



# Dynamic Positioning & WROVs: A Productive Union

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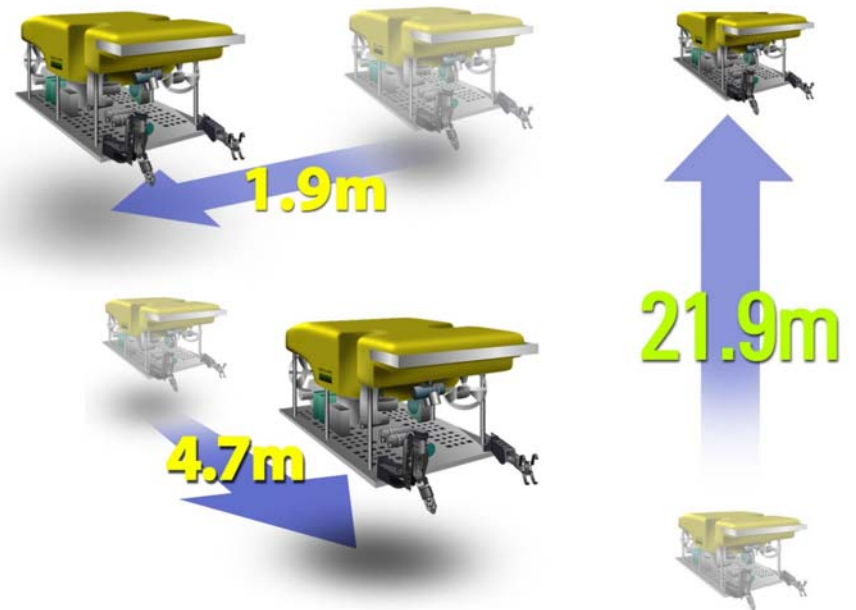
**DYNAMIC POSITIONING CONFERENCE**  
**September 28-30, 2004**

# Dynamic Positioning and WROVs

- DP used on surface vessels for 20+ years with great success.
- DP used on many AUVs.
- DP not used on commercial WROVs.
- Quest WROV provides DVL-based DP.
- Improved efficiency and equipment safety.

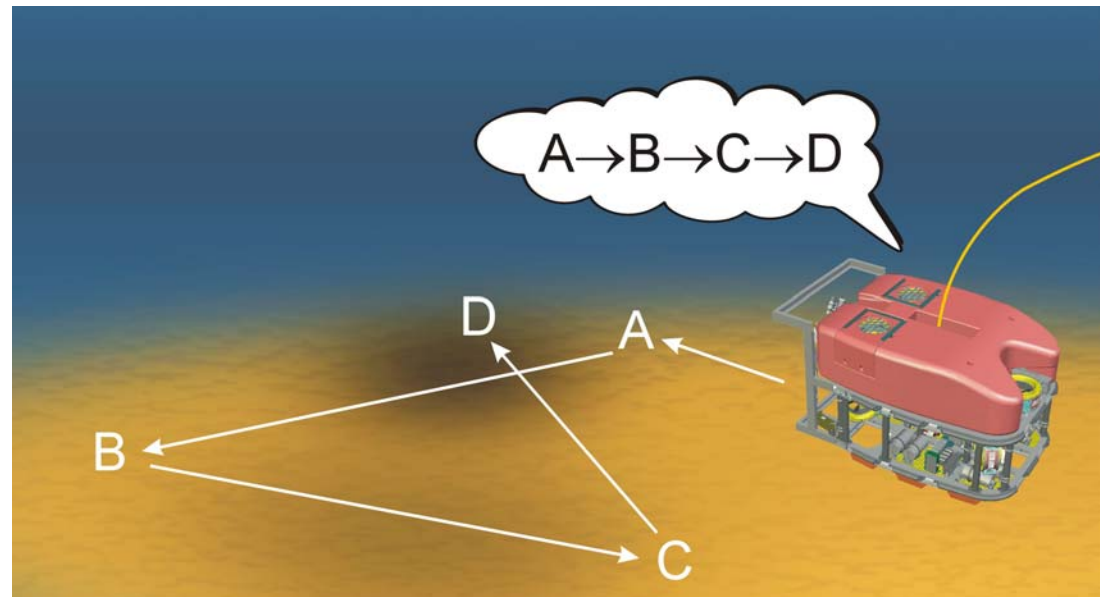
# WROV DP Characteristics

- Using its own propulsion system and sensors, vehicle can remain stationary (within a decimeter) for unlimited time.
- Vehicle can accurately displace (move to) another location in the x, y, and z axes in arbitrary pitch, roll, and yaw orientations.



