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Agenda



Maritime Systems Technology Office

Fuel Cells

Precision Navigation

Acoustic Communications

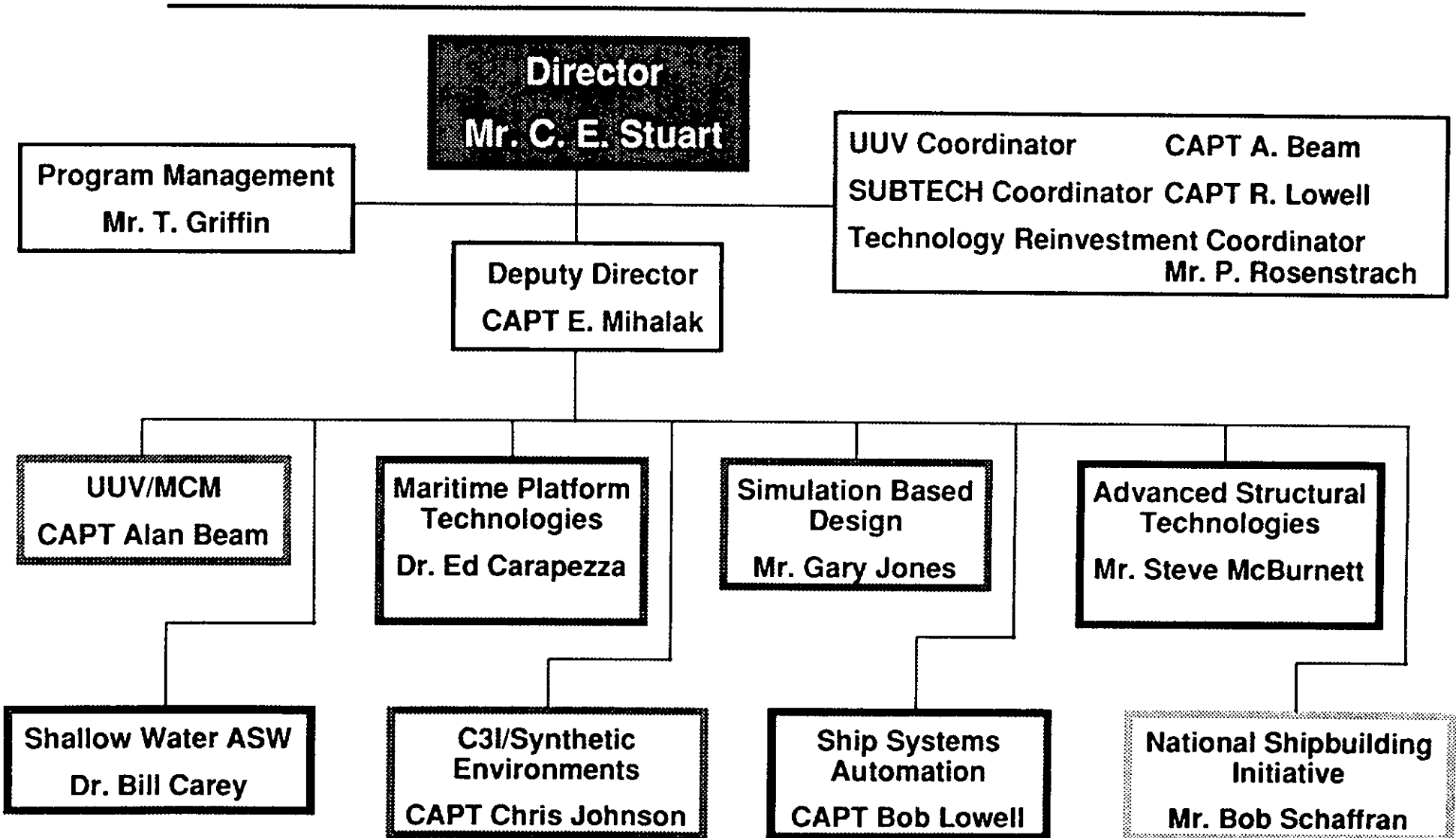
Automated Surveillance Network

Magnetic Communications

Future Programs

#590
94-F-0331

MSTO Organization

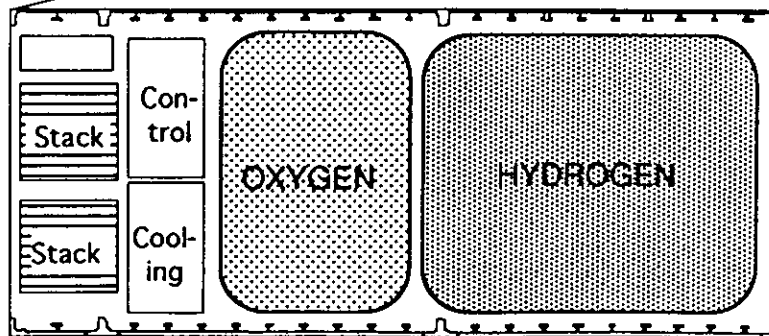
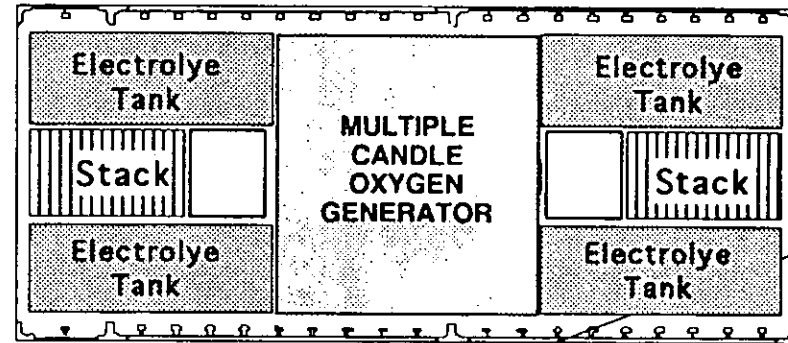


