Innovating for the Future

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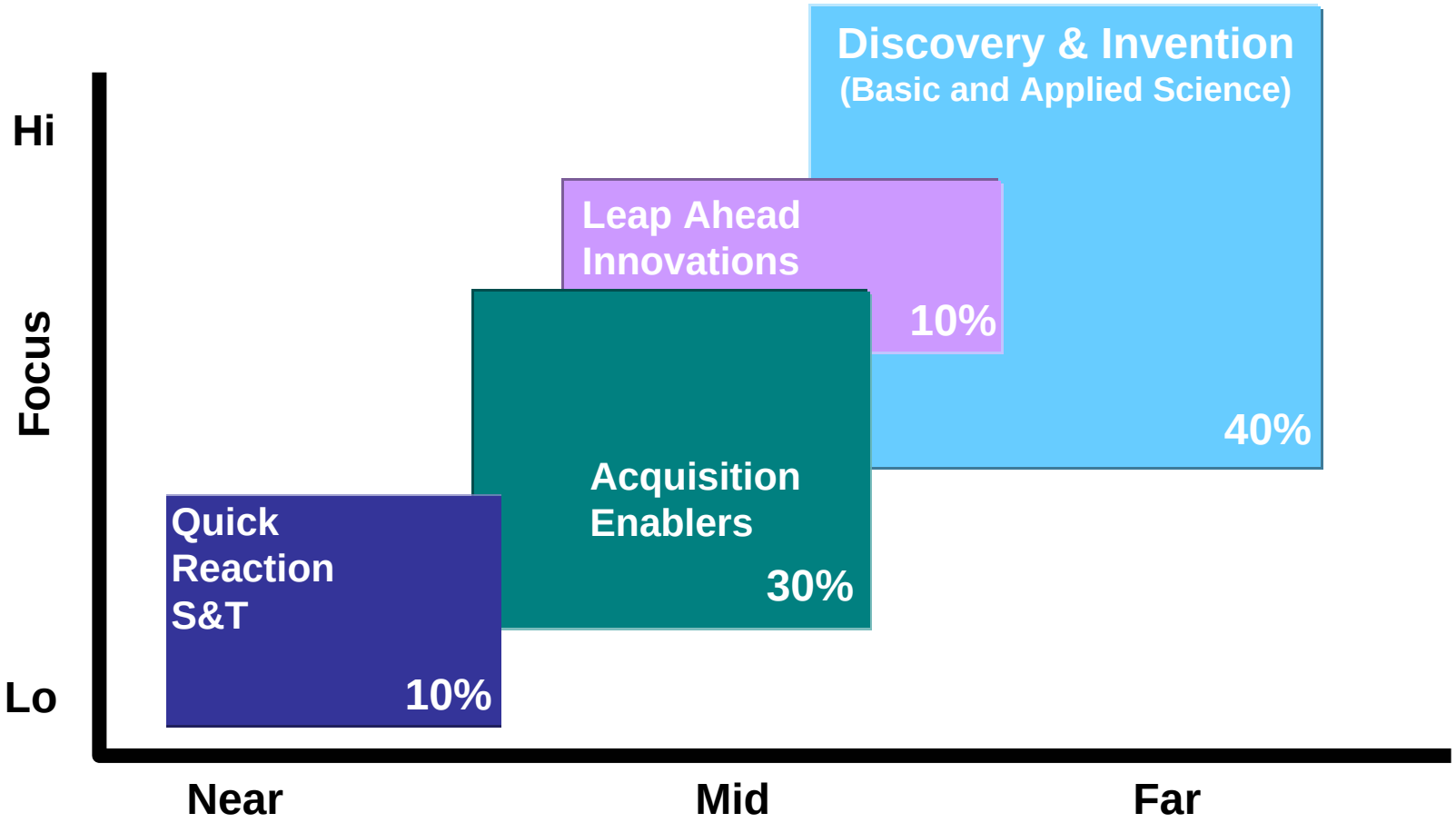
DoN Investment Portfolio



S&T occurs across the Time Horizon. DOI focuses on Quick Reaction and Leap Ahead.

Current Innovative Naval Prototypes

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- High risk, high payoff
- Mix of weapons, platforms and sensors
- $10-$50M/yr, 4-8 year efforts

Current INPs

EMRG

SBE

TACSAT

PLUS

FY-10 INPs

FEL

INT TOPSIDE

- What alternate futures can these INPs enable?
- What disruptive guidance should we adopt for future INPs?

