Unmanned Maritime Vehicle Test and Evaluation Conference

AUV Fest 2005
June 14, 2005

Testing and Evaluation of REMUS Vehicle Systems

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Hydroid, Inc.
www.hydroidinc.com

Hydroid Inc. holds the exclusive license from the Woods Hole Oceanographic Institution for the manufacture and further development of REMUS Autonomous Underwater Vehicle (AUV) technology.

REMUS

Concept, Development, Transition, Commercialization, War

HYDROID

FY 93 / 94 | FY 95 | FY 96 | FY 97 | FY 98 | FY 99 | FY 00 | FY 01 | FY 02 | FY 03 | FY 04 | FY 05

Development

Prototype Tested

Environmental Sensors

1.2 MHz ADCP Operational

Predictive Coastal Modeling

20 NM Surveyed in 5.5 Hours

Autonomous Docking Node

Docking Node

Operation LEO 15

Vehicle Docked Autonomously

Hydro Model

6DOF Model

HYDROID, INC
WHOI Spin-off

LCS Mission Module

REMUS Development for NSW

600 KHZ SSS Integrated

UUV Fest 1 | FE I | FE II | FE III | ADM | SDV Demo

ORD Threshold Achieved

EDM | DT | OPEVAL | IOC 8 Units | FOC 18 Units | Product Improvement Plan ACOMMS, CAD/CAC, OAS, PNAV

REMUS Development for MCM

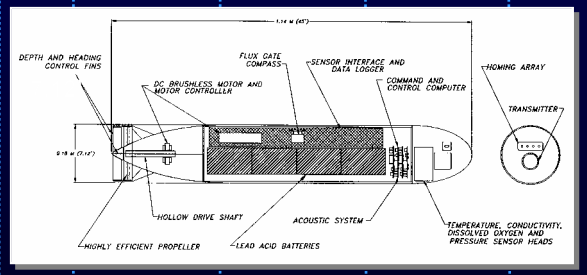
(DEMO FOCUS) → FBE-H (SCM) | KB-01 (R-I) | UUV Fest (ACOMMS) | FBE-J (CAD/CAC) | UUV Fest (Multi –UUVs) | CJTFEX (MSN Modules)

PMS EOD SCM / RIN

UOES SCM | ATFP | SCULPIN | UOES R-I | IOC SCM SYS

REMUS Original Concept

45"



Call to Duty

- Umm Qasr – FEB 03 (IRAQI FREEDOM)

REMUS Production Version

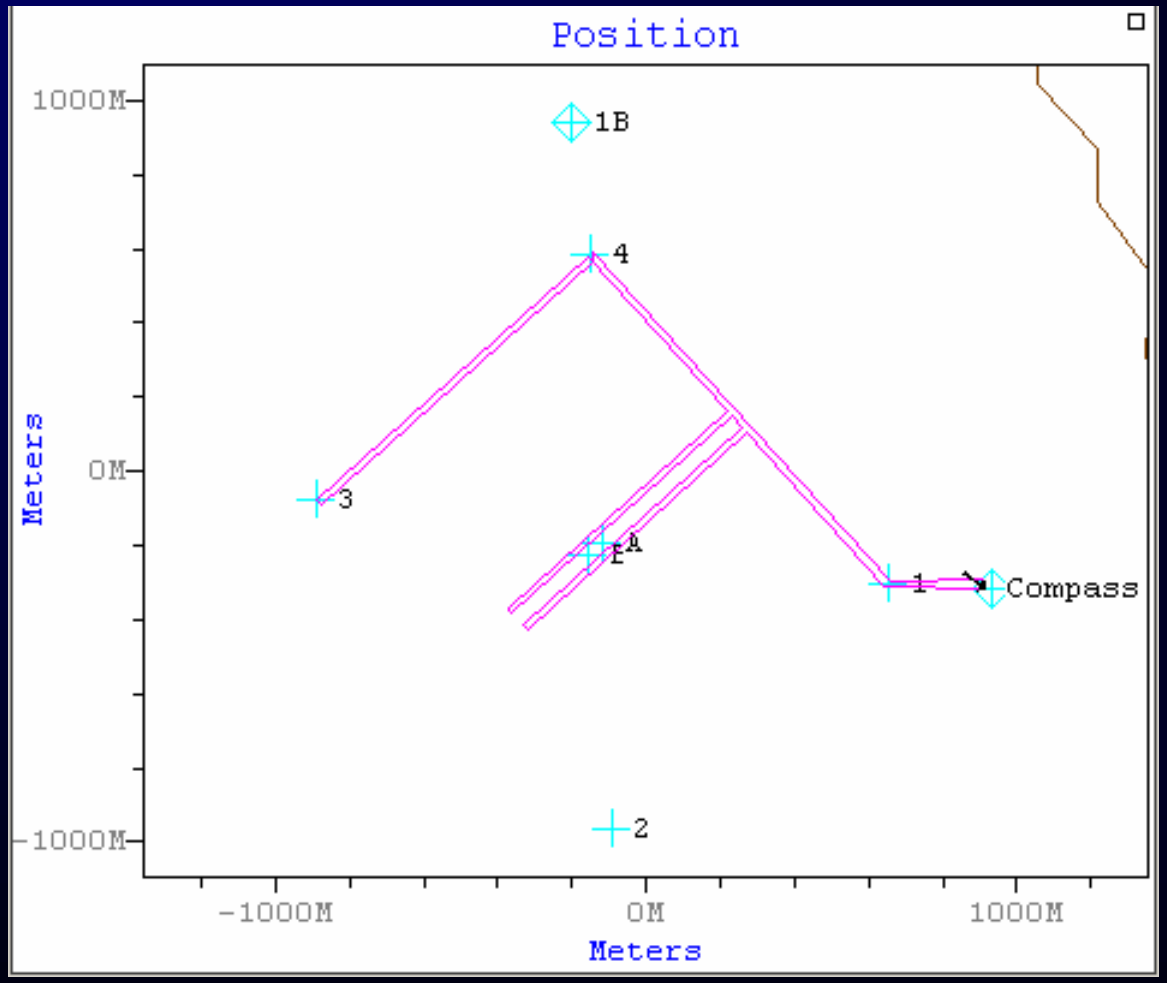
Transitions

ACAT IV-T MK 14 Mod 0 SAHRV

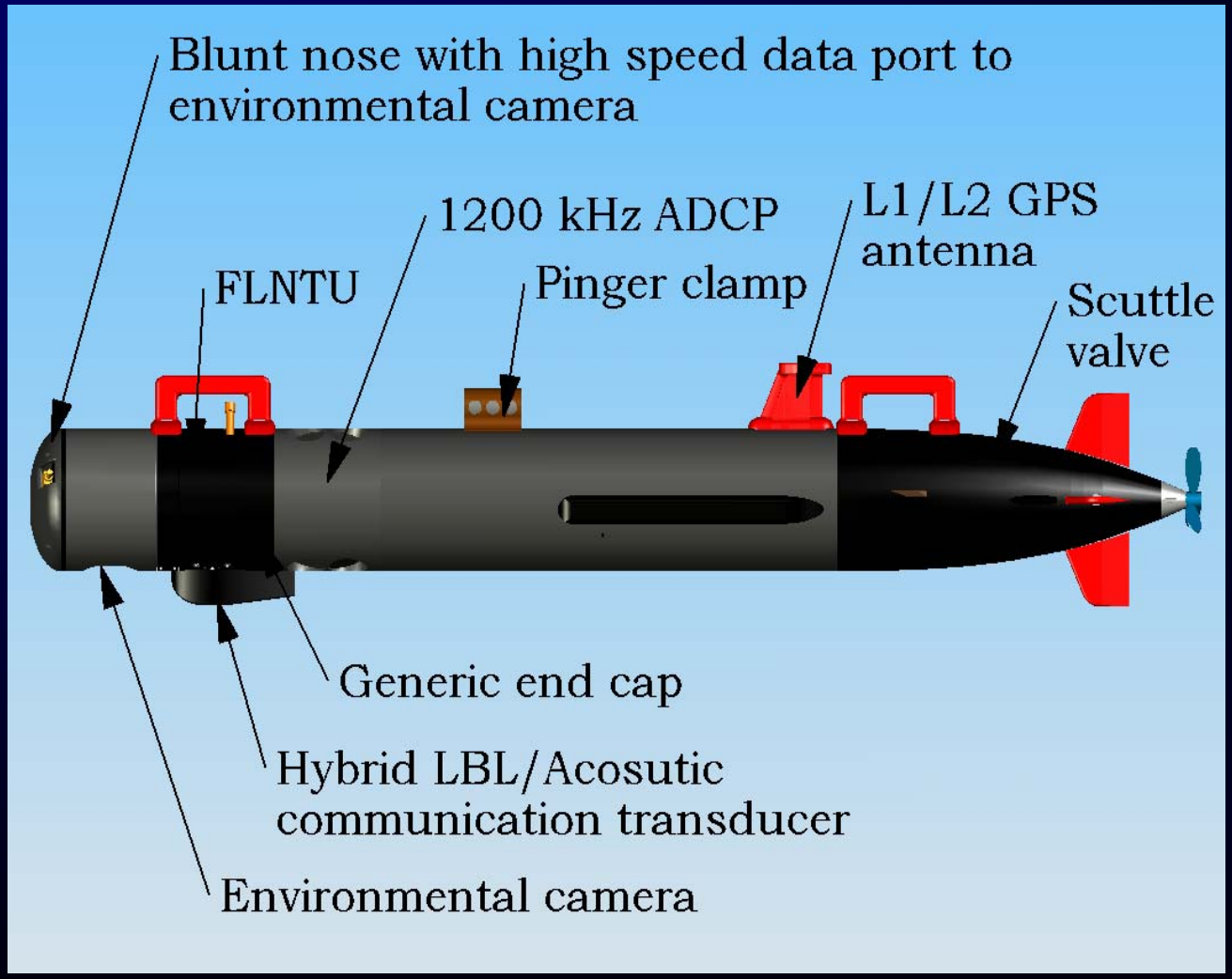
SAHRV Factory Acceptance Test (FAT)

- Reviewed and approved by U.S. Navy to test SAHRV systems
- Verifies system's capabilities to meet specification for:
  - Compass Calibration
  - LBL Navigation Range
  - Navigation Accuracy
  - Sonar Resolution
  - Battery Capacity
  - Vehicle Speed
  - Altitude Accuracy
  - Depth Accuracy
  - HTML Report Generation

All Requirements are evaluated during two hour mission



EOD UUV SCM Prototype



UK MOD System

Hydroid received major contract from the United Kingdom Ministry of Defense to supply (10) REMUS Autonomous Underwater Vehicle systems to the Royal Navy

"REMUS will enable the Royal Navy to undertake rapid mine reconnaissance in the Very Shallow Water (VSW) zone an area which, currently, is accessible to divers only. Employing REMUS will reduce the risk to clearance divers during operations in the detection and clearance of maritime mines."