UUV Fuel Cell Program

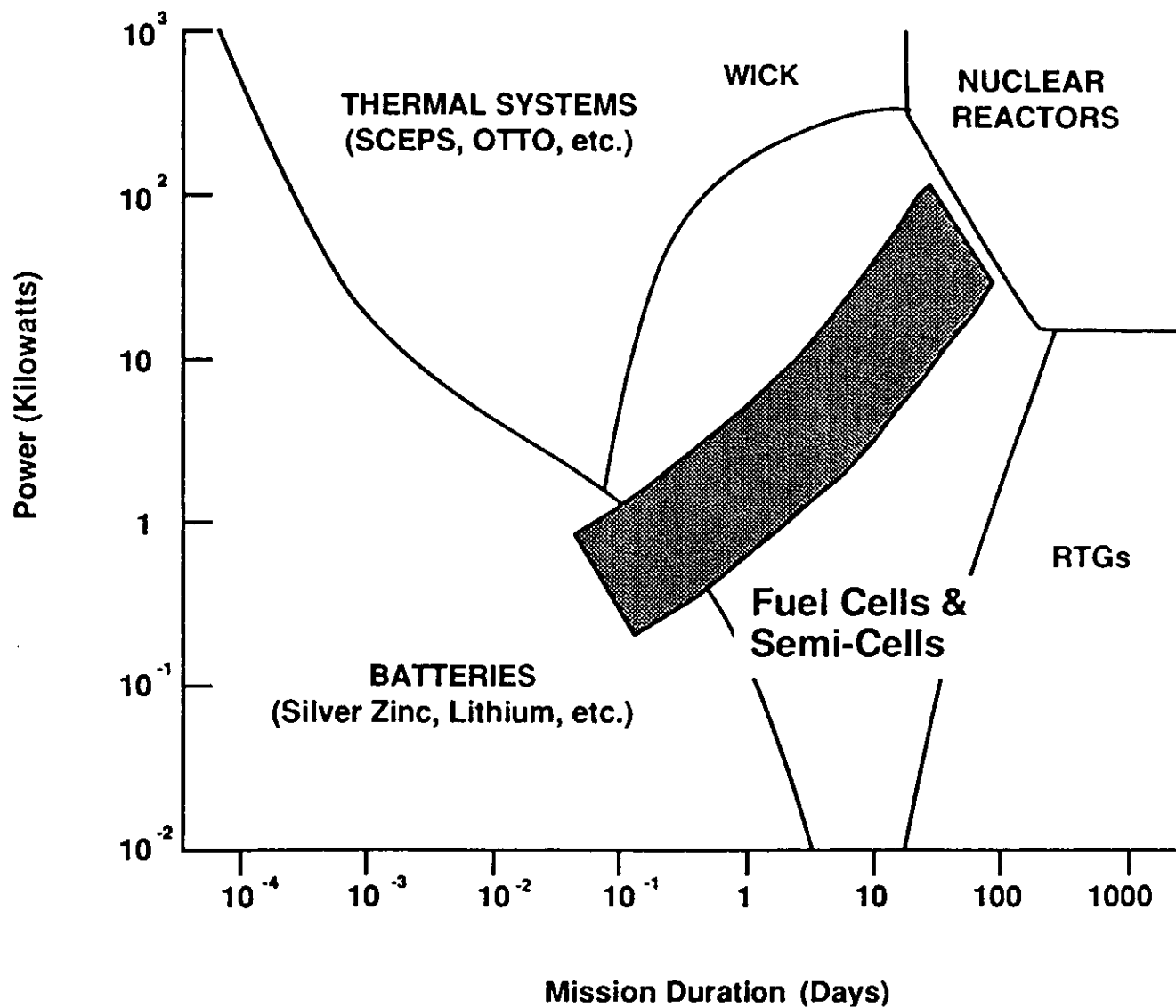


Objective

Develop a fuel cell power system with an energy density three times greater than current batteries



