies
  - Maintenance facilities
- CONUS-deployed ISIS
  - Unmanned
  - Launched from U.S. locations
  - Global deployment in 10 days
  - Regenerative fuel sources
  - Ten-year service life
  - Permanent CONUS ground station

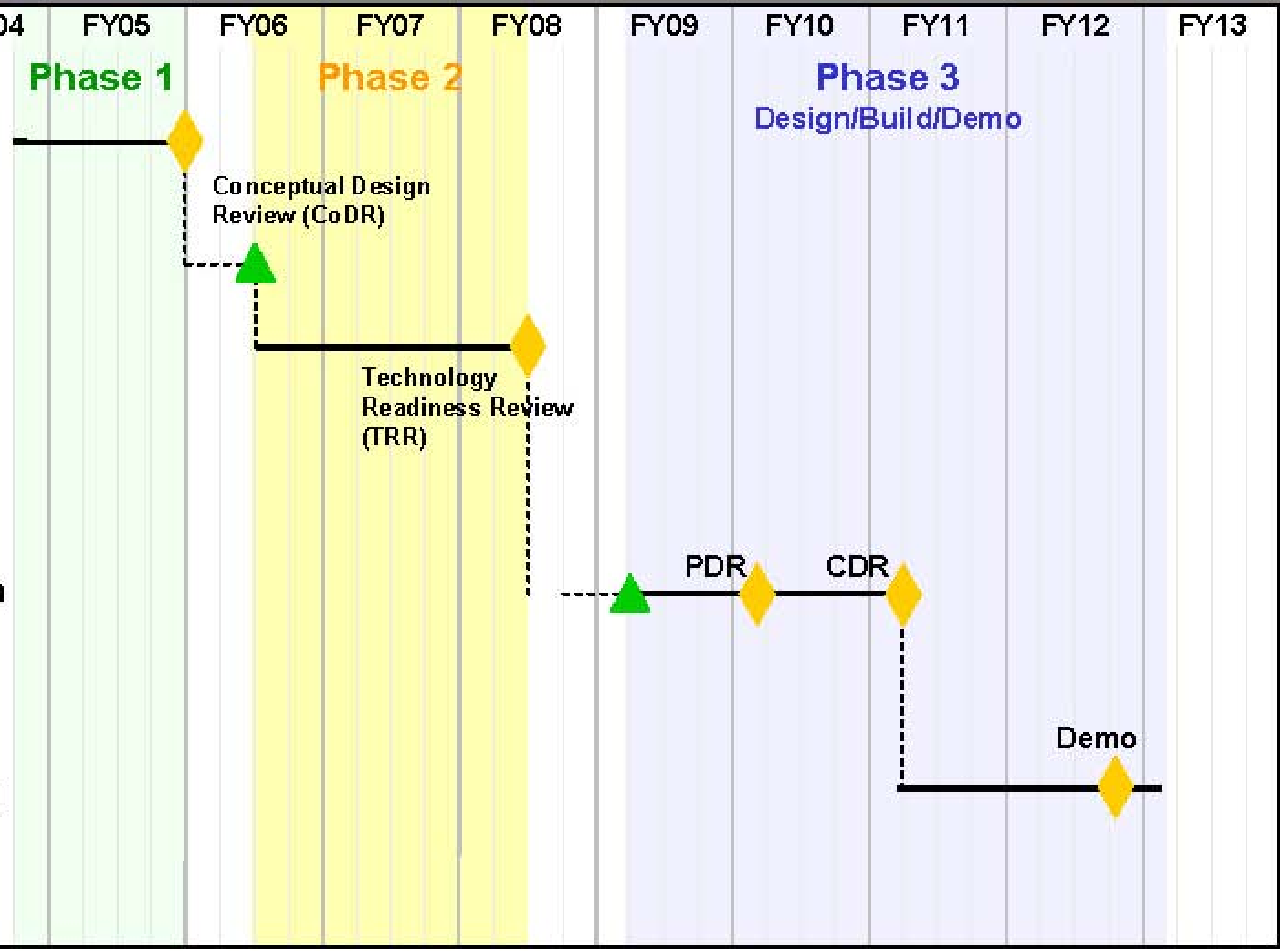
Multiply the cost delta by the number of AOI's and multiple platform types (JSTARS, AWACS, P-3, E-2C, etc)