RECENT REMUS DEMONSTRATIONS/TRAINING

REMUS Trials in Germany
Trials in Rotterdam Harbor
Trails Finland
German Navy training
NATO Undersea Research Centre (NURC)
Scandinavian demonstrations

Shallow Water Reacquisition Technology

3 REMUS 100 vehicles
86 lbs, 7.5 hours @ 4.5 knots modular end cap

SENSORS
900/1800 kHz sonar
1200 kHz ADCP
Optical backscatter
Conductivity Temp
CAD/CAC

NAVIGATION
LBL acoustic
P-code GPS
Kearfott T-16 IMU
(ADCP, GPS, LBL aided)

COMMUNCATION
Acoustic Modem
Iridium Modem

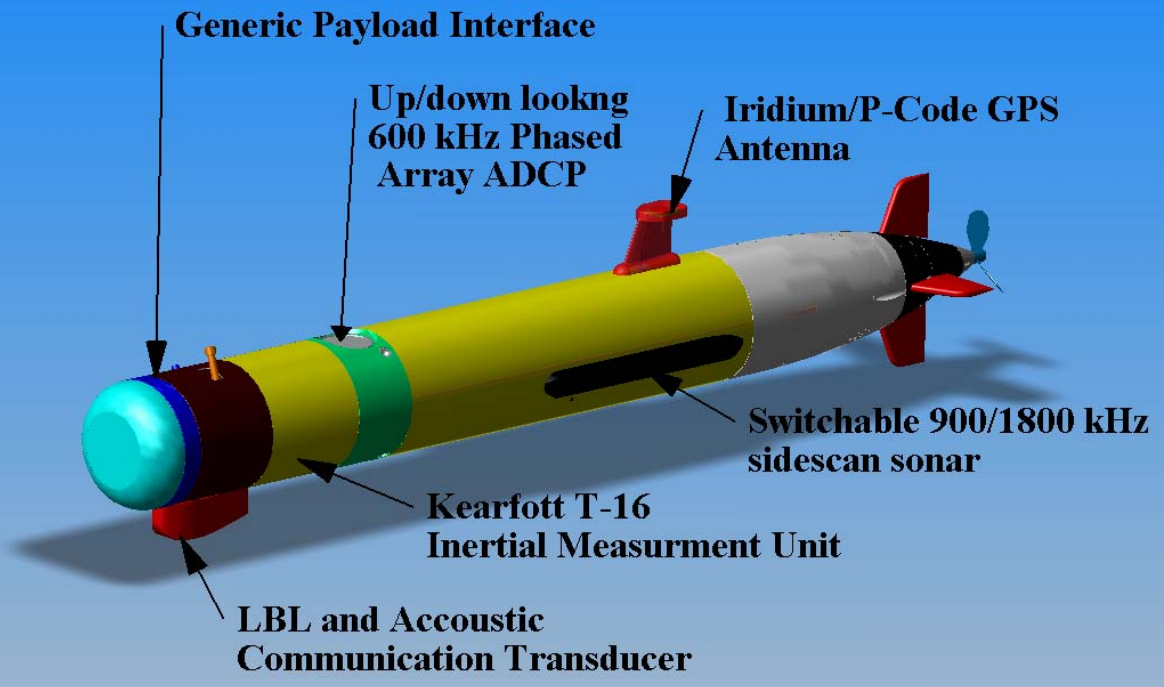
2 Gateway Buoys

COMMUNCATION
Acoustic Modem
Iridium Modem
FreeWave Modem
GPS

REMUS 100 –MCM Vehicle
Mission Flexibility

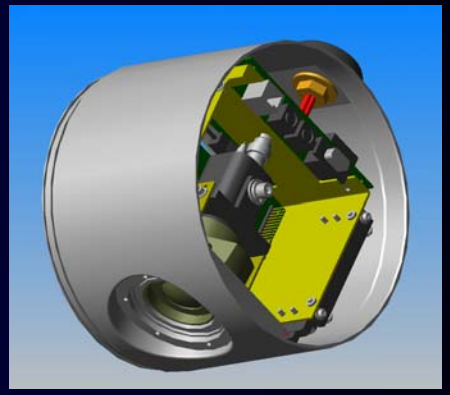
HYDROID

Supports Search & Classify & Map and Reacquire & Identify Missions



- 1.6 m long vehicle
- 39 kg – 14 hour mission duration at 1.5 m/s
- Ship by commercial overnight carrier
- Submarine compatible

Forward-looking Sonar DIDSON



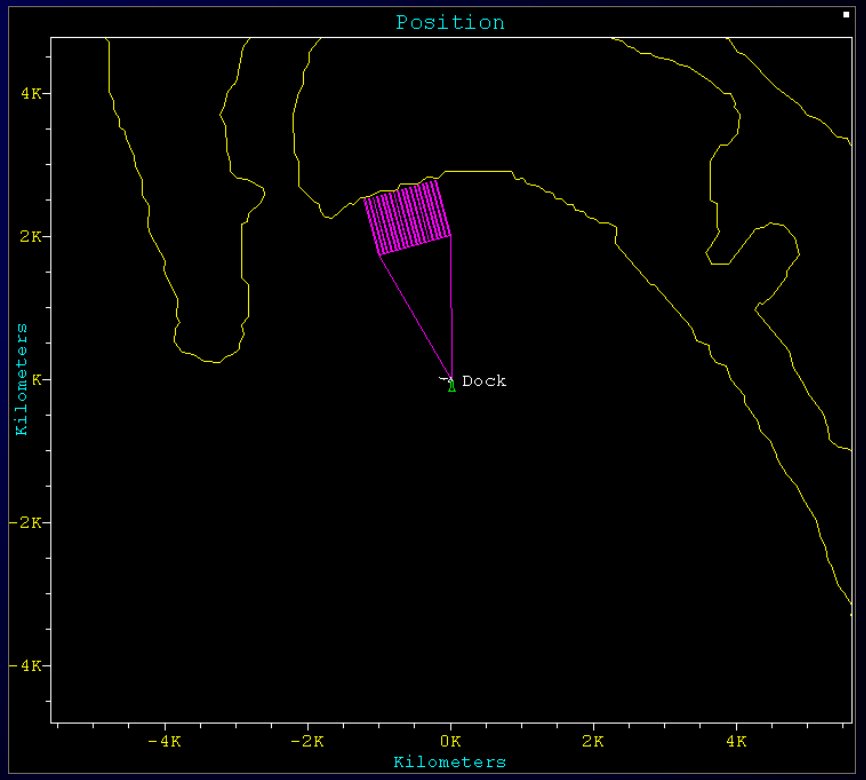
Low-light video camera

REMUS Customers

- WHOI has delivered 17 REMUS systems
  - 4 Academic institutions
  - 13 U.S. Navy
- Hydroid has delivered 60 REMUS systems
  - 36 U.S. Navy
  - 6 U.S. Government
  - 8 Academic institutions
  - 1 German Navy
  - 2 Royal Dutch Navy
  - 2 NATO Undersea Research Centre
  - 2 Singapore Navy
  - 3 Commercial

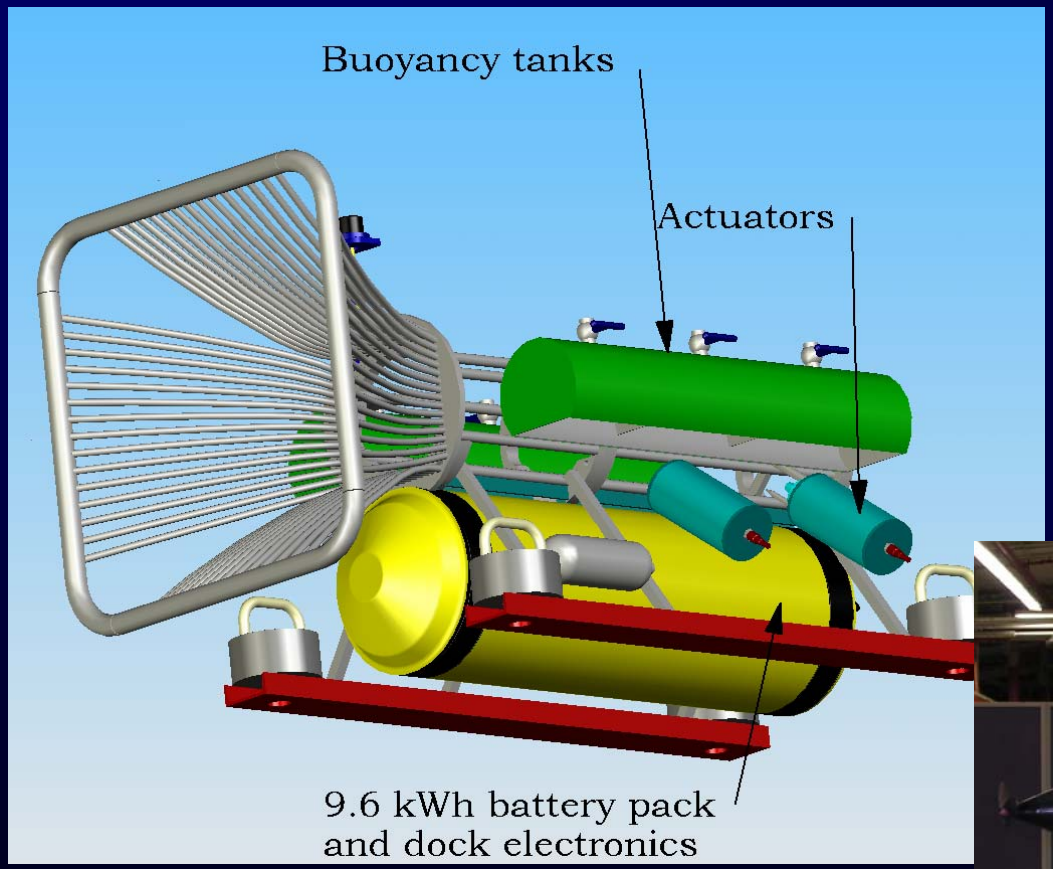
Autonomous Docking Problem

- Provide sustainable and affordable access to littorals using robotic technologies that are compatible with fleet technology
- Provide technology that facilitates its creative use by war fighters