Energy Alternatives

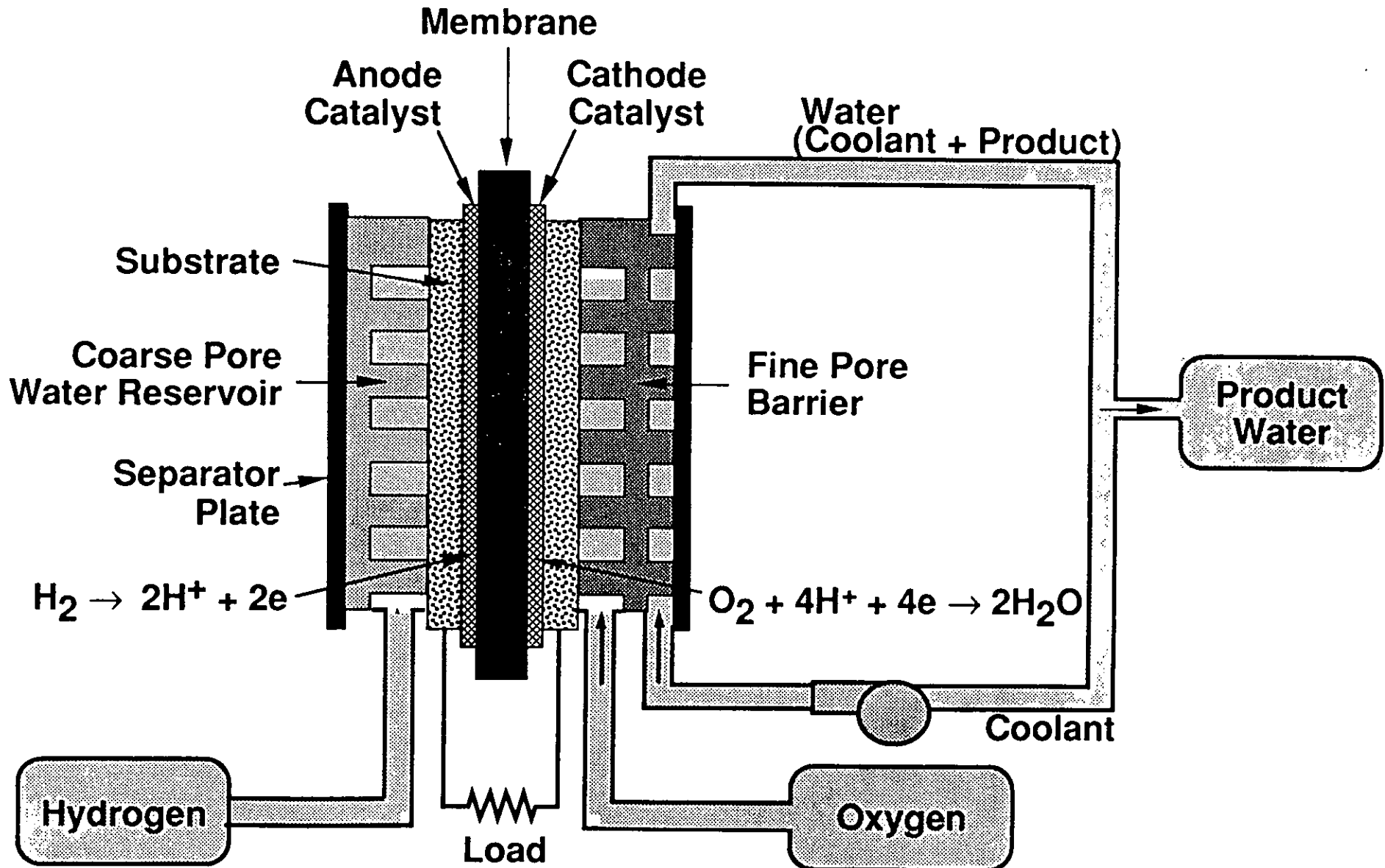


Fuel Cell Types and Applications

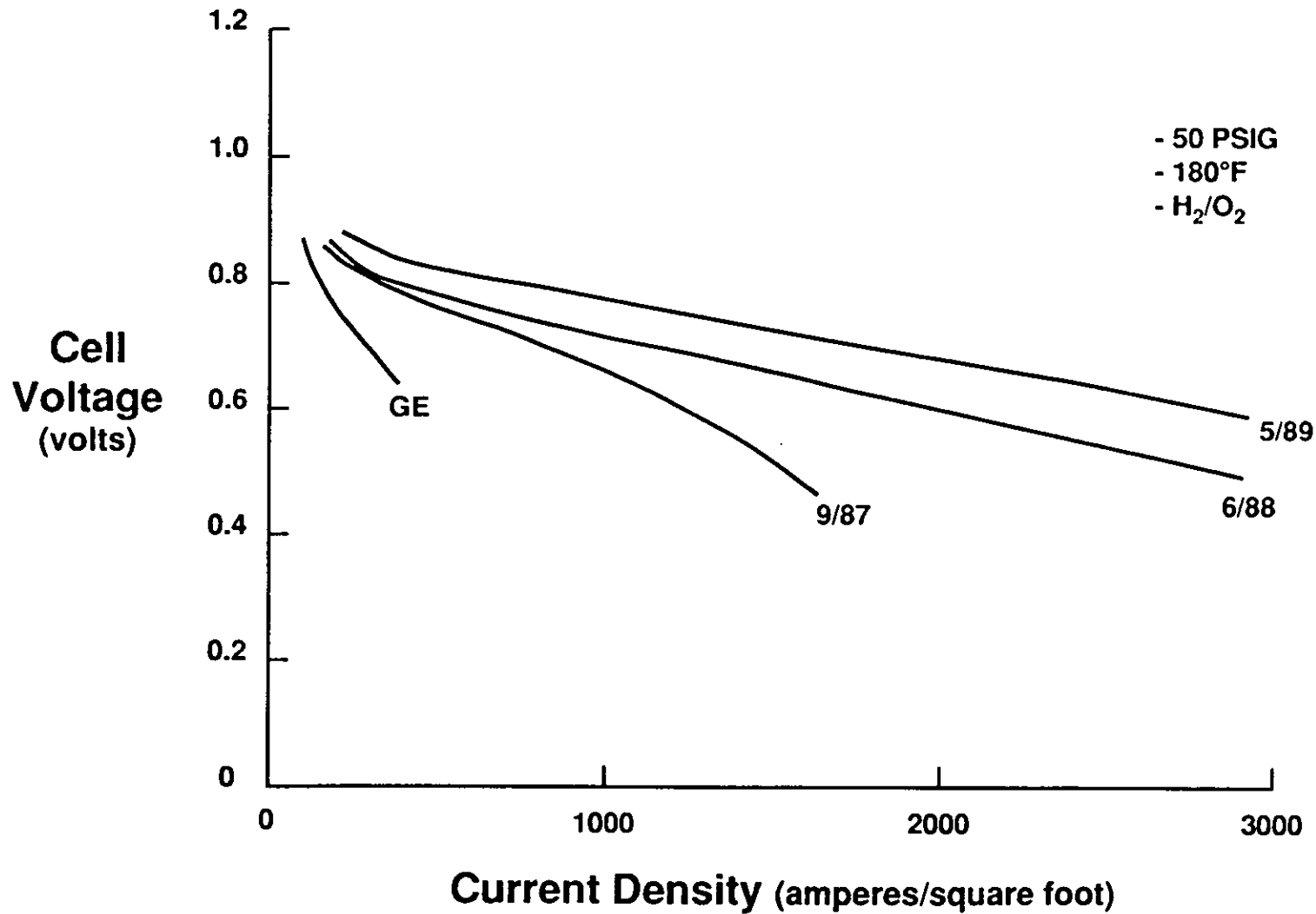


<u>Type</u>	<u>Advantages</u>	<u>Applications</u>
Proton Exchange Membrane (PEM)	<i>Commercial at small scale</i> Low temperature (fast starting)	UUVs and submarines Portable equipment Zero-emission vehicles
Alkaline	<i>In production for NASA</i>	Space
Phosphoric Acid	<i>Available commercially</i> Medium temperature	Stationary power
Molton Carbonate and Solid Oxide	<i>MCFC is nearly commercial, SOFC is developmental</i> High temperature (constant operation) Fuel versatile Very Efficient (molton carbonate)	Stationary power Large vehicles

