Robodata
Unmanned System Data Archives

Project Support for JIFX and CRUSER

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10 August 2016

Overview

Objectives

Background

- Bootstrap a short course to expose initial capabilities, if approved
- Evaluate course suitability, provide recommendations for further work

Current

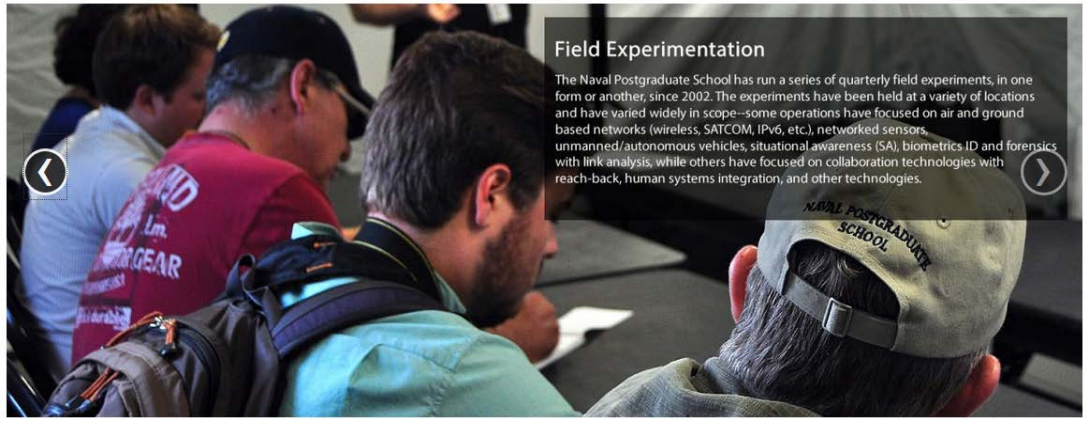
- Scale across/outside campus to support JIFX experimentation, Camp Roberts
- Build a growing institutional data archive

Long term

- Ensure that every NPS experiment with unmanned systems is archived and reusable
- Enable steadily improving analysis, insights, applications and data-driven progress
- Influence, align with broader DoD and scientific practice

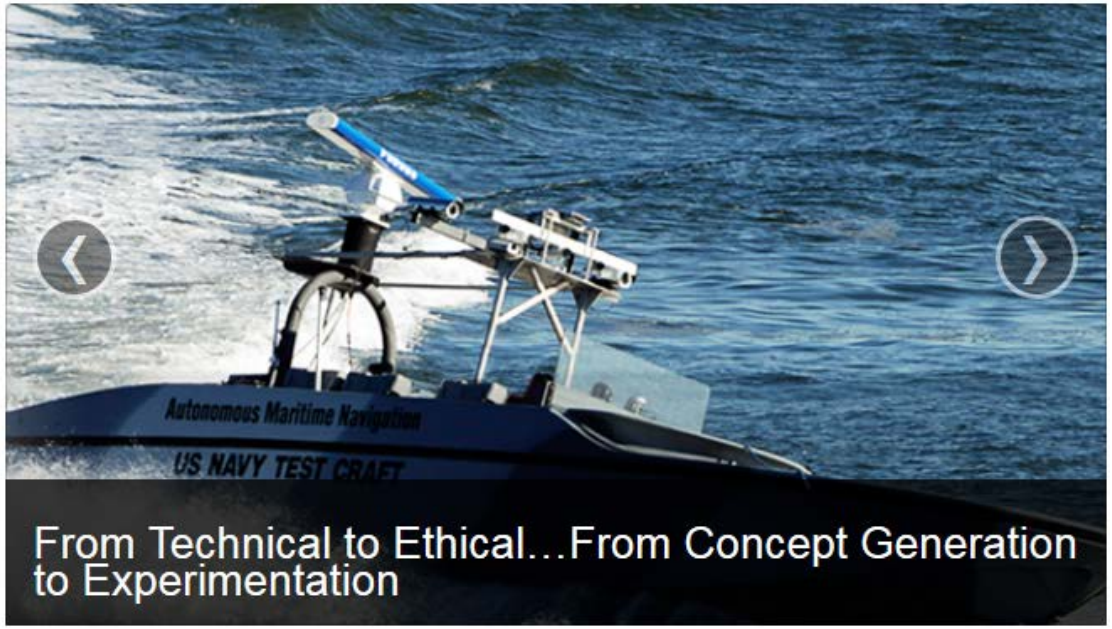
JIFX: Joint Interagency Field Experimentation

- Held quarterly, usually at Camp Roberts
- Run robots in controlled airspace/playpen
- Open to industry and external academia, each self supporting
- Experimentation, not exercise: includes freedom to fail and learn
- Established ~5-year program with DoD sponsorship
- Closely affiliated with CRUSER



CRUSER

- Consortium for Robotics and Unmanned Systems Education and Research (cruser.nps.edu)
- NPS leverages long-standing experience and expertise in research and education of robotics and unmanned systems to support the Navy's mission.
- CRUSER serves to align disparate research efforts and also integrate academic courses across disciplinary boundaries.