Integrated Topside INP

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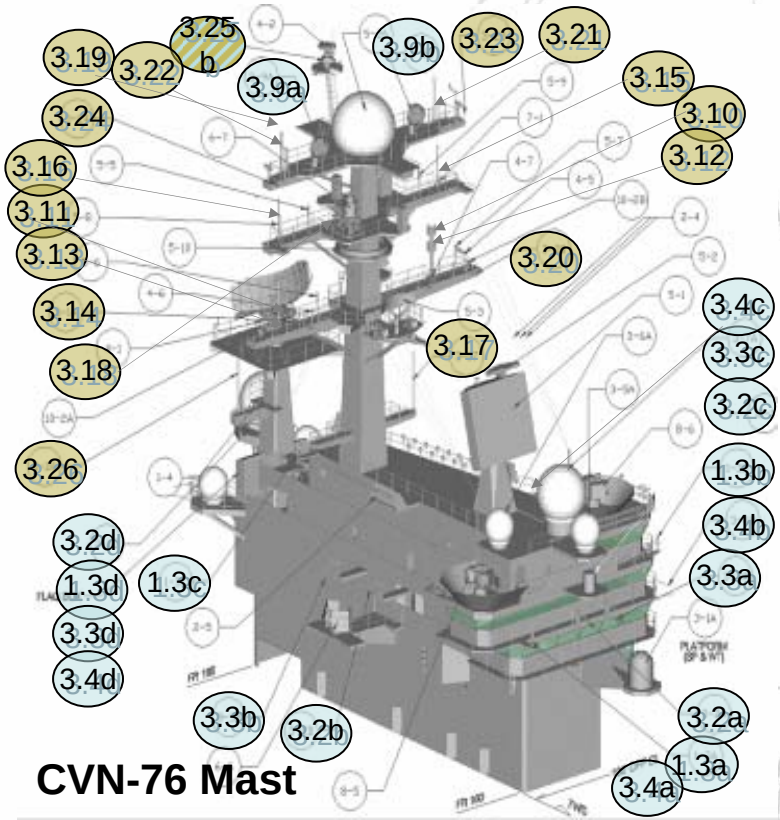
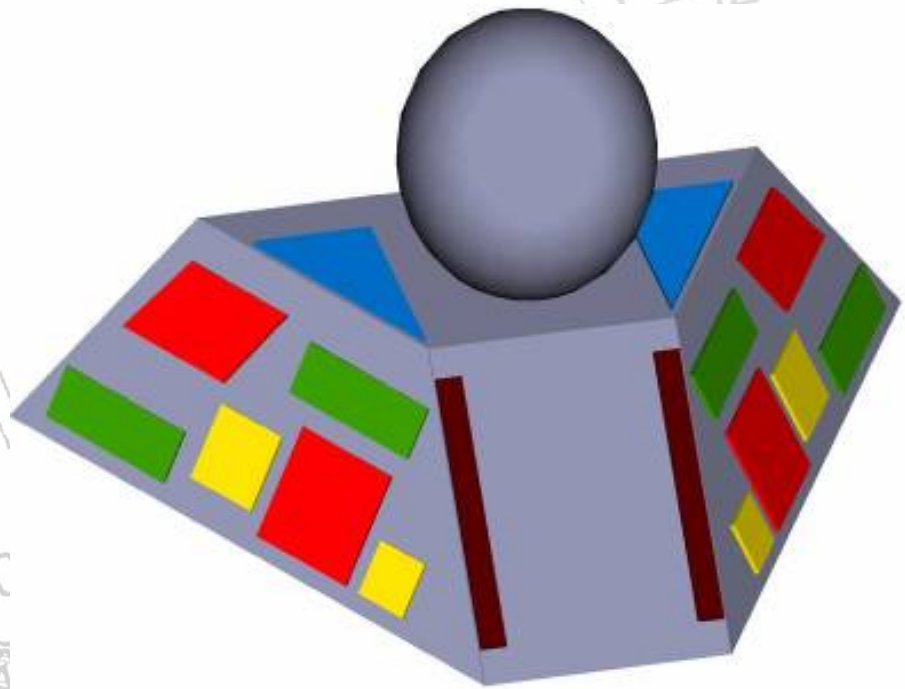