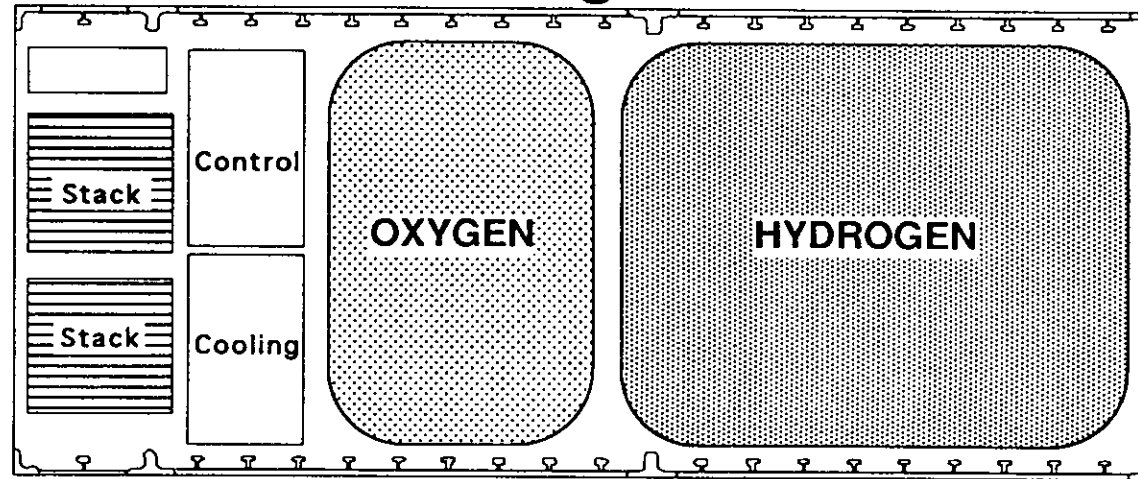
Proton Exchange Membrane Fuel Cell



PEM Performance Evolution



Proton Exchange Membrane



International Fuel Cells

Technical Challenges

- Precision assembly of stack
- Passive water removal without Dryout or Flooding
- Thermal management
- Integration of packaging for high fuel and oxidant packing density

Status

- 1st 80 cell stack completed
- Controller software developed
- 2nd stack assembly in progress
- Power plant test in September

A. F. Sammer Corp., Ringwood, New Jersey

Purpose

Develop chemical-hydride hydrogen source for PEM fuel cells

Phase 1 Accomplishments

- **Tested various hydrides**
- **Control of hydrogen generation rate (load responsive generation)**
- **Design accomodated volume expansion of solid reactants**