Establishing New NPS Capabilities

… by applying an operational system from MBARI

MBARI Monterey Bay Aquarium Research Institute

A nonprofit oceanographic research center

STOQS

Spatial Temporal Oceanographic Query System

Inputs

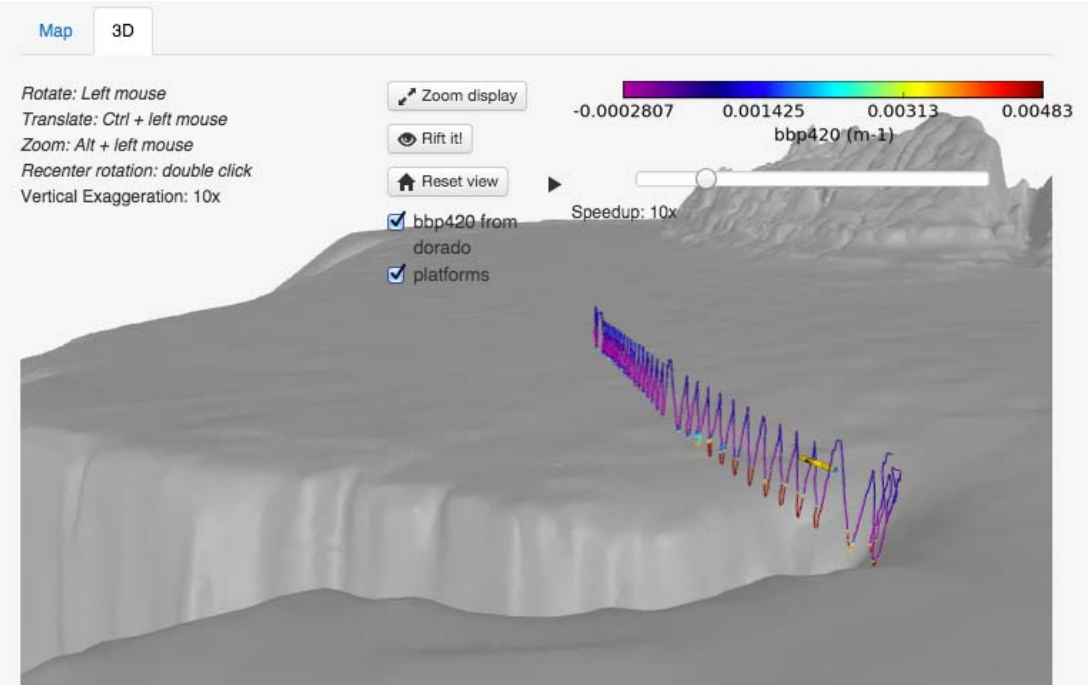
- Diverse robots, sensors and systems
- Collected air, surface, subsurface data
- Precise metadata tags, scientific terms

Outputs

- Queries, filters and mashups
- Data plots, 2D maps, 3D views

Learn more

- STOQS home page and paper
- STOQS overview video
- Online query and open source



