Undersea Positioning and Navigation

Tulane Engineering Forum
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Outline

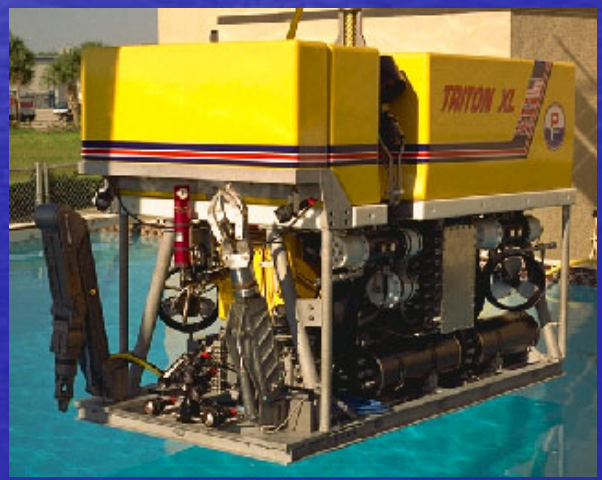
- Unmanned Untethered Vehicles (UUVs)
  - Navy and commercial needs/uses
  - Some examples
  - Technology Issues
- Undersea Positioning Basics
- Recent/Future Research Efforts

UUVs – needs and uses

Fundamental trade-off: Power vs. Speed

- Tethered vessels
- Untethered vessels

Hugin UUV – 3000 lbs, 3000m max



Triton XL ROV - 7700 lbs 1500m max

Klien Sidescan Towfish 155 lbs, 150m max

UUVs – Navy needs and uses

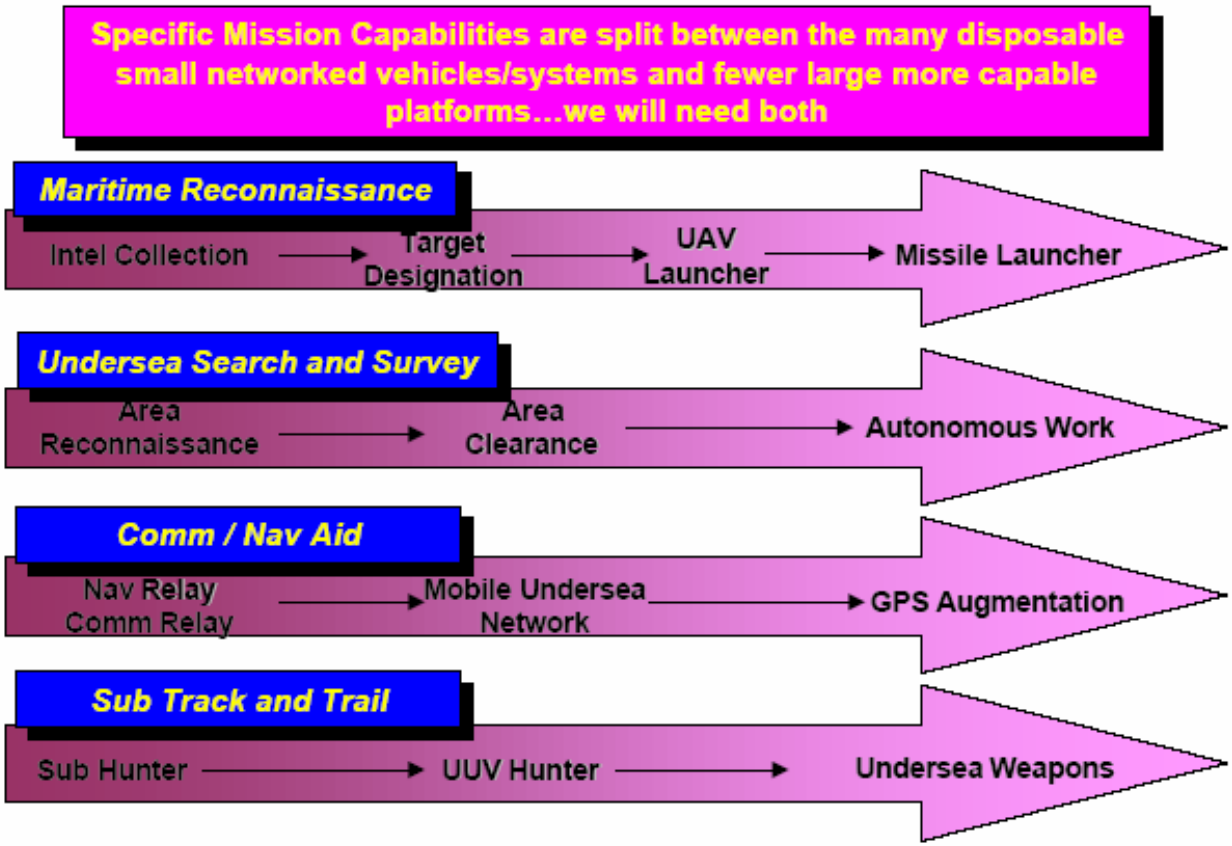


Figure 3-1: Signature Capabilities From the Present to the Future

From: The Navy Unmanned Undersea Vehicle (UUV) Master Plan, Approved for Public Release 27 March 2001. Distribution is unlimited. Available online at http://www.auvsi.org/resources/UUVMPPubRelease.pdf

UUVs – Commercial needs and uses

Maridan 600

Now:

- Deepwater oil and gas surveying – 50% reduction in survey time over tethered vessels (the Industrial Physicist, AUG02)
- Pipeline Route Surveys (C&C Technologies Press Release)
- Fiber-optic cable laying (Intl. Submarine Engineering)

Slocum Glider

ISE Theseus

Soon: (Undersea Vehicles and National Needs (1996) Commission on Engineering and Technical Systems)

- Synoptic Observation Systems
- Oceanography, hydrography, search and survey, resource exploration
- Fish management