CVN-76 Mast

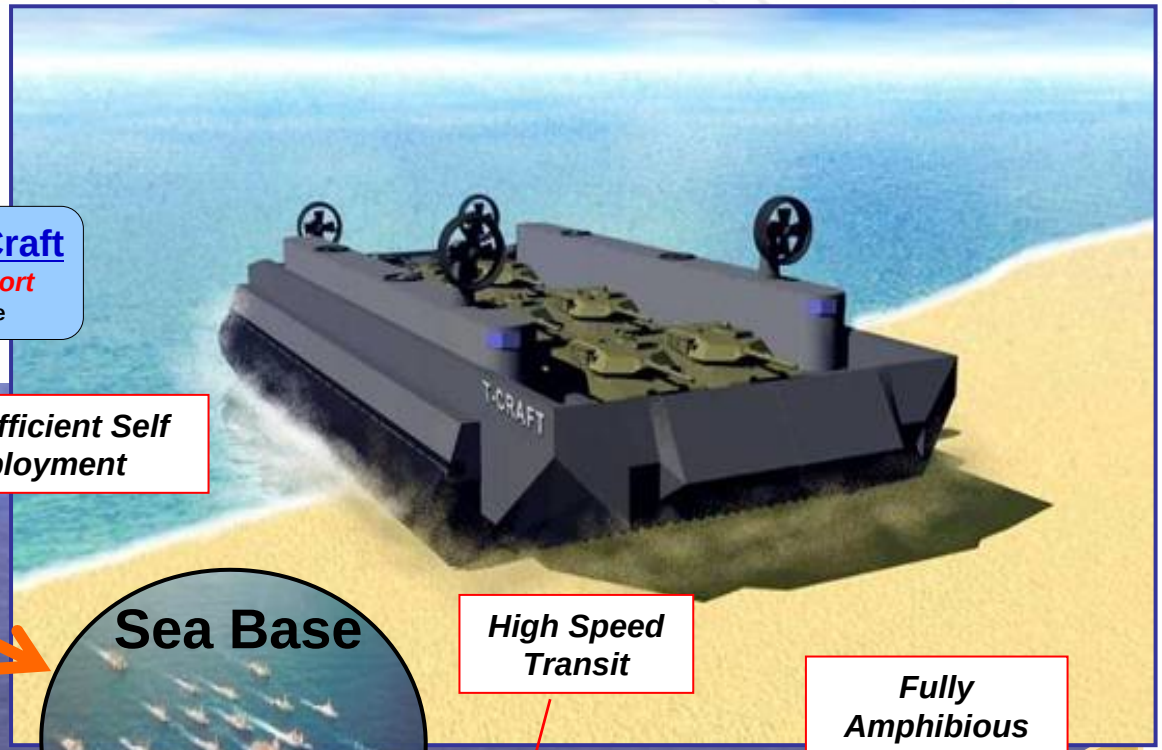


46 to 51 antennas
> 3500 pounds (Ant. Only)

NEW

4 panels , 20 meters ^{2}
< 1800 pounds

Seabasing Enablers INP



T-Craft

Multi-Mode Vehicle Delivery Craft

T-Craft: High Speed Beach-able Transport

40kt in SS-4 with beaching & amphibious mode

ISB

Fuel Efficient Self Deployment

Sea Base

High Speed Transit

Fully Amphibious

2000 – 2500nm

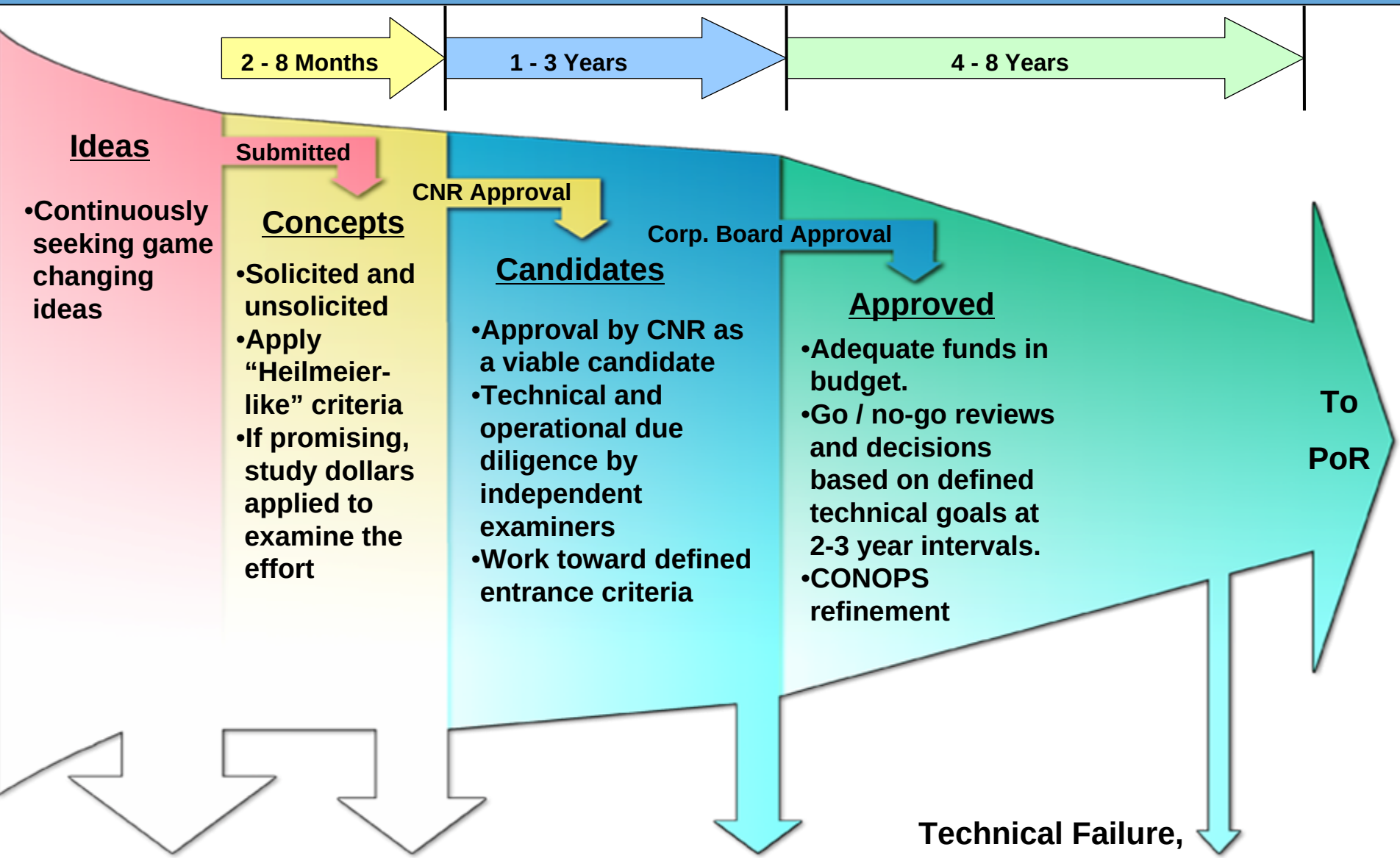
T-Craft Payload Capacity: Between 4 and 10 M1 Tanks