# WROV DP Characteristics

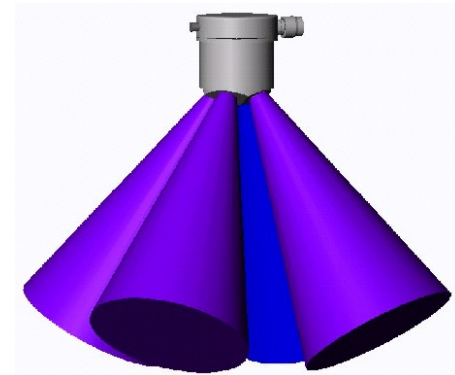
- Set point can be altered via joystick.
- Can accurately report the distance and vector between two locations.
- Can follow a set of way points or fly a pre-planned path.



# DP Sensors



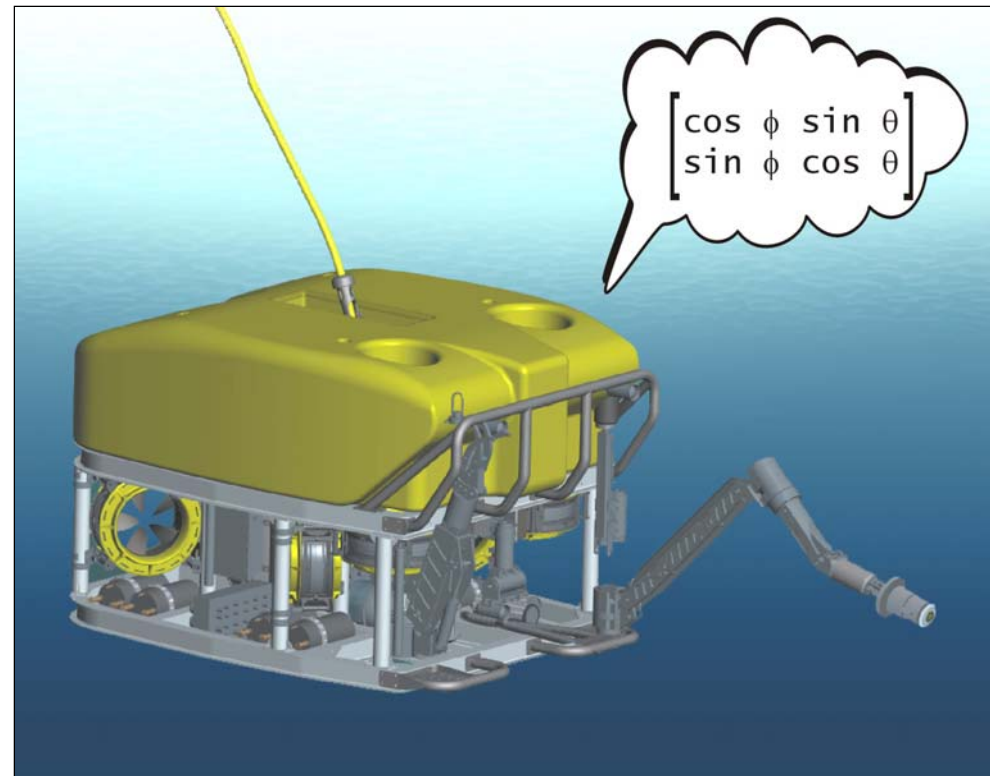
- DVL-based, using RD Instruments Workhorse 1200 with 9-Hz update rate. Off-center compensation in software.
- MRU augments DVL. Crossbow 700CA updating at 40 Hz. Supplies pitch and roll angles; pitch, roll, and yaw rates; x,y,z accelerations.



# Control Model



- PID model with additional actuation modeling. No modeling of drag, coriolis, or buoyancy.
- Body-to-inertial linear transform.



# Control Model



Thrust (lbf)	RPM
0	0
100	210
200	430
300	600
400	850
450	1000

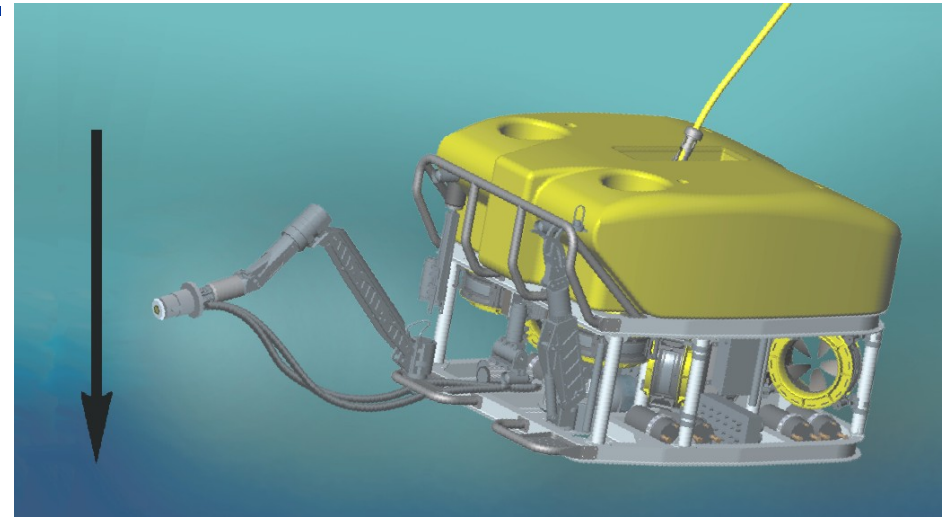
- Affine transform on resultant thrust vector to thruster components.
- Thrust-to-speed map.

