Conducting robotics field trials: experiences, alternatives and best practices

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Outline

- Introduction
- Classes of field testing
- Prescriptive advice
- Conclusion

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Introduction

- Our experience
- Field testing analogues

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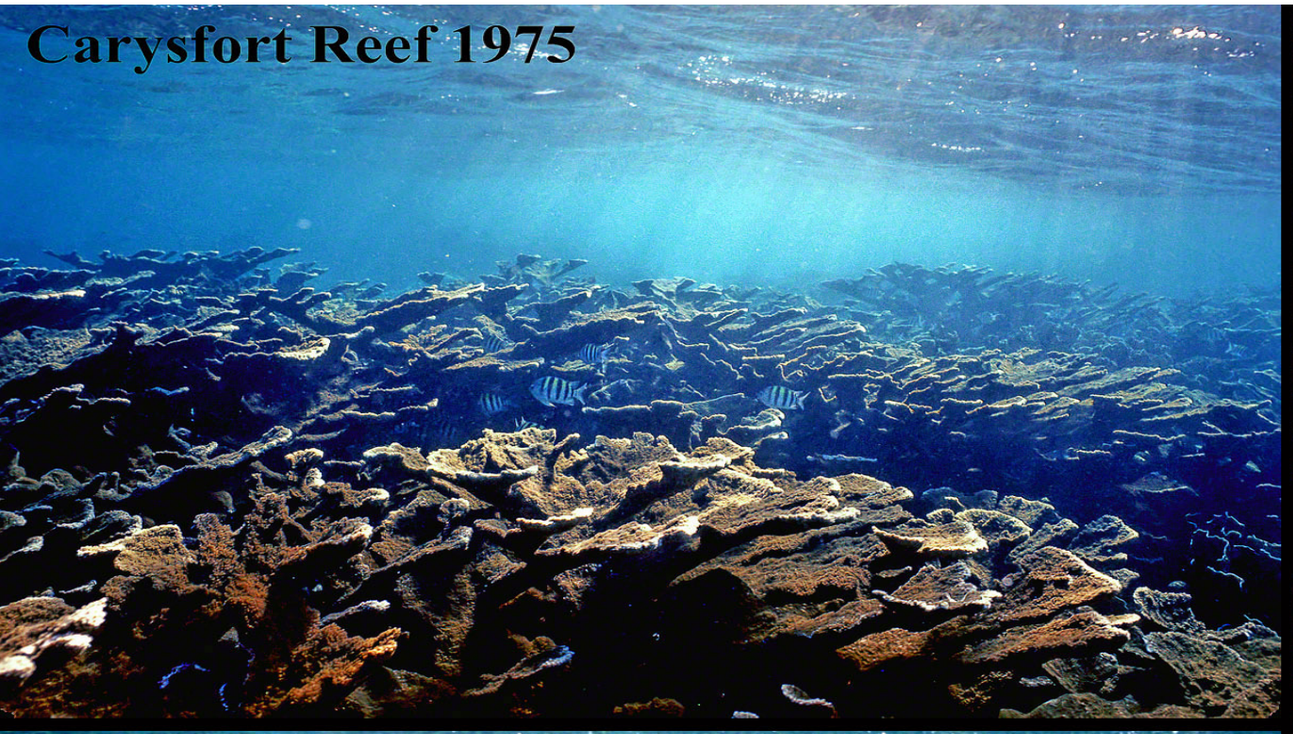
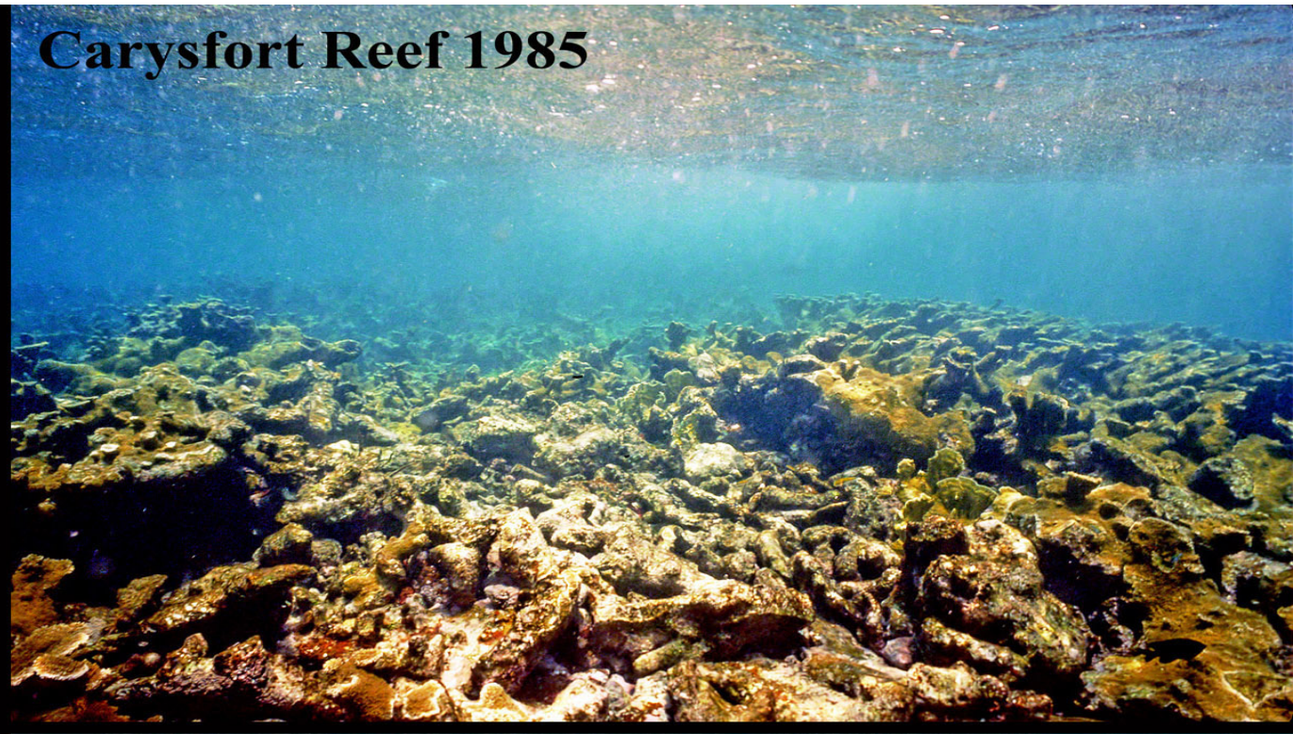
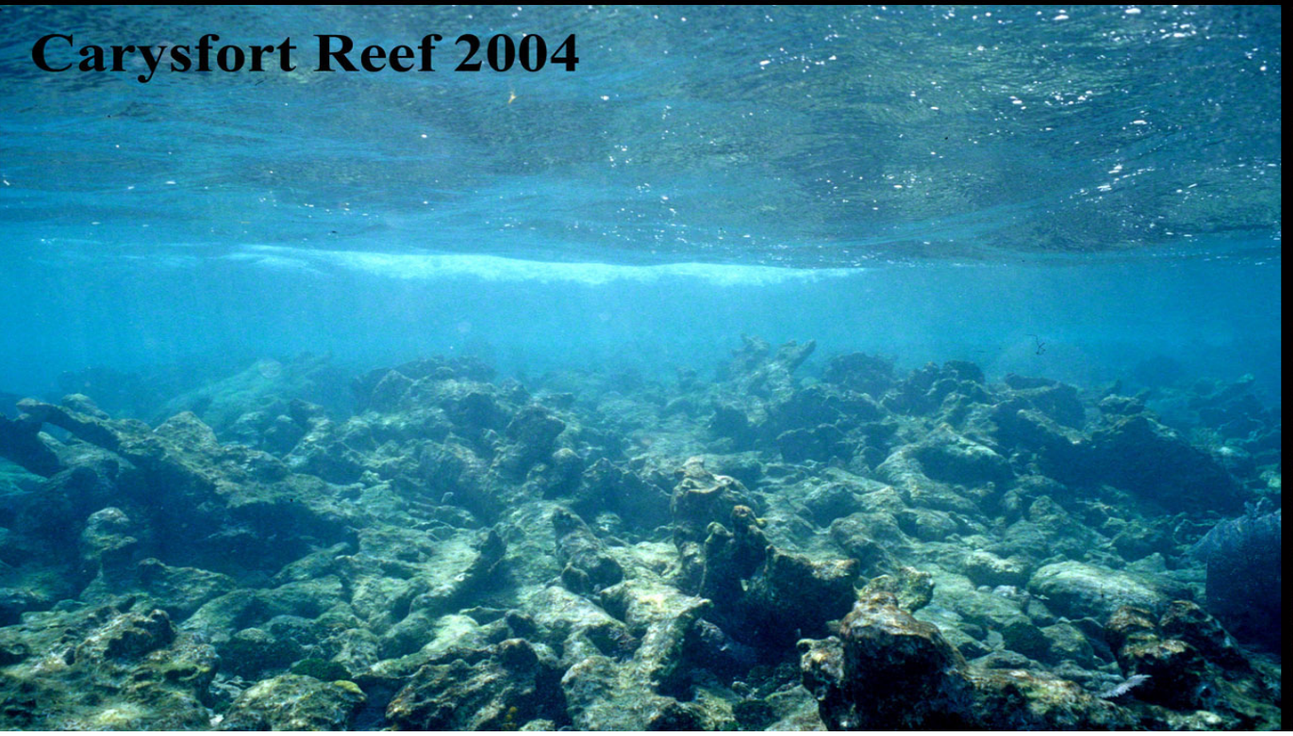
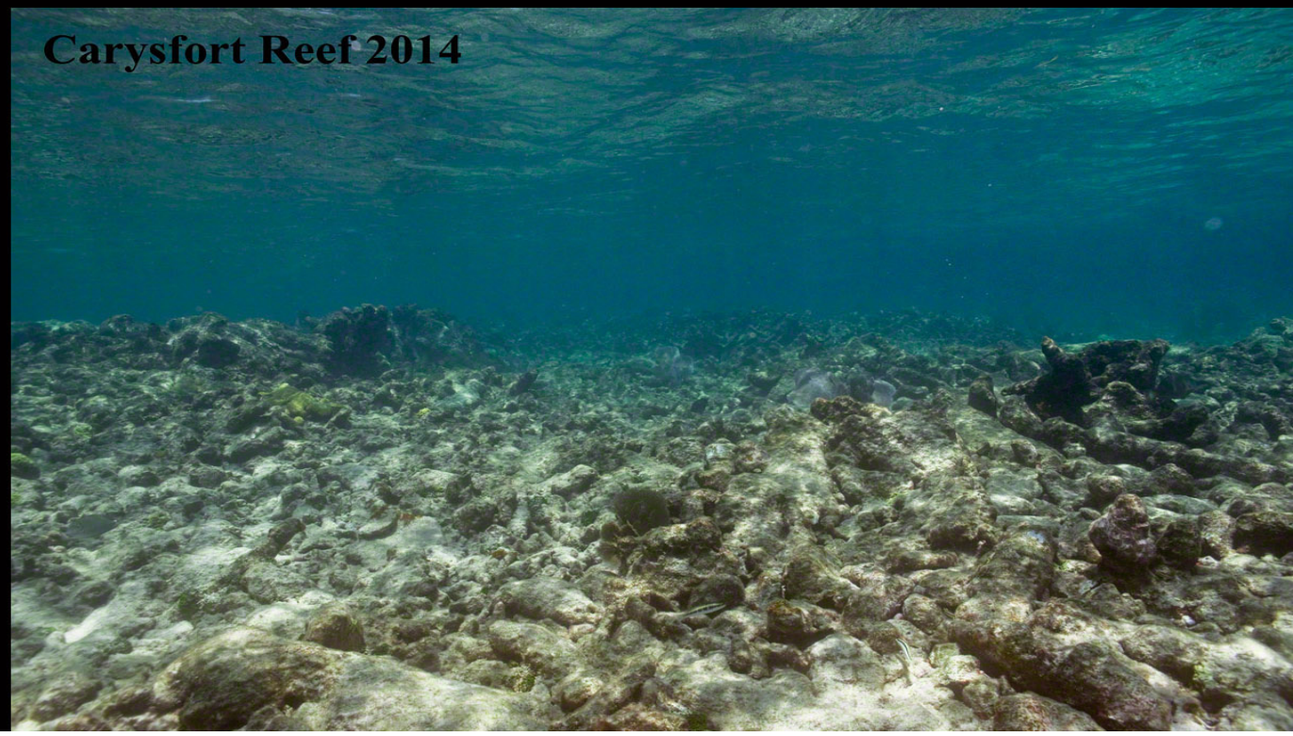
Annual Marine Field Trails