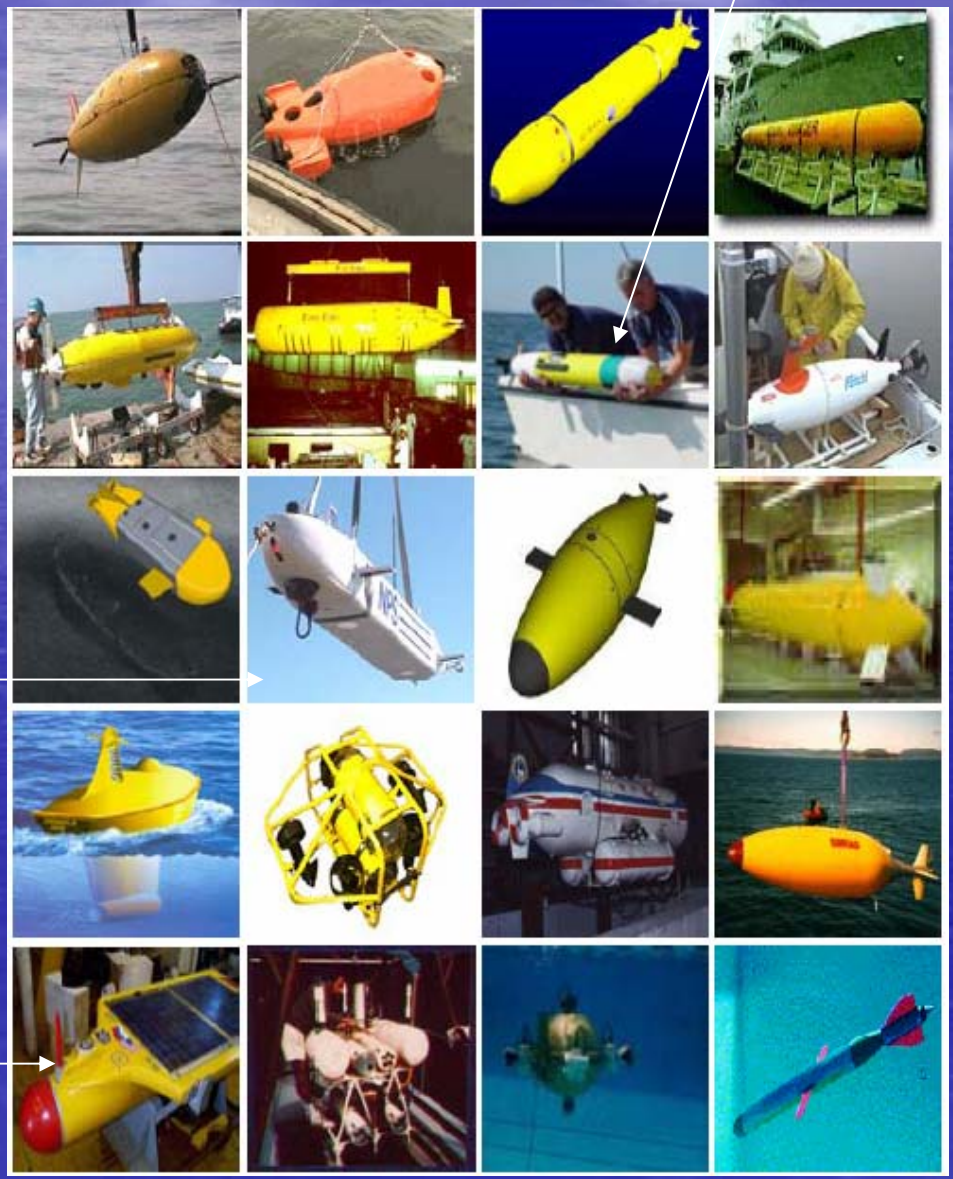
UUV examples

From: Autonomous Undersea Systems Institute http://www.ausi.org/auvs/auvs.html

Remus

Cetus

Autsub



Ocean Voyager

Ocean Voyager II

Sias Peterson Fecth

Atlas Maridan

ISE Theseus

NPS Aries

Caravela

Hugin

Solar Powered SAUV

Slocum Glider

UUVs in our neighborhood

University of Southern MS
NOAA Undersea Research Program

ISE Ltd. Explorer UUV
Operating Specs:

- 2200 meters depth capability
- Multibeam, CTD
- INS / USBL / DVL / DGPS
- 4.6m long, 0.6 m diameter, 940kg
- Lithium Ion / 36 hours @ 2.9 kts
- Radio & Single Acoustic Telemetry

C&C Technologies
Lafayette, LA

Krongsberg-Simrad Hugin3000
Operating Specs:

- 3,000-meter Depth Capability
- Multibeam, Sidescan, Subbottom, CTD
- INS / USBL / DVL / DGPS
- 5.4m long by 1.0m diam. / 1200kg
