AUVs: Designing and operating next generation vehicles

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Conclusions

Challenges in designing and operating next generation AUVs fall:

- 80% to the Business Model
  - Paying customers with well-stated requirements
  - Affordable solutions
  - Partnerships to develop the capability
- 20% to Technological Advance
  - Cost-efficient energy; Lower through-life costs
  - Appropriate sensors; Docking; Data to networks

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EuroGOOS: Customer-led Strategy

- “Foresee rapid growth in the demand for operational services for paying customers”
  - Main growth areas:
    - Offshore Energy
    - Shipping
    - Coastal Protection
    - Managing Pollution
    - Health
    - Climate Prediction

From Woods, Proc. 2nd EuroGOOS Conference, p7.

What can we learn from other sectors?

Sector Size in Europe		AUV adoption
➢ Offshore Energy	€41bn	Emerging, operational
➢ Marine Tourism	€41bn	None known
• Of which ~97% is holidays		
➢ …		
➢ Fisheries	€9bn	Research
➢ Navy (data for UK & France only)	€6bn	R&D, operational analysis
➢ R&D and Education	€0.9bn	

From Brown, Proc. 2nd EuroGOOS Conference, p. 30.

Broad context business models

Offshore Industry

Marine Environment
Oceans 2020

Competitiveness
Profitability

Drivers

Impacts on Society
Concerns of Society

Look to Suppliers
for solutions

Two key areas:
Climate Change
Ecosystems

Need for cost-effective
measurement, fit
for purpose

Increased need for
measurement

Degree of commonality

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Offshore Energy: Benefits of AUVs

Conclusions from the Shell 'Gamechanger' project

Customer-assessed benefits …

" We estimate that operational cost savings of over $30M and increased leverage of over $75M are in prospect within 5 years. Key elements of this are:

Investment in the Hybrid ROV/AUV will yield operational cost savings of about **$22M**.

Investment in the Survey Class AUV will yield operational cost savings of about **$9M**, and significantly increased leverage from the data of over **$50M**.

Marginal investments in oceanographic and geochemical applications will yield significantly increased leverage from the data in excess of **$25M**.

Further spin-off benefits can also be expected, which are not elaborated here "

Chris Graham, Shell - June 1999

Supporting Offshore Energy

- Example: A European-based Global Support Company
  - 4,000 staff
  - Capital intensive: 112 ROVs & 23 ships
  - 3rd Quarter 2002 revenues of €224m (EBITDA €29m)
  - Strongly focused on subsea field development and robotic intervention
- Significant annual investment in technology & R&D
- Key to realising the savings for the customer

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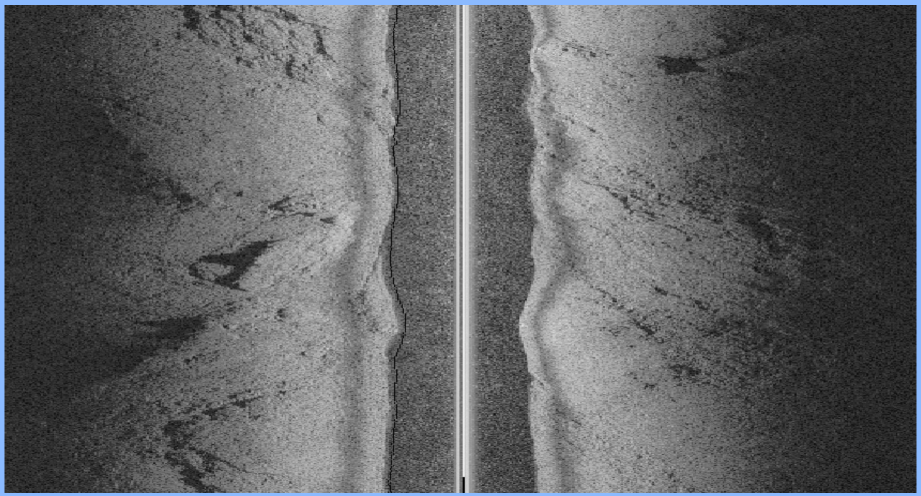
AUV use: Diamond extraction

- Drivers:
  - Most gem quality diamonds not present in mines on land
  - But, on beaches and offshore Southern Africa
  - Estimated up to 10 billion carats of diamonds released this way.
  - Over 90% found in the coastal region are gem quality.