The control system uses a lookup table to convert thrust commands into thruster rpm.

# Control Model



- Distributed closed-loop control of both position and velocity.
- Pitch and roll compensation provides a very stable platform.
- Use of *a priori* knowledge, such as ROV pitching up when thrust is applied forward: inject counter force.



Automatic responses are calculated to counteract known tendencies

# Control Model

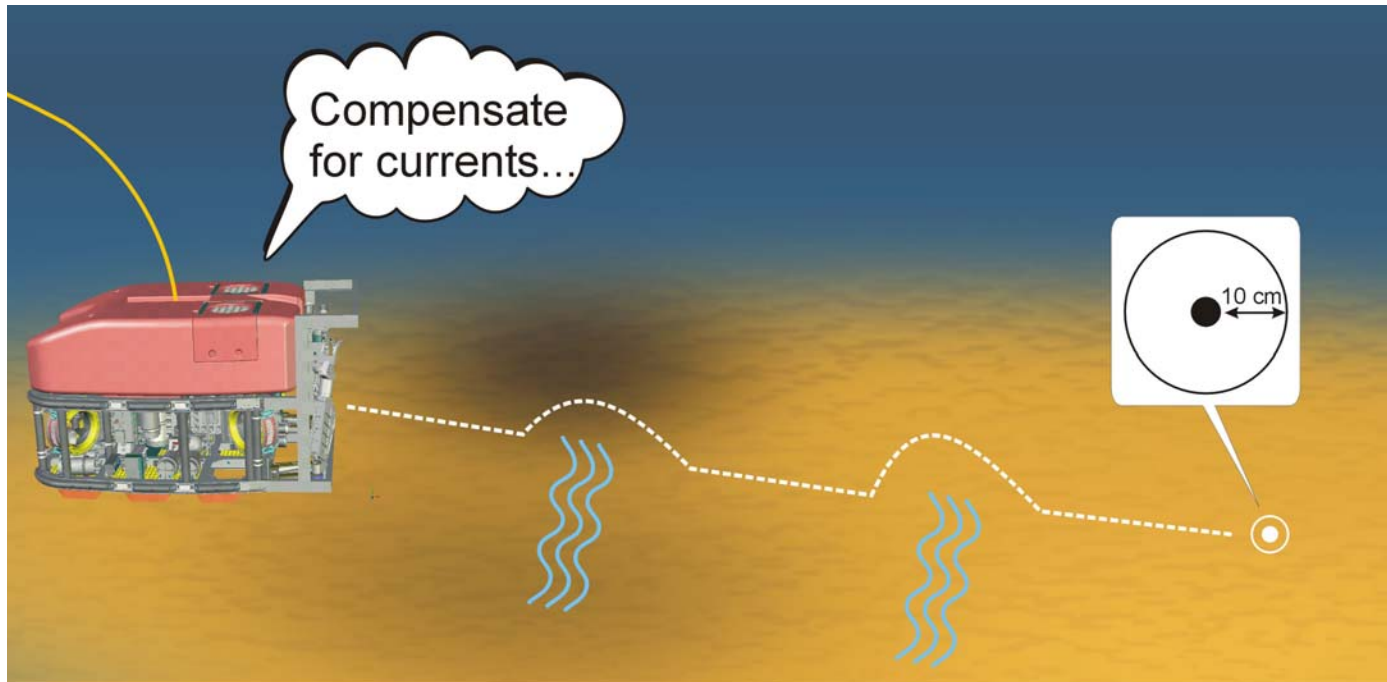


- Proprietary trajectory generator based on velocity tracking.
- Deviated less than  $\pm 1$  meter from path in cross currents.

