Australian Government
Department of Defence
Defence Science and Technology Group

MOOS Chat Down Under

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MOOS DAWG'15

Who did what

Developer: Niloy Chowdhury, Adelaide University
Contributors: Weizhen Zhou, DST Group
Stuart Anstee, DST Group

ATR engine: Phil Chapple, DST Group
Trajectory planner: Graeme Best, ACFR Sydney University

Trials support: Peter Formby, DST Group
Roger Stuckey, DST Group

Program funding: David Battle, DST Group

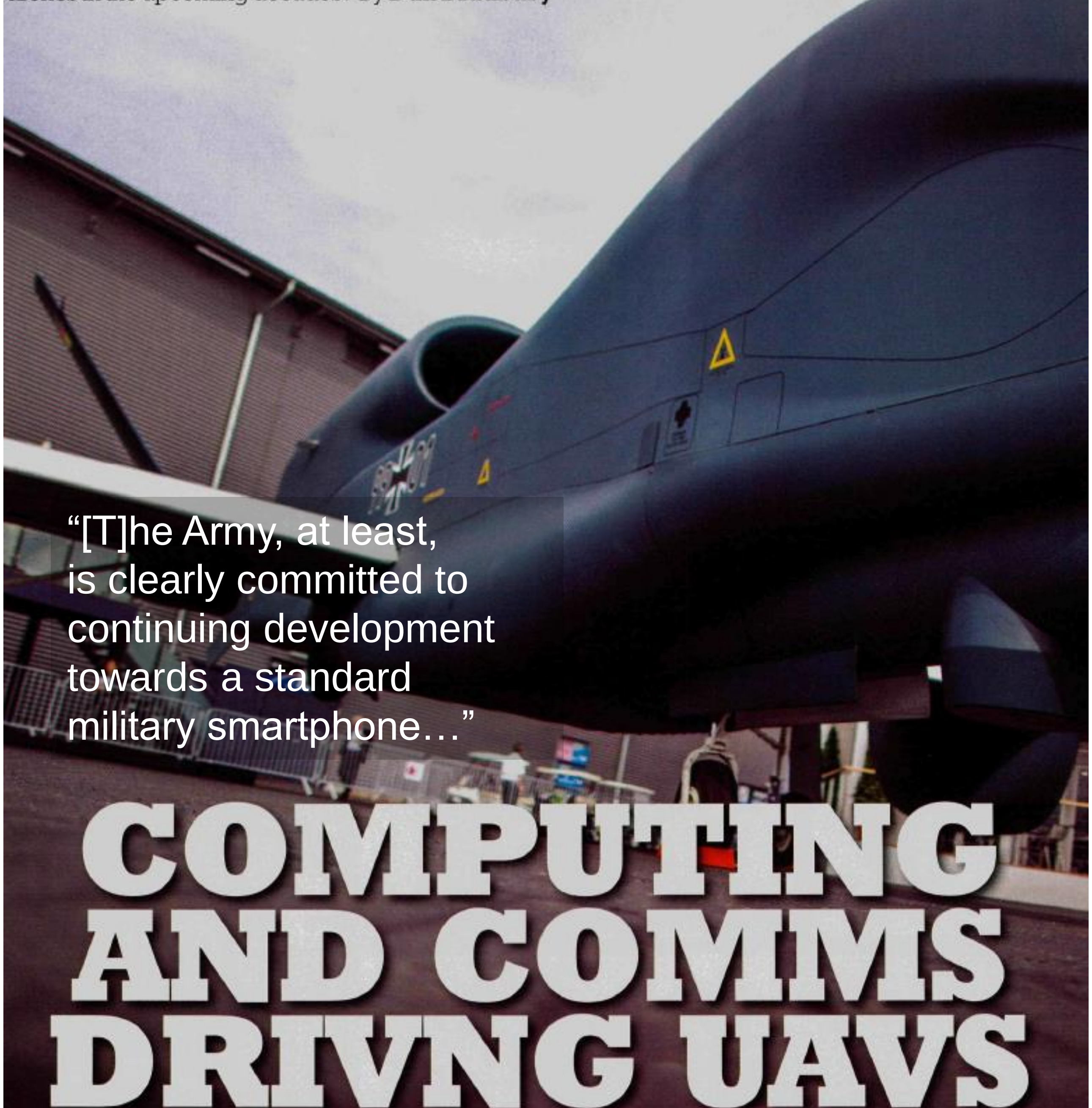
Program admin: Helen Dorsett, DST Group

Develop a small, portable human-computer interface that exploits features commonly available to smartphones, including attitude and inertial sensors, and touchscreen input capabilities.

COMPUTING AND COMMS DRIVNG UAVS

The use of UAVs in the military context is a great headline grabber, but a wealth of computer technology is really helping the sector take off in much more creative directions. How will we be employing drones in the upcoming decades? By **Dan Bradbury**

"[T]he Army, at least, is clearly committed to continuing development towards a standard military smartphone…"



The Northrop Grumman RQ-4 Global Hawk provides high-resolution synthetic aperture radar and electro-optical/infrared imagery at long range with long loiter times over target areas