Charlie Heyes,
Diamond Fields International

- Need for Operational Information: 60 km^2 per year, in 60 days

Courtesy Paul Nicholson, De Beers Marine PTY



Sonar image off Namibia

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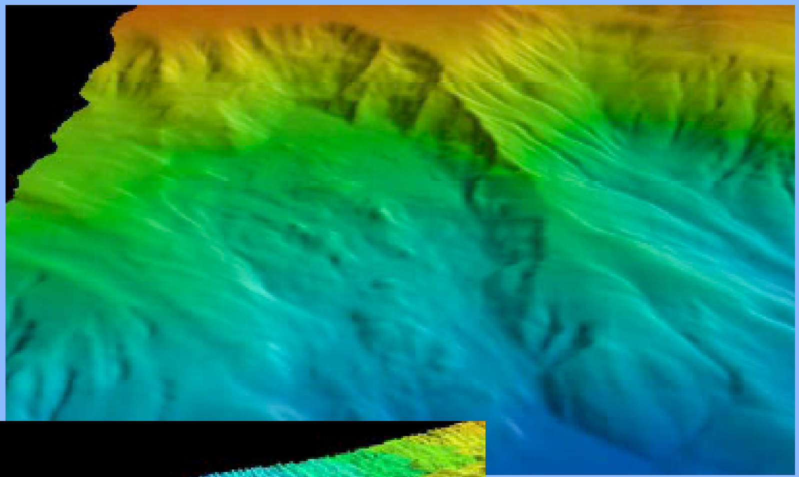
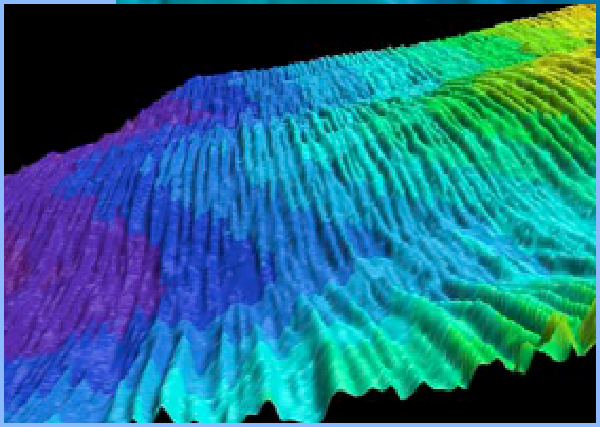
AUV use: Geophysical survey

“AUVs - there’s no going back”

‘Using the AUV technology, the survey was completed in **one-fifth** the usual time (three days *vs*. 15 days before), and at roughly **one-third** to **one-half** the usual cost associated with traditional techniques, says Andy Hill, BP's geohazards team leader. "The beauty of the AUV is that it allows us to be able to do the types of surveys that we've never been able to do in deeper water before, except at exorbitantly high cost," says Hill’
(Business Week On-line 16 August 2001)