- Fuel Cell / 380km Range @ 4 kts
- Radio & Dual Acoustic Telemetry

UUV's Technology Issues

Undersea Vehicles and National Needs (1996) Commission on Engineering and Technical Systems and Navy UUV Master Plan (2000)

- Sensors
- Communications
- Autonomy
- Energy
- Navigation and Positioning

Undersea Position Determination

- Pop-up for a GPS fix
- Dead Reckoning
- Acoustic transponder systems
  - Long baseline (LBL)
  - Short baseline (SBL)
  - Ultra Short baseline (USBL)
- Map/Terrain Relative
  - Gravity, Magnetic, Topographic
  - Features in Imagery

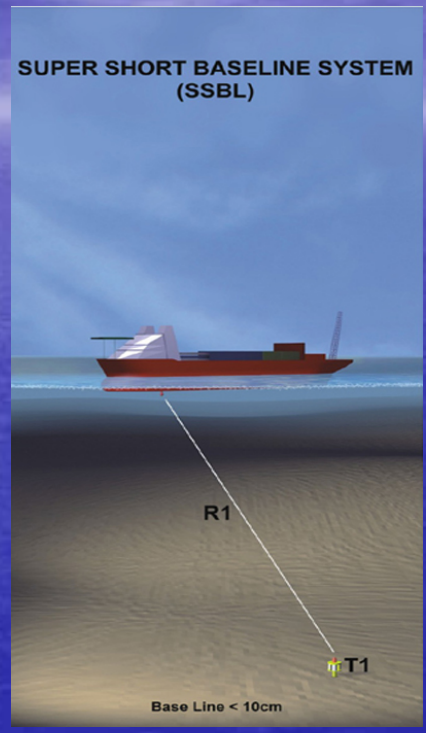
Dead Reckoning

- Screw RPM/magnetic compass – 5% position error growth (peg) with distance
- Inertial without velocity aiding – 1nm drift/hr
- Inertial with DVL – 0.05% peg achievable