Good Seakeeping Mode at the Sea Base

25 – 250nm

OBJECTIVE

Going From Idea to INP



What's the Next Big Bet?
Potential FY-12 INP Candidates

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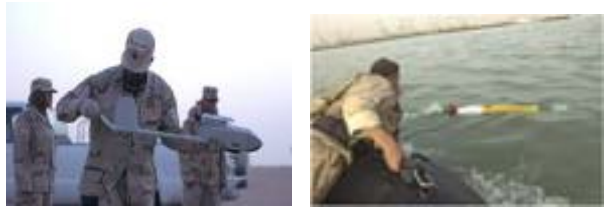
- **Autonomous & distributed electronic warfare capabilities**
- **Autonomous cargo/medevac UAV**
- **Autonomous Damage Control Technologies**
- **Maintenance-free ship/aircraft**
- **Electric ship/submarine**
- **High bandwidth communications with submerged submarines and UUVs**
- **Intense/Immersive simulation training**
- **Unmanned Vehicle Sentry System**
- **Land, air, surface and sub-surface vehicles**
- **UUV for ASW training**
- **Ship-board Autonomous Logistics Enablers**

Most are Autonomous in nature, which is the most game changing?
Which will change how we fight?

What's Holding Us Back?
Limitations of Current Autonomous Systems

-Require multiple operators
-Cannot easily share assets or collaborate



-Forward units need dedicated operators (require protection)
-Data hard to disseminate

-Require human intervention to maintain performance

-Autonomy tailored for specific missions, users, and environments
-Reliance on pre-programmed plans
-Tough to adapt

-Not as smart as animals
-Limitations in challenging weather
-Cannot exploit environmental conditions
-Cannot navigate without GPS & reliable maps
-Cannot collaborate in close proximity to others

What should we fix? In what order?

Ultimately, where are we going?

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- Distributed system relying on decentralized control that is flexible in its level of autonomy
- Hybrid force with manned systems and platforms
- Automated image/scene understanding, data gathering, purposeful sensing/seeking, information analysis and distributed information management
- Cooperation to perform a mission or task
- Automated distribution of tasks
- Autonomous determination of the best way to accomplish each task, with appropriate human guidance