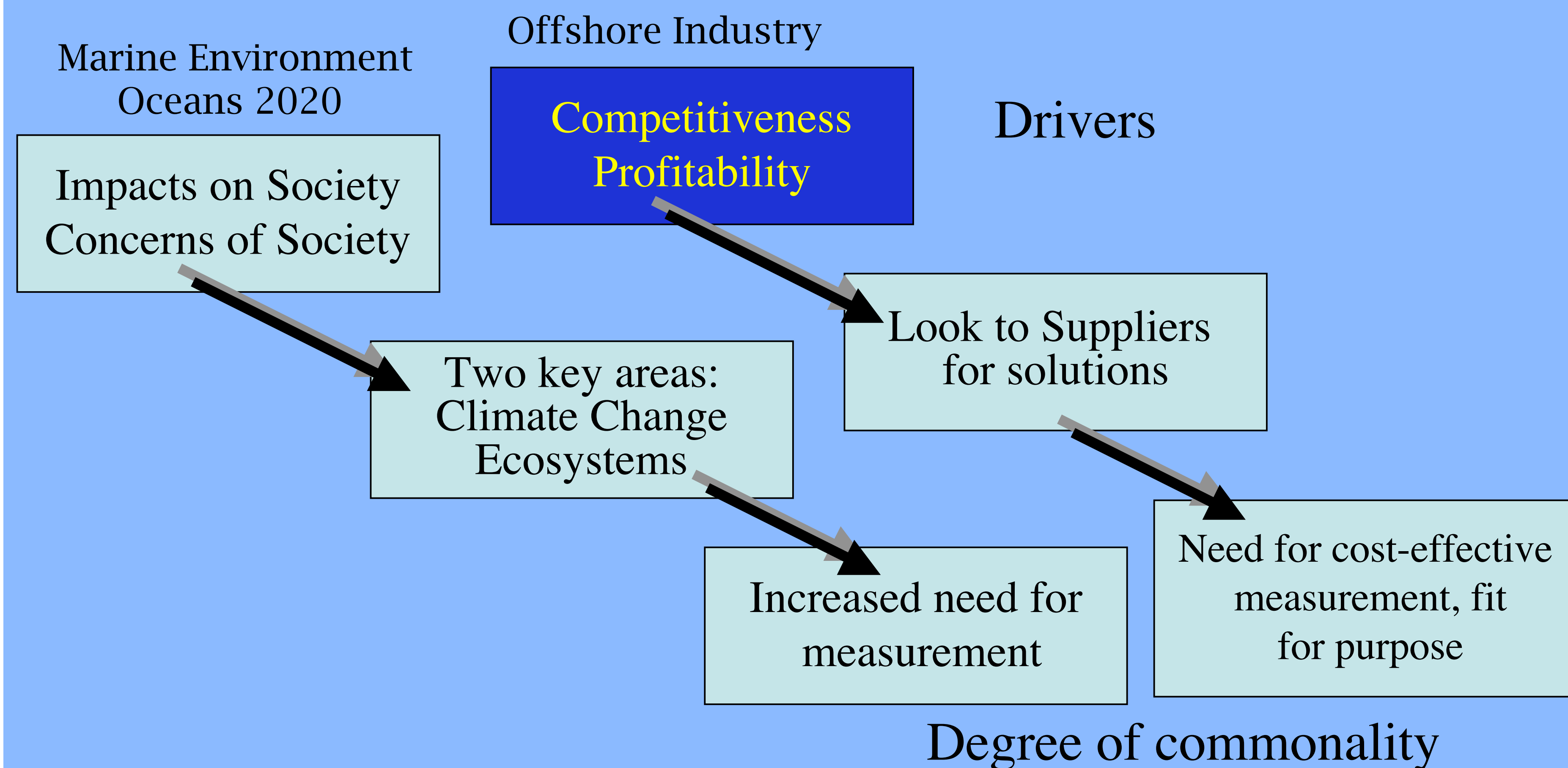
Bathymetry of the Sigsbee escarpment in the Gulf of Mexico (top) with a, high-resolution view of mega-furrows (left)

Courtesy C&C Technologies and BP Americas Inc.

Next Steps for AUVs in Offshore Energy

- Move from wide area survey to pipeline survey
- Move from 3 degree of freedom to 6 degree of freedom AUVs
- Move to riser surveys
- Field abandonment environmental studies
- Move from survey to intervention

Broad context business models



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The Scientific Context

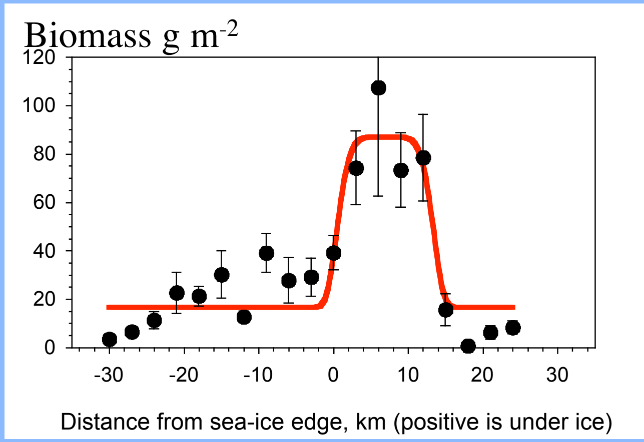
- ‘Undersampling is the main limitation on our understanding and modeling of problems such as global climate change… variability in biomass, fish abundance and regime shifts …’
  Dickey, Oceans 2020, p209
- ‘There is no single dominant customer for marine environmental data … with dozens of customers requiring dozens of different variables in dozens of different combinations’

Fischer and Fleming, Proc. 2nd EuroGOOS Conference, p.42.