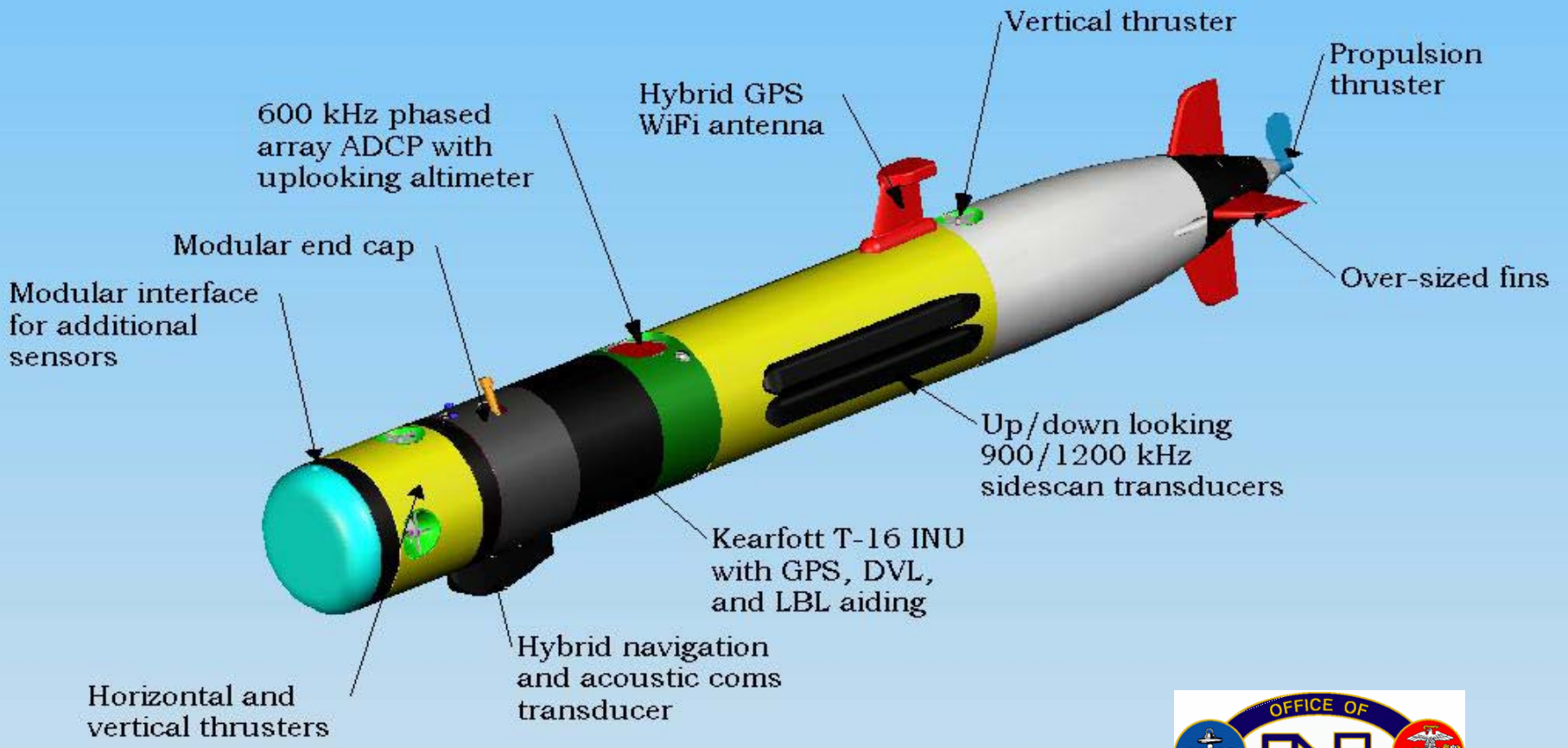
Sustained autonomous operations in the littoral environment

REMUS Docking system



Docking Test Results

REMUS 100
Harbor security and under hull surveys

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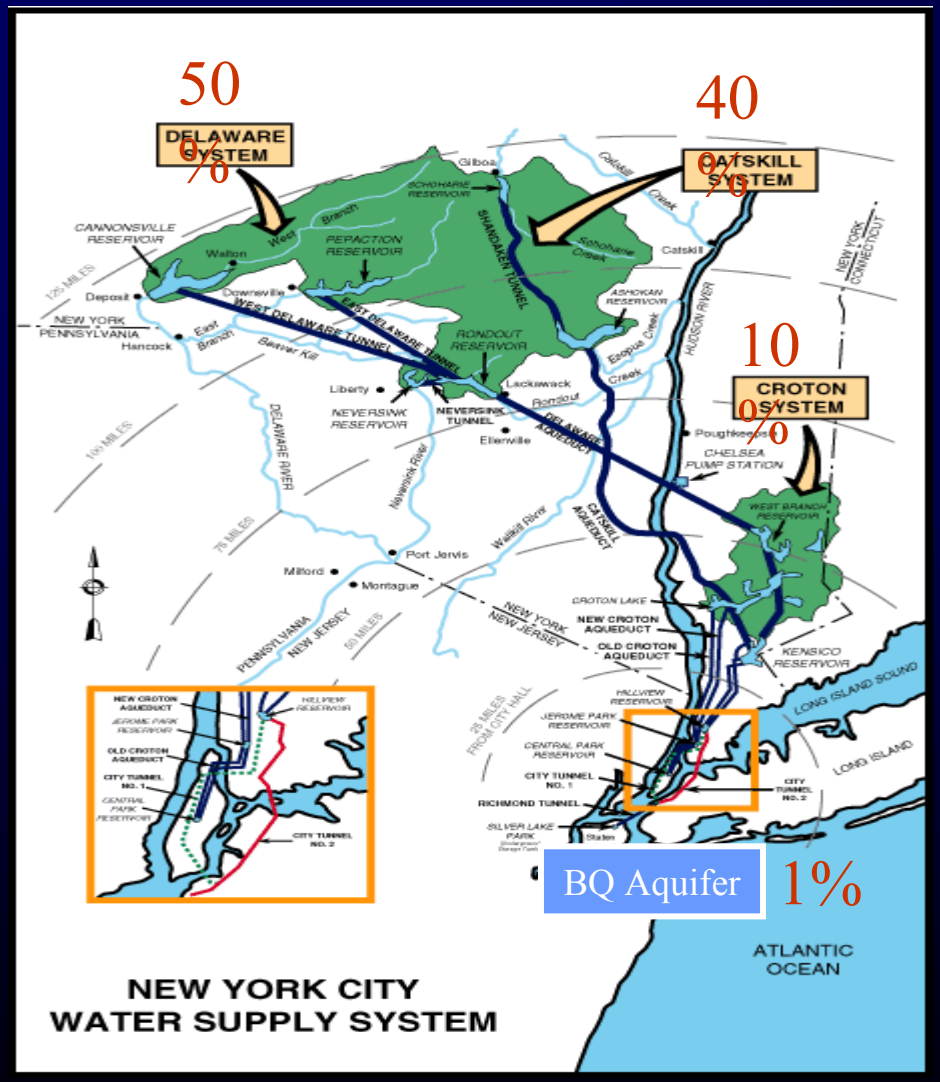
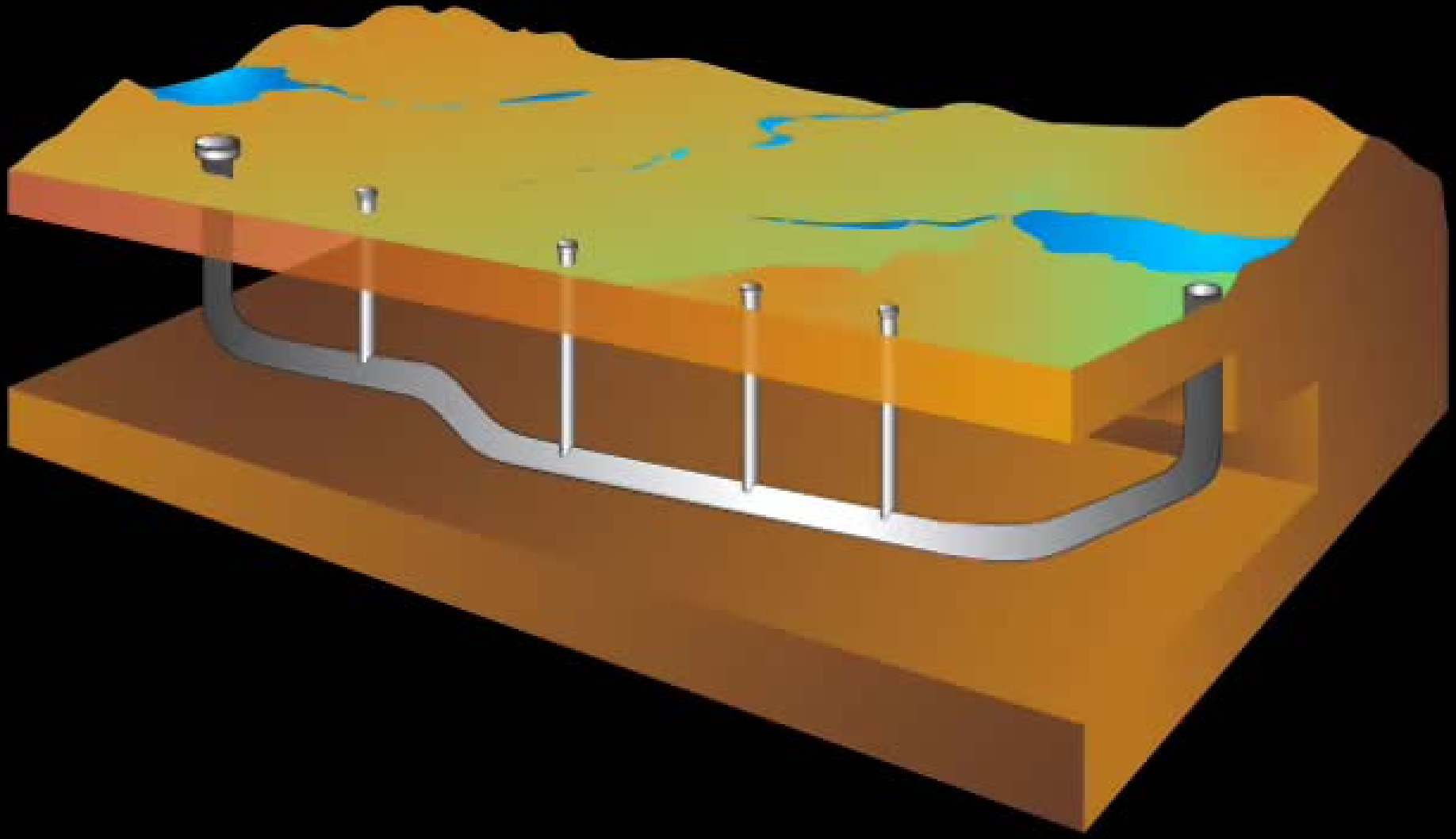
Map of New York City Watershed