Can view 3D flythrough in Web browser

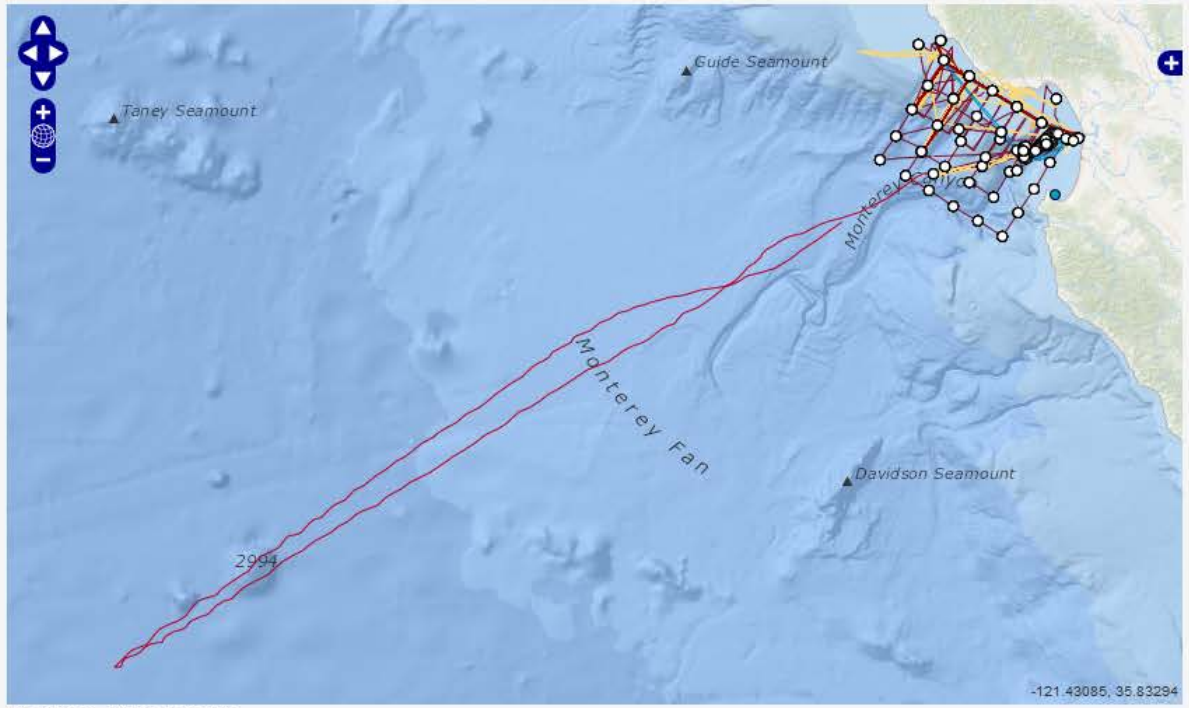

M B A R I
0:27 / 2:48

stoqs.mbari.org:8000/stoqs_canon_september2015/query/

MBARI stoqs_canon_september2015 | Campaign list | Share this view | STOQS Software

Spatial

Map | 3D



Zoom to extent on update

Metadata: about 21,303,321 data values - 2.688 seconds

Parameter-Parameter Clear Selection

Measured Parameter Data Access

Temporal: 2015-09-09 20:11:46 to 2015-10-16 00:00:00 Clear Selection

Depth: -4.04 to 1002 | Parameter

Click and drag to zoom

Measured Parameters Clear Selection

Parameter Values Clear Selection

Platforms Clear Selection

auv

- daphne
- dorado
- tethys

glider

- SPRAY_L66_Glider

mooring

- M1_Mooring
- OA1_Mooring

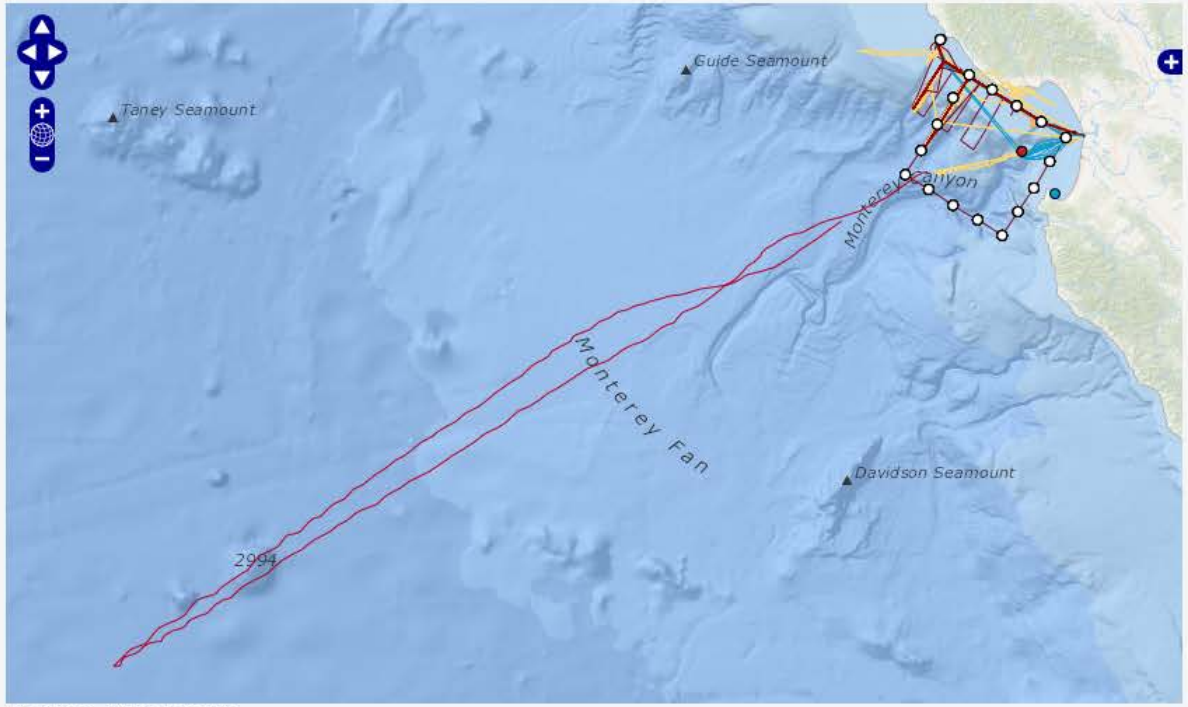
Can view 2D maps and data graphs

stoqs.mbari.org:8000/stoqs_canon_september2015/query/

MBARI stoqs_canon_september2015 | Campaign list | Share this view | STOQS Software