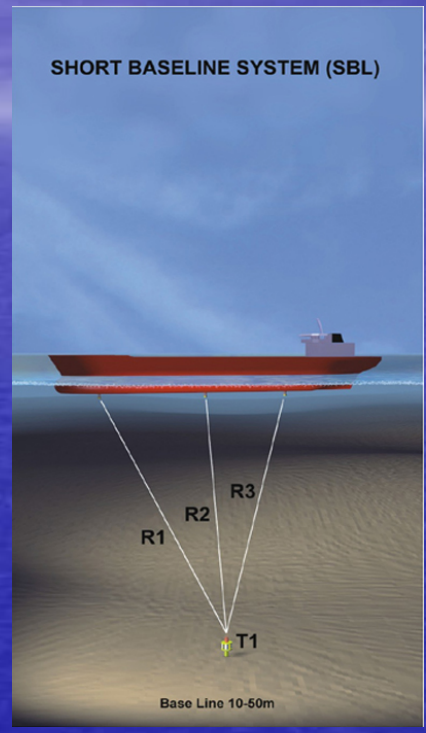
Acoustic Transponder Systems

Figures from http://www.kongsberg-simrad.com

- Range: >10 km
- Accuracy: <5m repeatable relative to transponders
- Issues: difficult to deploy, constrained operation area



- Range: several km
- Range accuracy: 1-5m repeatable relative to transponders
- Bearing accuracy: 0.1º available
- Issue: shipalt rqd, self-noise, ship movement constrained

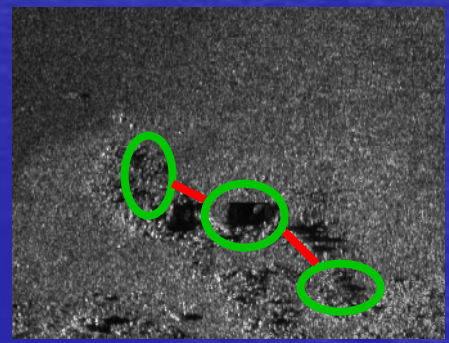


Rarely used
Issue: poor accuracy

Map/Terrain Relative

- Methods:
  - Optical imagery
  - Acoustic imagery
  - bathymetry matching
  - Gravity fields
  - Magnetic fields
- Common issues:
  - Lack of high resolution maps
  - Sensors and software in R&D