Why Autonomous Behavior is a Hard Problem

Constrained by size, weight, power, money

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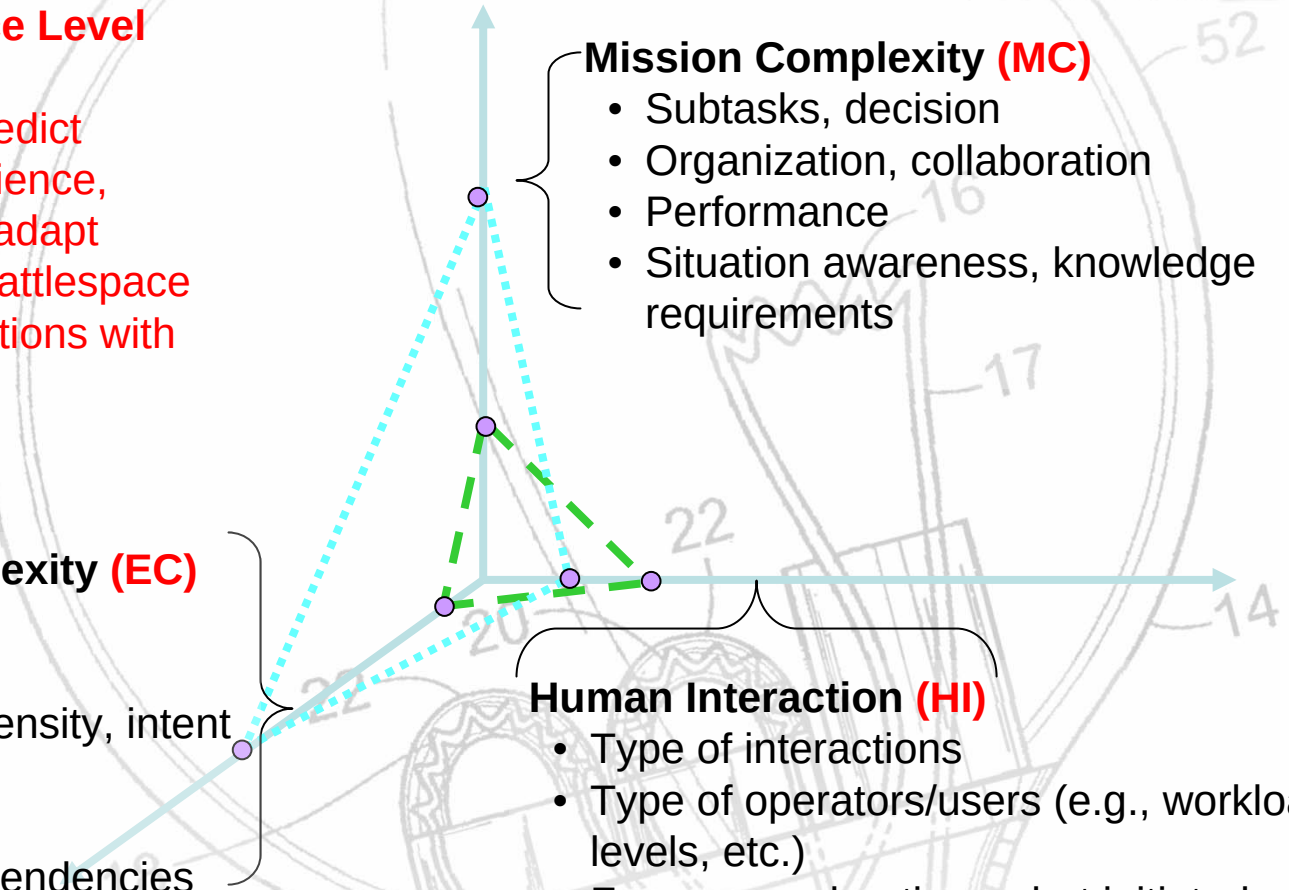
Machine Intelligence Level

Ability to:

- Reason, Plan, Predict
- Learn from experience, instructions, and adapt Understand the battlespace
- High-level interactions with humans



Mission Complexity (MC)

- Subtasks, decision
- Organization, collaboration
- Performance
- Situation awareness, knowledge requirements

Environmental Complexity (EC)

Solution ratios on:

- Terrain variation
- Object frequency, density, intent
- Weather
- Mobility constraints
- Communication dependencies

Human Interaction (HI)

- Type of interactions
- Type of operators/users (e.g., workload, skill levels, etc.)
- Frequency, duration, robot initiated interactions

Autonomy Level required is driven by EC, MC, HI

Benchmark for Autonomous Systems? Assembly Line Robotics

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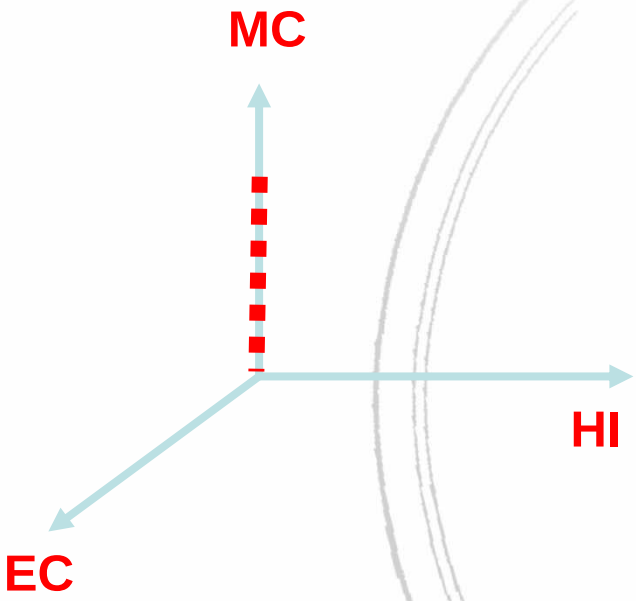
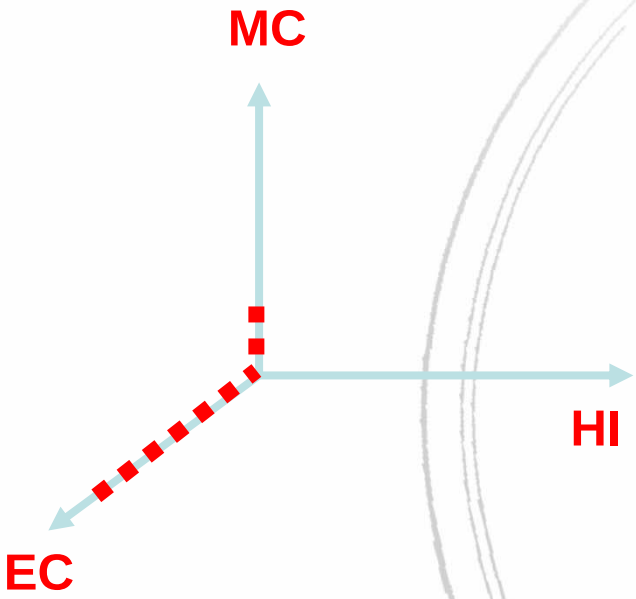