Phase 2 Proposal Submitted

- **Build system for use with PEM fuel cell in ARPA UUV**

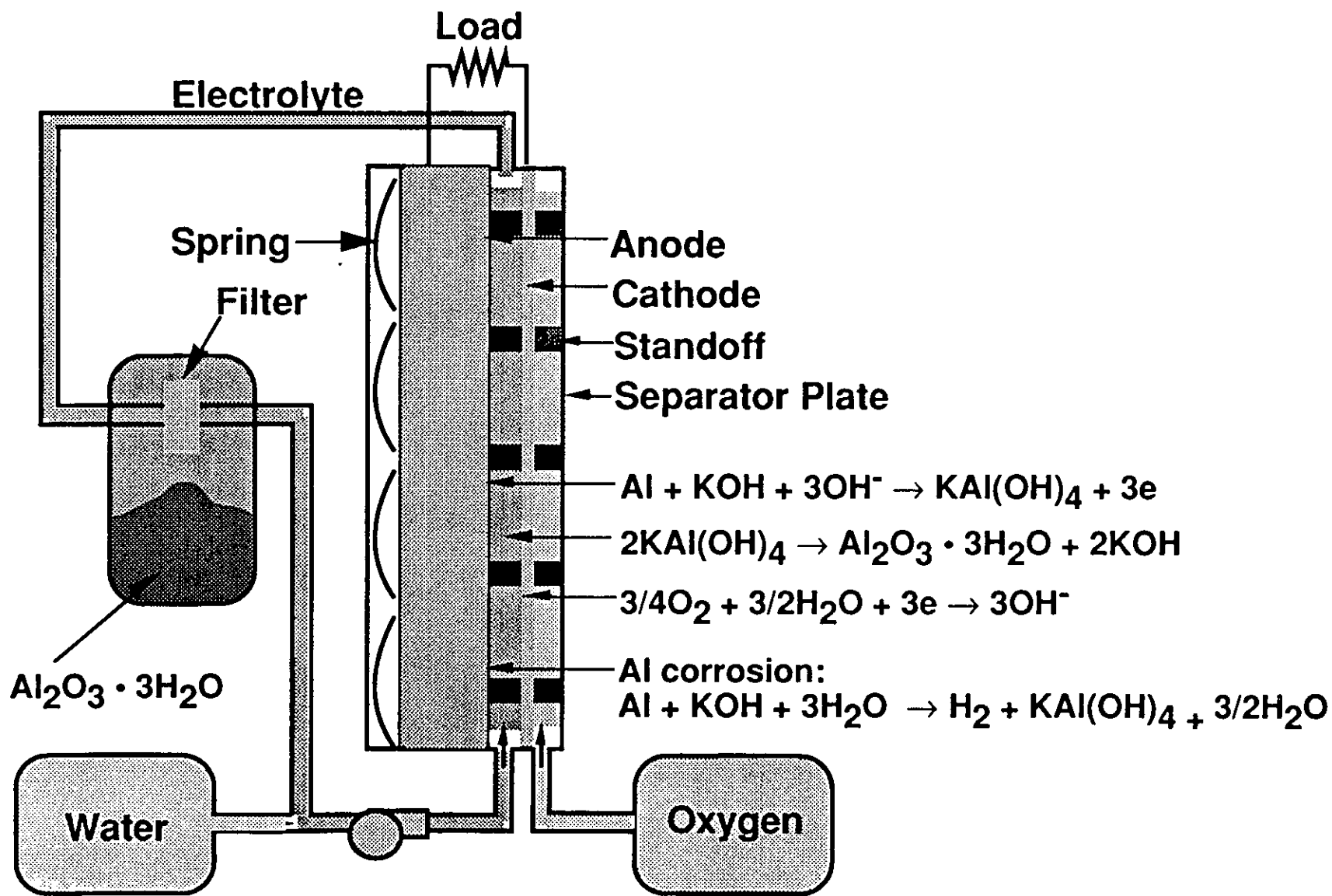
Semi-Cell Power Systems



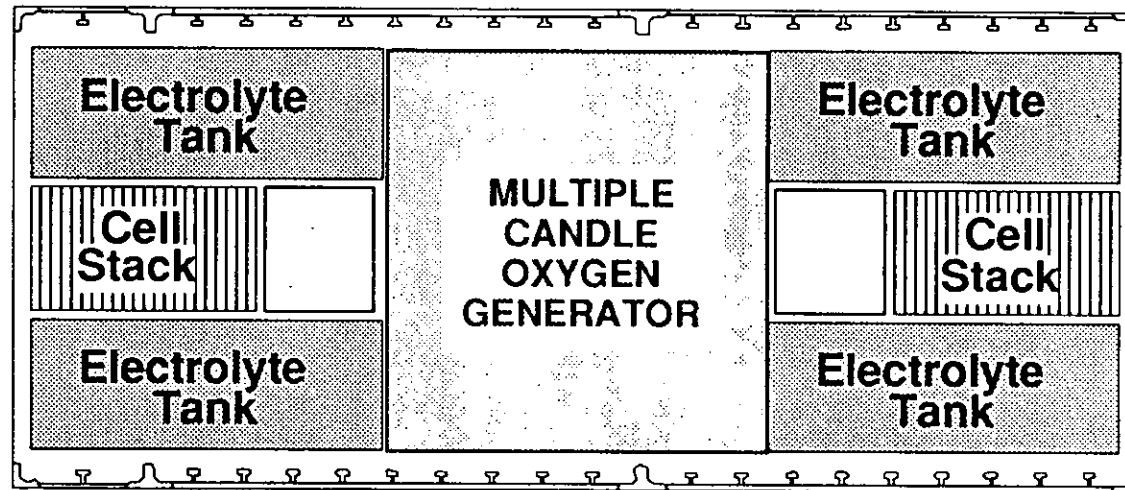
Issue: Improved energy density

<u>Candidate</u>	<u>Use and Issues</u>	<u>Energy</u>
Aluminum hydrogen peroxide	Demonstrated in laboratory by NUSC for torpedo application.	900 kWh in UUV
<i>Aluminum oxygen</i>	<i>High energy density, anode corrosion, product removal.</i>	<i>1300+ kWh in UUV</i>
Aluminum silver peroxide	NUSC developing for torpedoes. Demonstrated in laboratory. High rate of corrosion. Hard to power down.	1600 kWh in UUV
Lithium oxygen	Similar to Al-Oxygen, but very difficult to control. Energy gain.	1830 kWh in UUV

Aluminum / Oxygen Semi-Cell



Aluminum / Oxygen Semi-Cell



Loral / Eltech / NUWC

Technical Challenges

- **Anodes**
 - High current generation
 - Low parasitic corrosion
- **Cathodes**
 - Catalyst wetting without flooding
- **Removal of aluminate from electrolyte**
- **Thermal management**

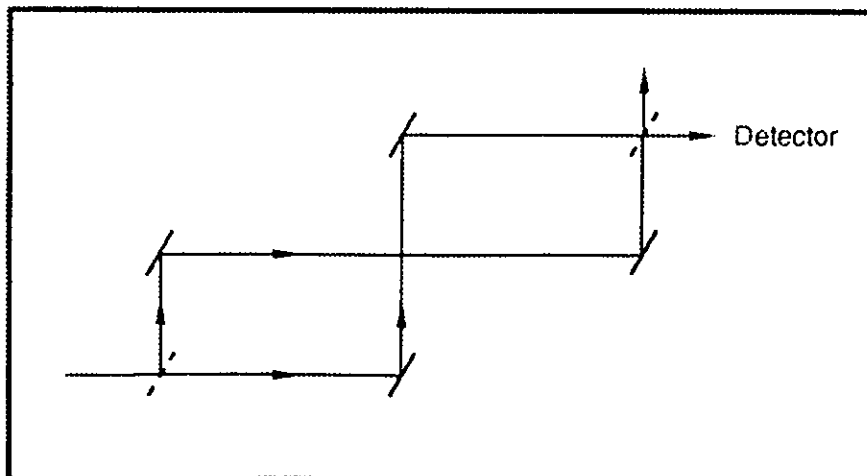
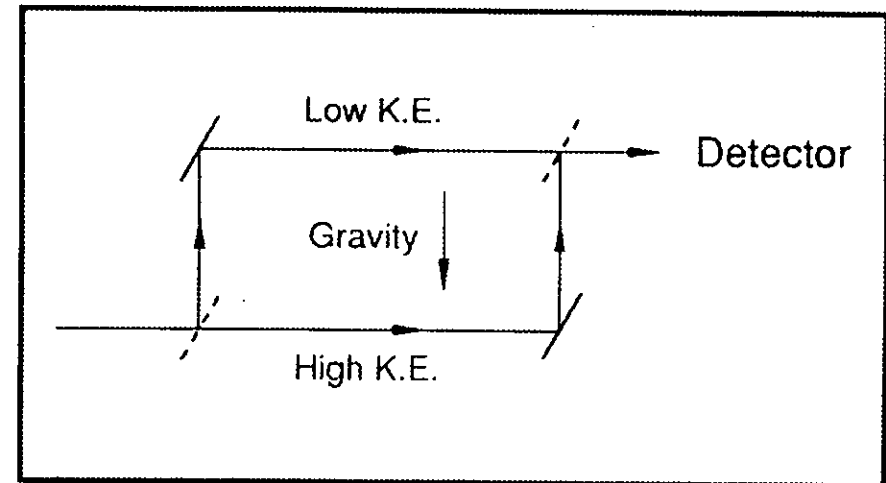
Status

- Full scale single cell testing
- Examining non-uniform cathode reaction
- NUWC MCOG program initiated

Atomic Interferometer

- Utilize wave properties of atoms to detect inertial effects
- Analogous to ring laser gyros
- Extremely sensitive (10^4 improvement)
- Potential for gyroscopes, accelerometers, gravimeters, gravity gradiometers