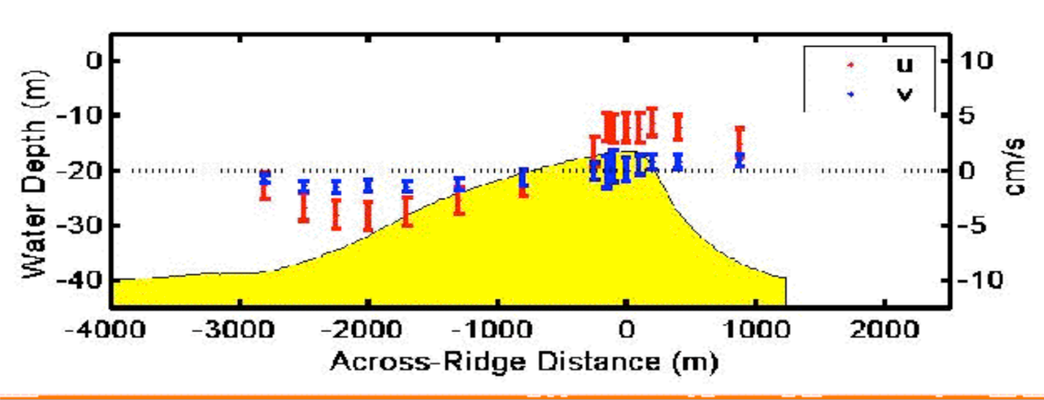
Understanding through Process Studies

Where scientific AUVs have made an impact

- Ecosystem studies of Antarctic krill in relation to sea ice
  Brierley et al., Science 296, 2002.