Schedule

Phase 1: Feasibility Study
- Objective system design
- Technology requirements
- Sensor analysis

Phase 2: System Studies and Technology Development
- Continued objective system design
- Develop core technology

Phase 3: Demo System Design
- Demo system design
- Large-scale integration
- Hi-fidelity flight test simulation
- Demonstration system build
- Flight demonstration



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VULTURE

Program Goals and Objectives

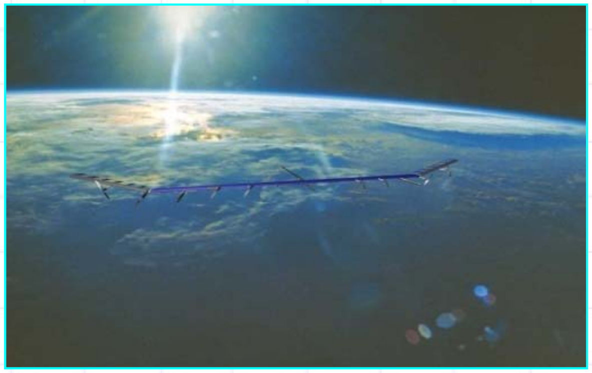
- Develop a high altitude, long endurance UAV that can maintain a 1000 lb, 5kW payload on-station continuously for 5 years

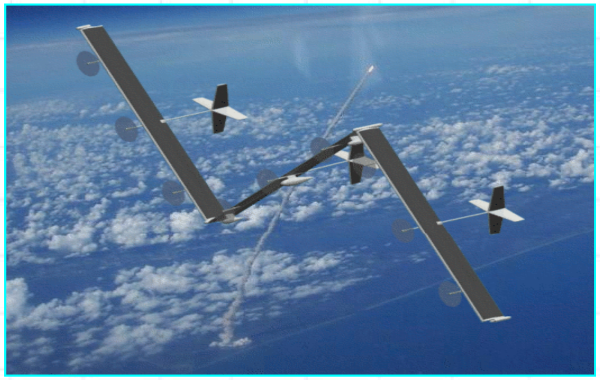
Technical Approach

- Satellite design paradigm with ultra reliability requirements
- Collecting, storing and dispersing solar electric energy
- High Lift/Drag (~40) – low mass fraction structures
- Efficient electric propulsion

Military Utility

- 24 / 7 / 366 persistence
- Very high resolution capability without large aperture sensors needed from space
- Reduced power required in pseudo-satellite role
- Flexible re-tasking/responsiveness
- No depot or foreign basing
- ‘Zero Maintenance foot print’
- Pre-deploy eliminates weather launch issues/reduces response time
- Decreased Cost and fleet size

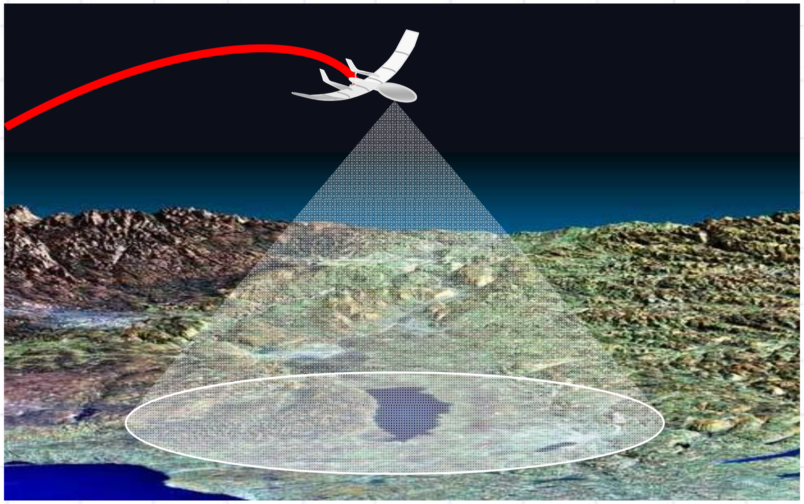




Rapid Eye

Program Objective and Goals

- Develop and demonstrate the ability to deliver a persistent intelligence surveillance and reconnaissance (ISR) capability anywhere on the globe within 1-2 hours
- Program goals:
  - Worldwide-delivery of ISR capability from alert pad < 2 orbits (~ 2 hours using existing solid rocket)
  - Use only two START-compliant launch sites
  - Aircraft time-on-station > 7 hours
  - Aircraft payload > 500 lbs, 5 kW