Spatial

Map 3D



Zoom to extent on update

Metadata: about 18,339,297 data values - 11.322 seconds

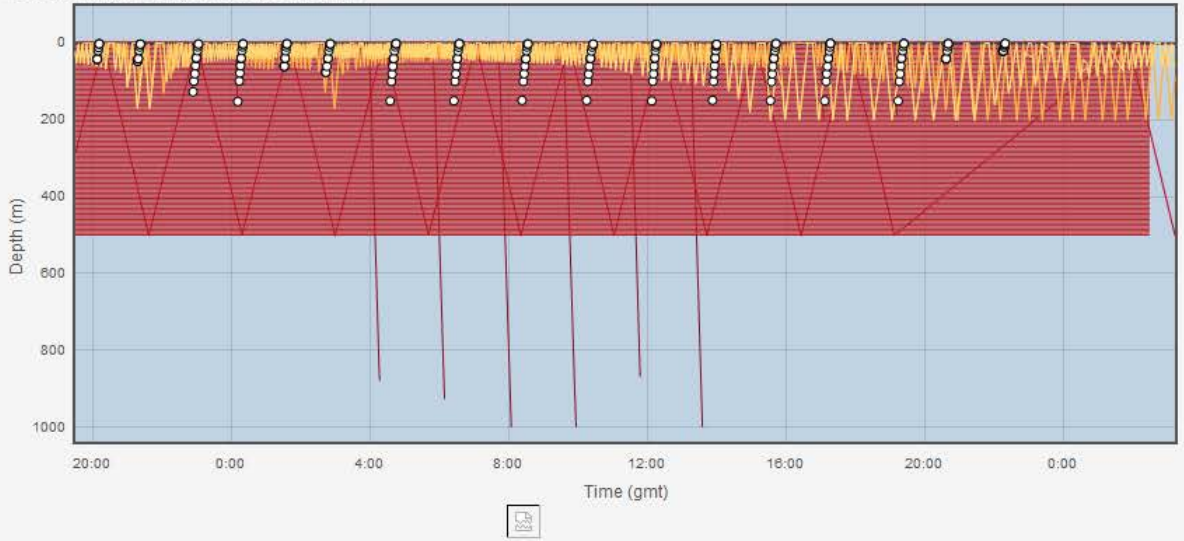
Parameter-Parameter Clear Selection

Measured Parameter Data Access

Temporal: 2015-09-30 19:29:48 to 2015-10-02 03:13:56 Clear Selection

Depth: -96.46 to 1037.94 Parameter

Click and drag to zoom, right-click to un-zoom



Measured Parameters Clear Selection

Show Parameter-Parameter Show coordinates Filtered out parameters Standard Names

Filter & Select for data access

Plot Data

Clear Selection

air_temp

AIR_TEMPERATURE_HR

altitude

atm_press

avg_wind_spd

bb470

bb_470

bb_650

bb676

Web-based queries can filter and select

Making data useful

(subtitle: making data not suck!)

Dataset collection conventions

- Precise timestamps, locations, measurements. Scrubbing, cleanup. “It is what it is.”
- Validation of correctness, schemas if possible, pay attention to units and conversions.
- Unambiguously describe the meaning of each data value with type and metadata.
- Adding narrative data: exercise logs, operator comments, images, ephemera.
- Logging, archiving, network access, security considerations, backups.

Metadata vocabularies

- Strictly defined nomenclatures and data-dictionary definitions, specialized as appropriate for each community of interest. Examples: oceanography, meteorology.
- Community of practice that governs standardization, adoption and evolution.

Success metrics

- Exploration, analysis, re-use, comparisons, publication, insight, understanding
- Big Data Mashups!

Related NPS work: recorded datasets, outputs

- Shelley Gallup's FIRE database for Trident Warrior exercise data capture
- Core Lab suite of Defense Analysis tools
- Operations Research SEED Center
  - Large datasets produced by clusters, computational modeling & simulation
- MOVES Savage tool suite for 3D models
  - X3D model archives, Autonomous Unmanned Vehicle (AUV) Workbench
  - X3D-Edit authoring, visualization using simkit Discrete Event Simulation (DES)
- ARSENL lab data/video records of swarm simulations, experiments

  … and still more? Please tell us about it!