# Control Model



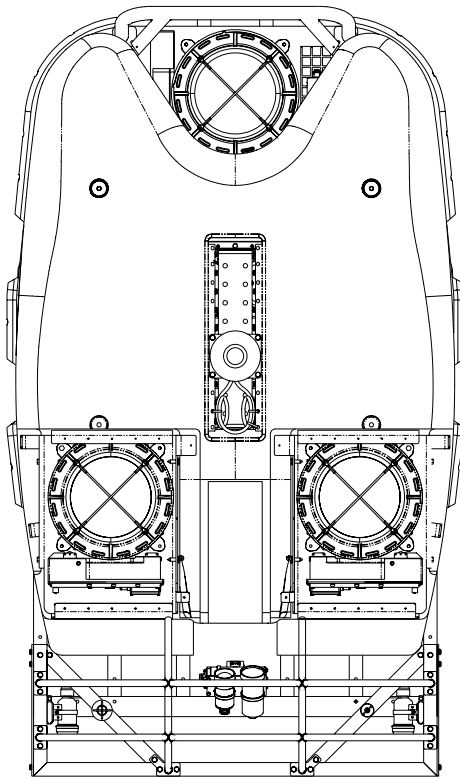
- Very accurate; moves greater than 60 meters and arrives within a decimeter.
- User-controllable velocity.



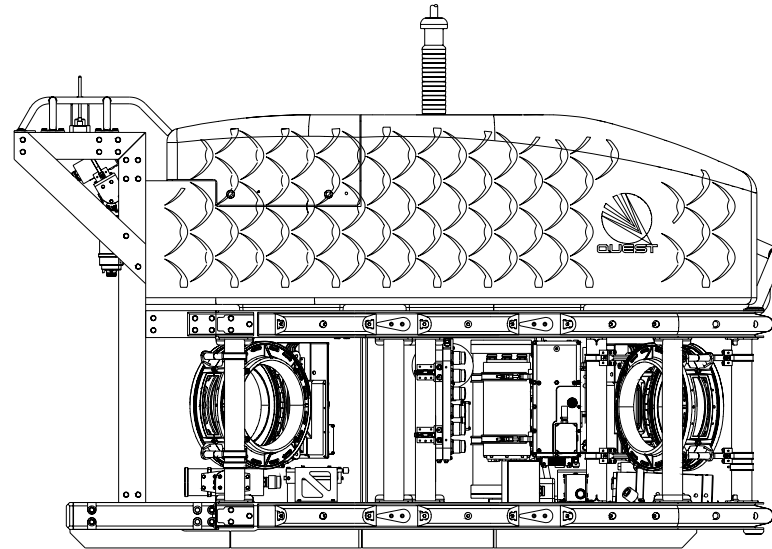
# Actuation



- Uses 7 thrusters, 4 lateral and 3 vertical.



Top View (vertical thrusters)



Side View (horizontal thrusters)

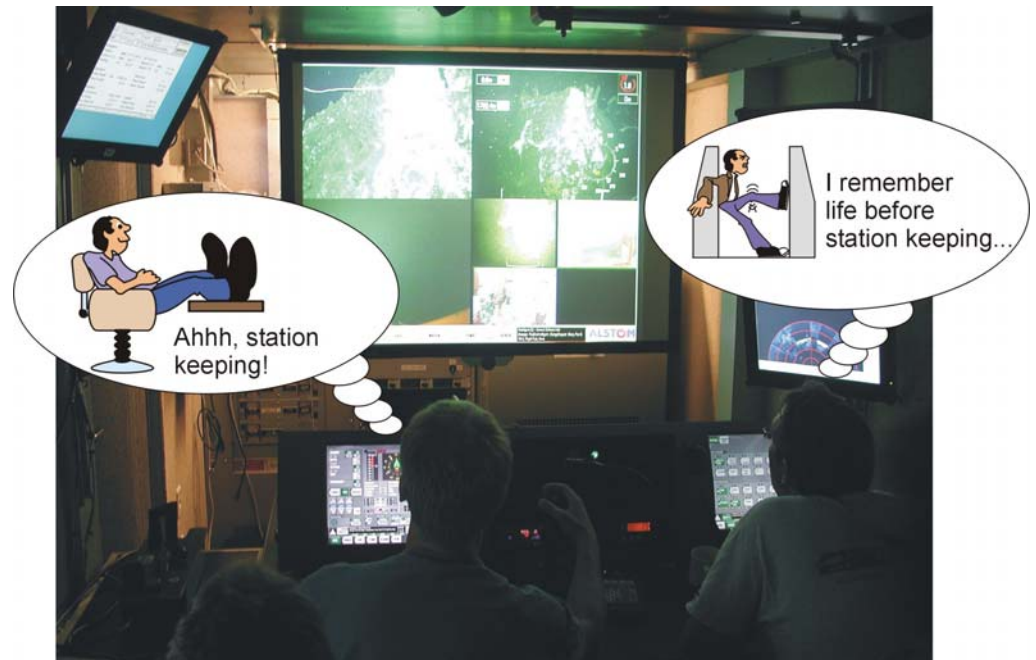
# Actuation



- Closed-loop speed controlled at the thrusters.
- Thruster acceleration rates greater than 2500 rpm/sec/sec.
- Uses feed-forward technique for quick, accurate response.
- Hydraulic thruster has local control of pressure and flow.