- We have been running annual marine field trials for over 10 years
- Initially 6 people, but now around 40 people from multiple institutions
  - Once targeted one experiment
  - Now we have a suite of experiments
- Mutual logistic support is a key advantage


Carysfort Reef 1975


Carysfort Reef 1985

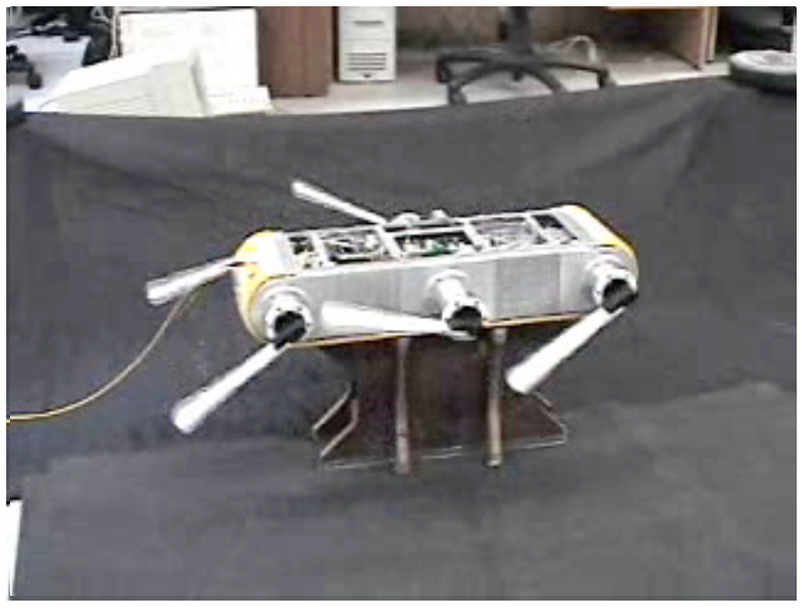

Carysfort Reef 2004


Carysfort Reef 2014

Legged marine robots

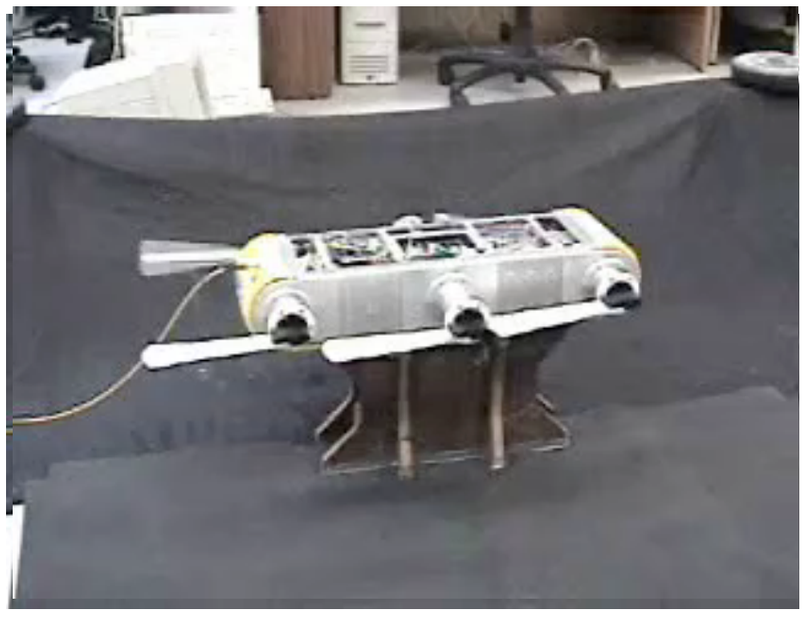
- The **Aqua robot family**: physical robustness, maneuverability, navigation and the ability to interact usefully with humans using only natural interfaces.