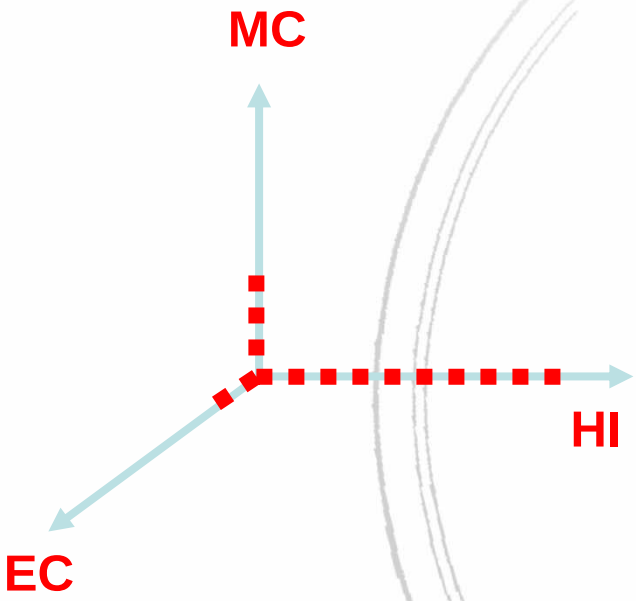
- Complex mission
- Well known environment
- No Human interaction
- Better than a human at the task
- Thousands of iterations to get it right

DARPA Grand Challenge - UGV



- Tougher Environment than underwater or air
- No Human Interaction
- Controlled Mission Complexity by reducing speed
  - About 15% as effective as a human
- In use on Mars – where no man has been

UAV Mission: Find, observe, kill



- Obvious crawl, walk, run road ahead
- Complex mission driven by high human interaction
- Lots of other missions ripe for unmanned air vehicle

UAV Focus To Date Has Been on Large Systems

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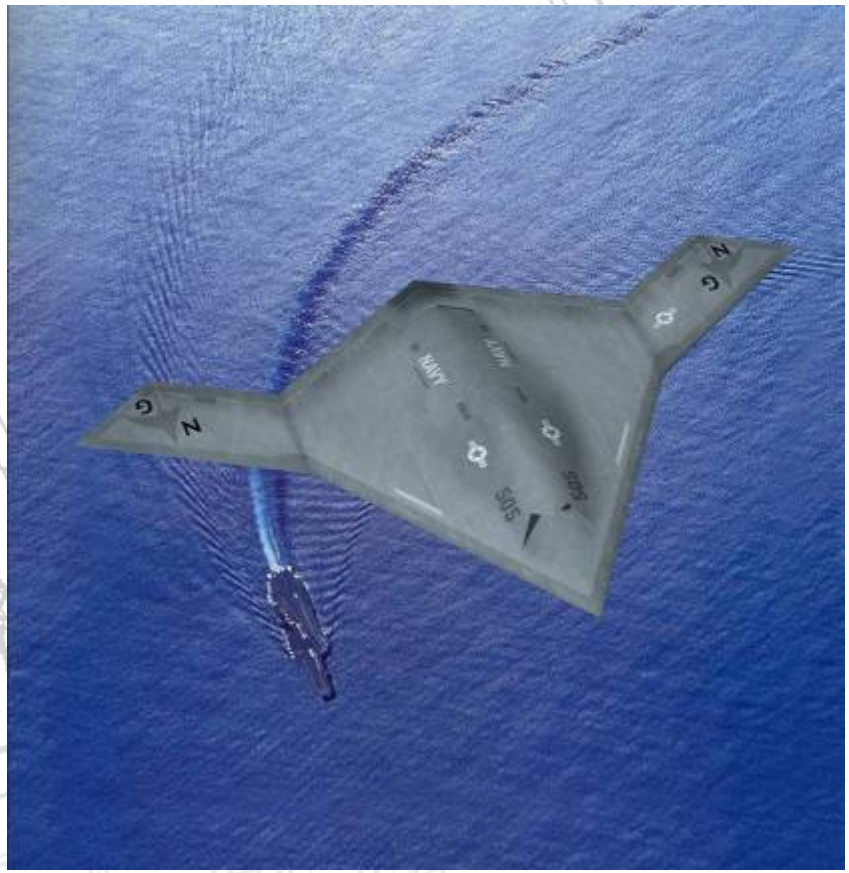
- Consider future of small UAVs (<50lb)
  - Missions these systems are uniquely qualified to address
  - Cheaper
  - Decoy cost, expendable