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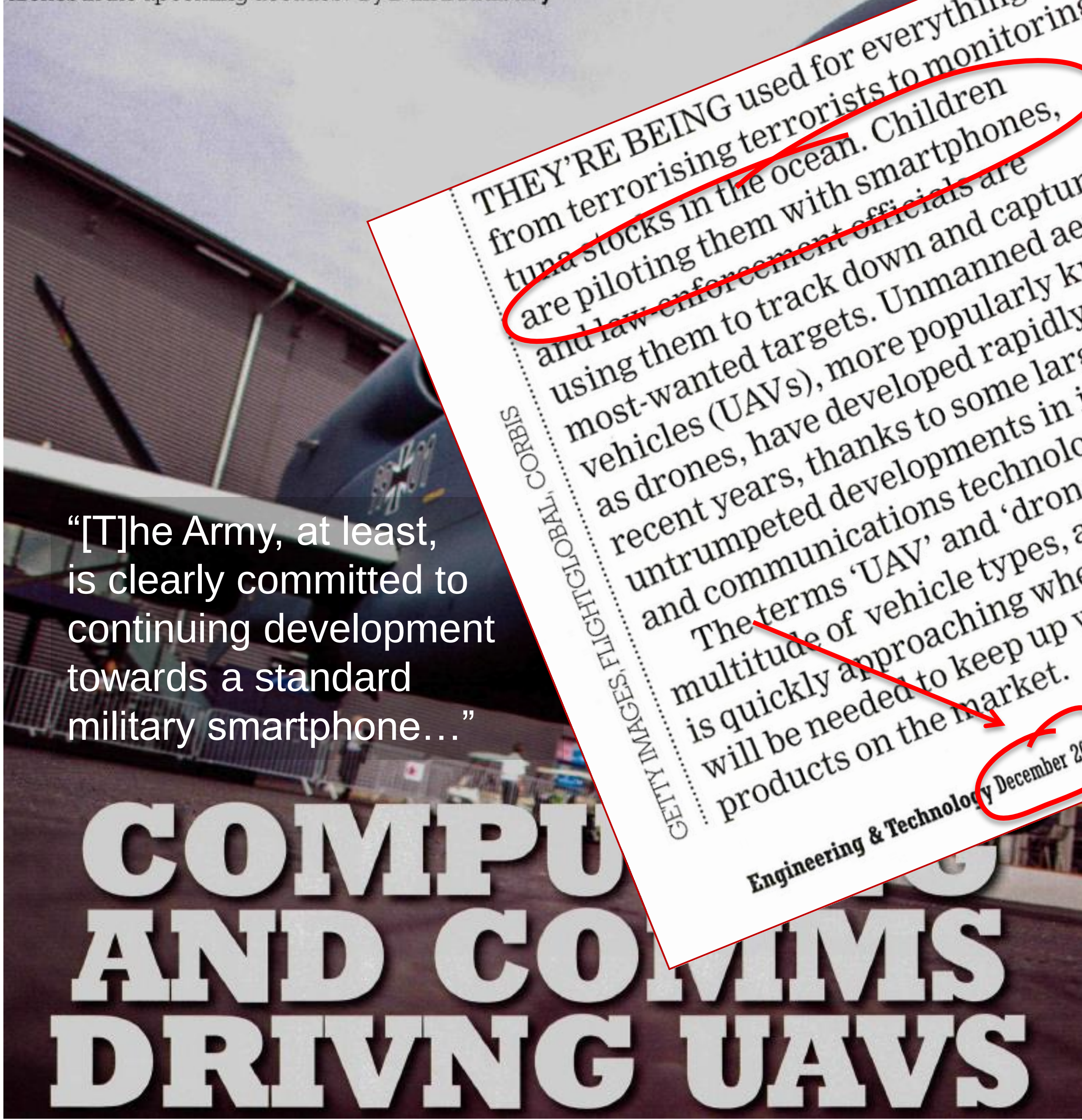
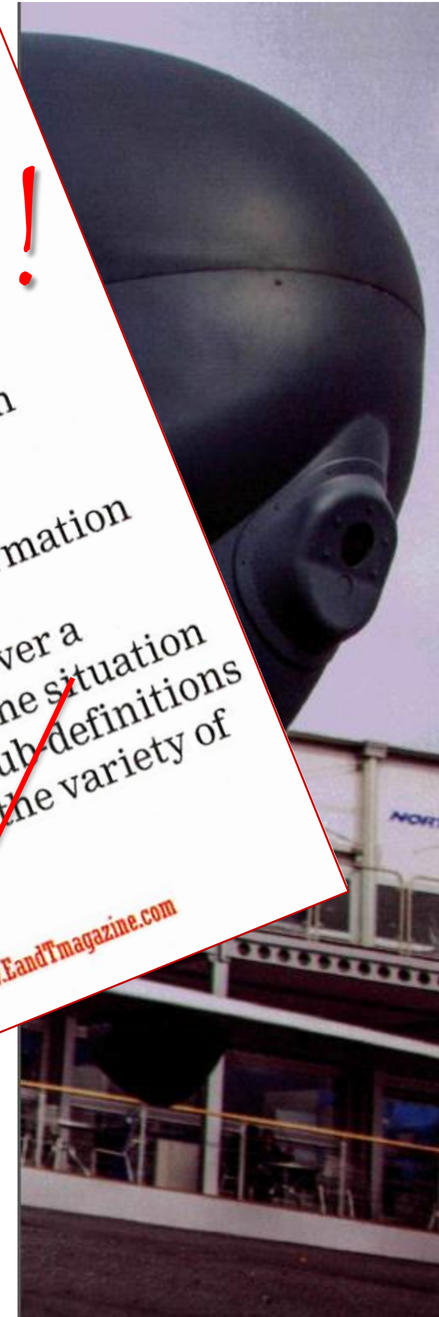


THEY'RE BEING used for everything from terrorising terrorists to monitoring tuna stocks in the ocean. Children are piloting them with smartphones, and law-enforcement officials are using them to track down and capture most-wanted targets. Unmanned aerial vehicles (UAVs), more popularly known as drones, have developed rapidly in recent years, thanks to some largely untrumpeted developments in information and communications technology.

The terms ‘UAV’ and ‘drone’ cover a multitude of vehicle types, and the situation is quickly approaching where sub-definitions will be needed to keep up with the variety of products on the market.

GETTY IMAGES, FLIGHTGLOBAL, CORBIS



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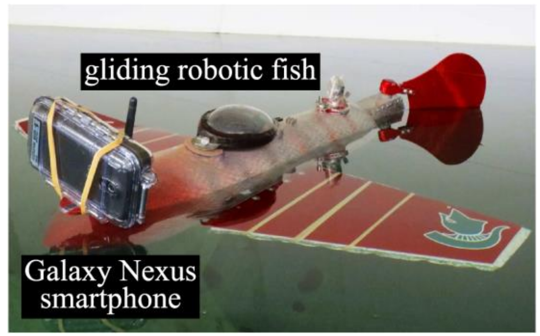
What’s out there †



Aquabotix Hydroview ROV, with smartphone-based control screen

Smartphone –based debris sensor on robotically-controlled ‘gliding’ fish (Michigan State)

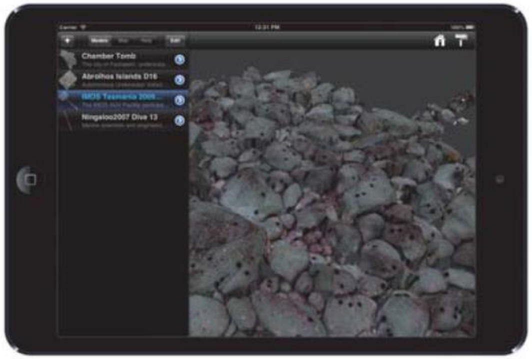
Mares AUV with simple mission planner with Google Maps (Michigan State)

† See notes page for citations.

HITL as a response to complexity

"The world is too complex for us to be able to code every possible appropriate response" [1]

- **Reactive systems** (1980s): developer creates models that divide the world into pertinent and irrelevant information
- **Learning systems** (1990s-2000s): developer creates tools that enable robot to learn what is pertinent in different contexts
- **Leveraging systems** (current): take advantage of other knowledge systems and ask for help

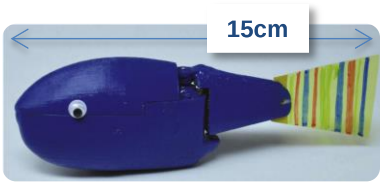


Screenshot from *Seafloor Explore*, a mobile app that displays 3D maps of the seafloor and gathers and logs interaction data from users to identify points of interest.[2]

[1] S. Redfield, "Perspectives in Robotics," *Robotics: Systems and Science Conference 9-13 July 2012,* Sydney, Australia.

[2] Johnson-Robertson, J. et al., "Crowdsourced Saliency for Mining Robotically Gathered 3D Maps Using Multitouch Interaction on Smartphones and Tablets," *IEEE Conference on Robotics and Automation (ICRA)*, 31 May – 7 June 2014, Hong Kong, China.