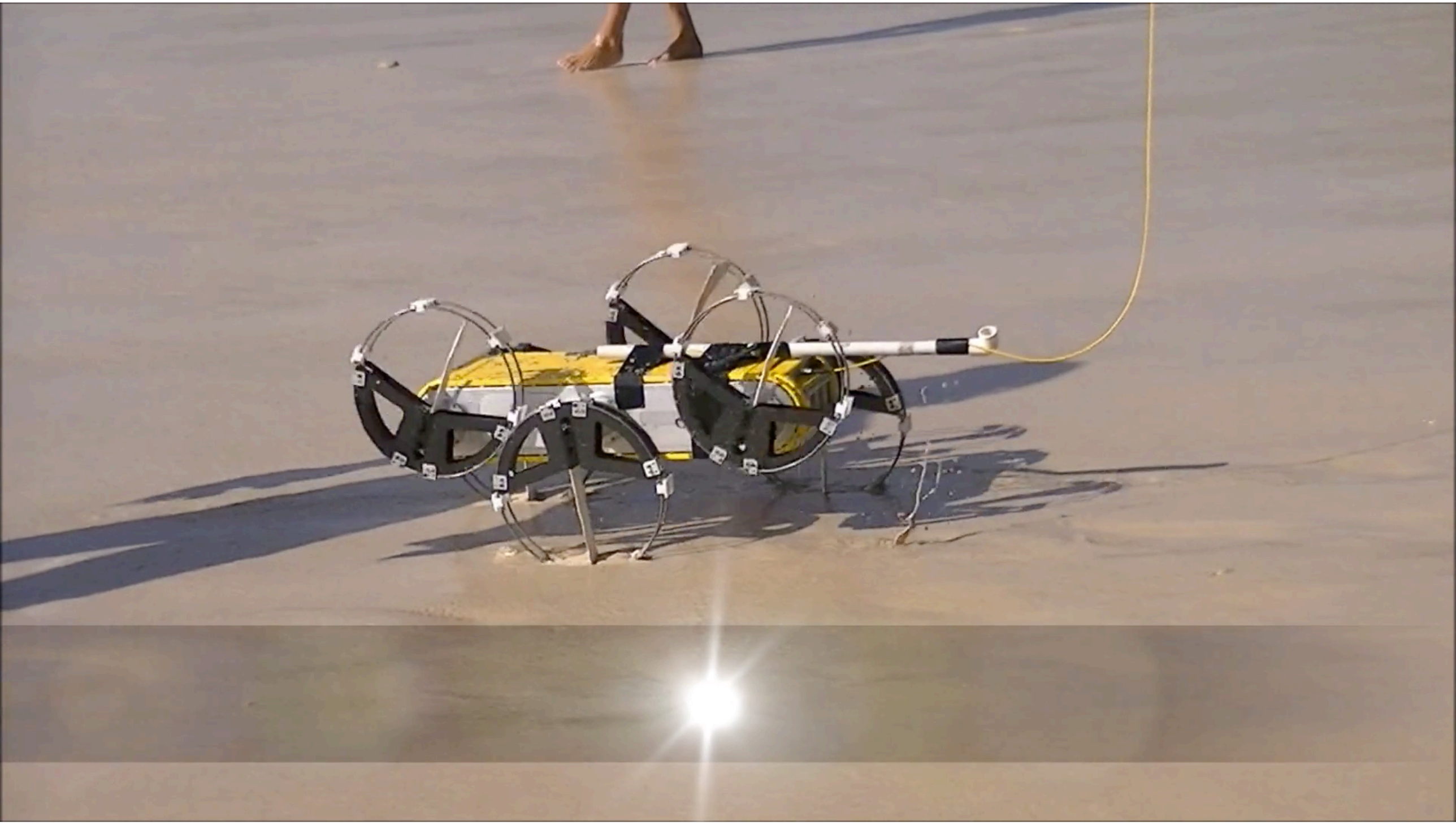
Pitch



Roll

Yaw





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Remote Lab

- To be able to improvise or repair, we create a remote lab environment
- Once small, now quite extensive
  - An advance team does installation
- Managing the equipment is a significant issue
  - Cases are planned, inventoried, weighed, indexed, photographed


ULTRA DUO


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AIR CANADA
49.7
LBS
3
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Box 8

PACKING LIST	10-Jan-07				By:	Chris Prahacs	Chris Prahacs
PART NAME	Model/Part number	Serial #	QTY	Box#	MANUFACTURER	COST/PART (CAN$)	TOTAL COST
ROBOT	AQUA	AQUA01	1	1	McGill University	$24,000.00	$ 24,000.00
ROBOT	RAMIUS	AQUA02	1	2	McGill University	$32,000.00	$ 32,000.00
ROBOT shell	KROY	AQUA03	1	6	McGill University	$8,000.00	$ 8,000.00
Operator Control Unit		AQUA-OCU1	1	0	McGill University	$2,400.00	$ 2,400.00
Operator Control Unit		AQUA-OCU2	1	4	McGill University	$2,000.00	$ 2,000.00
DRIVE COMPONENTS							
Battery - NiMH (A, b)			4	5			
Battery - NiMH [c]	BB390/U		2	3	Bren-Tronics	$380.97	$ 761.95
Maxon GP32C Gearhead	166938		1	5	Maxon Motors	$251.36	$ 251.36
Maxon HEDS Encoder			0	-	Maxon Motors	$99.42	$ -
Maxon RE35 Motor	118778		1	5	Maxon Motors	$222.99	$ 222.99
Motor Driver Board	MDB v1.5		1	7	McGill University	$1,500.00	$ 1,500.00
Motor Driver Board Spares Bag			1	7	Assorted	$200.00	$ 200.00
Power Switch			3	7	Judco	$1.13	$ 3.39
Power Switch Board			1	7	McGill University	$110.00	$ 110.00
Power Switch Boot			1	8	APM hexseal	$5.00	$ 5.00
ROBOT MECHANICAL							
Adapter spares			0	-	McGill University		inc
Amphibious Legs			7	4	McGill University	$1,125.00	$ 350.00
AQUA 1.0 middle motor assemblies			2	3			
AQUA 1.0 spares			1	7			
Back Shell v2			0	-	McGill University	$1,125.00	$ -
Ballast Plate			3	3/8	McGill University	$15.00	$ 45.00
Battery Carrier			0	-	McGill University	$160.00	$ -
Battery Connector Support			0	-	McGill University	$85.00	$ -
Battery Door			0	-	McGill University	$265.00	$ -
Battery Door 1/4 turn	Handle		0	-	Southco	$30.00	$ -
Battery Door 1/4 turn	Retainer		0	-	Southco	inc	inc
Battery Door 1/4 turn	Receptacle		0	-	Southco	inc	inc
Battery Door Lever			0	-	McGill University	$95.00	$ -
Bearing			4	7	NSK	$13.75	$ 55.00
Body Seal			1	8	Reiss	$74.01	$ 74.01