No doubt additional NPS activities will emerge, this is a common need

Complex Systems Field Experimentation: objectives, activities and lessons learned

- "You get what you measure" - deciding on data to record not only produces information, but also establishes feedback loops and progressive refinement on areas that are get focused attention

- Experimental design shows *intention*
  - What are the questions that your project is pursuing?

- From engineering and analysis perspective: Data is Design

  - Mashups and "big data" initiatives become practical
  - Paul Pappas, "How Big Data Is Revolutionizing Design," WiReD, November 2014

Looking ahead

Designing for future evolution

- Growing collection of datasets over years and different locations
- Scientific basis so that all data values are well defined for long term
- Repeatable “business model” fully aligned with institutional practices
- Useful for emerging, evolving Big Data activities
- Real-world approaches adaptable to simulation outputs
- Questions/analysis/answers for naval robotics is not so different from assessment of actual ships and aircraft deployed in the real world
- Partnership with MBARI might grow to include other participants
- Supports Department of Navy Innovation Goals for Data-Centric Navy

INNOVATION ELEMENT 3: TRANSFORM HOW THE DON USES INFORMATION

The Department of the Navy collects more data each day than the total amount stored in the Library of Congress. Yet, the DON is organized and funded around systems and hardware and lacks the tools to ensure the information is used to its full potential. DON organizations dedicate time and resources to turn their data into useful information, then face institutional bottlenecks in sharing that information, vastly restricting its value.

The DON recognizes that information is a strategic asset which empowers people to make informed decisions. Sharing information across organizational boundaries enables innovation to thrive. The DON will integrate technology and learn from other organizations' best practices to maximize the value of our existing information and become a learning organization by mastering the information cycle.

"Someday, on the corporate balance sheet, there will be an entry which reads, 'Information'; for in most cases, the information is more valuable than the hardware which processes it." - *Rear Admiral Grace Hopper*

KEY OBJECTIVES:

- Become a Data-Centric DON
- Develop an Advanced Analytics Agenda
- Increase Agility in Training and Acquisition Processes
- Build Analytics Expertise and Certification Pathways
- Reduce the Burden Associated with Sharing Information

All key objectives supported

Working to establish NPS institutional support

Relevance to NPS educational objectives and research deliverables

- Catalog entries being prepared for Calhoun library archive search

Partnered support to establish system by multiple NPS stakeholders

- Information Sciences (IS) Department, JIFX/CRUSER, NPS Research Office, ITACS network infrastructure, Dudley Knox Library Calhoun Archive, others
- White paper available for review, discussions in progress

Feedback, participation from participants & users always welcome

Work in progress

Starting to connect first few unmanned systems for current JIFX experiments, early August 2016

Installing, testing local copies of STOQS open source

- robodata.ern.nps.edu (and eventually local copy at Camp Roberts when testing)

Adapt data-upload modules to NPS robots, prepare short-course module

- Developmental testing this time, production requirements/capabilities next time

Photographic and video recordings will be handled separately

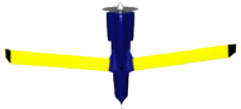
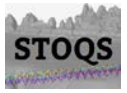
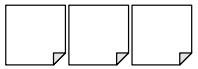
- Media, storage, serving and playback requirements are quite different
- Shared need for common, cross-linked time/position/metadata annotations

Evaluate whether NPS publication-review rules sufficiently address data

- Acceptable open-source licenses; participation invitation
- Access restrictions: someday For Official Use Only (FOUO) on nps.navy.mil

Preparing robot mission data

Information flow

	Data schema design: identify types, metadata
	Robot collects, records sensor data
	Relay or transfer data to long-term storage
	Archive all data: telemetry, imagery, video, 3D
	Convert telemetry to NetCDF, load in STOQS
	Operators record mission logs, narrative, links
	Publish catalog entries to Calhoun for search
	Analyze, query, mashup, re-use, etc. etc.

Contributing data

Interested? We're keen to work with your team.

Please email robodata@movesInstitute.org with as much of the following information as possible.

- Robot name, type, configuration and identifying information
- Experiment goals and outcomes
- Location, date, times
- Sensor types
- Telemetry data files
- Images with captions, date/time/location
- 3D models (we will convert into X3D for Web use)
- Video availability

Open-Source Data Licenses

Suggested:

- **Creative Commons Attribution-ShareAlike 4.0 International**
- **(CC BY-SA 4.0)**

Other open-source licenses are acceptable

creative commons

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This is a human-readable summary of (and not a substitute for) the **license**.

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Questions for users – all feedback welcome!