Goals for the UI

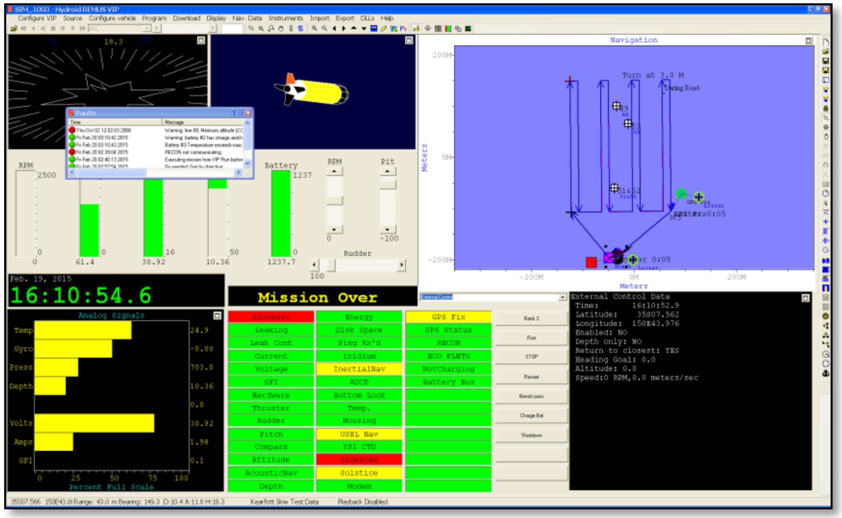


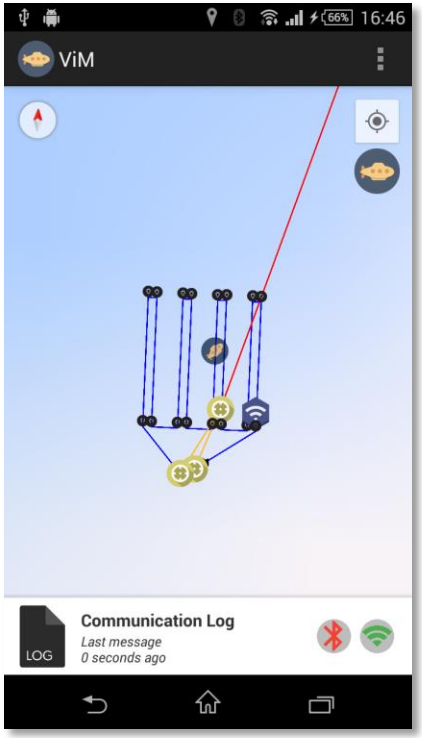
- Limit user actions, but don’t limit user options or functionality
- Don’t trust the user, do as much as possible automatically
- Consistency
- No clutter in the view(s)
- Animations to inform the end-user, not the robot designer

Abaid, N., *et al*., “Controlling a robotic fish with a smart phone,” *Mechatronics* **23** (2013) 491-496.

SVS Project: Mission IM-possible*

Develop a smartphone app for monitoring & control of an autonomous underwater vehicle





*IM: Instant Messaging

Existing AUV Comms Systems*

Mission monitoring:
Just “listen” to AUV

Mission planning &
assessment (at surface)

Wi Fi

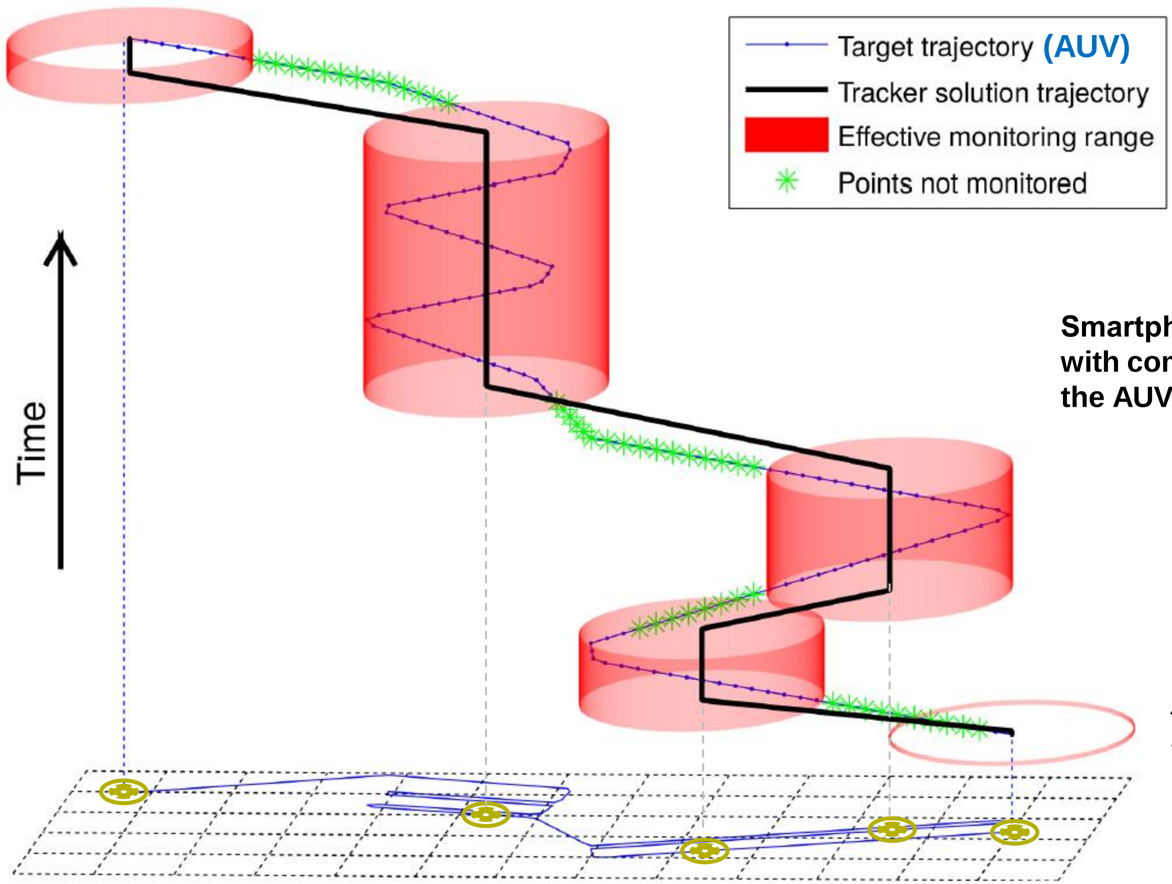
Acoustic communications

** Also available:*

- *IRIDIUM SATCOMMs (emergency)*
- *Freewave radio via Gateway Buoy*

Supervising Trajectory Planner

- Keep supervisor in communications range as long as possible
- Keep supervisor silent and stationary as long as possible



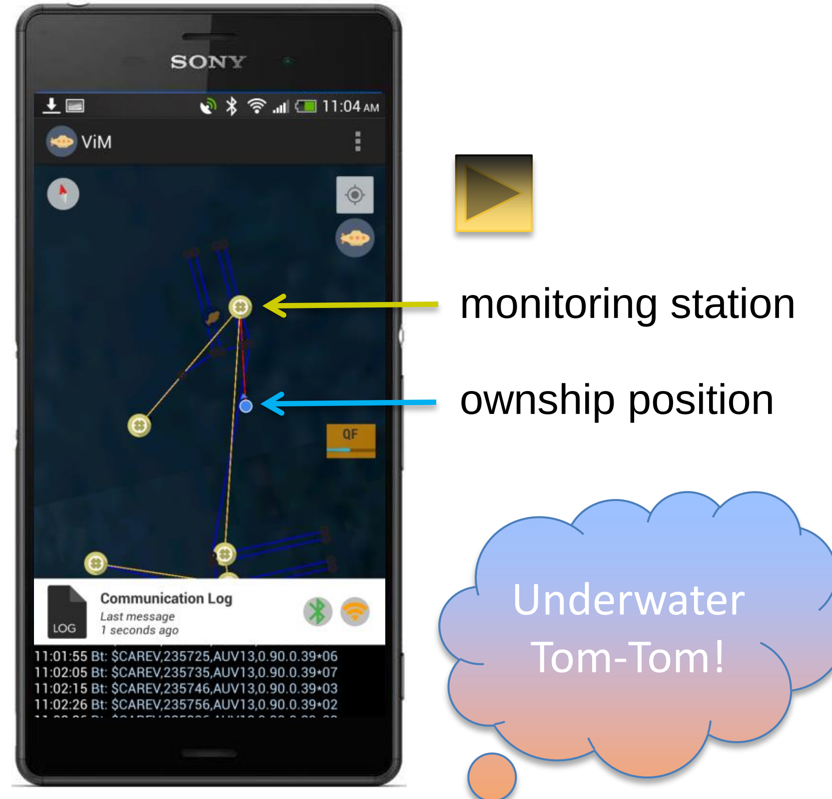
Smartphone uses the "greedy" algorithm, with communications points located on the AUV trajectory.