- Physical measurements in coastal seas



Voulgaris et al., 2002

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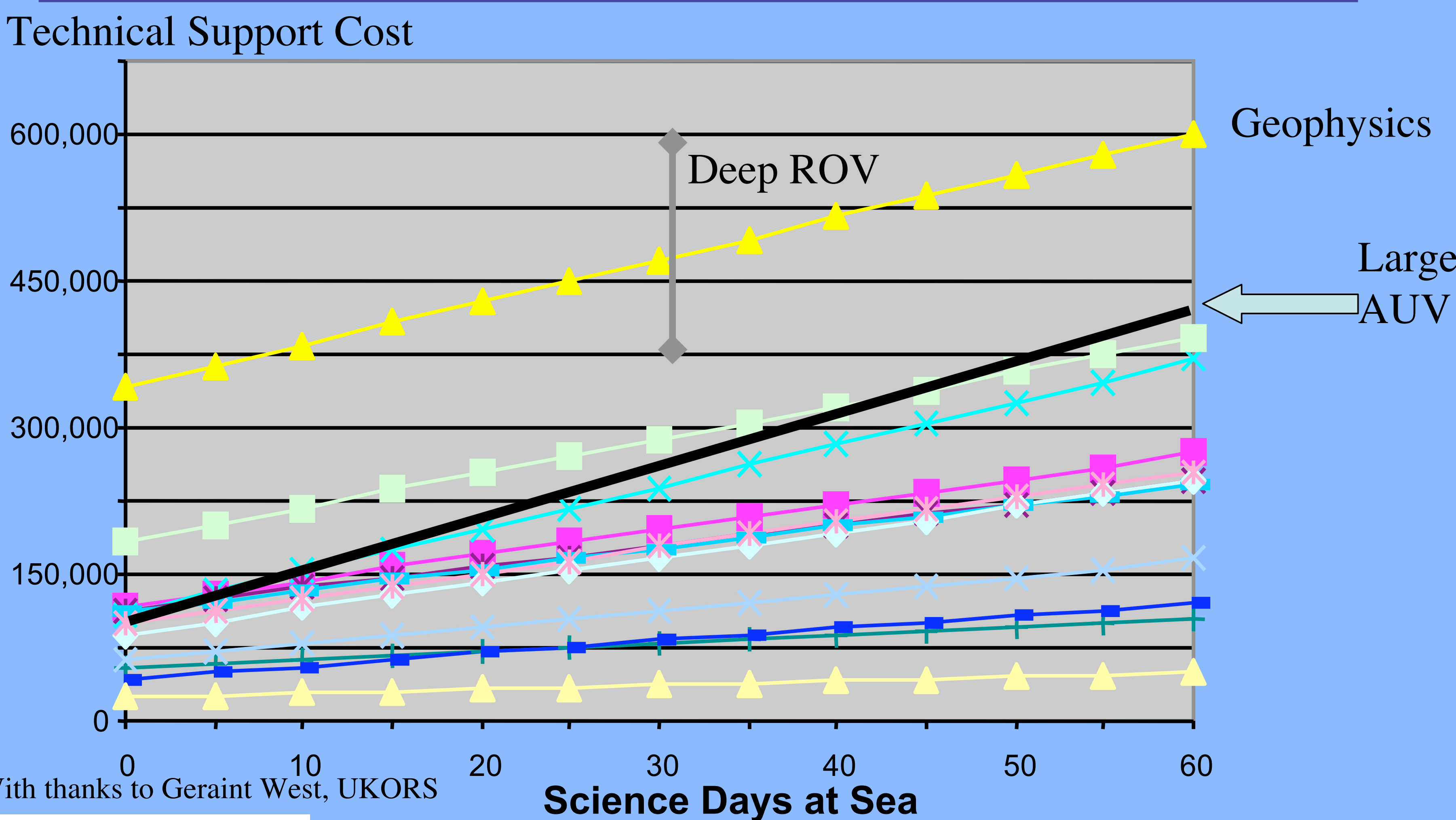
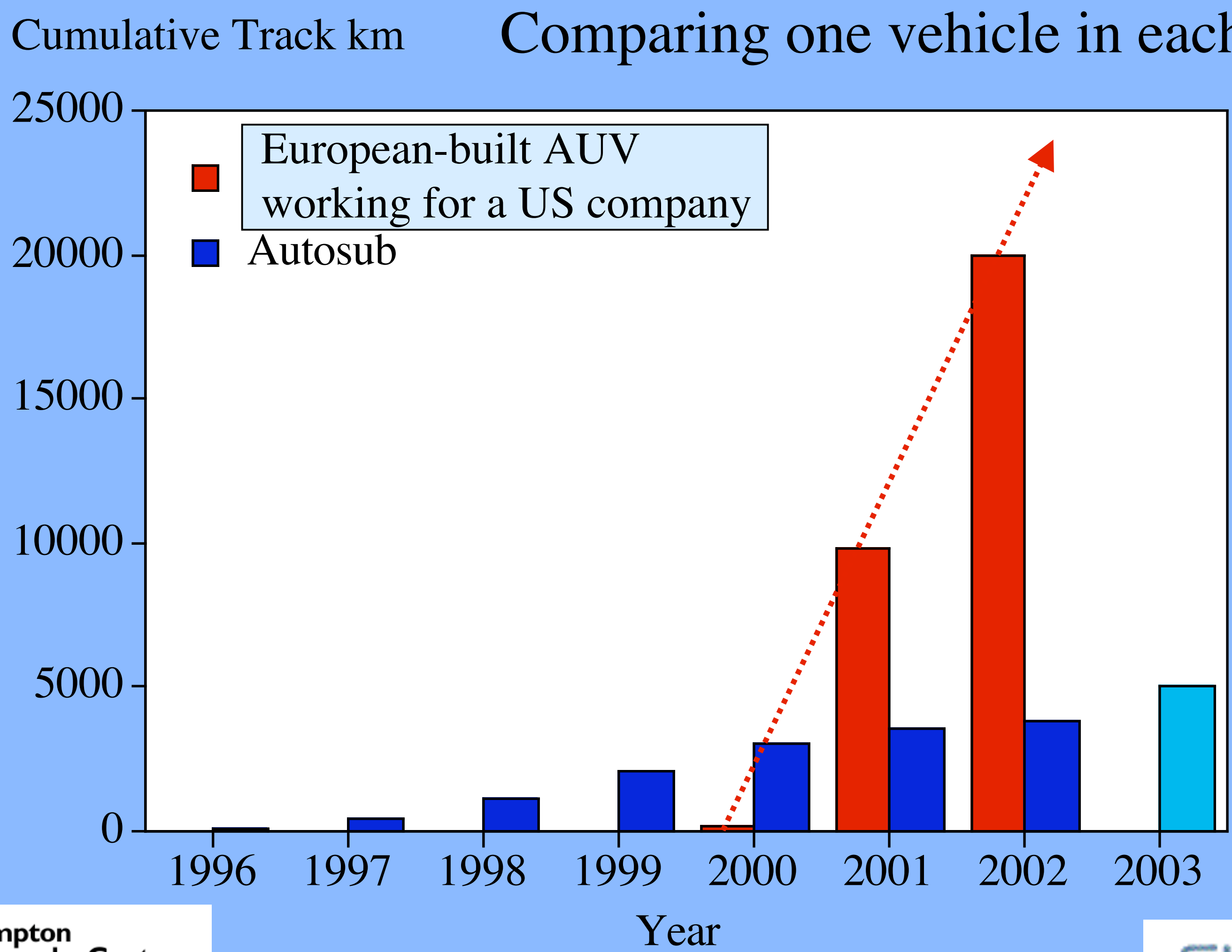
Large AUVs for Research are Affordable