What data does your unmanned system record?

- Data type, metadata classification, timing, location, purpose

Do you have past archives of data available?

Do you want to configure an active system to feed robodata archive?

What additional requirements and goals do you have?

Contact

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Design Thinking and robot data

Designing a Short Course for Creating Robotics Data Archives

NPS DA4500 Design Brief

Don Brutzman, Ann Gallenson, Shelley Gallup

June 2016

Objectives

Background

- Bootstrap a short course to expose initial capabilities, if approved
- Evaluate course suitability, provide recommendations for further work

Current

- Scale across/outside campus to support JIFX experimentation, Camp Roberts
- Build a growing institutional data archive

Long term

- Help NPS become a design-competent organization
- Influence, align with broader DoD and scientific practice

Project goal: given a short course, show students how to apply design thinking

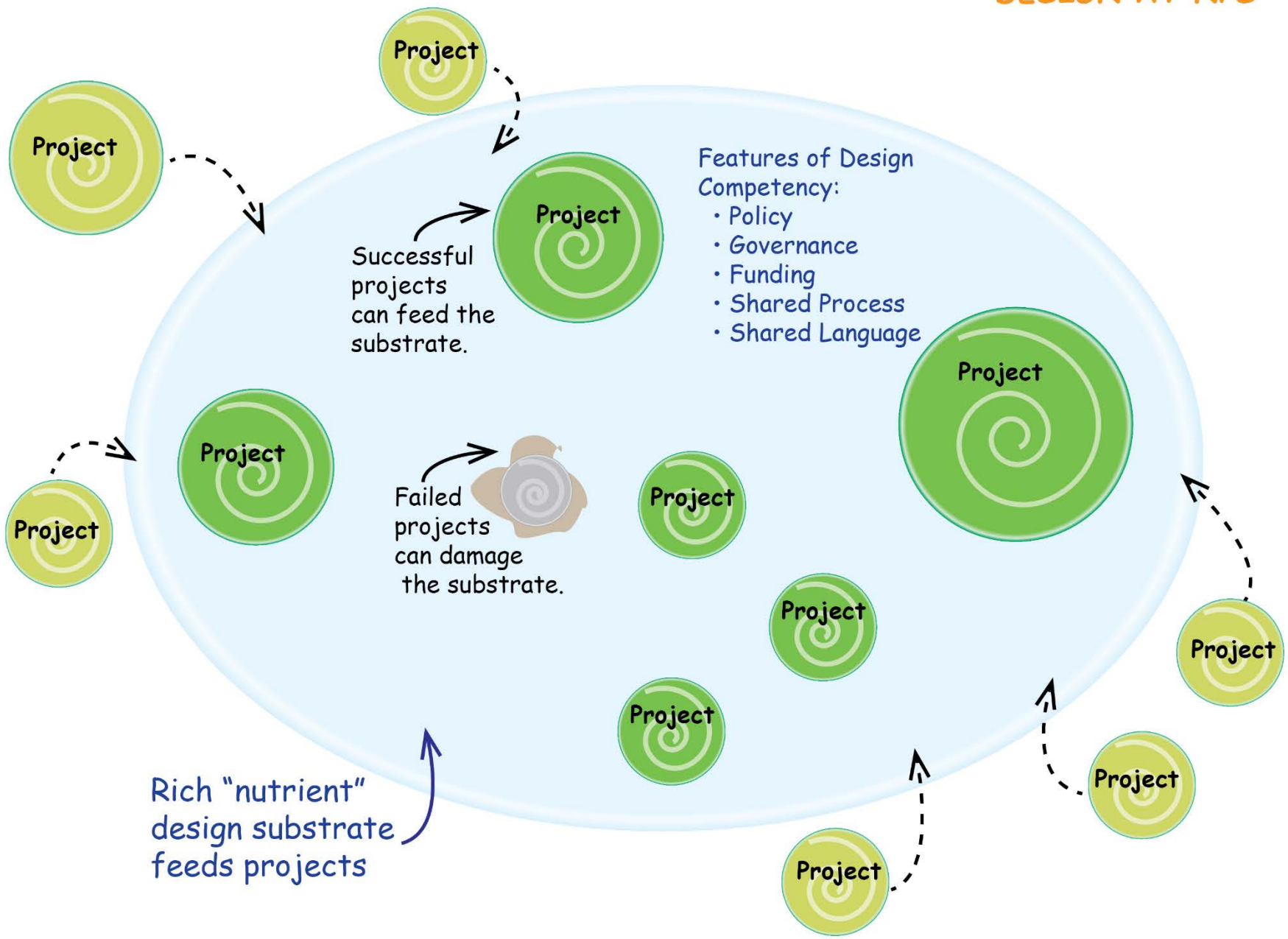
Background: creating a new short course to utilize a system that supports ongoing needs and emerging capabilities in data capture.