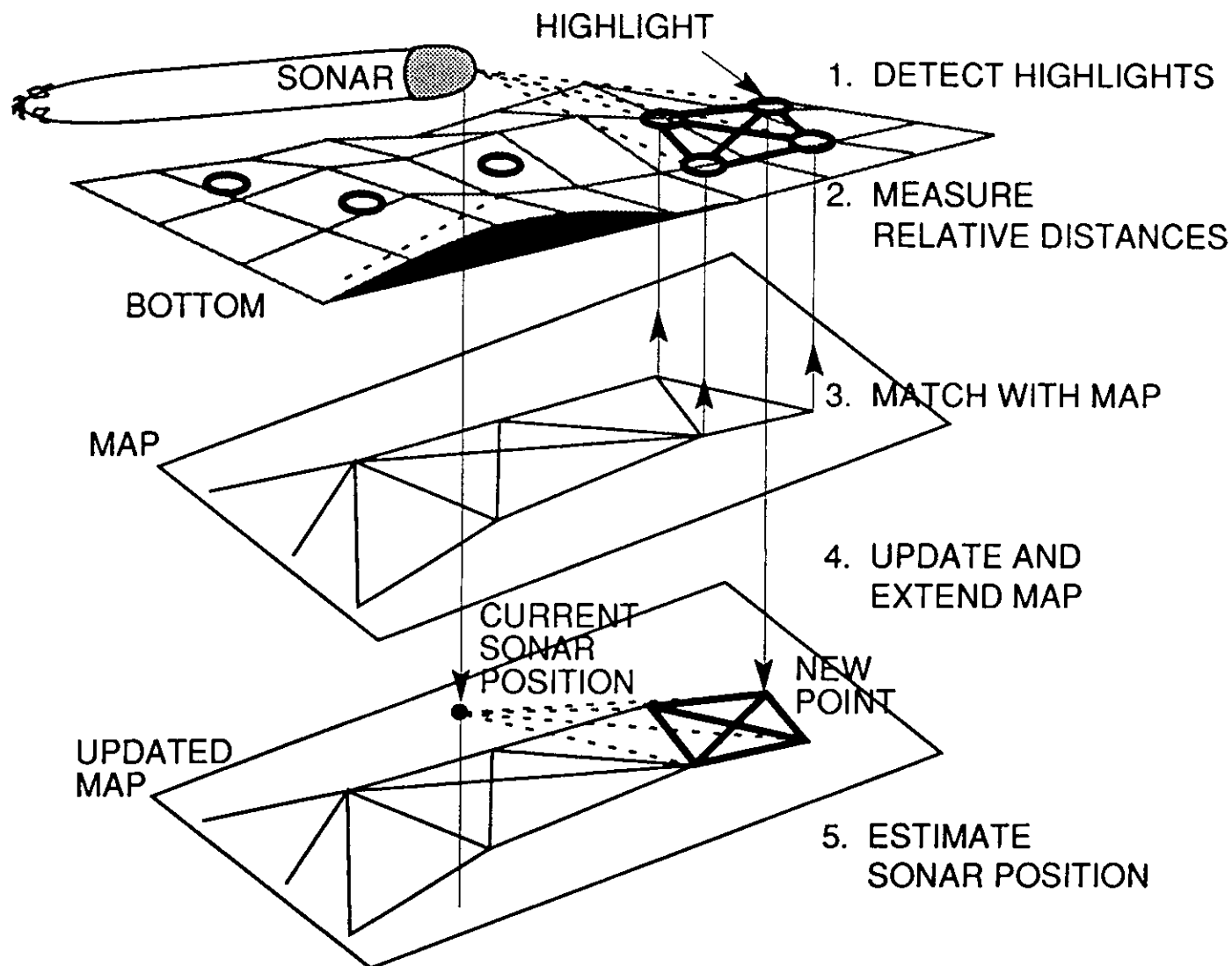
Wavelength - 1 Angstrom



Gradiometer Implementation

- The phase shifts from rotation or acceleration have the opposite sign in the two loops and cancel out
- Signal is proportional to gravity gradient
- Easier to implement due to insensitivity to vibrations, etc.

Sonar Aided Navigation

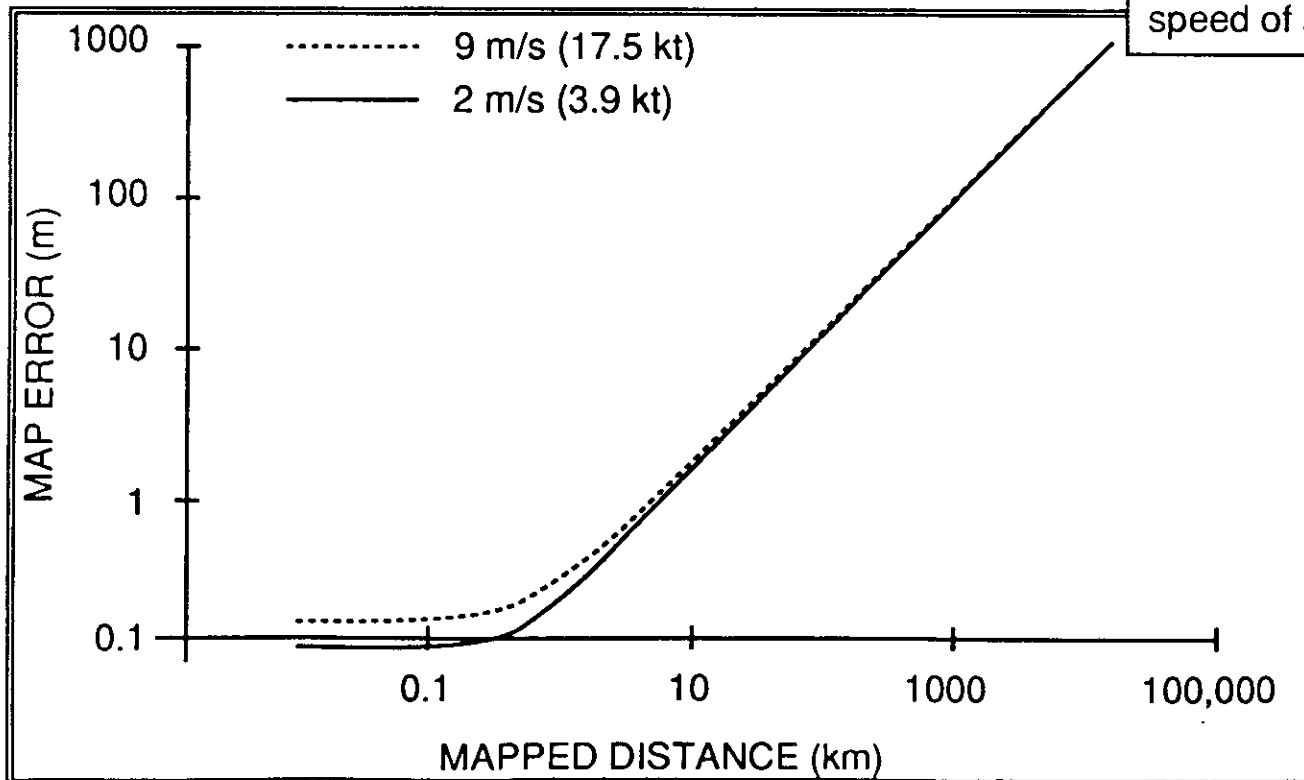


Sonar Aided Navigation Accuracy



Parameters

height above bottom	50 m,
range scale	2000 m
sector width	150°
area coverage	2.6 X 10 ⁶ m ²
highlight density	1.5 X 10 ⁻⁵ m ⁻²
number of detections	10 @ 9 m/s, 45 @ 2 m/s
range uncertainty	0.5 m
elevation uncertainty	0.5°
speed of sound bias	0.15 m/s