Best, G. and Anstree S., *Motion Planning for Autonomous Underwater Vehicle Supervision*, ACRA 2014.

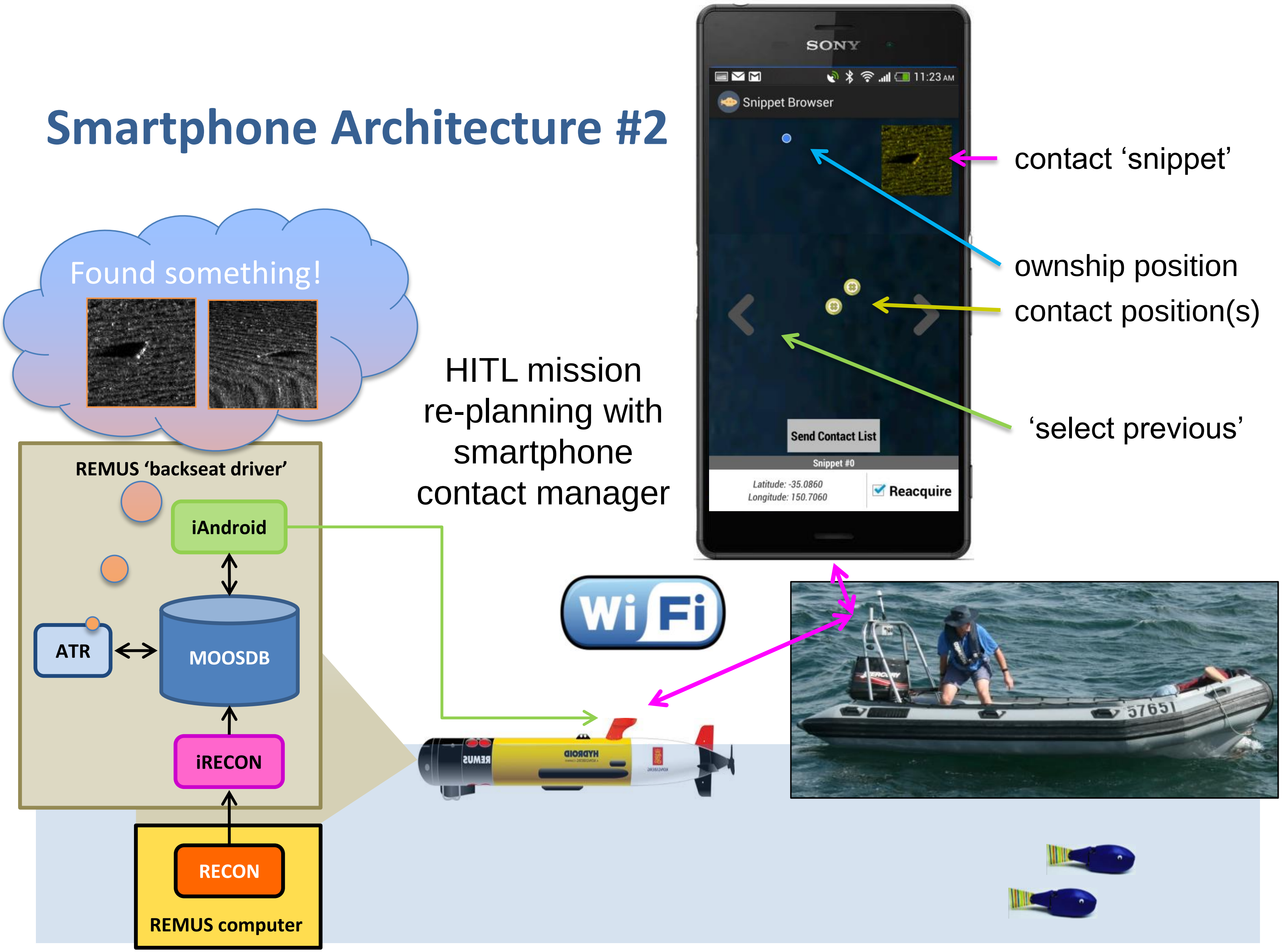
Best, G., Martens, W., and Fitch, R., *Spatio-temporal Optimal Stopping Problem for Mission Monitoring with Stationary Viewpoints*, RSS *2015*

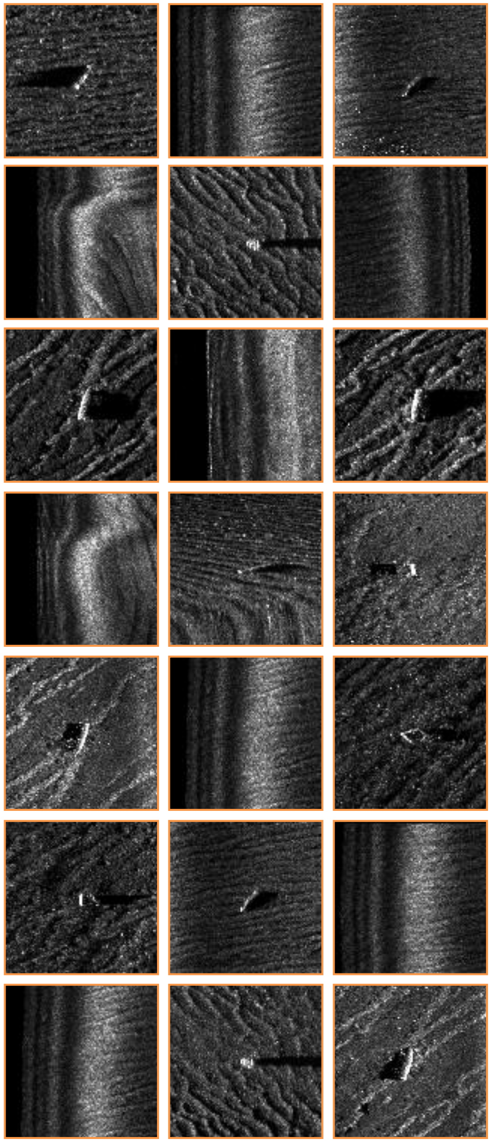
Smartphone Architecture #1

Mission monitoring:
Just “listen” to AUV

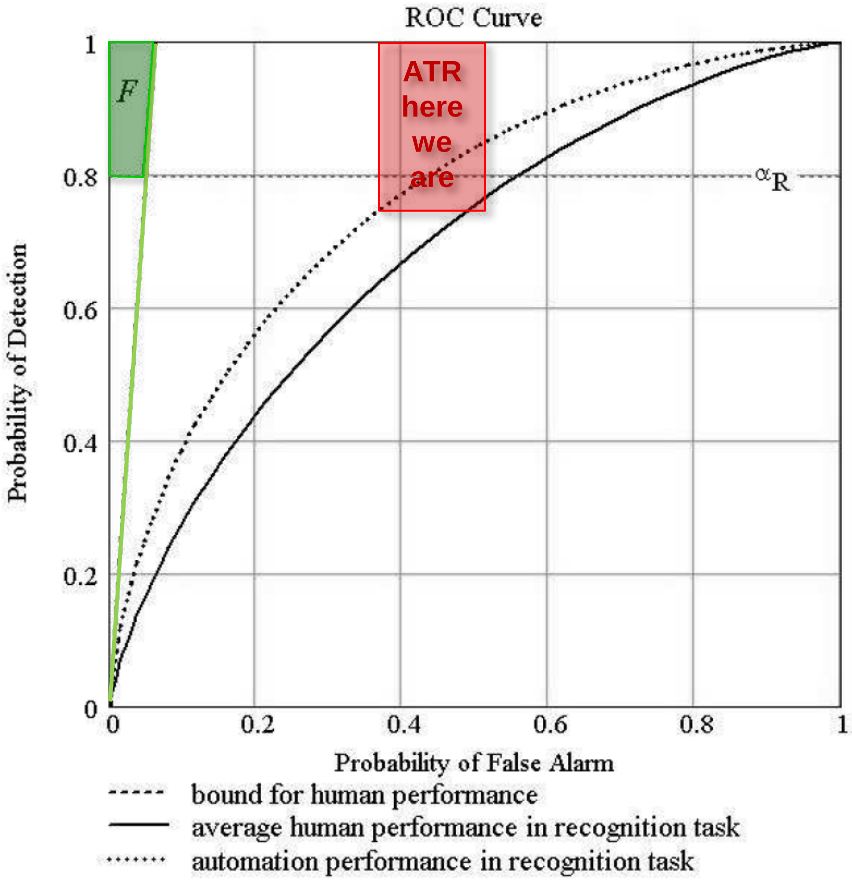


Smartphone Architecture #2





Some Science: "Apparent Reliability"



Kessel, R. (2005) *Apparent Reliability, Conditions for Reliance on Supervised Automation*, DRDC Atlantic TM 2005-155.