# WROV Tasks: General Operation

- Allows the operator to “take a break” from controlling the vehicle while other tasks are performed (checking sonar, manipulators, tether position, etc.).
- Crew isn’t panicked.
- Allows less experienced operators to provide quality operations.



# WROV Tasks: No Grabber Needed

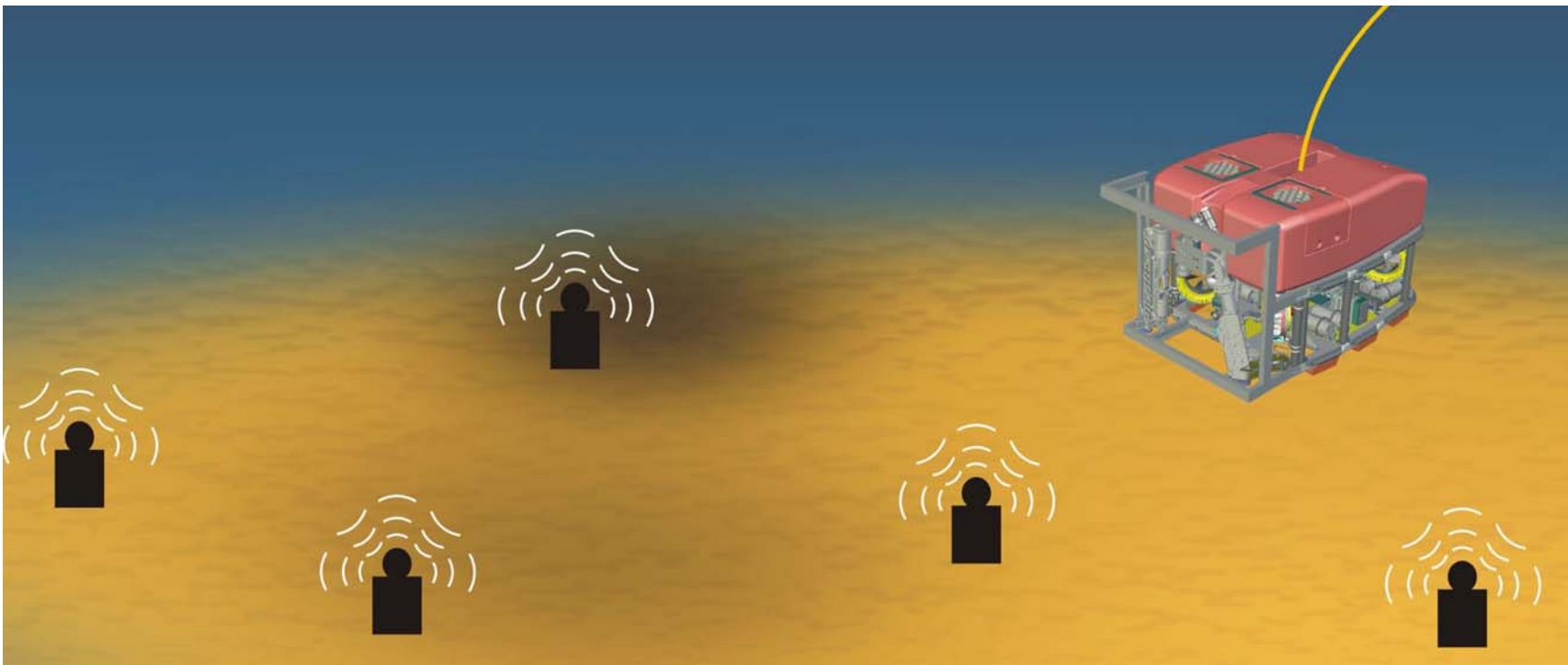
- Grabber does not adequately stabilize the vehicle; it acts as a pivot point and the pilot must counter any additional forces acting on the vehicle.
- Many older subsea structures don't have grab points.
- DP makes close-quarters work much easier.



Deepwater Subsea Manifold

# WROV Tasks: Deployment and Retrieval

- Find first location using surface methods.
- Find all other locations using DP.