Collect Imagery

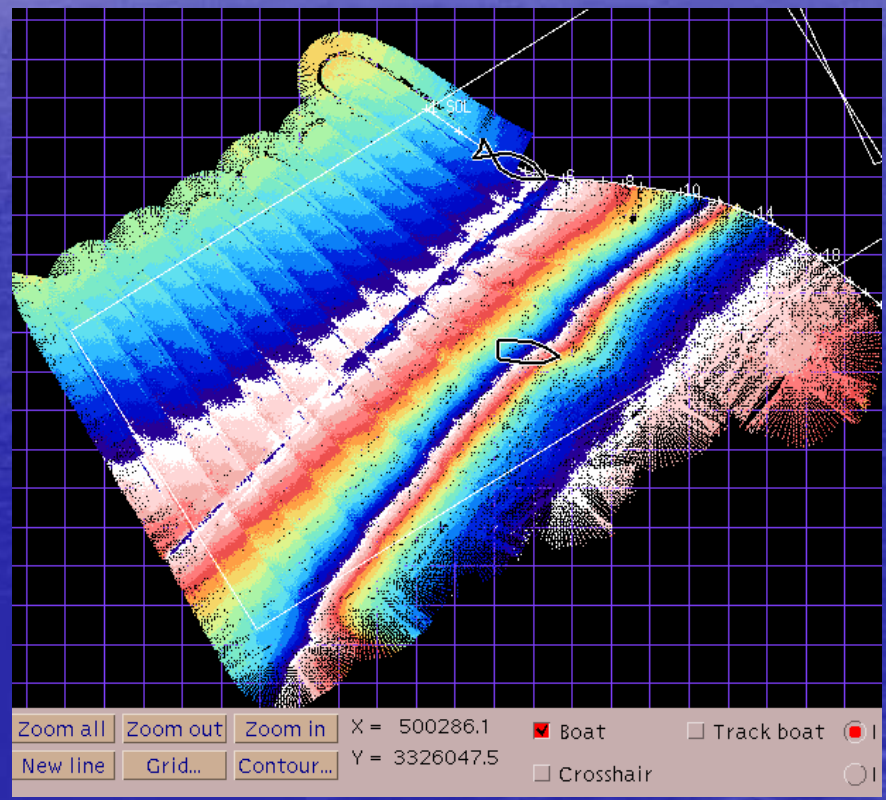


Locate/Extract Features

Recent Research Efforts

AutoSurvey™

- Reduces survey time by 30%
- Adapts vessel navigation to sensor coverage
- Transitioned to NAVOCEANO hydrographic survey fleet



Recent Research Efforts

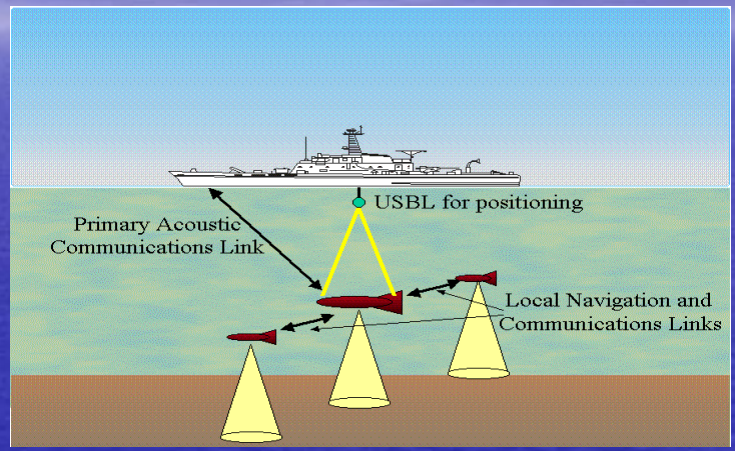
MTI Ltd. Precision Magnetic Compass
- 0.9” Diameter for UUVs and Towed Arrays
- Designed for 0.1º accuracy at 30º latitude.
- Navy SBIR funded

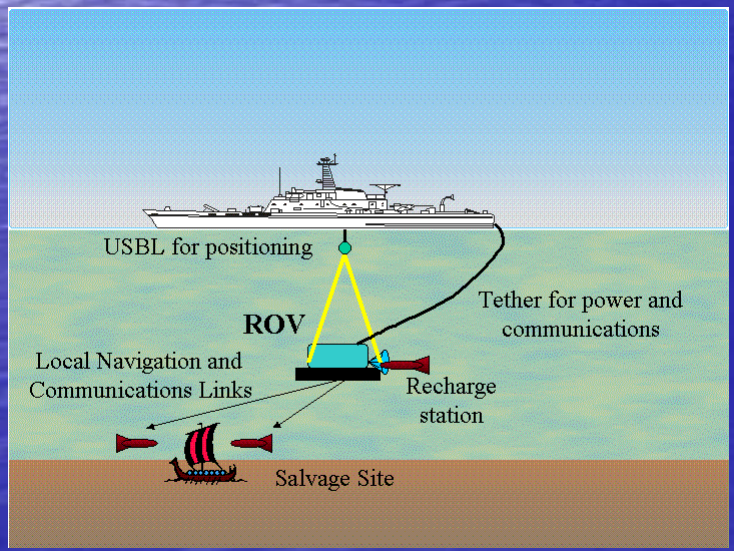
Benthos Inc. Directional Acoustic Transponder
- Goal: positioning accuracy of 5m at 2Km and 1m for < 500m
- Navy SBIR funded