With thanks to Geraint West, UKORS

AUV use: Offshore Industry vs. Science

Comparing one vehicle in each case



Closing the Gap

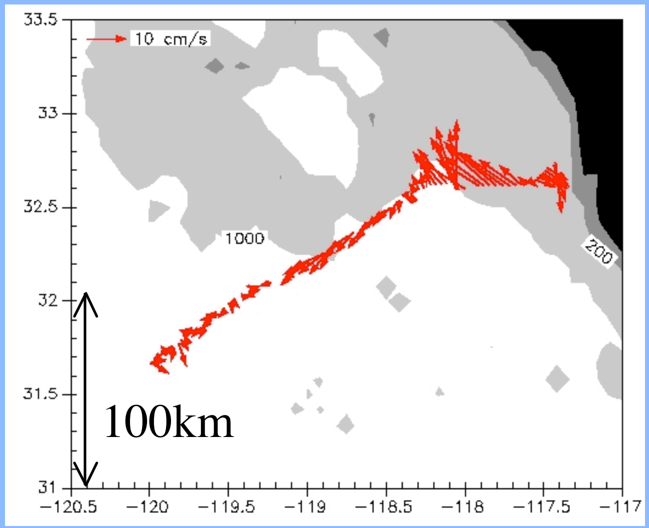
- Work with potential customers to define operational requirements in the context of complete information delivery …
- Analyse, then demonstrate *cost* **and** *scientific* effectiveness of pre-operational AUV environmental applications, e.g.
  - Repeat (enhanced) hydrographic sections;
  - Ecosystem surveys (fisheries, habitats, …);
  - Responsive mode: post-incident assessment

Oceanic Micro-AUVs

Buoyancy driven

Courtesy C. Eriksen, U. Washington

Transect of the California Current by a glider



Courtesy R Davis, SIO

Propeller driven

CONSTRUCTION:
Anodized aluminium alloy, plastic
SIZE length 1.68 m, diameter 0.2 m
WEIGHT 50 kg in air
OPERATIONAL DEPTH: 2000 m
SURVEY SPEED: 1.5 to 2.0 m/s
TURNING RADIUS: 3 m
BOTTOM TRACKING: Minimum height 1 m
BATTERY TECHNOLOGY: NiMH, LiIon or Lithium primary
OPERATIONAL CYCLE: 7 hr to several days depending on speed, equipment use and power modules
RANGE (typical): 40 km @ 1.0 to 2.0 m/s

Courtesy Hafmynd

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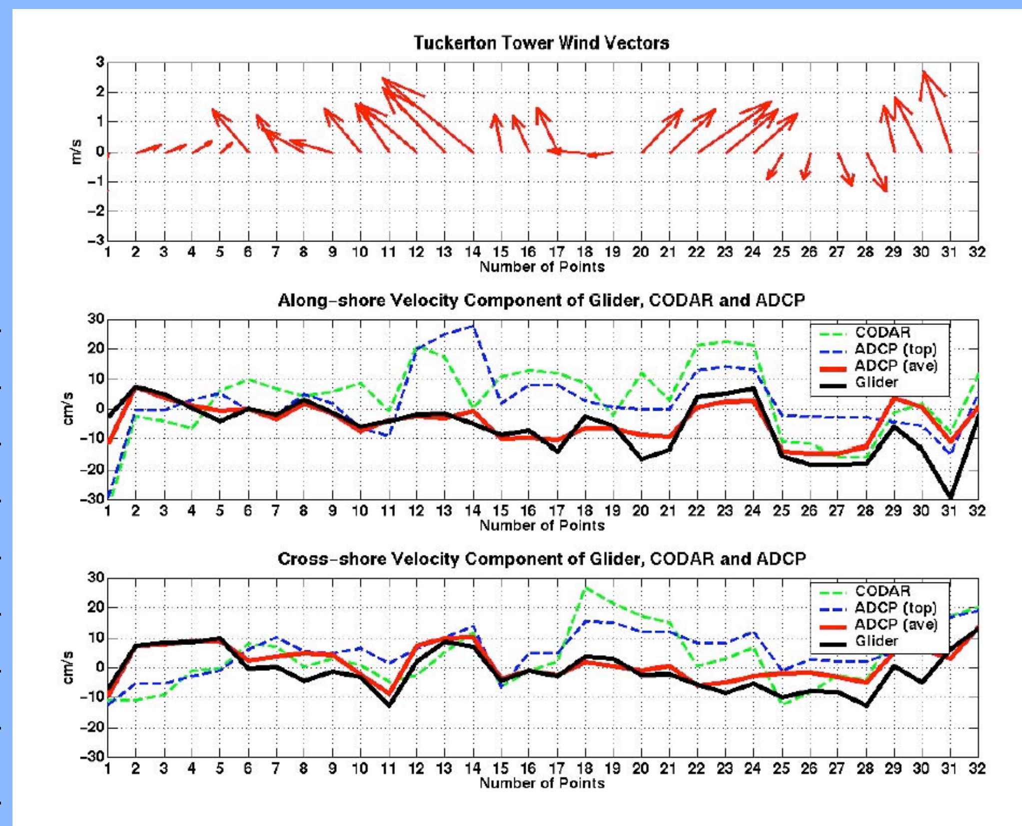
Coastal Micro-AUVs