- Course shows how to plan, prepare, contribute and utilize datasets in the online archive.

Need to show how design thinking can be applied within any student project involving the collection and interpretation of data collected by robots or other unmanned systems.

Motivations

- Expose many individuals at NPS to process of design thinking
- Create data products that themselves are building blocks for ongoing design mashups and assessments
- Better data produces better understanding
- Not try to be all things for all people, but apply design principles well within a given context that has broad implications and connections


Project
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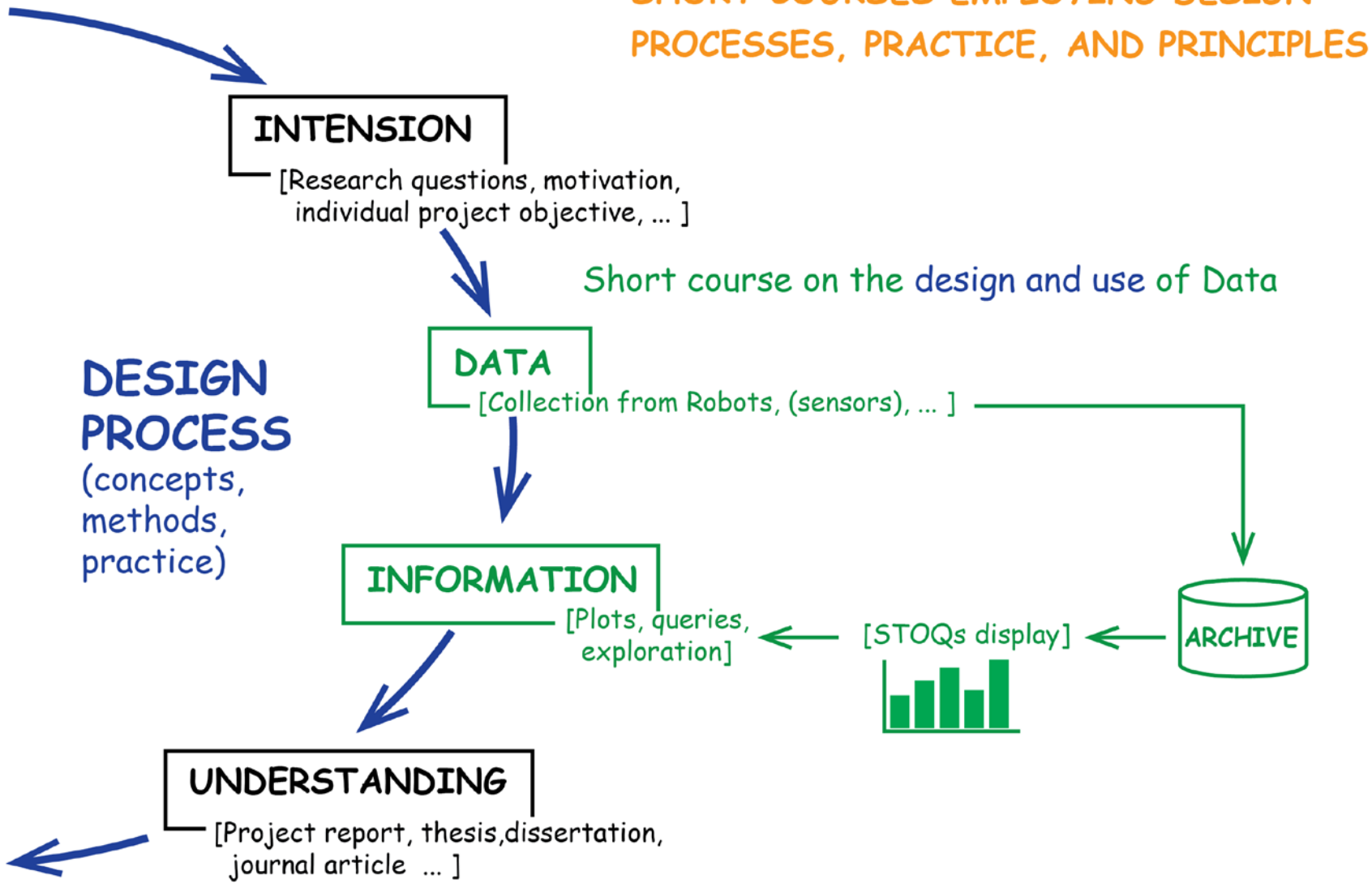
Successful projects can feed the substrate.
Failed projects can damage the substrate.
Features of Design Competency:
• Policy
• Governance
• Funding
• Shared Process
• Shared Language
Rich "nutrient" design substrate feeds projects