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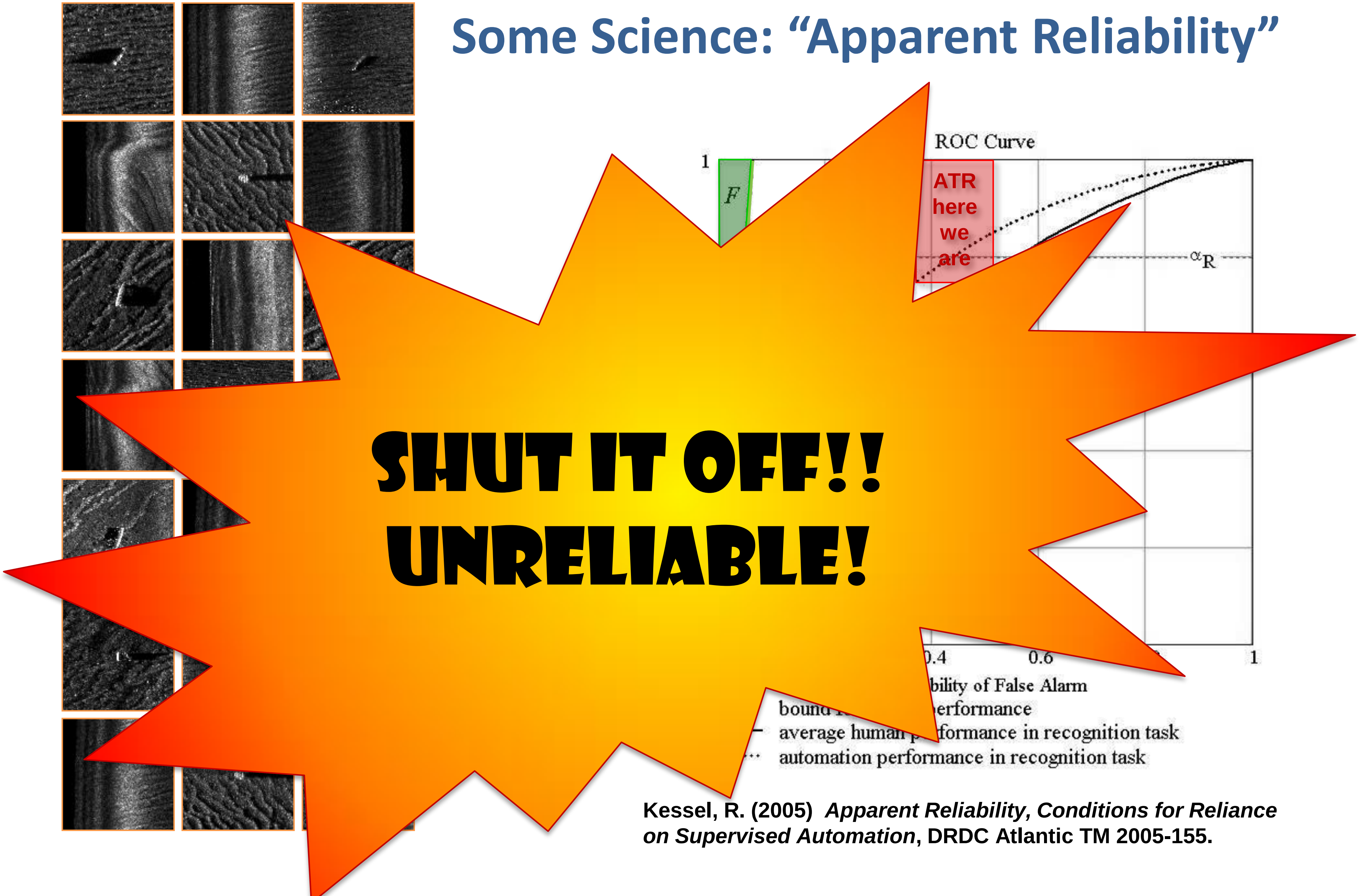