Delaware Aqueduct Under Construction

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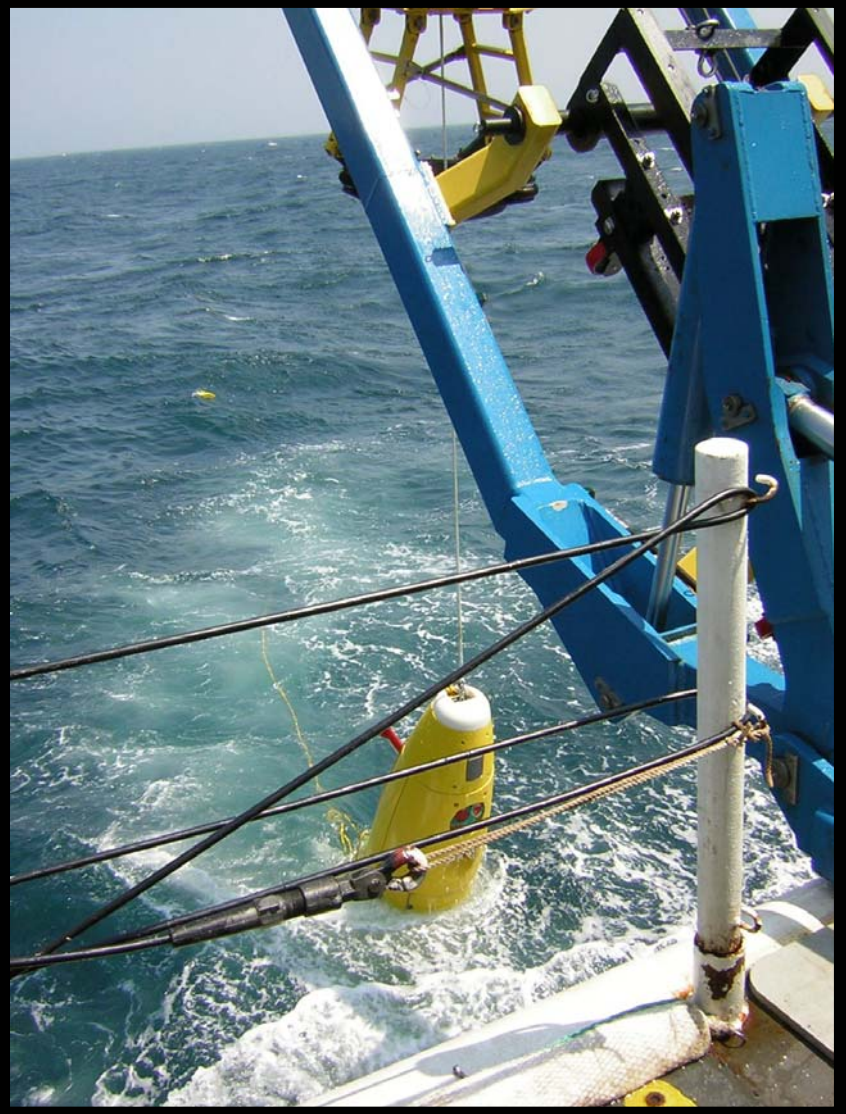
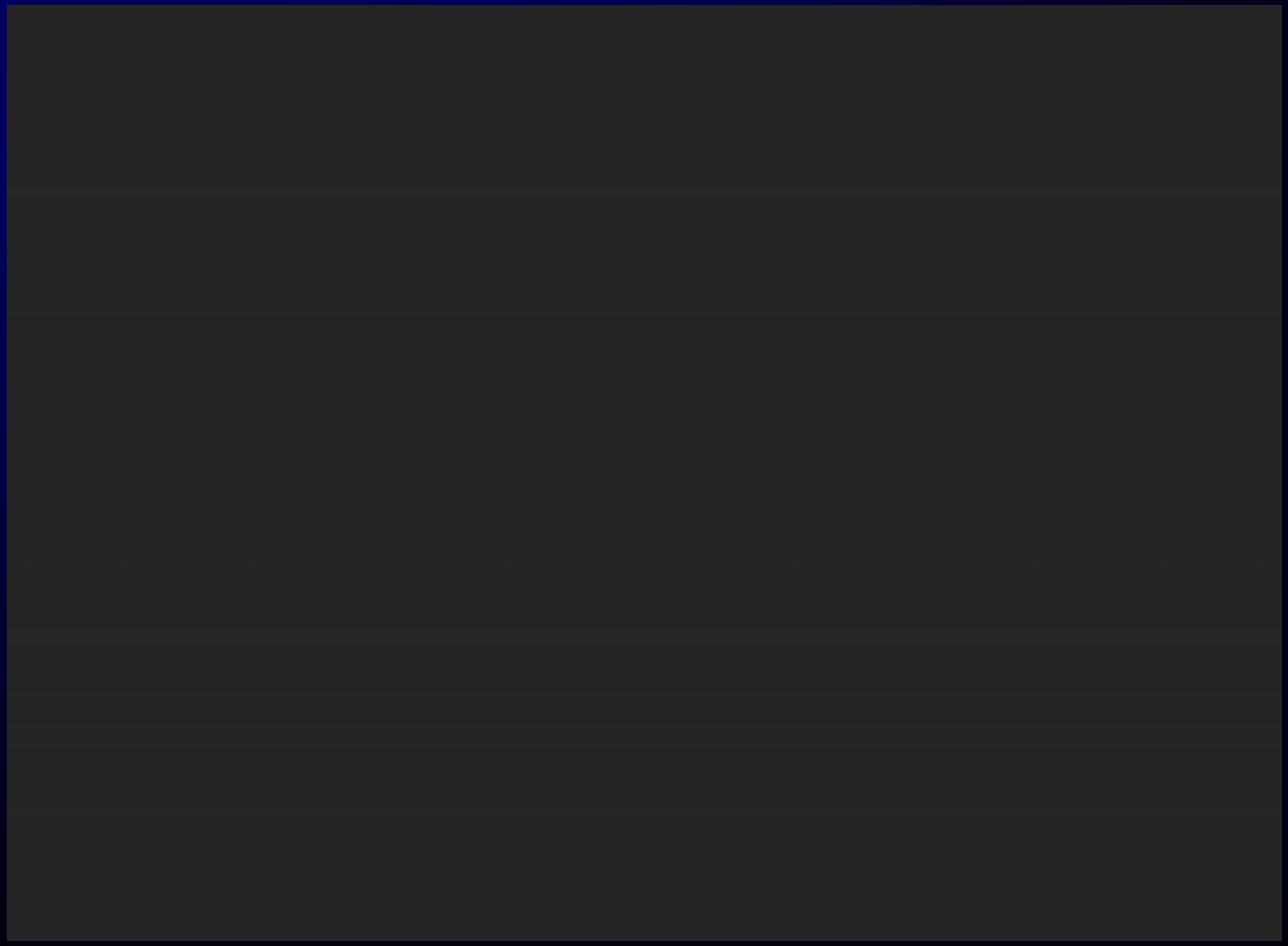
REMUS 6000
Base line Configuration

- Survey
  - Switchable 300/900 kHz sidescan
  - 12 hour duration at 4 knots
  - Field exchangeable battery packs
  - Multi-vehicle operations
  - Mission redirection over acoustic or Iridium links
- Navigation
  - Acoustic long base line
  - INU aided with GPS and ADCP
- Communication
  - Iridium modem
  - Acoustic communications –WiFi
- Payload exchange
  - Electronic still camera & strobe
  - Sub-bottom profiler