Technical Approach

- Conduct military utility and system-level design trade studies, and derive a technology maturation plan to culminate in a system flight test demonstration

Technical Challenges

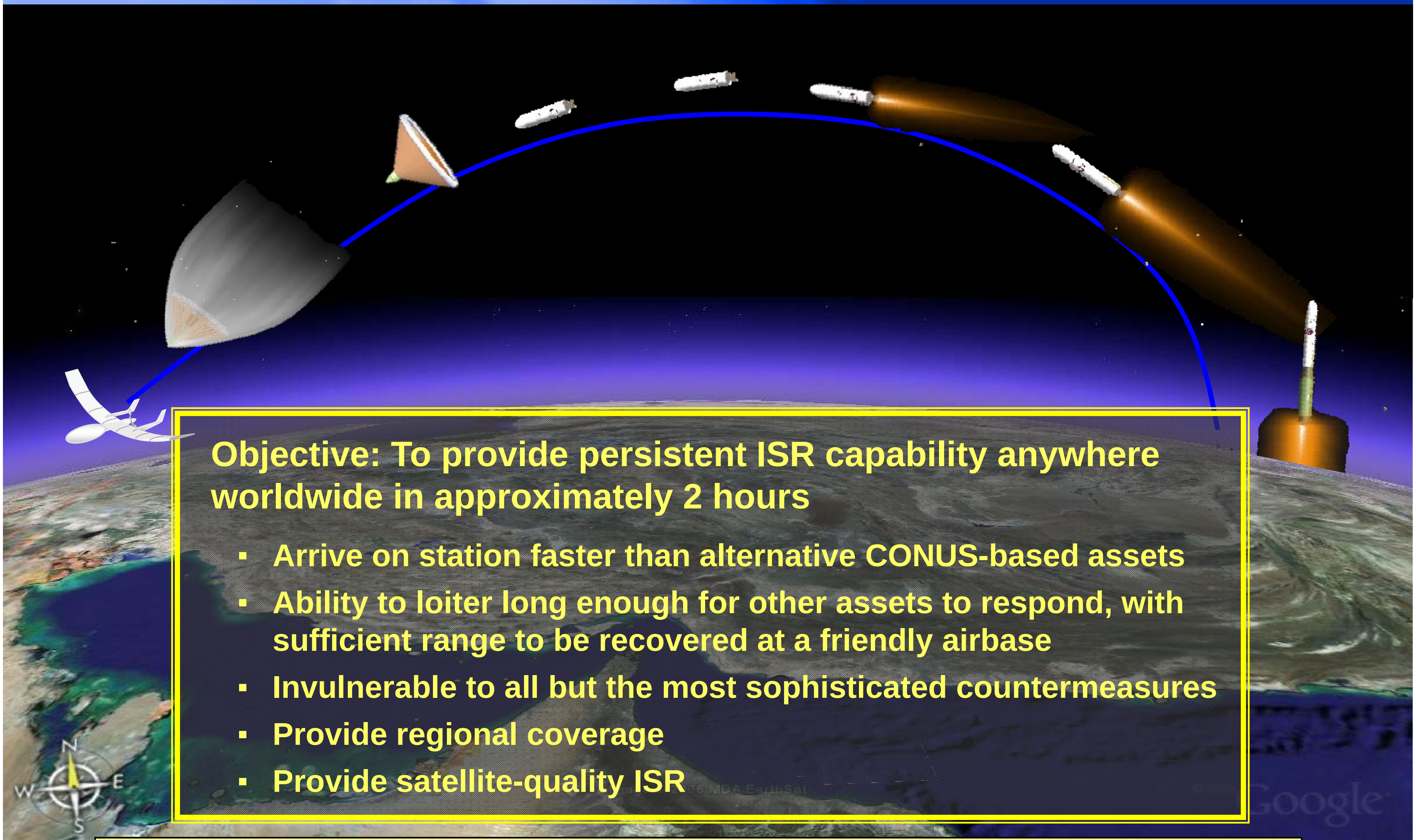
- Volume of stowed aircraft, deployable wings
- Deceleration at high altitude using inflatable aero-shield
- Propulsion suitable for >15 hrs at high altitude

Military Utility

- Provide an extremely rapid deployable ISR/C2 platform to surge capability until lower cost assets can be positioned
- Provide capability to enter denied airspace while avoiding border air defense