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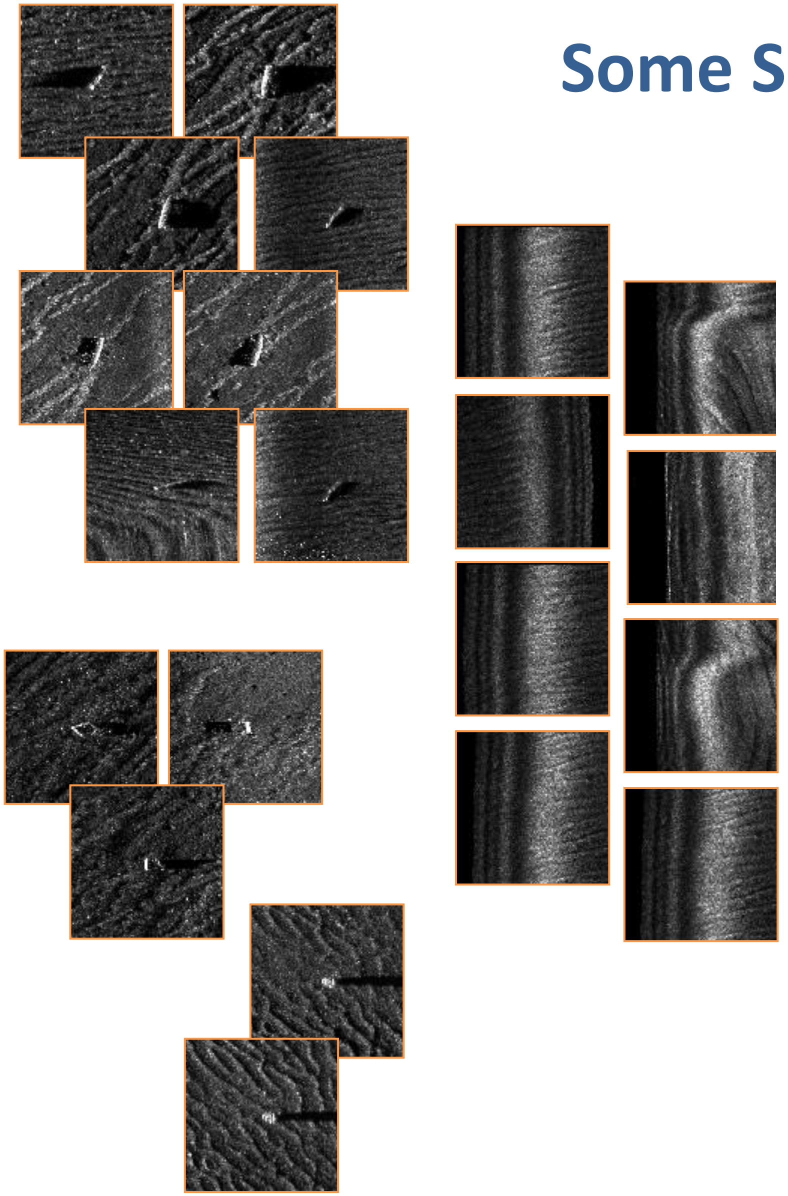
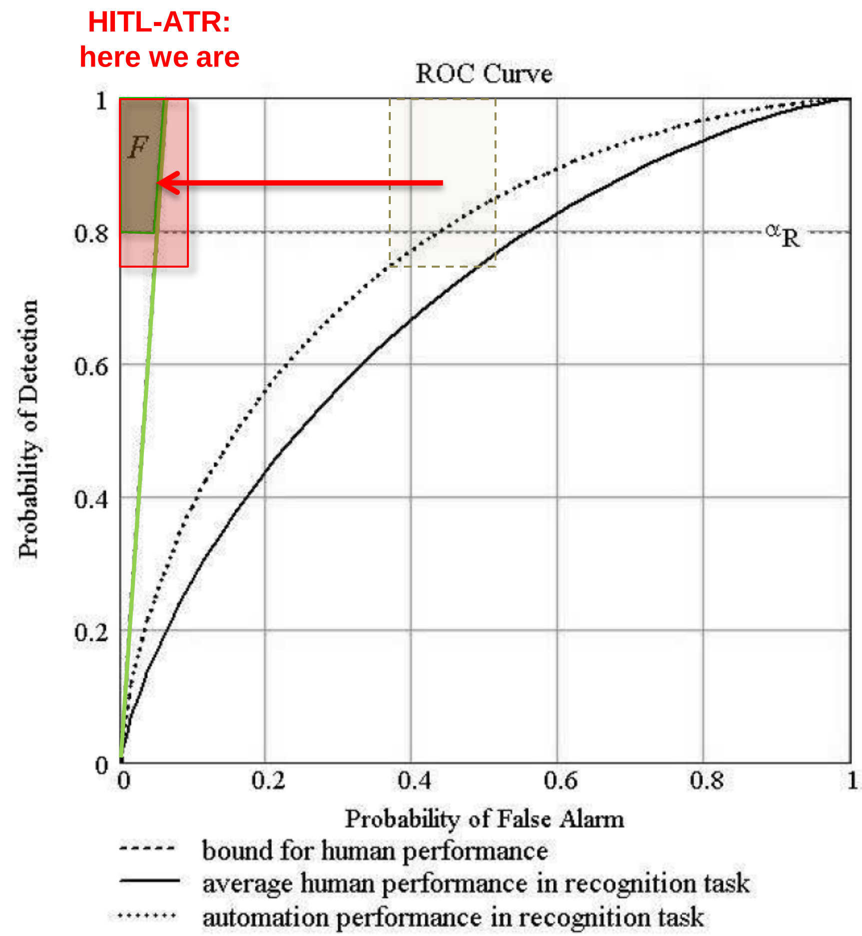
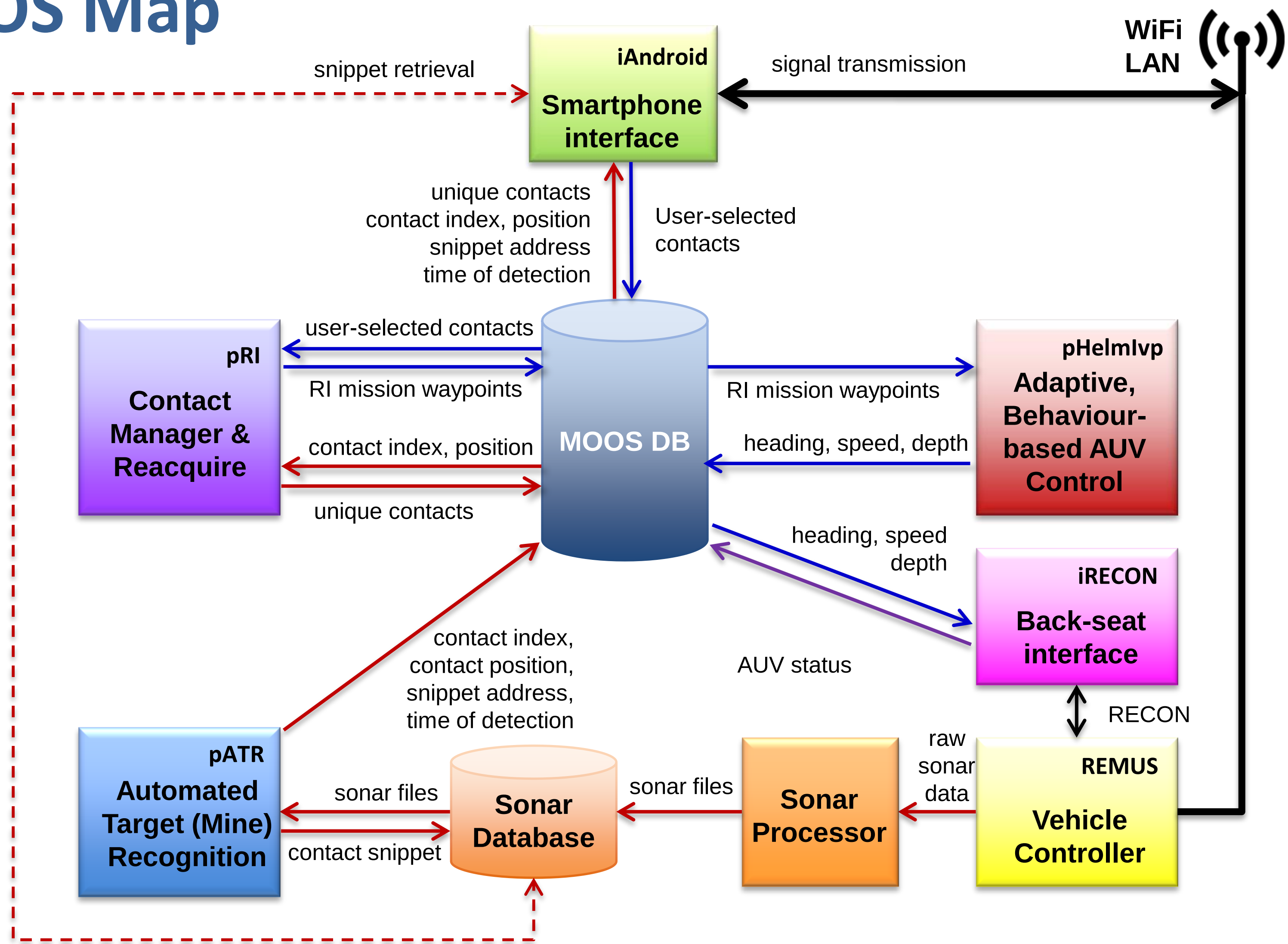