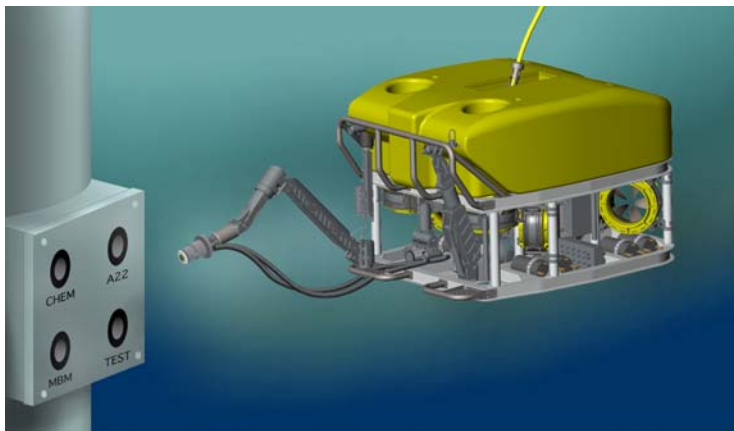
# WROV Tasks: Deployment and Retrieval



- More accurate than surface-based methods, particularly at great depths.
- No searching on retrieval; arrive exactly at location.
- Can work in low- to no-visibility conditions.

# WROV Tasks: Hot Stab Connection

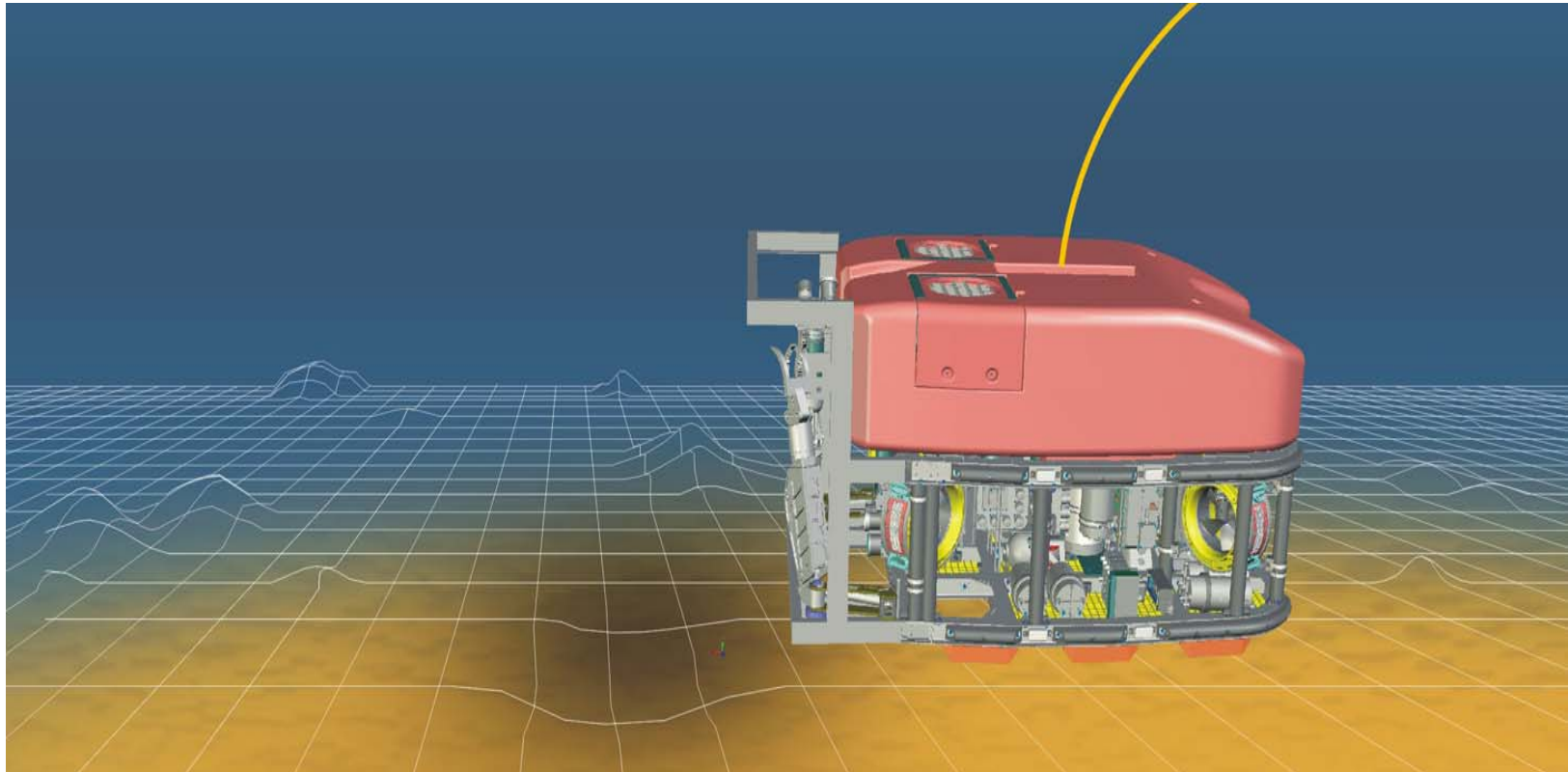
- Make and break hydraulic or electrical connections.
- Requires stable platform to get hot stab into slot.
- No need to freeze the manipulator and fly the hot stab into the socket.