Course syllabus: initial outline

- Establish your project motivation, goals, and critical research questions
- Experimental design
  - What measures and scenarios answer the questions of interest?
  - List robot and sensor assets available, desirable
  - Data design: sensors availability, how to collect it, assigning correct metadata
- Data archive mechanics
  - How to use STOQS to display collected robot data for evaluation and analysis
  - How to log, extract, massage, and upload your system data into NPS archive
- Practical exercise
  - Work with prepared data (from course or student project), create report

SHORT COURSES EMPLOYING DESIGN PROCESSES, PRACTICE, AND PRINCIPLES



Course Outcome: Robot data archive contribution & use

NPS Outcome: Improved Design Competencies

Relation to John Arquilla “Sponsor” Vision for Defense

- DoD operations are increasingly unmanned
- Data-driven evaluation of robotic systems is cross-cutting necessity
- Opportunity: exploding availability of sensors, Internet of Things (IOT)
- Humans have difficulty evaluating what they can’t see or measure
  - “Captain, how did your team do out there?” versus “what happened to the robot?”
- Deluge of data needs to be transformed into coherent information that effectively informs judgements and decisions (both human and artificial)

Bottom line:

- Adapt NPS activities to understand changing nature of modern warfare
- Foster design competencies in NPS course work and research projects

Sections of a Design Brief

1. agency (i.e. decision makers, stake holders, etc.)
2. intension / direction or strategy for approach
3. systems assessment (i.e. context, environment, elements etc.)
4. establishing limits or boundary / enabling judgments (i.e. priorities,
5. defining performance specifications (i.e. outcomes of good design)

intention - outcomes

6. defining prescriptive specifications

Designing (not part of brief)

7. concept development
8. design development
9. realization

Agency: decision makers and stake holders

- **Students**: course work and capstone/thesis investigation
- **Faculty**: course assignments, research experimentation projects
- **NPS**: pedagogy, research support, institutional archive, mission

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- Sponsors: reusable record of project results
- Partners
  - Capture results from NPS JIFX field experimentation
  - Share data compatibly with other universities and groups
- Navy and DoD
  - Mandates: Data-centric Navy, Data.gov imperatives
  - Good practices worth repeating will continue to improve

intension / direction or strategy for approach: **design a short course**

Demonstrate mechanics of simple data collection

- Overview of STOQS system: capabilities, products, prerequisites
- Mechanics of collecting/converting simple sample series to build data sets
- Assigning proper metadata to data items, including timestamp and location
- Uploading annotated data stores into the archive
- Performing data analysis using online tools: graph plots, 2D maps, 3D flythrough

Communicate design principles for common tasks

- Define objectives and goals for a given robotics project
- How to develop key questions that support objective exploration
- Figuring out how their robot data can support answering those key questions

systems assessment
(i.e. context, environment, elements etc.)

Context

- Frequent reinvention of common task with poor results, then assets are lost
- Strategy thumbrule: “We all know how this plays out. How do we get there?”

Provenance

- MBARI has produced open-source system answering most of our technical needs
- NPS has mission goals and many stakeholders needing better support

Environment

- Modest budget: open source, high-tech infrastructure already available, sustainable
- Competence: skilled champion MBARI for support, repeatable demonstrated system

Elements

- Students and faculty running robotic data-collection systems need support
- Assume initial STOQS capability gets installed, becomes operational at NPS

establishing limits or boundaries, enabling judgments (i.e. priorities)

- Keep expectations well scoped to what system can accomplish today
- “Good data” is definable, supportable based on existing exemplars
- Limited time available to course participants
  - Only half-day/full-day tutorial is currently practical
  - Keep It Simple Smartypants (KISS principle) with ongoing spiral improvement
- Understanding data results is a process that comes from well-defined questions, open examination and iterative improvement
  - Scientific method combined with scholarly inquiry, not a checklist
- Technology is an enabler, not end goal or “silver bullet” per se
  - Example: VR headset may help understanding but is not the end objective

defining performance specifications (i.e. outcomes of good design)

- Course goals, design rationale and syllabus
- Ready to prepare initial course supporting JIFX, NPS quarterly break
- Participants can apply material immediately after course completion
- Student projects and theses presented in live forum, also archived
- Iterative process: share lessons learned, encourage exploration
- Second/third pass: record class video to support study at any time
- Expectation: advanced and complementary course work will follow

Design is relevant at multiple levels of context

- Supporting role: creation of new course to support students

- **Teach design principles for participants to apply in their projects**

- Designing for success: possibility of scaling up or adapting over time

Careful to identify specific context
when discussing relevant design points

Feedback welcome ☺

- Questions and improvements please

Contact

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