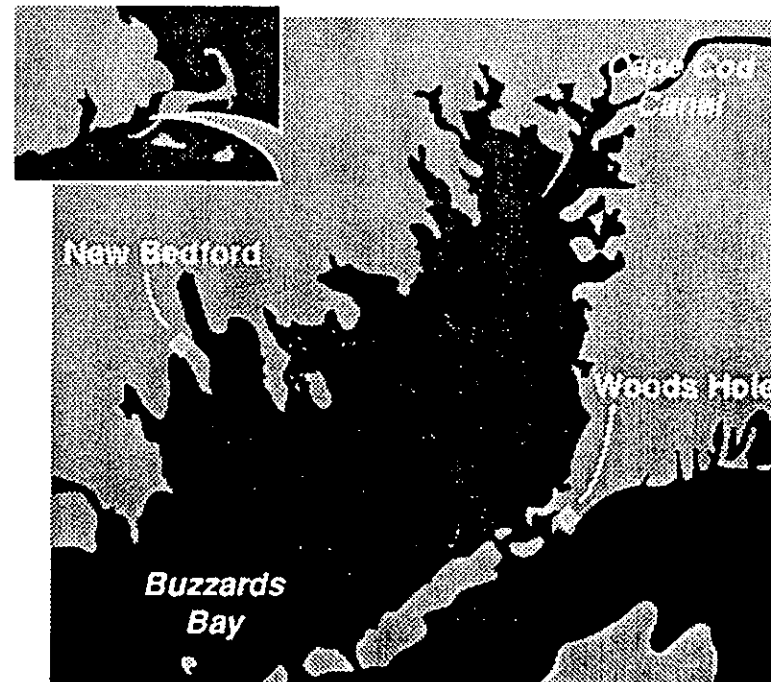


Technical Concepts

- Coherent signal processing (4X bandwidth efficiency compared to incoherent)
 - Single receiver
 - Multiple receivers
- Diversity
 - Spatial (multiple receivers)
 - Temporal
 - Spectral
- Doppler tracking

Buzzards Bay test

- 20 Kbit/sec at 4 nm
- Water depth 20-40 feet
- 0-7 knots doppler correction
- Modulation format: QPSK, QAM
- Transmitter 12-20kHz, 185 dB re uPa



Acoustic Local Area Network



Goal: Provide robust communications in very shallow water

Approach: Autonomous routing of messages between acoustic network nodes

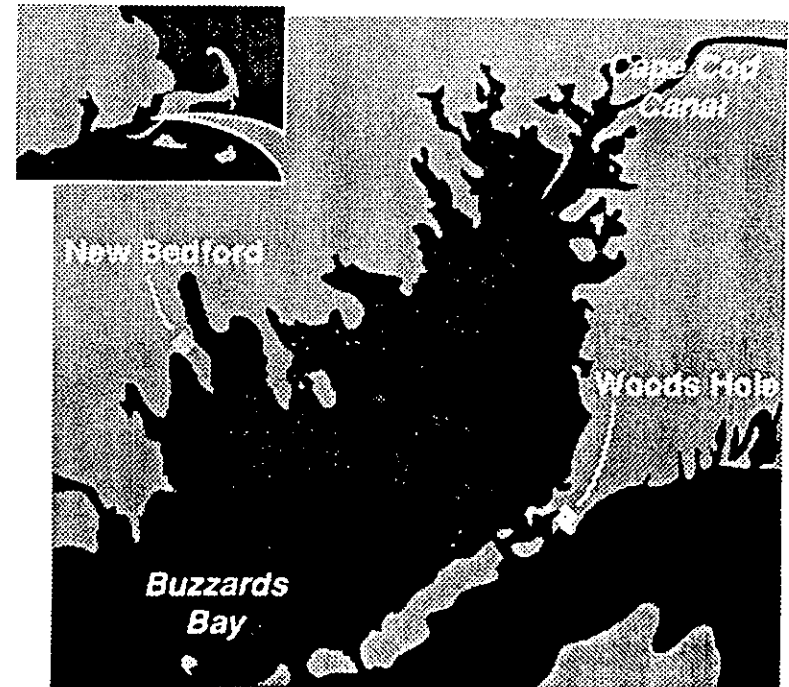
Issues: Message contention, error detection/correction, network control