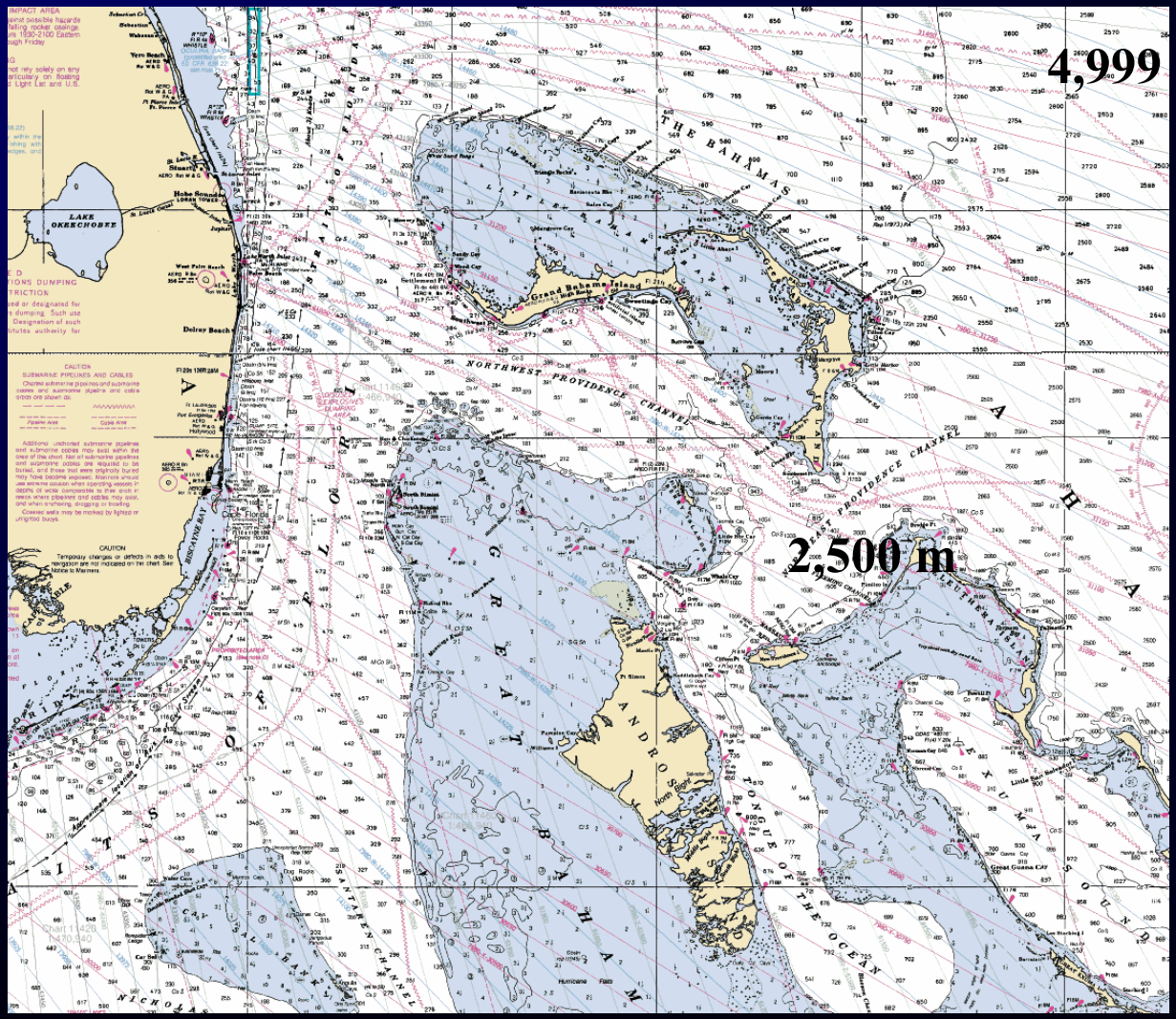
REMUS 6000 Launch and Recovery



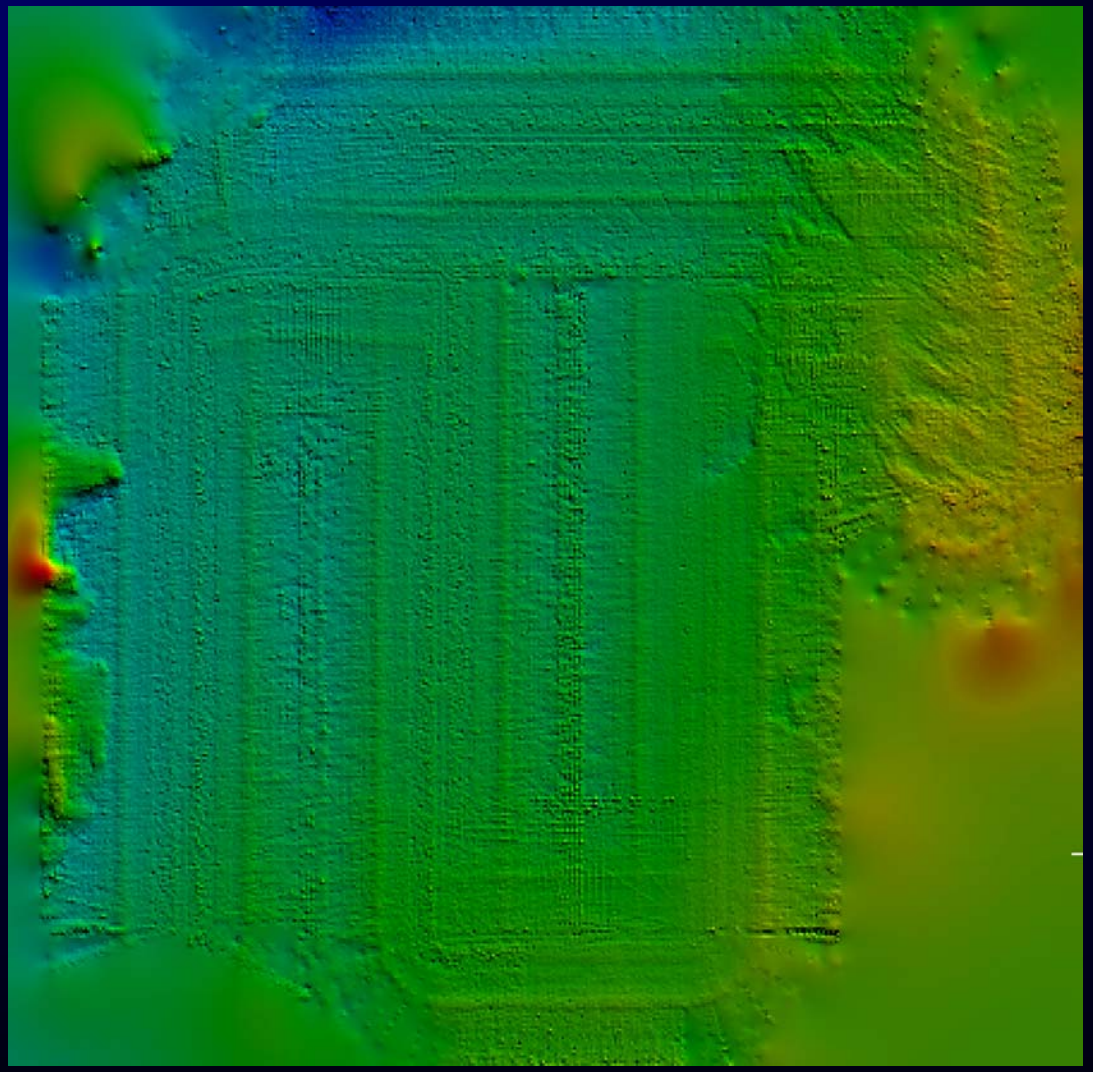
Successful Operations have been conducted in 15 foot Seas