5 YEAR
Corrosion Protection
Zerust dividers!
TUFF TAINER
Storage Systems
Flambeau
FDM Technology
Patent Number 5,121,329

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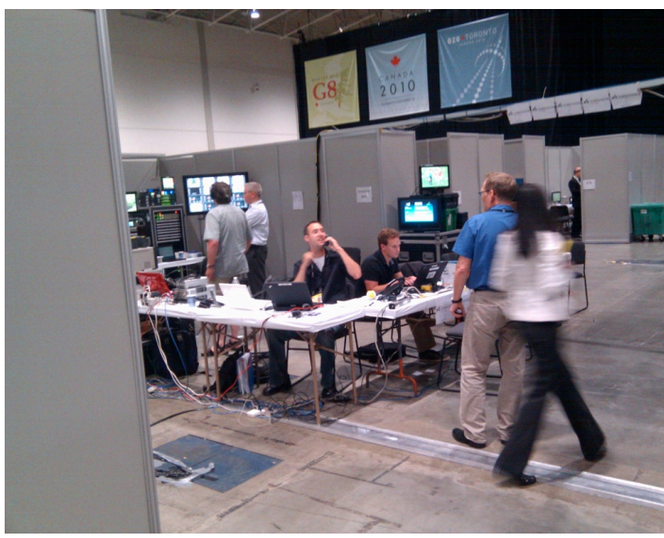
Similar Activities

A field trial is a bit like...

- a regular robotics experiment (e.g on campus)
  - But you need to bring everything with you, and can't go back next week and the week after,
- a trade show demo,
  - but it entails a new experiments with surprising results, and they won't all work,
- a remote television broadcast
  - but with unique equipment and no on site crew to purchase and prepare it.



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Classes of testing

- Kinds of activity
- Key roles and issues

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Objectives of field tests

- Falsification of theories.
- Validation of feasibility/competence.
  - range of test cases, from easy to hard.
- Quantification of performance.
  - system identification
  - competitions

- Discovery of incorrect assumptions (and ensuing failure modes).
- Team building: moral, confidence and skills.
- Getting the “money shots”.

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Underwater is high overhead

- Terrestrial experiments are much easier.
  - You can do more testing at home.
  - Much simpler logistics (no scuba).
  - Communications with & within the team is easy.
  - High-overhead, locales.
- Multi-robot experiments are much harder.

Relation to Software Testing

- Testing robot systems differs substantially from either software testing or conventional hardware validation.
  - Research-class systems.
  - Lack of formal tools.
  - Several types of test objective (combining traditional exploratory concept development, alpha, beta and usability testing).

- Formal specifications are generally not available or not sufficient.
  - Even though software and hardware components pass through individual test cycles, the overall system does not.

Classes of tests

- feasibility/competence verification
- quantification of performance
- enumeration of failure modes
- user satisfaction/capability assessment
- discovery of failed/poor assumptions
- discovery of new phenomena/properties

Ground truth

- Many robot test scenarios would benefit from ground truth data of some kind.
  - Easiest to define for simple problems
    - e.g. localization
      - Ground truth from simulation, manual measurements, GPS
    - using multiple robots to truth one another (i.e. collaborative localization) can help sometimes.

Prescriptive statements

- Script the experimental plan
- Develop a management hierarchy
- Create contingency plans
- Consider psychological factors

Key Roles

- Project leader (PL), me
- Manager: reports to PL, coordinates all other activities.
  - Ideally, lead should be out of the critical path to allow for emergencies
- Packing and unpacking head
- paperwork person
  - insurance, airports, schedules, clearances and passports.
- health and security
  - emergency contact info, emergency facilities, decompression facility location/contacts.
- experiment leader for each experiment.
- dive teams
- experiment teams (re-defined *ad hoc*).

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The Morning Briefing

Indispensable activity, especially when on an extended trip with complex plans.

- What happened yesterday.
- What will happen today, what has changed, key players, objectives, timing.

- Very important to keep team in sync.
- Important as a mechanism to soften effects of hardships/failures.
- Critical for team cohesion to explain/justify problems.