- Vehicle is stable; operator can use a manipulator to insert hot stab.

# WROV Tasks: Grid Searches & Surveys

- WROV can make searches and surveys with accuracy measured in centimeters.



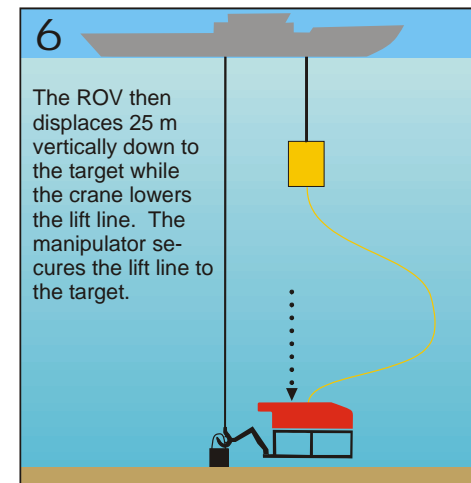
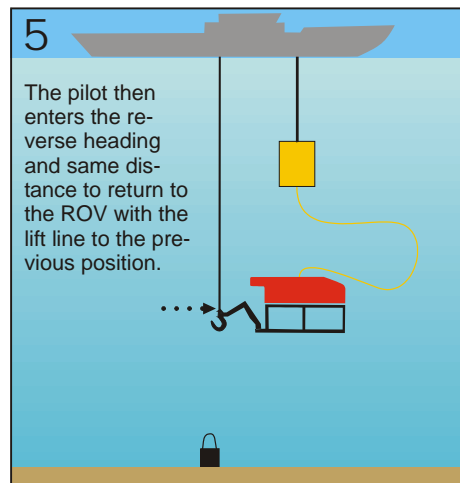
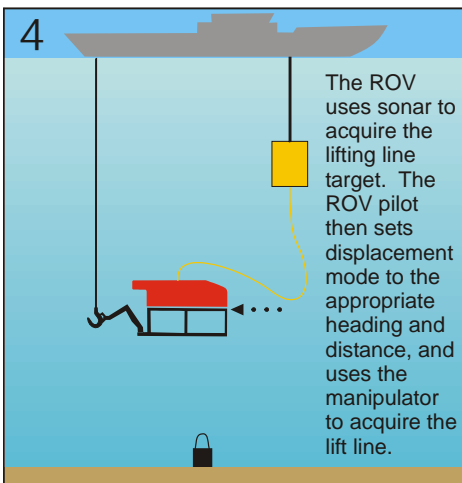
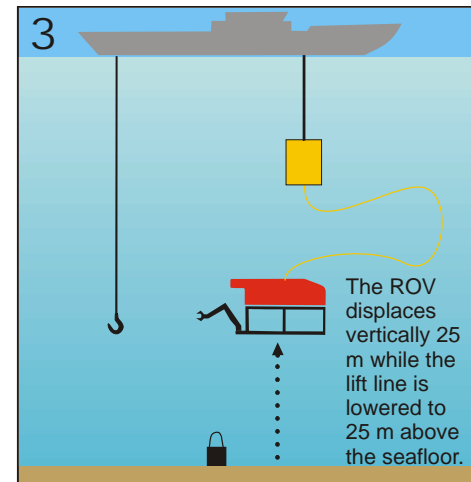
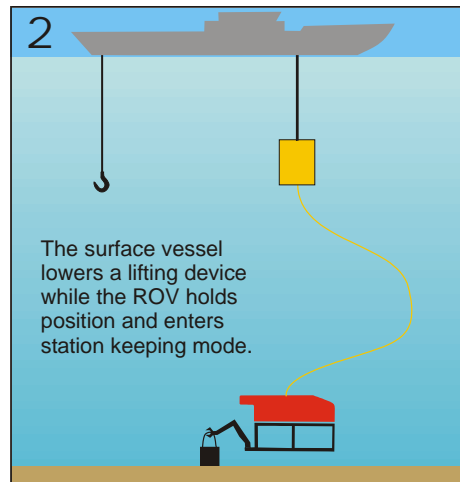
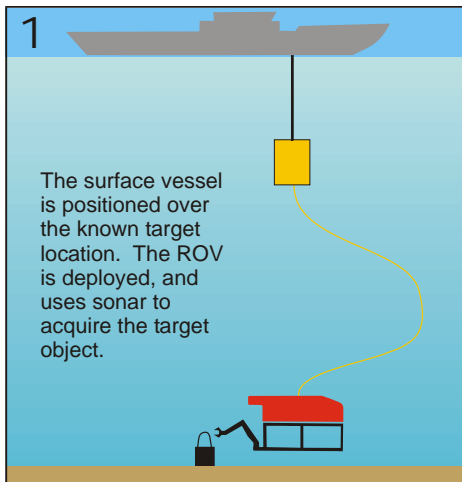
# WROV Tasks: Grid Searches & Surveys



- Telepresence allows quick changing of task parameters based on real-time view.
- Can view video live instead of in post-dive download.
- WROV has “unlimited power.”