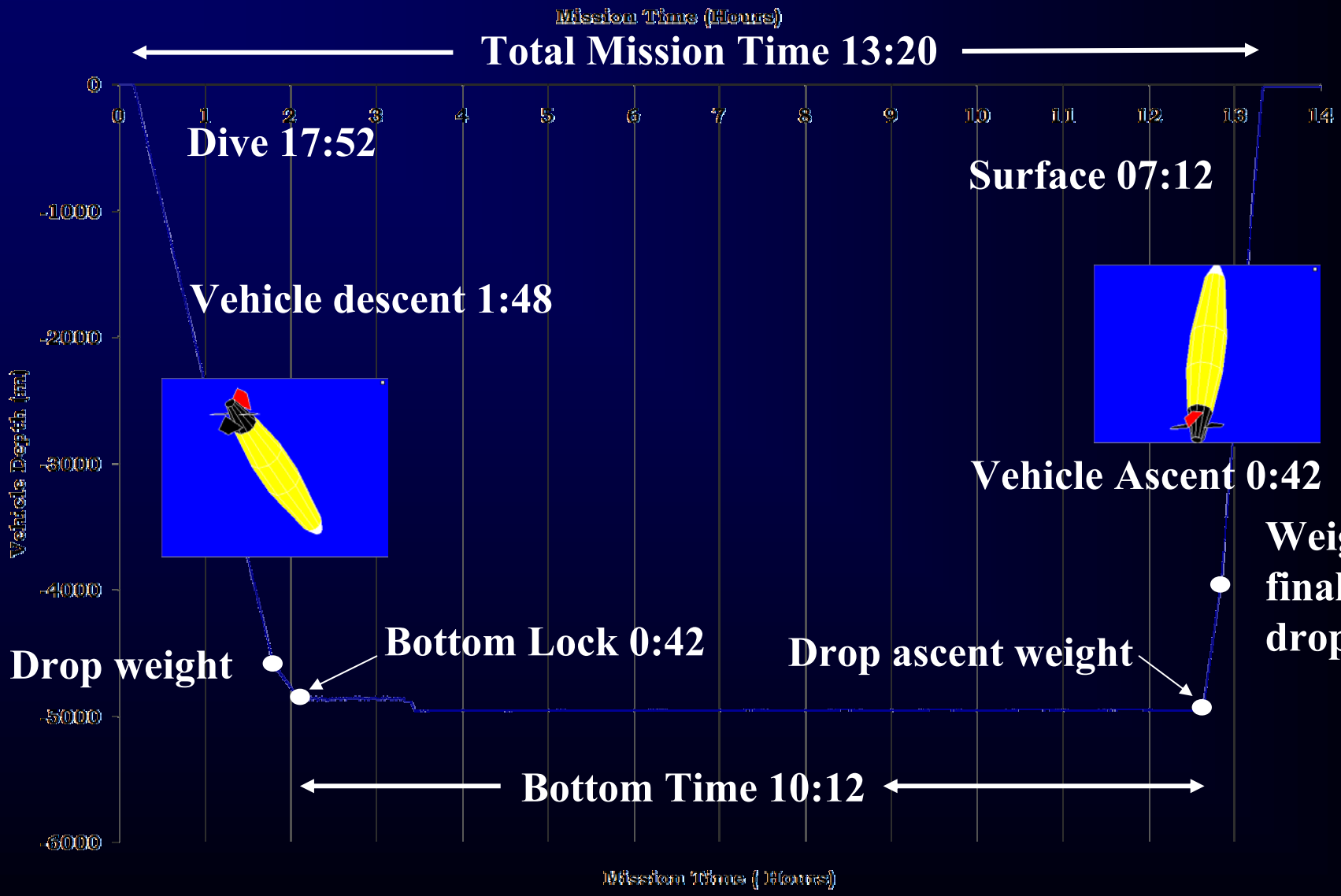
March 03 Test Areas



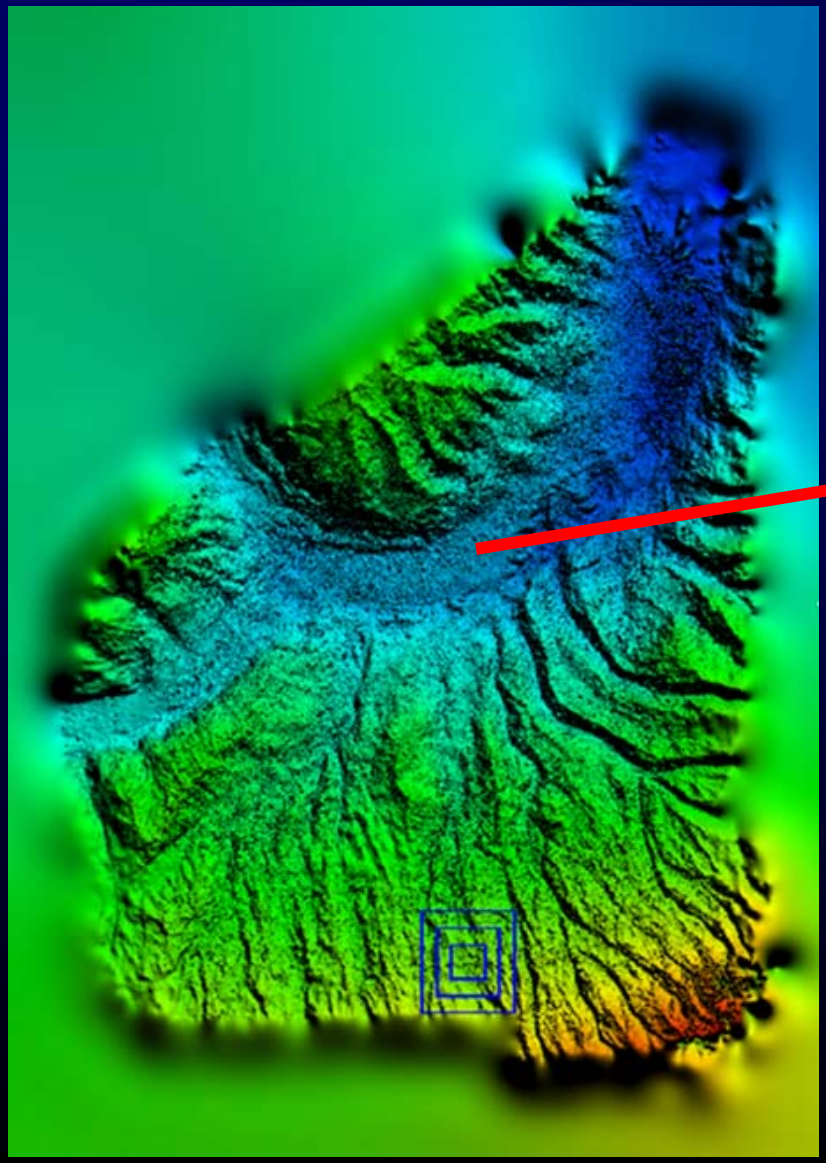
4,999 M Test Area

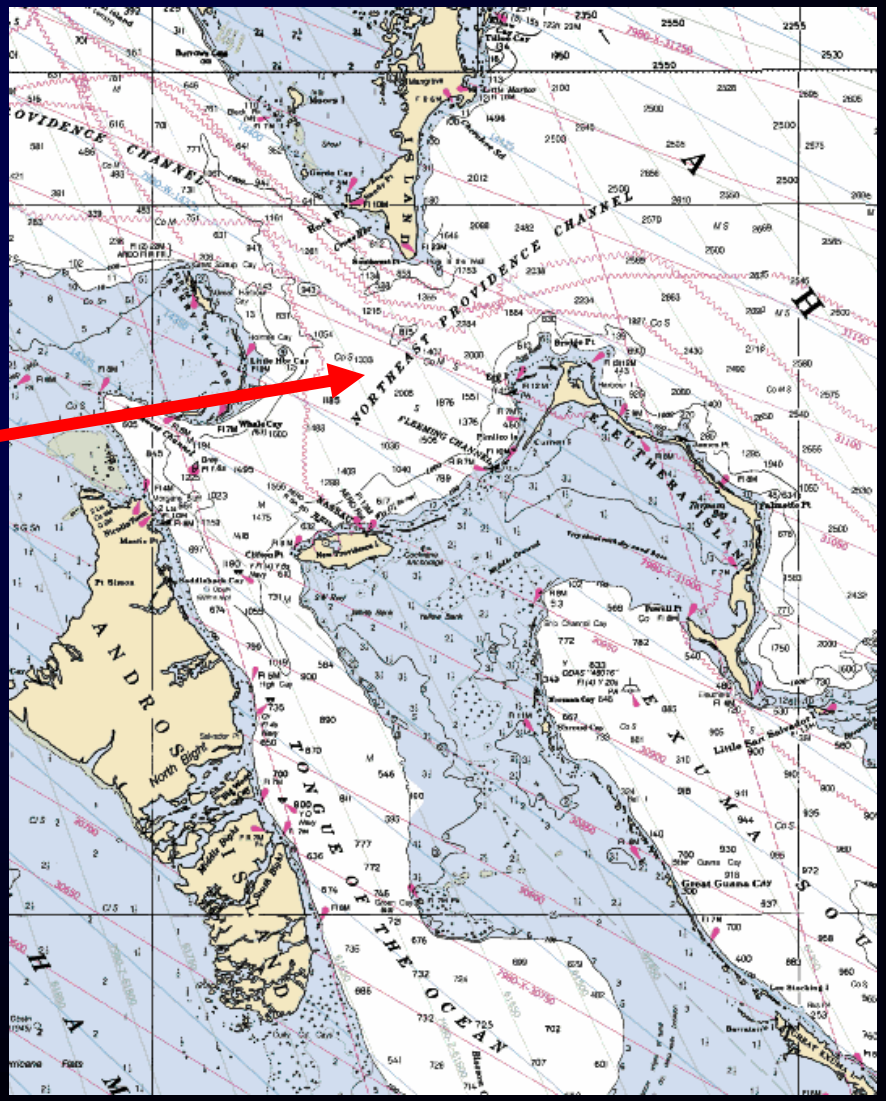


SAMS Mission 9 Profile

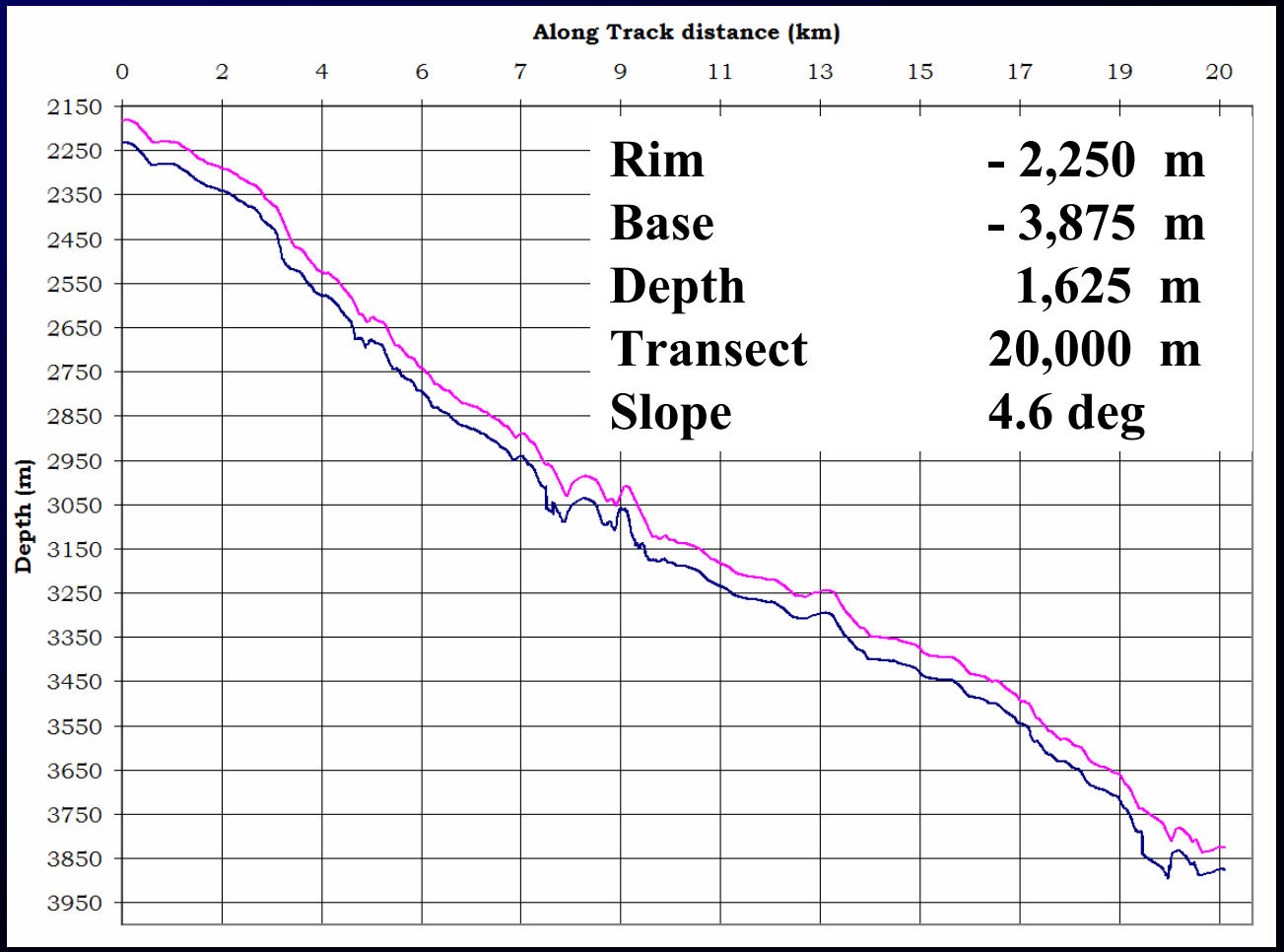


2,500 m Test Area

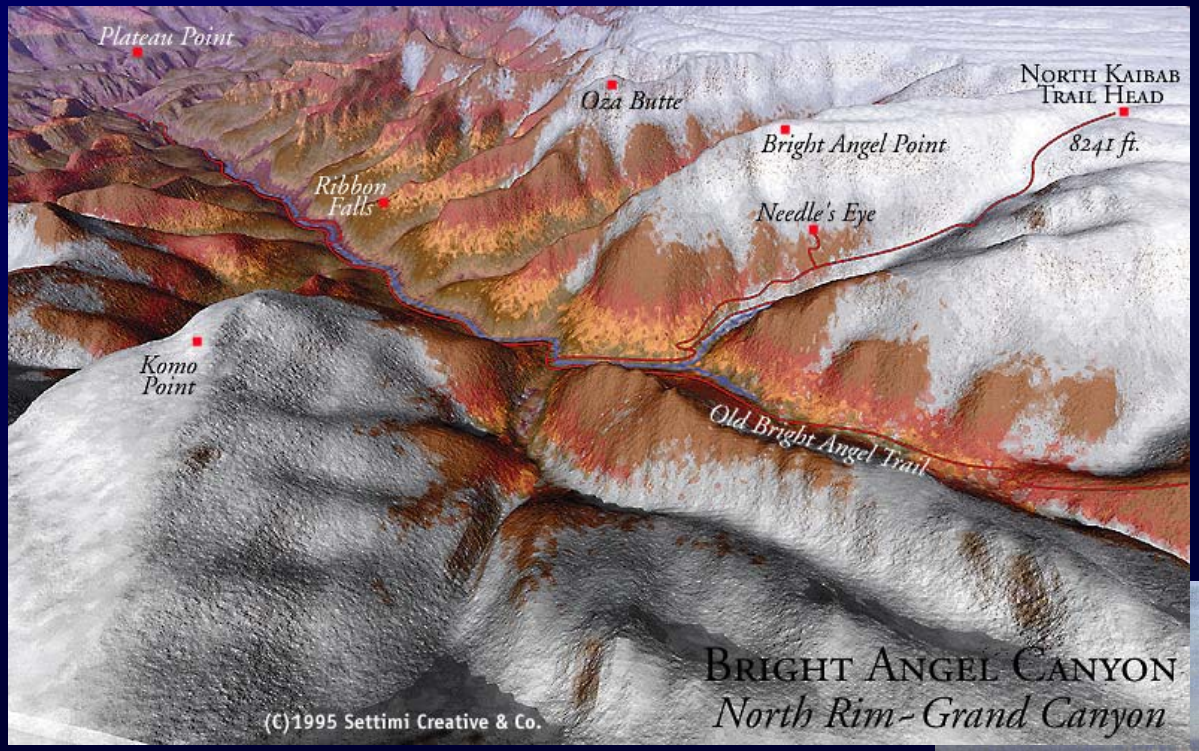




Mission 13 12nm Redirect



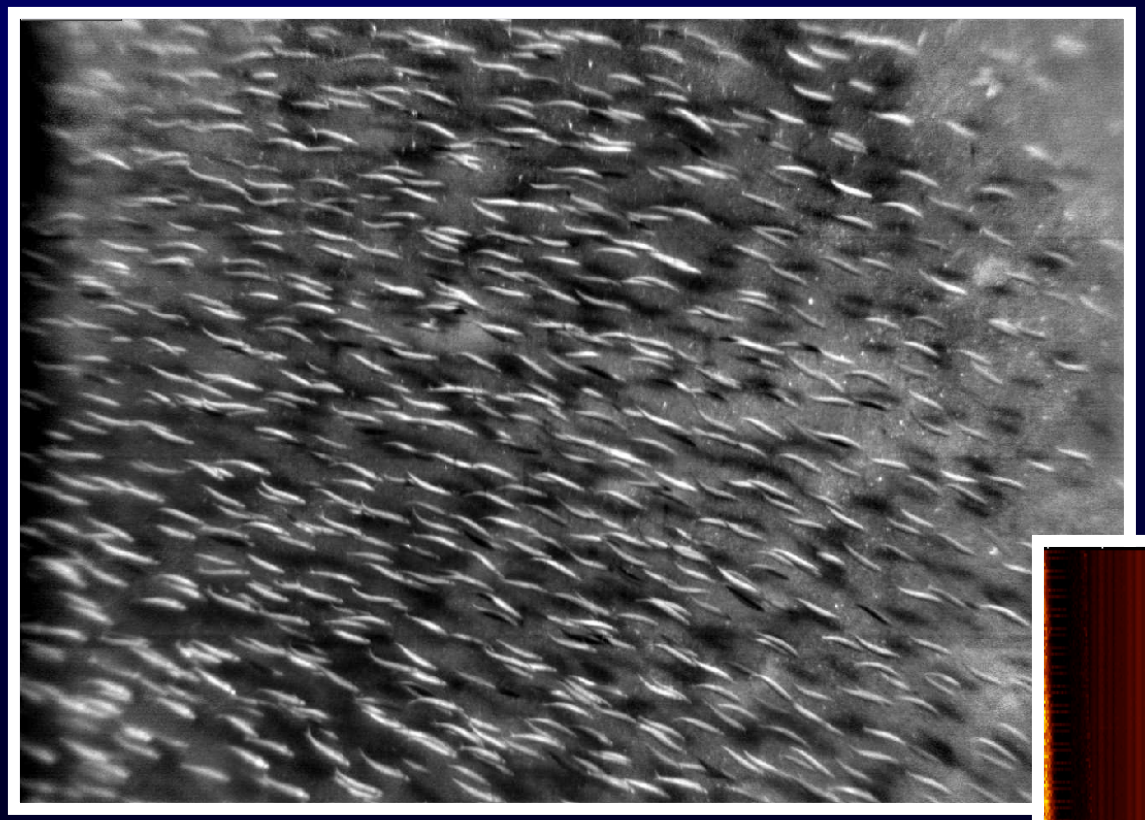
Descent Down the North Kaibab Trail



