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

- 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

CVN-76 Mast

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

NEW

4 panels, 20 meters
< 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

Fuel Efficient Self Deployment

Sea Base

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

Good Seakeeping Mode at the Sea Base

2000 – 2500nm

High Speed Transit

Fully Amphibious

25 – 250nm

OBJECTIVE
Going From Idea to INP

- Solicited and unsolicited
- Apply “Heilmeier-like” criteria
- If promising, study dollars applied to examine the effort

- Approval by CNR as a viable candidate
- Technical and operational due diligence by independent examiners
- Work toward defined entrance criteria

- Adequate funds in budget.
- Go / no-go reviews and decisions based on defined technical goals at 2-3 year intervals.
- CONOPS refinement

- Rejected, delayed, or referred to another process
- Technical Failure, Change in Priorities

- Ideas
  - Continuously seeking game changing ideas

- Concepts
  - Submitted
  - CNR Approval

- Candidates
  - Corp. Board Approval

- Approved
  - To PoR
What’s the Next Big Bet?  
Potential FY-12 INP Candidates

- 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?

- 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

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

- 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

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

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

**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

**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**
- Maritime Video
- Robustness to Weather

**Current Efforts**
- Guidance & Control
- Automated Tasking
- Maritime Video
- Silver Fox

**2025**
- Support of Small Expeditionary Units
- Safe Operations
- Airspace Management
- Shipboard Operations
- Distributed Control of Large Numbers of Small Systems
USV Mission

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

- 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
USV Autonomy

Adapted Autonomy
- Adapt submarine periscope sensing & image processing
- Adapt Jet Propulsion Lab Autonomy technology to USVs

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

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

Tracking
- Recognition & tracking of a sailboat

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

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.
Takeaway Challenge

• 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
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