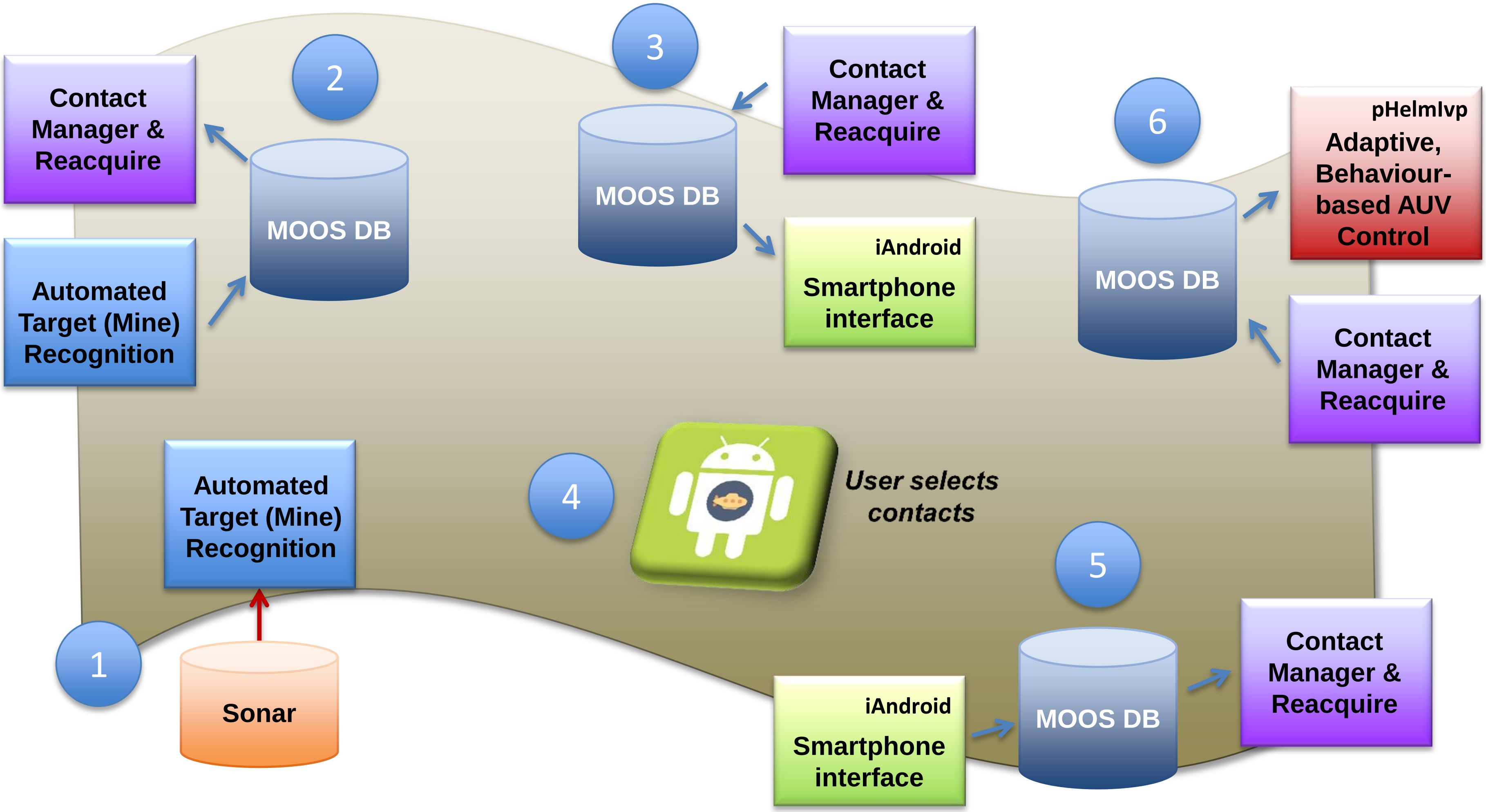
Kessel, R. (2005) ***Apparent Reliability, Conditions for Reliance on Supervised Automation*****, DRDC Atlantic TM 2005-155.**

MOOS Map



snippet retrieval
iAndroid
Smartphone interface
signal transmission
WiFi LAN
unique contacts
contact index, position
snippet address
time of detection
User-selected contacts
user-selected contacts
pRI
Contact Manager & Reacquire
RI mission waypoints
contact index, position
unique contacts
MOOS DB
RI mission waypoints
heading, speed, depth
pHelmIvp
Adaptive, Behaviour-based AUV Control
heading, speed
depth
iRECON
Back-seat interface
AUV status
RECON
contact index,
contact position,
snippet address,
time of detection
pATR
Automated Target (Mine) Recognition
sonar files
contact snippet
Sonar Database
sonar files
Sonar Processor
raw sonar data
REMUS
Vehicle Controller

MOOS Transactions



What's next?

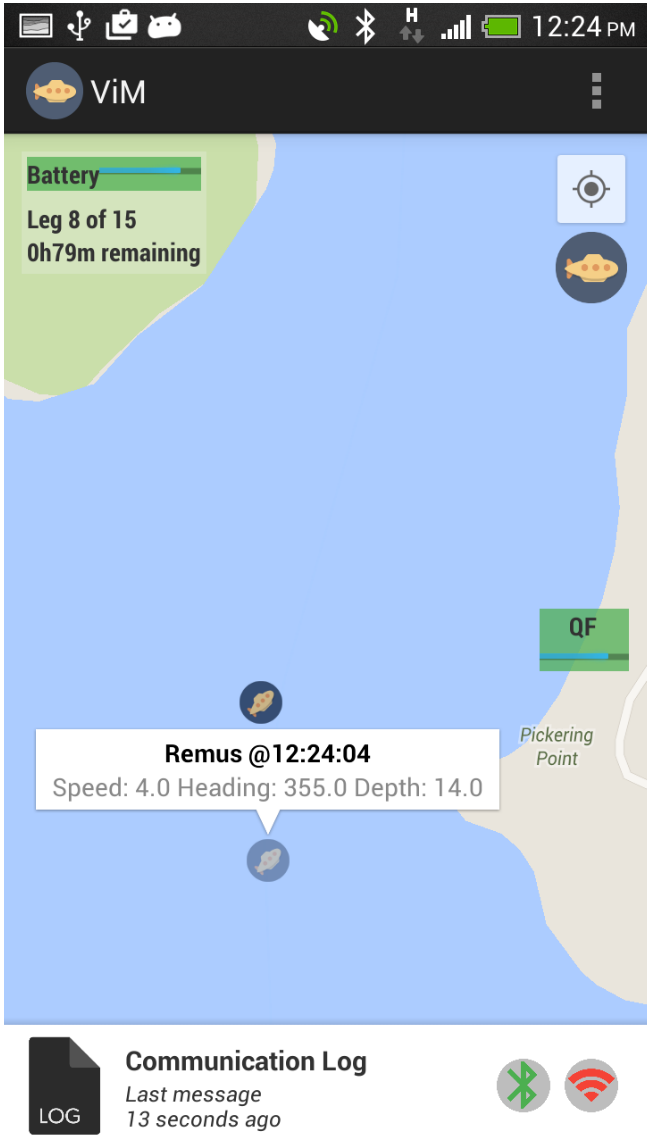
- Client need – yes
- Future Activities
  - Add direct command capability
  - 'Operationalise' app (*e.g.*, nautical charts)
  - Multi-vehicle command & control
  - Pax River 2015: TTCP interoperability
  - 'Autonomise' Underwater Tom-Tom*
  - Near-field communications -?

* Best, G., Martens, W. and Fitch, R. (2015), "Spatio-temporal Optimal Stopping Problem for Mission Monitoring with Stationary Viewpoints," *2015 Robotics: Science and Systems Conference*, 13-17 July, Rome.