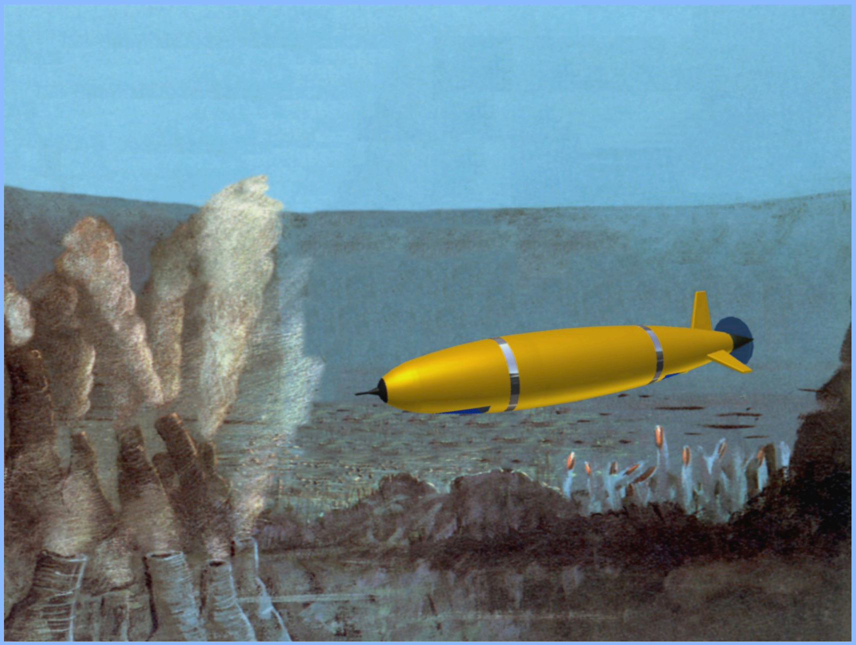
Length 215 cm, dia. 21 cm, mass 52 kg, payload 5 kg
Wing span 120 cm swept 45°
Alkaline power pack 260 C cells, energy 8 MJ at 21°C
Buoyancy change 0.52 litres, efficiency 50%
RF LAN, 5.7 kb/s, 3 J/Mb, 30 km range, GPS navigation
Max *P* 200 dbar, Max *U* 0.40 m s^{-1}
U=0.25 m s^{-1}, 20° glide, range 2,300 km (est)
Construction 50,000, Refuelling 800



Courtesy Webb Research Corp.

Technology challenges

- Energy storage
  - Target 1000 Wh kg^{-1}
- Sensors
  - Stable, self-calibrating, biological & chemical as well as physical
- Intelligent behaviours
- Communications
  - Speed, energy & cost per bit
  - Subsurface communications
  - Integration into data networks



- Docking standards
- Navigation accuracy

Observations

It is not technology that is holding back the widespread adoption of Autonomous Underwater Vehicles as components of sustained ocean observing systems

The technology is proven in many areas of ocean research, in commercial ocean survey and, increasingly, in defence applications.

For those charged with defining Operational Requirements - AUVs are ready, willing and able to contribute.