# WROV Tasks: Intercepting Down-Lines

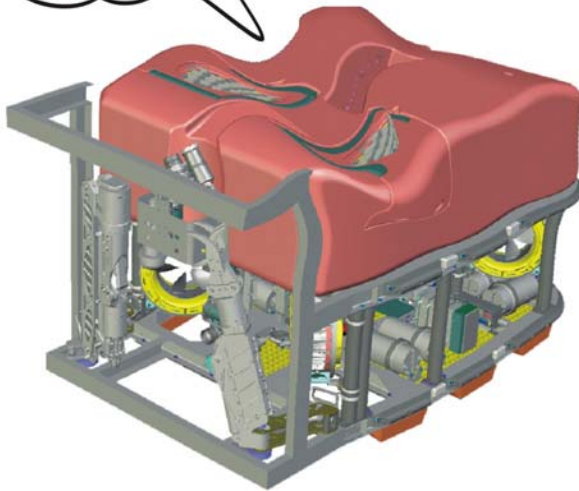
- Locating/fixing down-lines is quick and easy.



# WROV Tasks: Deployment of Heaving Loads

- Visibility loss as seabed is stirred up.
- Reduces crew stress when visibility is poor.
- Reduces chance of WROV/pipe collision.

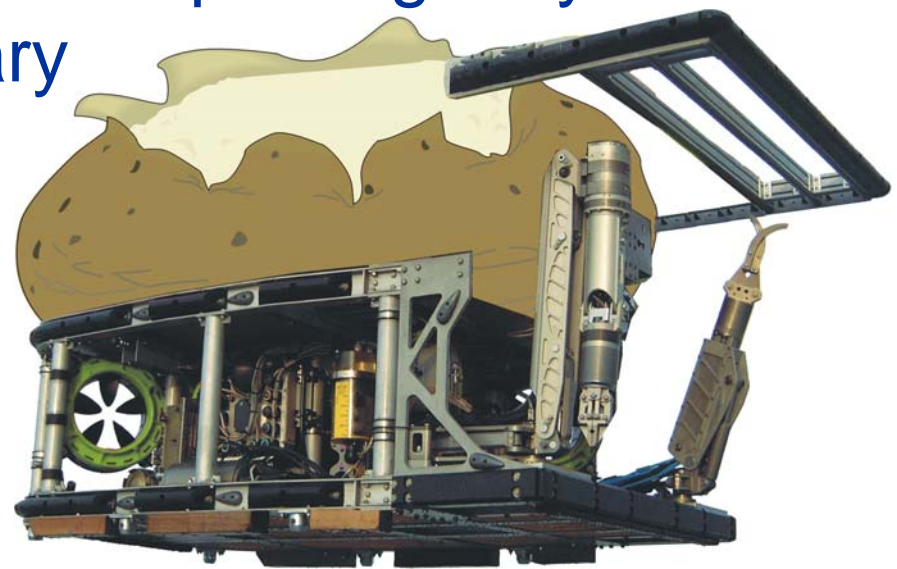
If only they'd used  
station keeping...



- Reduces chance of trapping tether under pipe.
- Crew focuses on providing good camera and sonar views.

# WROV Tasks: Lengthy Observation

“So the ROV is on station for 1-3 days during spudding in. SK is used here to keep the ROV close to the drill bit and watch for gas. As you can see, a drill bit spinning very fast in front of you is a scary thing, a tether and ROV killer, so panic can set in if visibility is lost. But with SK, nerves are relaxed and you don’t drift anywhere you don’t want to be.”



“Spudding in” is simultaneously stressful and boring.

# WROV Tasks: Maintain Camera View



- Small vehicle movements produce unusable video when camera is zoomed up close.
- Can wait for hours or days for a single event to occur. Easy to miss if WROV is not stable.
- Less stress on crew than non-DP method.



# The Future of DP on WROVs



- Absolute DP
- Multi-WROV DP
- Midwater DP
- Position storage and recall
- DP for WROV tools

# DP and WROVS: A Productive Union



- Saves significant time on a large variety of tasks.
- Safer environment for equipment.
- Less stress and fatigue for crew members.
- Makes possible some tasks that are infeasible without DP.
- Will it become a standard feature of WROVs?

**QUESTIONS?**

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