Questions

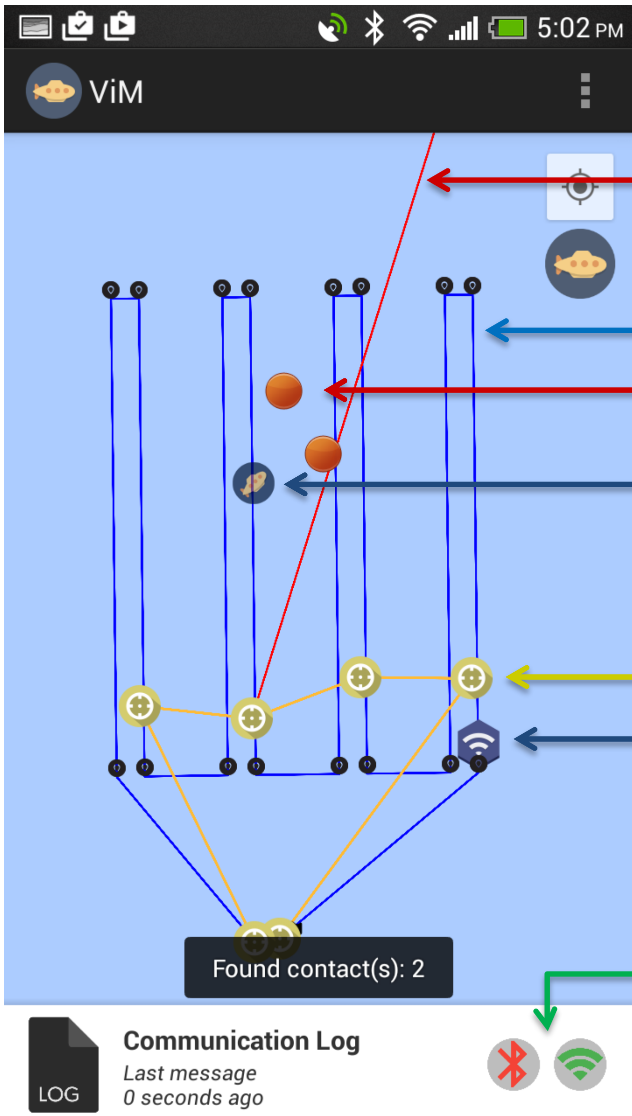
Extra Slides

ViM – VIP iMproved



- Runs on Android
  - “huge” range of devices
  - waterproof
  - well-documented API
  - Google maps API
  - Java and C++ programmable
- Passive monitoring from acoustic messages
- Real-time WiFi monitoring
- Enables human in the loop autonomy
- Completely wireless.

Overview - Capabilities (Mission Monitoring)

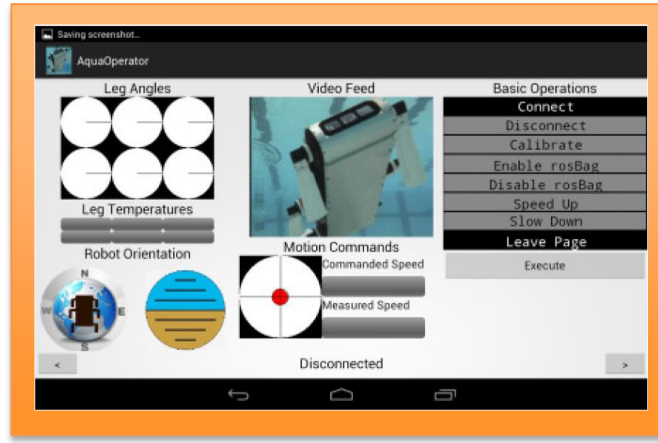


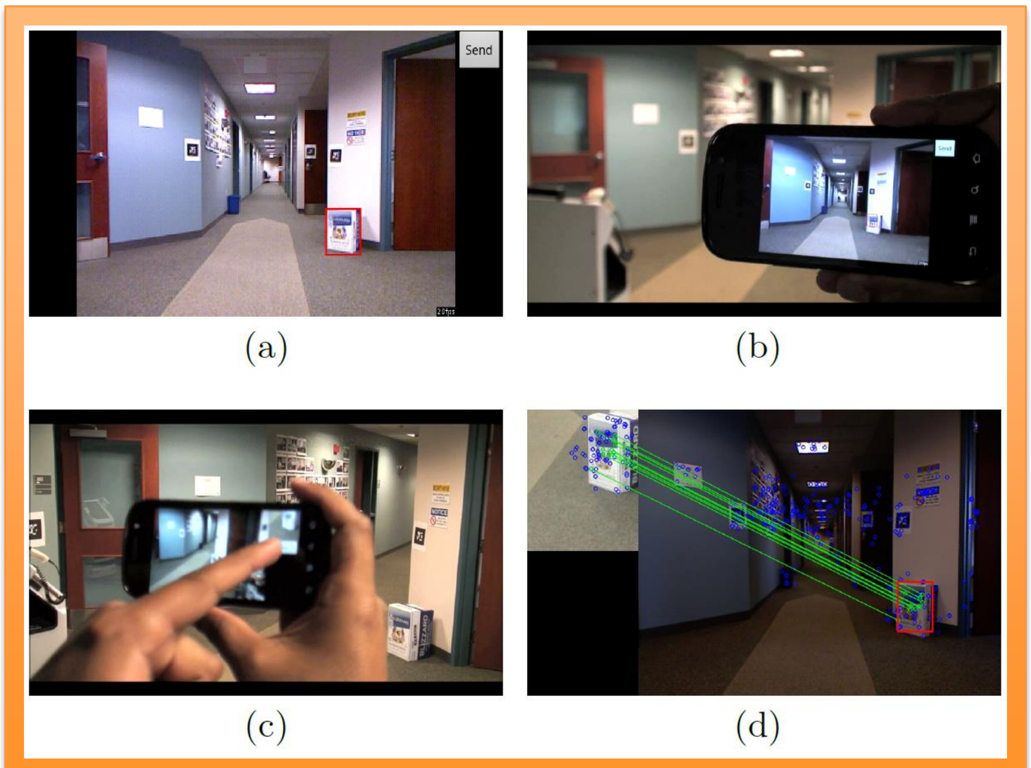
- ownship position (somewhere off-screen)
- ownship trajectory to next monitoring station
- AUV mission plan
- contact(s)
- current AUV position
- Suggested optimal monitoring station
- GPS fix / WiFi rendezvous point
- comms activity indicator

HCIs: Remote Control vs Autonomous

Driving an underwater swimming robot requires command of vehicle properties such as pose, heading, speed and status, and display of system feedback to enable corrective measures. →

Image sourced from Speers, A., *et al*., “Lightweight tablet devices for command and control of ROS-enabled robots,” *16th ICAR (IEEE)*, Nov 2013.





← An autonomous robot can be directed to a place or object of interest by either defining waypoints on a map, or selecting features within a sensor image, all of which is possible with a touchscreen.

Image sourced from Checka, N., *et al*., “Handheld Operator Control Unit,” HRI, Mar 2012, Cambridge MA.

Tools

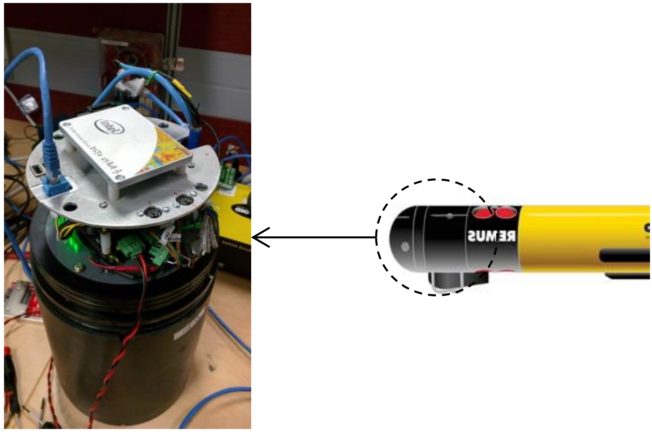
Main Application

- Android studio (IDE) with the Android developers API
- Google Maps API used for mapping

(src: Google)

Autonomy Module Application

- Application written in C++ for the stack for 2-way communication
  - Send vehicle data to phone
  - Put commands on vehicle from phone



Others

- Testing tools created with the Qt API
  - Log/Replay acoustic messages

(src: Digia)