Rapid Eye

Bridging the ISR Deployment Gap



Objective: To provide persistent ISR capability anywhere worldwide in approximately 2 hours

- **Arrive on station faster than alternative CONUS-based assets**
- **Ability to loiter long enough for other assets to respond, with sufficient range to be recovered at a friendly airbase**
- **Invulnerable to all but the most sophisticated countermeasures**
- **Provide regional coverage**
- **Provide satellite-quality ISR**

Only one vehicle required to be anywhere in the world in ~ 2 hours

Current DARPA Programs

That support EUCOM/AFRICOM needs

- Networking/SA for Distributed Operations
  - UltraVis

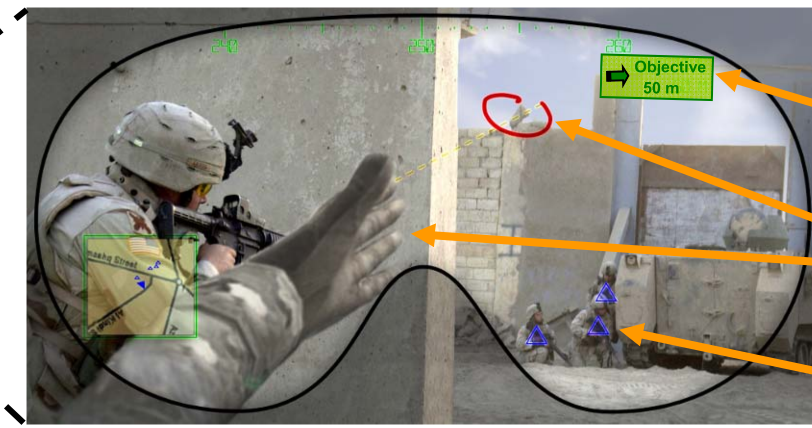
ULTRA-Vis
... A revolution in Small Unit C^2

Problem: ***Small unit coordination inadequate to conduct NLOS, Distributed Operations***

- Communicate by shouting
- Operate within earshot and LOS
- Radios hard to hear
- Stop to use handheld CDAs

Solution: **Interpret/disseminate/display time-critical combat information**

- while looking ahead, hands on weapon, and on the move



Revolutionary approach to small unit C2 and Situational Awareness at the lowest echelon for hand-off of *actionable combat information*

ULTRA-Vis Program Gates

Phase 1: Critical Technology Demonstrations

- Task a: Recognize hand and arm signals (gestures)
- Task b: Create/display geo-registered icons from different perspectives
- Task c: See icons in full sunlight conditions on see-through display
- Task d: Conduct system design trade study and CONOPS development

Phase 2: Multi-Modal Testbed Demonstrations

- Task a: Display icons in 3 colors (R-G-B)
- Task b: Integrate multi-modal testbeds for test and evaluation
- Task c: Support system test and evaluation