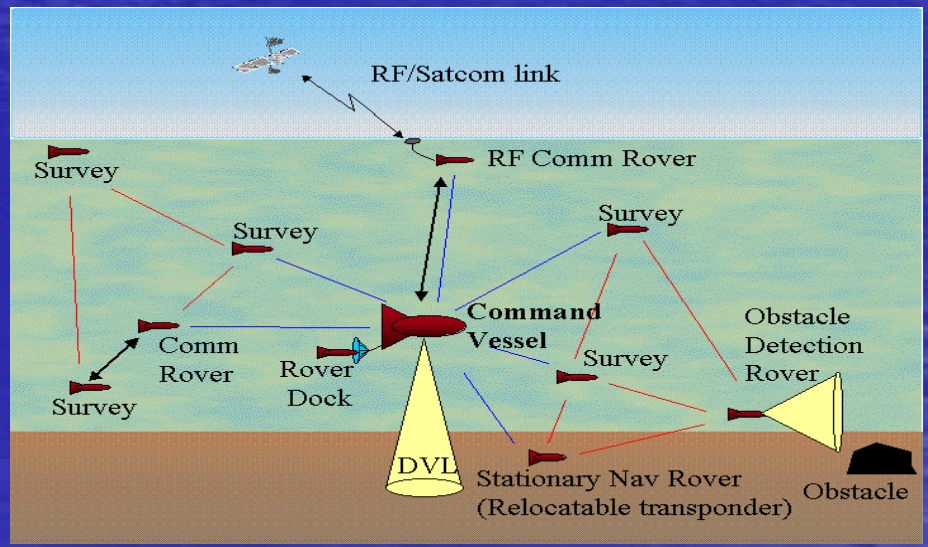
What could we do with teams of UUVs?

Decrease operation time/cost

- more vessels = faster coverage
- more vessels reduce overhead cost for tending ship
- Reduce positioning and comms cost/complexity
- Specialization of vessels lowers overall system costs







Technical Challenges for UUV teams

- Relative navigation
- Acoustic networks
- Time Synchronization
- Combined comms/positioning
- Intelligent software

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Additional Slides

Acoustic Transponder Systems - LBL

- Triangulate position using ranges between multiple transponders and vessel
- Capabilities
  - Range: >10 km
  - Accuracy: <5m repeatable relative to transponders
- Options
  - On the surface
  - On the bottom
- Many COTS systems

	Frequency	Max Range	LBL Accuracy
Low	**7.5 – 15 kHz**	**10 – 12 Km**	**2.5 – 5 m**
Medium	**18 – 36 kHz**	**2 – 3 Km**	**0.25 – 1 m**
High	**30 – 64 kHz**	**> 1 KM**	**0.25 m**
Extra High	**50 – 11 kHz**	**<1 Km**	**< 0.05 m**
Very High	**200 kHz**	**100 m**	**0.02 m**

From Keith Vickery, Sonardyne

Acoustic Transponder Systems - USBL

- Position is determined by range and bearing relative to sonar head
- Capabilities
  - Range: several km
  - Range accuracy: 1-5m repeatable relative to transponders
  - Bearing accuracy: 0.1º available
- Options
  - On the surface
  - On the vessel (inverted USBL)
- Many COTS systems

Sonatech NS-031
39”x9”D, 120lbs
9000m range

Simrad Hipap
40cm, diameter
4000m range,

ORE Offshore
4330B
11”x3”D, 4lbs
1000m range

Acoustic Transponder System Issues

- Restricts operations to a small geographic area
- Vessel must Dead Reckon (DR) between position updates from acoustic positioning system
- ↑ range = ↓frequency = ↑ size
- Speed of sound variations can affect accuracy, even ability of systems to function
- Ambient noise levels and multi-path degrade operation