Diana
TASH
JACKIE
VIL
DOM
STEPH
GABE
BITS
MATT
THIS IS OUR SPOT, THESE ARE
EPIGENOME 2016
Mike
Our SLAM by Global SFM
Visual odometry:
– Points and cameras solved together (by global sfm)
– A new frame updates both points and cameras
SFU
Canadian Robotics
La robotique au Canada

Meltdowns

- Be prepared to deal with crises and meltdowns.
  - This is one of the reasons a manager, as well as a group leader, is needed.

- Most common classes of crisis:
  1. Hardware failure (this is the easiest class!)
  2. Physical injury &incapacity (ear problems, wounds).
  3. Psychological meltdown triggered by...
     1. hardware failure, experiment failure, inter-personal issues, physical problems, stress, fatigue.
  4. Weather

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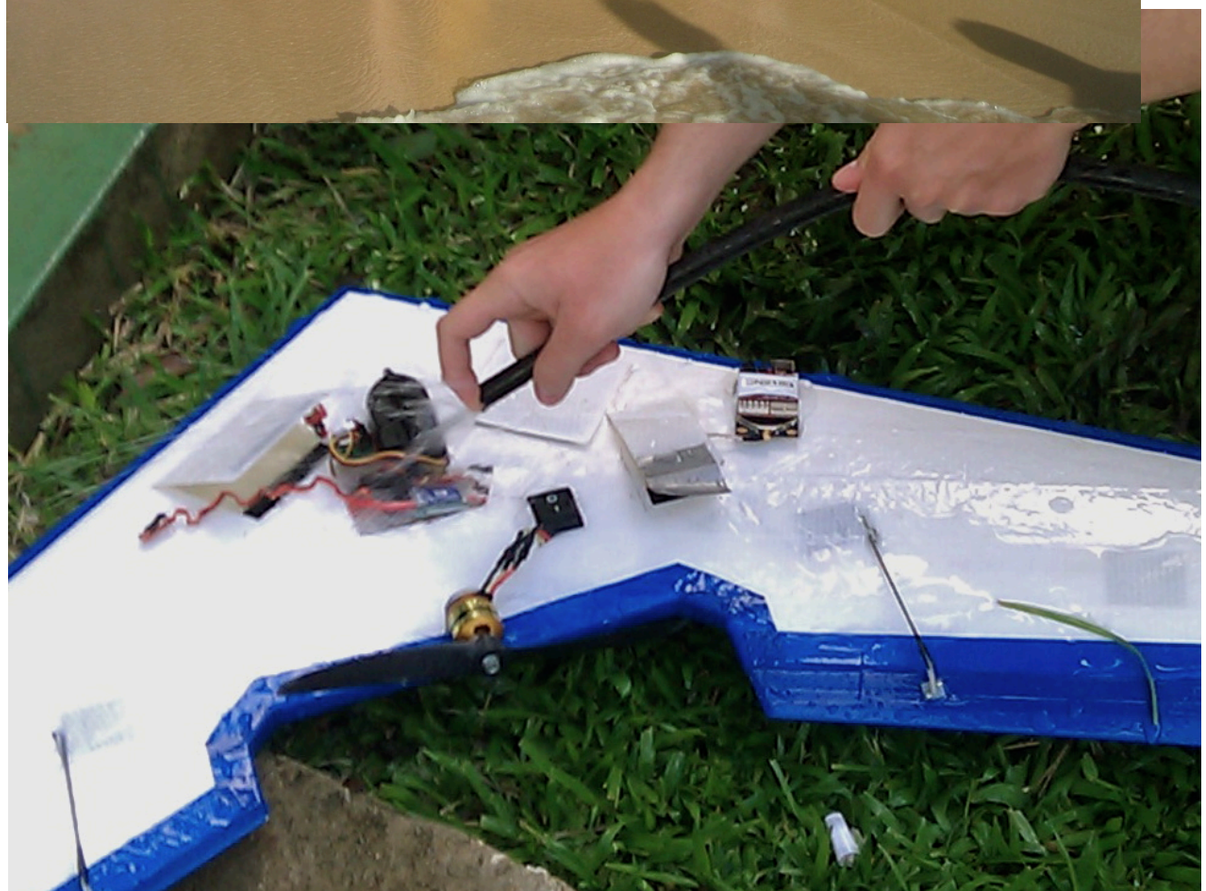
Anecdotes of pain

- Ear infections
- Stolen passports
- Stolen laptop(s)
- Jellyfish stings
- Broken toe
- Broken fiber-optic cable(s)
- Drowned UAV
- Fried robot CPU
- Sunburn, seasickness, ...