Global Hawk

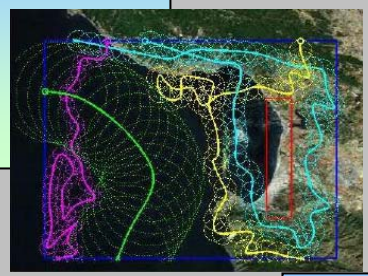


N-UCAS

UAV S&T Autonomy Roadmap & Goals

Guidance & Control
- Shipboard Landing
- Autonomous Maneuvering

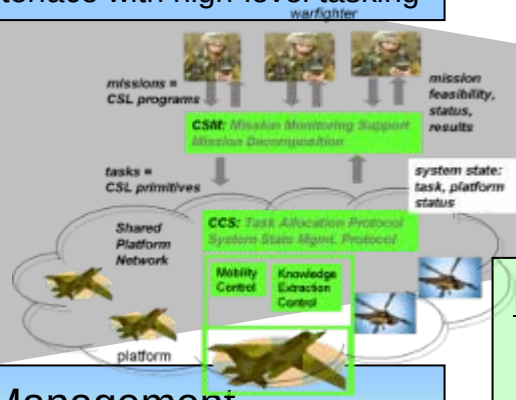
Automated Tasking
- Search Planning
- Convoy Protection
- Reconnaissance
- Small numbers of multiple systems



Maritime Video
- Automated capability to detect and track multiple targets
- Address small boat threat

Silver Fox
- Small UAV with traditional auto-pilot for control
- Limited operational eval

Support of Small Expeditionary Units
- Distributed control of multiple air systems
- Simplified interface with high-level tasking



Airspace Management
- Planning & human interface technologies

Shipboard Operations
- Control & human interaction approaches for autonomous deck operations

Robustness to Weather
- Small UAS control in Challenging weather conditions
- Increase endurance taking advantage of atmospheric effects

Safe Operations
- More like manned aircraft ops for naval missions & environments

Distributed Control of Large Numbers of Small Systems
- Control of Expendable UAS Systems that can be Mass Produced & Deployed in Great Numbers

Past 10 Years | **Current Efforts** | **2025**

USV Mission

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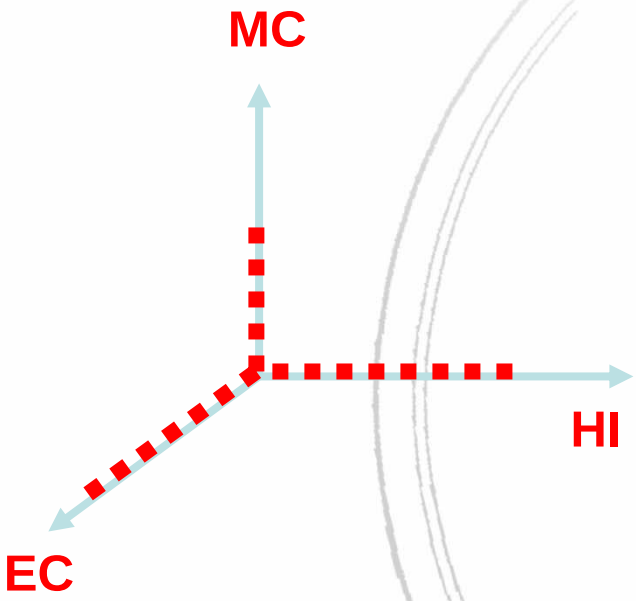

- **Tough environment**
  - **Sea state**
  - **Obstacle avoidance**
- **Range of missions to mitigate need for human interaction**