Rim	2,512	m
Colorado River	739	m
Depth	1,773	m
Trail Length	22,000	m
Slope	4.6 deg.	

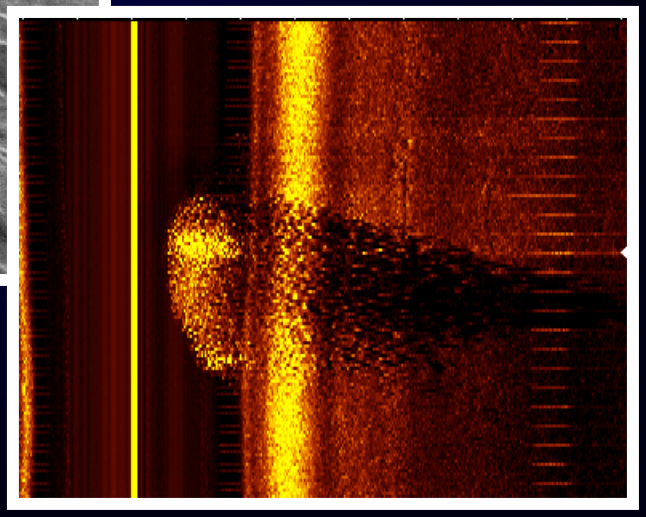
Bright angel point

Shallow Low Altitude Imaging (4 meters)



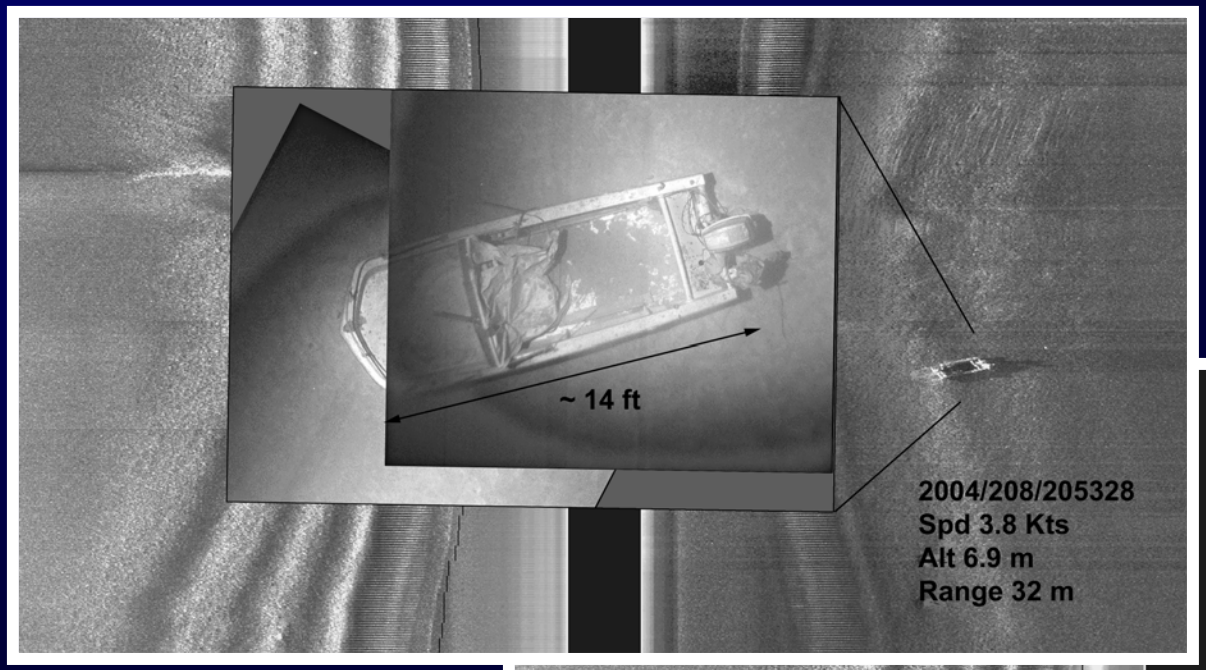
Electronic Still Image, with 200 W-S strobe illumination

900 kHz Side Scan

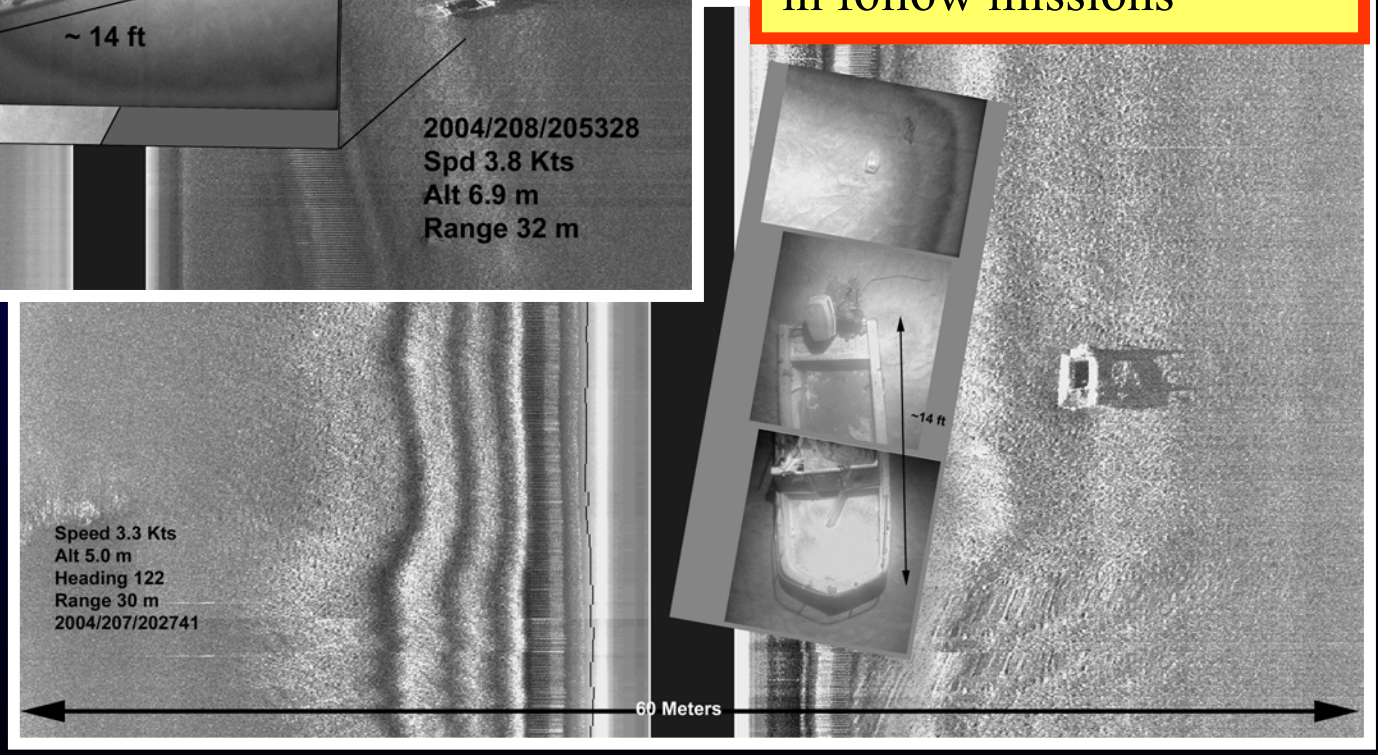


Fish School off Charleston in 30 meters.