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Implications of meltowns

- Team makeups may change spontaneously
- Hardware components may become unavailable
- Third-party resources

->

- Experimental plan must be dynamic

Airport and Borders

- Simply getting everything and everybody there on time can be a challenge.
    - Especially tricky with trans-national travel.

- Lithium batteries.
- Absence of affordable insurance.
- Redundantly backup all data at both ends.
- Wear “uniforms.”
- Synthesize additional documentation.

Experiment planning

- Graded schedule:
  - easy experiments go first
  - high risk experiments last
- "Money shots" have a privileged place
- Do *some* experiments with assured success
  - lock in payoff
  - build confidence & morale, verify capacity

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Sample schedule

ea trials and scheduling will vary depending on weather conditions, equipment, and other eventualities.

	Friday 15/01	Saturday 16/01	Sunday 17/01	Monday 18/01	Tuesday 19/01	Wednesday 20/01	Thursday 21/01
Prep Session	Catch your flights!	Breakfast 0830 hours Daily Briefing 0845 hours	Breakfast 0800 hours Daily Briefing 0845 hours	Breakfast 0800 hours Daily Briefing 0845 hours	Breakfast 0800 hours Daily Briefing 0845 hours	Breakfast 0800 hours Daily Briefing 0845 hours	Breakfast 0800 hours
Morning		1. Dive Refresher (All divers except those who have been diving recently) 2. Equipment checkout and setup: assure suitable power available, trim robot bouyancy, sensor nodes, robots, etc. (All students)	• HRI • Junaed, Chris, 1 diver, 1 asst. • Ramius • Scouting to find location for air trials • Greg, Yogi, Anqi, 1 asst.	• Visual Terrain Surveying • Yiannis, Phil, 2 divers, 2 asst. • Ramius • Air Trials • Anqi, Yogi, 2 asst.	• 6DOF state estimation • Yiannis, Phil, 2 divers, 1 asst. • Ramius • Air Trials • Anqi, Yogi, 2 asst.	• 6DOF state estimation • Yiannis, Phil, 2 divers, 1 asst. • Ramius • Air Trials • Anqi, Yogi, 2 asst.	Full day activity for whole group
Afternoon	Arrivals	1. Hardware test in the water 2. Yiannis: caliberation	• Control Experiment • Nicola, 2 divers, 3 asst. • Aqua	• Visual Tracking • Junaed, Chris, 1 diver, 1 asst. • Ramius • Control Experiement • Nicola, 2 divers, 3 asst. • Aqua	• Visual Tracking+HRI • Junaed, 2 divers, 1 asst. • Ramius • Surf Exit • Anqi, Phil, 3 asst. • Aqua	• Group photos • beauty shots • Surf Exit • Anqi, Phil, 3 asst. • Aqua	
Post Afternoon	Dinner.	Dinner (Holetown or individual)	Dinner (Holetown or individual)	Dinner	Dinner	Dinner	Dinner
Evening	Robot Setup/Systems Check Test cameras Test vehicle (legs, seals) People Gathering	TBD (Equipment repairs)	1. Research presentations	Project PI overviews, Short talks	Longer talks	TBD	TBD

Boat available for dive and tests

TBD: To Be Decided

Participants:	Data Collection Tasks:	Dive Teams
1. Greg 2. Yogi		1. Chris Prahacs & Greg Dudek

Key scheduling factors

- For each experiment
  - Cost
  - Importance/significance
  - Probability of success
  - Ease of repetition

Key scheduling factors

- For each experiment
  - Cost
    - Time
    - Equipment
    - People: number, burn rate
      - e.g scuba burns people out quickly
  - Importance/significance
    - Intrinsic importance
    - Role with respect to other tests
  - Probability of success
  - Ease of repetition
    - Can we re-do easily?

Contingency planning

- Have backup tests/alternative plans
  - Experiments can swap slots if conditions warrant it
    - Makes logistics much harder
- Prepare for weather contingencies
- For each time slot, have preferred and backup plans
  - This can imply having a roster of "bonus" activities, but keep expectations bounded.

Contingencies and failures

- Have a clear sense of how to value experiments
- Don't let failures cascade
  - Pull the plug when necessary
  - But, make sure you give an experiment a fair chance
  - This decision needs to fall on the shoulders on somebody who can take the heat, and who knows the value function

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Conclusions

- There is no going back
  - Once you taste real experiments, lab studies seem simplistic
- Field testing is hard
  - It makes entails many new challenges and considerations
- Field testing is very rewarding


DIVER BELOW


INDEPENDENT ROBOTICS 2016
1429A
HN6000VG
A7
A6
A5