Data: Overall throughput - 50 kbps @ 5-10 km
Individual platform - 10-20 kbps

Power: >1000 bits/joule/km

Interface: Digital RF to shore, satellite

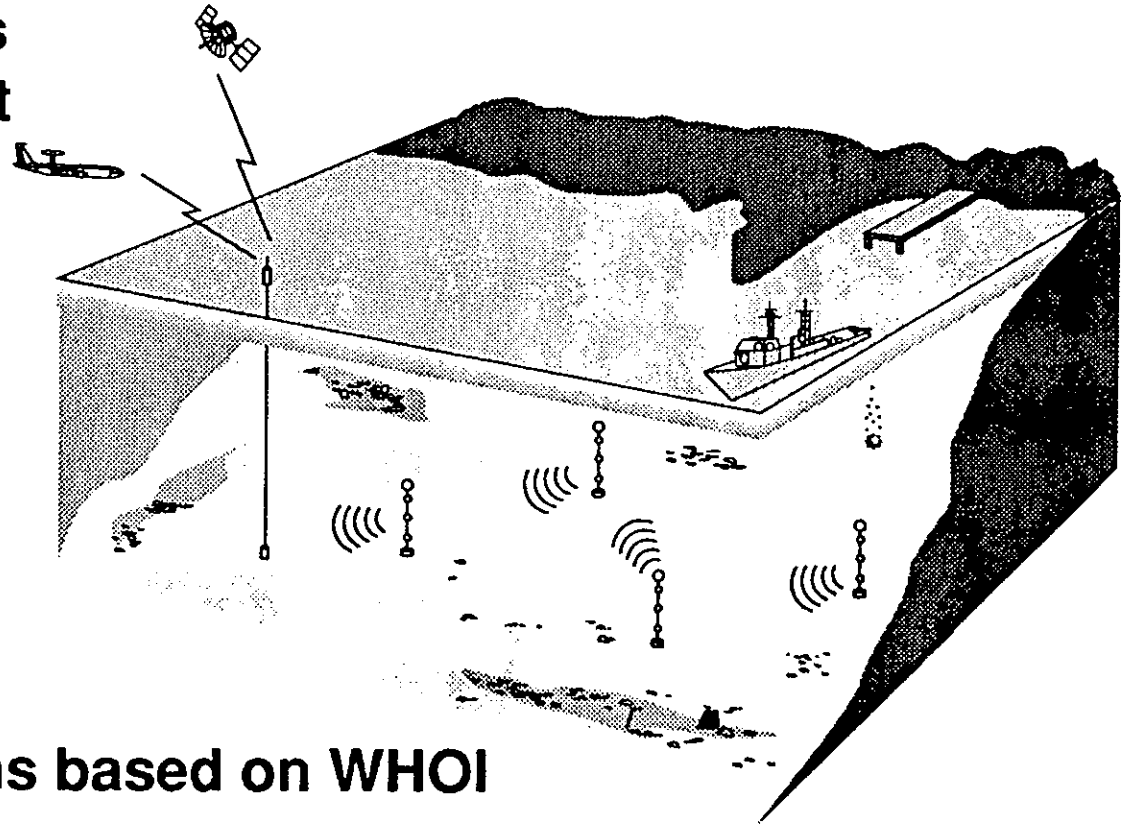
Status: pilot telemetry experiments Feb 92
prototype system under construction
first network deployment in Fall 93



Autonomous Surveillance Network



- **Develop a surveillance buoy system rapidly deployable by diverse platforms, including UUVs for detection of:**
 - mine laying operations
 - submarine deployment
- **Multiple sensor types**
 - passive acoustic
 - active acoustic
 - magnetic
 - E-field
- **Fuse multiple buoy data**
- **Inter-buoy communications based on WHOI technical developments**



Autonomous Surveillance Network



Technical Challenges

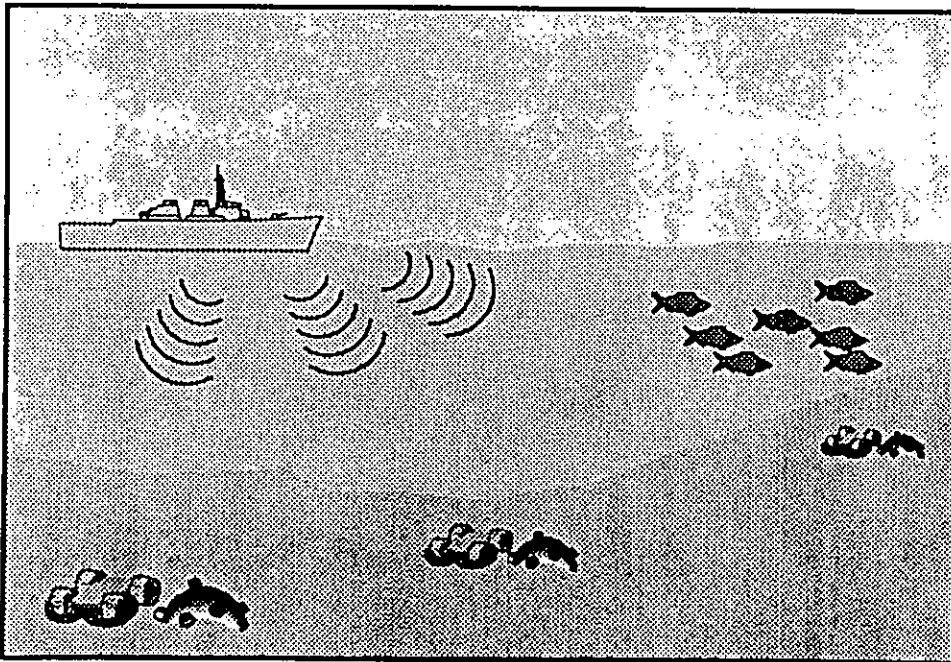
- High Pd, low Pfa
- In-situ processing
- Miniaturization
- Autonomous Control
 - Across nodes (e.g., ping management, tracking)
 - Selectable processing
- Sensor cost

Magnetic Communications



Objective

Develop underwater magnetic communication system for shallow water applications where acoustic communications are limited to short range



APPLICATIONS

- Simultaneous command detonation of charges placed near mines
- SPECWAR communications
- Surface / subsurface communications
- Inter array communications

CHARACTERISTICS

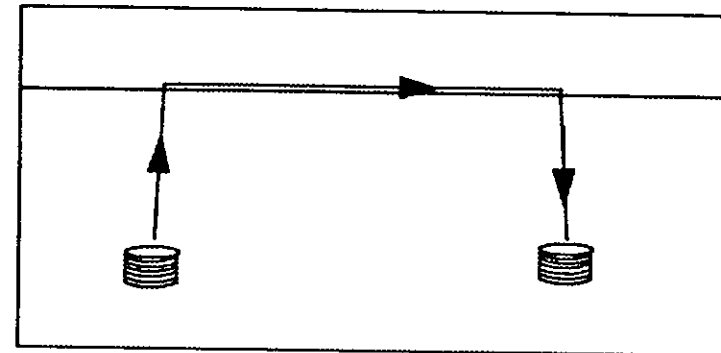
- Covertness (operation outside the conventional spectrum)
- Low susceptibility to jamming
- Operable in both air and water

Magnetic Communications



Phenomenon Exploited

- Lateral electromagnetic wave along the boundary between seawater and air
- Critical angle of 6.4 degrees



Technologies Exploited

- New material / processes for magnetic sensors
 - Amorphous magnetic alloys
 - Magneto--strictive material deposition technologies
- Signal processing electronics developments

Critical Issues

- Experimental validation of performance predictions (range, data rate)
- Size and power consumption of transmitter
- Size of receiver