Unmanned Surface Vehicle

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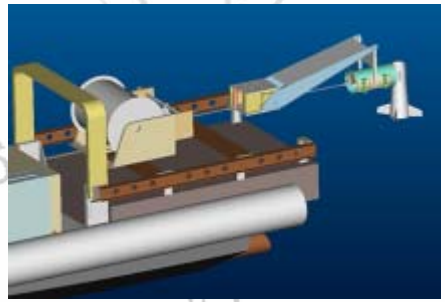
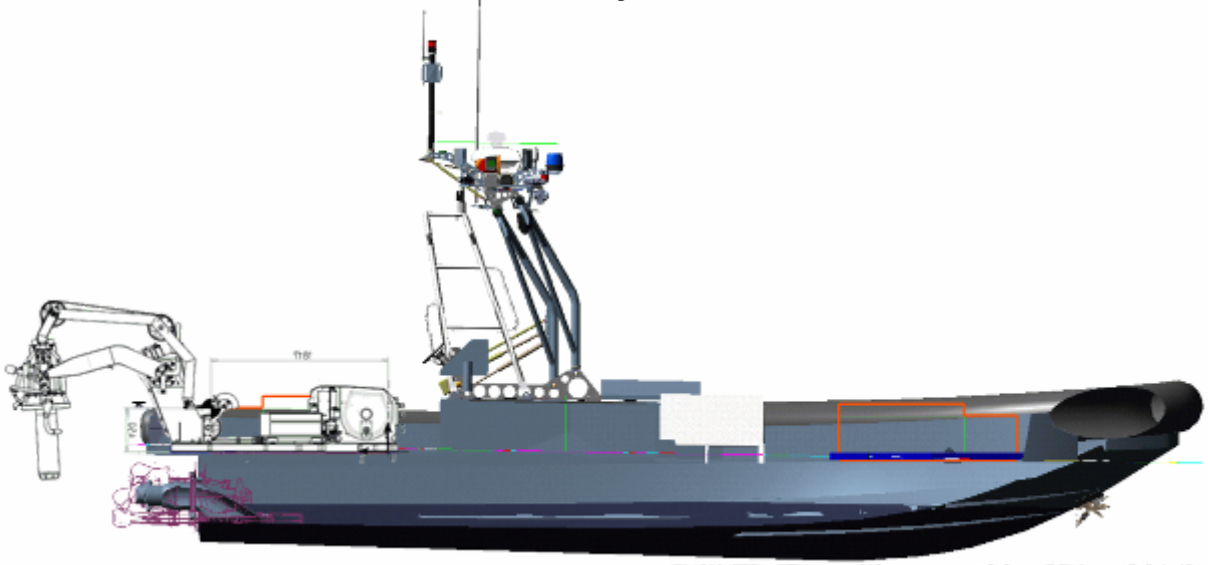
- Mine Warfare Mission Module
  - Mine Neutralization using Electromagnetic and Acoustic Sweep
- Antisubmarine Warfare Mission Module
  - Detection and Localization using
    - Airborne Low Frequency Sonar (ALFS)
    - Multifunctional Towed Array



Deploy & Retrieve:
Automated Handling of Influence Sweep

Acoustic Sweep:
Generates Subsurface Acoustic Influence Field

ALFS



USV Autonomy

Adapted Autonomy

- Adapt submarine periscope sensing & image processing

Adapt Jet Propulsion Lab Autonomy technology to USVs

Perception-Based Navigation

- Stereo camera-based, autonomous avoidance of fixed obstacles at boat speeds up to 25 kts
- Perception-based Navigation through bridge abutments

Multi-Vehicle Collaboration

- Multi-mission
- Multi-domain
- Persistent
- Scaleable
- Adaptable
- Affordable

USSV

- On-board auto-route generation via nav charts and GPS

Transitioned to LCS

- Part of the ONR-developed "MCM-USV"
- Part of MIW mission package #1 – USS FREEDOM

Tracking

- Recognition & tracking of a sailboat

Past 10 Years **Current Efforts** **2025**

UUV Autonomy

Maritime Reconnaissance
- Perform autonomous surveillance in littoral regions
- Torpedo-size underwater vehicle with ISR payload

MCM
- Area search, classify & map rates for mines in littoral regions
- Cooperative autonomous underwater vehicles with high resolution sonars

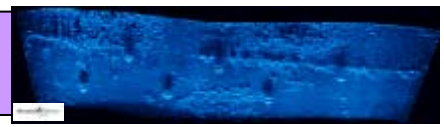
Ocean Surveillance
- Networks of undersea gliders with oceanographic and acoustic sensors

Unmanned Cooperative Cueing and Intervention
- Rapid (< 5 days)
- Standoff MCM target mapping

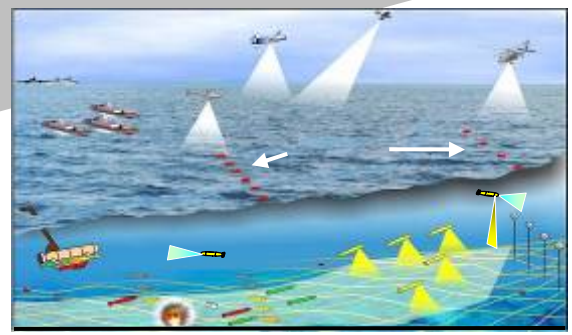
Undersea Surveillance
- Large area surveillance using autonomous unmanned vehicles to achieve undersea superiority of the designated battle space

Littoral ASW
- Use autonomous Unmanned Undersea Vehicles to support tactical anti submarine warfare

Harbor & Port Security
-Hull Inspection



Multi-Platform, Multi-Static, Distributed UUV
- Autonomous, self-deployable, heterogeneous, multi-platform, system capable of rapidly detecting, identifying mines, subs over wide areas
- Goal-oriented collaborative/ adaptive autonomy, multi-objective optimization & distributed control of large teams.



Past 10 Years **Current Efforts** **2025**

Takeaway Challenge

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- What are the missions that Autonomous systems will be better suited for?
  - Only extraterrestrial?
  - Only shop floor?
- What are the capabilities we would need?
- What manned platforms could we stop using?
  - 5 year plan
  - 10 year objective
  - 30 year ambition
- I look forward to your thoughts
  - larry.schuette@navy.mil