Phase 3: System Prototypes for Evaluation/Transition

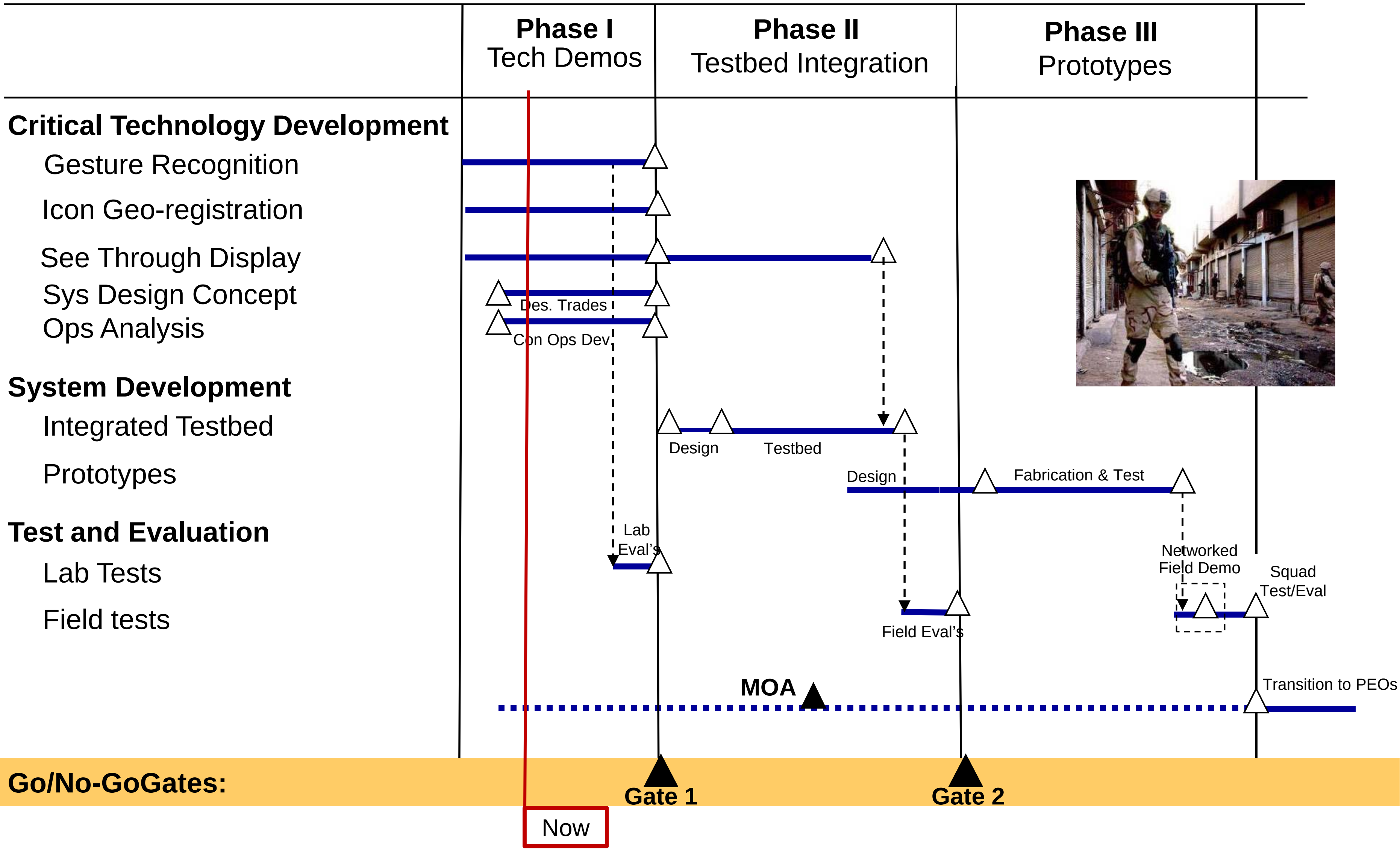
- Task a: Fabricate/test/demonstrate prototype units for transition
- Task b: Support Service field evaluation

ULTRAVIS

ULTRA-Vis Gate Metrics

Phase	Gate Rqmt	Operational Metric	Go/No-Go Criteria
1	**Gesture Recognition**	Recognize Leader’s Standard Hand & Arm Signals	> 99% probability of correct recognition of at least 10 hand & arm signals < 1% False Alarms
	Geo-Registered Icons	Create/display geo-registered icons from Leader’s pointing action on two see-thru displays	Placement Accuracy: < 10 mrad, angular accuracy (1m @100 m) < 0.1 m, range accuracy < 0.5 mrad, jitter @ 60 Hz update
	See-Thru Display	See icons (monochrome) in full sunlight	≥2000 Ft-L brightness (monochrome) 40° FOV
2	**Integrated Multi-Modal Testbed**	Create/disseminate command information using two, networked, Soldier-worn Testbeds with: - Head-Mounted Display - Navigation units - Audio interface (mic/headset) - Voice/Data Radio - Hand/Arm gesture interface - Tactile Cueing device	3-color (R-G-B) icons, ≥2000 Ft-L, 40° FOV > 99% probability of correct recognition (sender) and representation (receiver) of multi-modal commands (hand/arm gestures + voice) < 1% False Alarms
3	**Prototypes**	Demonstrate system functionality with fifteen (15) prototypes for Transition	System weight (including battery): < 3 lbs System power: < 6 W

ULTRA-Vis Program Schedule



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USMC SharePoint site

- *Info about unclas programs*
- *Collaborative site to interact with others in the USMC S&T community*
- *Calendar of upcoming events*
- *Weekly Activity Reports (WAR)*
- *Contact info for PM's*
- *To request access, send e-mail to: thomas.moore@darpa.mil or stephen.urban.ctr@darpa.mil*

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