Post Target Analysis



- Repeatedly returned to boat for imaging
- Redirected vehicle via modem to over fly target in follow missions

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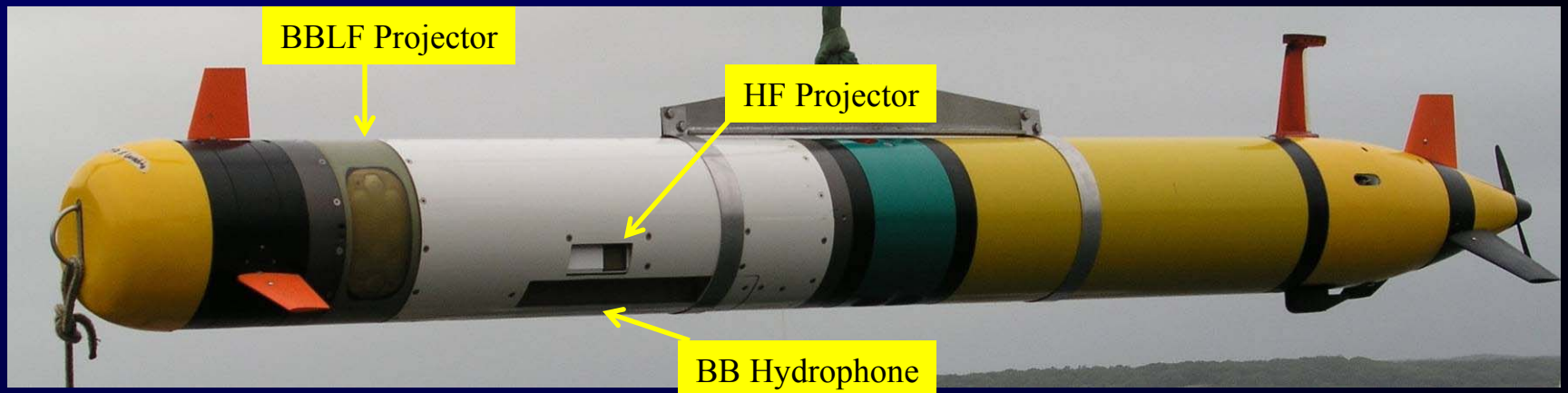
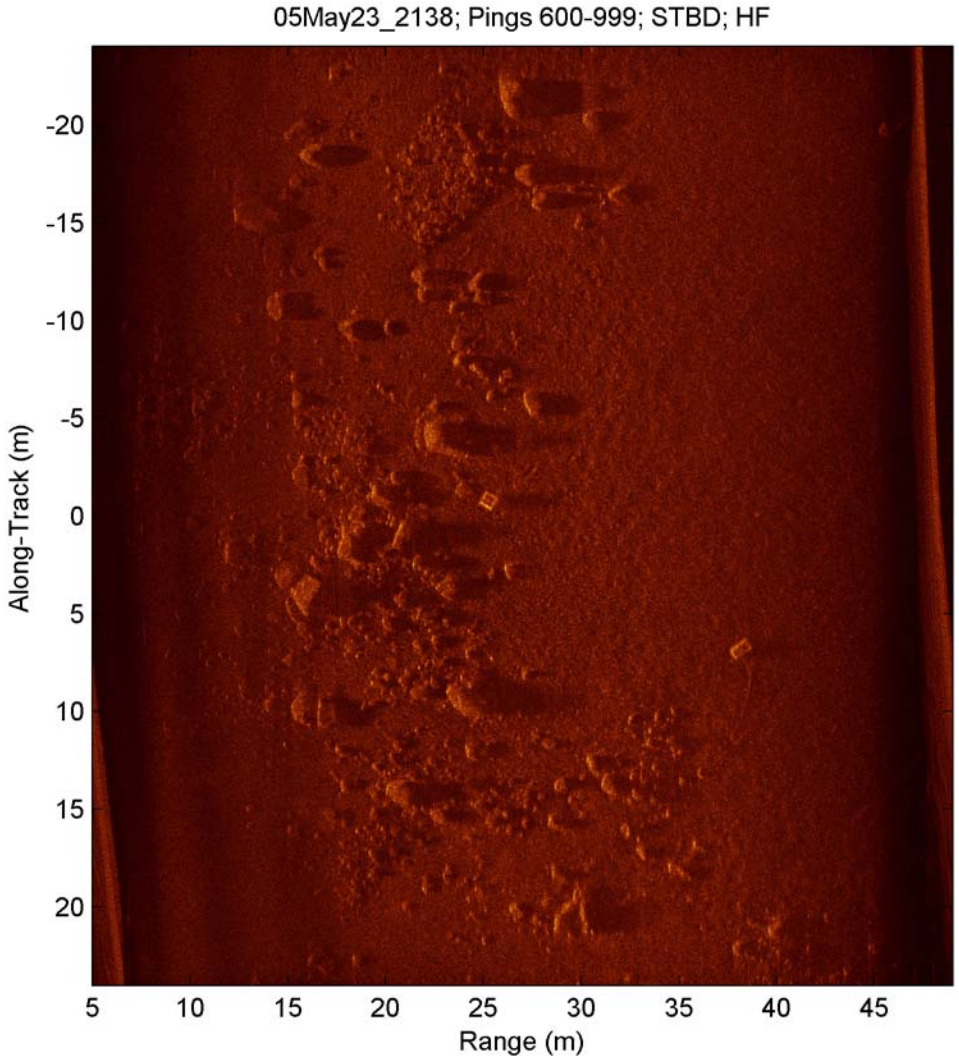
Light Weight Torpedo Class AUV

SSAM/Remus600 System (12.75” shell diameter class)

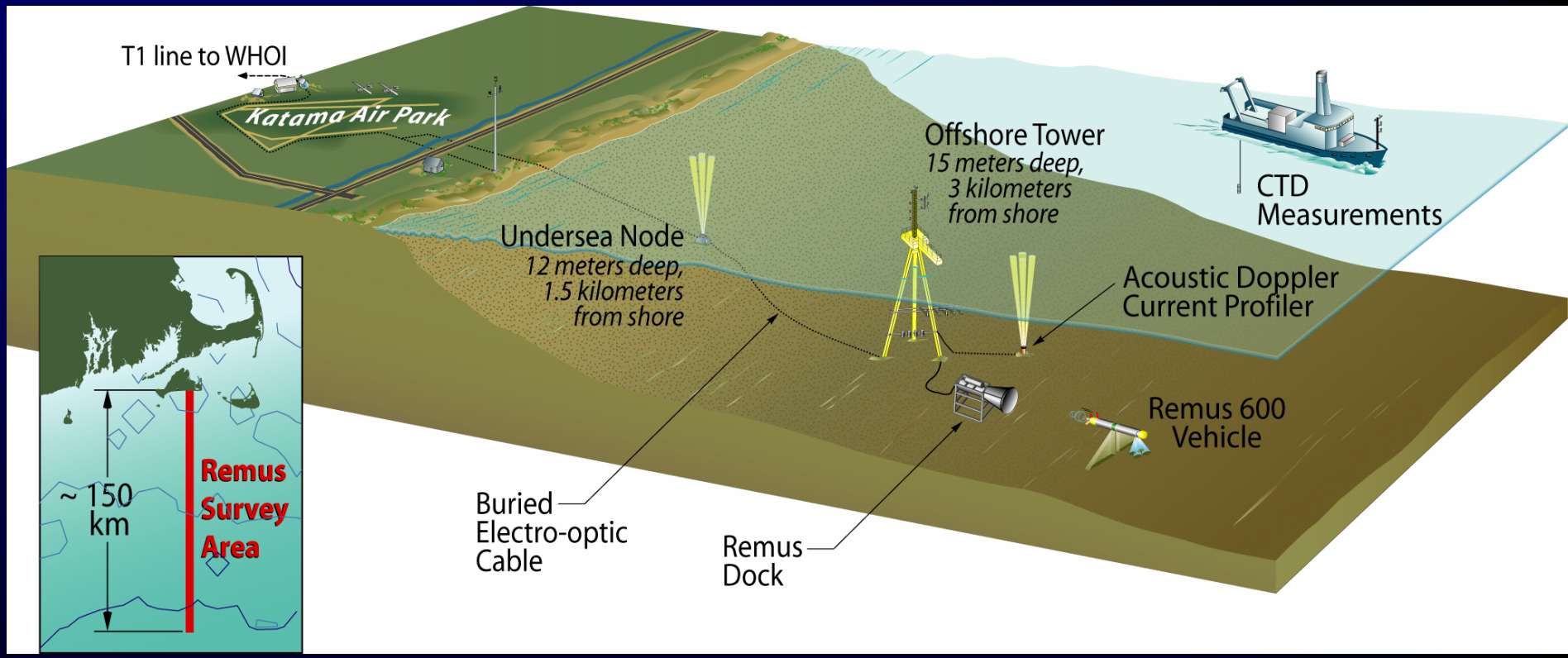


SAS Payload	UUV	Status	Team
SSAM •Simultaneous dual frequency band operation: HF band = 105 - 135 kHz, 1” x 1” res. LF Band = 8 - 52 kHz, 3” x 3” res. •DC Capabilities against proud & slightly buried targets. •Array elements used for MoComp = 2. •Range = 90/V (45 meters @ 2 m/sec). L_{SA} HF band = 11 meters L_{SA} LF band = 22 meters	WHOI Remus600	•Scheduled to participate in AUV FEST 05 (6-17 June).	Sponsor: ONR Tom Swean WHOI, ARL/PSU, VCT & NSWC-PC

SASS Images


05May23_2138; Pings 600-999; STBD; HF
Along-Track (m)
-20
-15
-10
-5
0
5
10
15
20
5
10
15
20
25
30
35
40
45
Range (m)

Repeated Autonomous Surveys of the Open Ocean thru shipping lanes



Repeated 300 km cross shelf transect from a seafloor docking station located at the end of cabled seafloor observatory

Subsurface observations are essential for properly constraining data assimilative models

REMUS Technology Demonstrated at AUV Fest 2005

- Multiple vehicle operations
- Dual frequency 900/1800 kHz Side Scan
- Dual Frequency SASS
- 600 KHz Phased Array DVL
- Kearfott T-16B INS
- LBL Nav on INS configured REMUS
- ACOMMS – high speed mode, image transfer
- Wet Labs BB2F
- Rockwell-Collins P Code GPS
- Iridium and WiFi Communications
- Simulated AUV Launch from a Dry Deck Shelter
- Autonomous Docking System for REMUS 100


Questions?