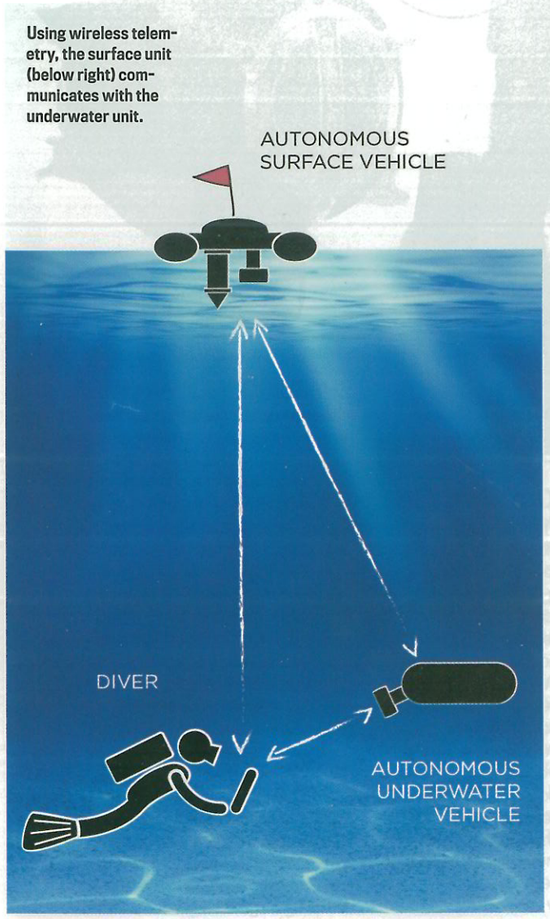
DIVING WITH R2D2?

BY KARL SHREEVES, EDUCATION & TECHNICAL EDITOR



Using wireless telemetry, the surface unit (below right) communicates with the underwater unit.

"R2, pass me the ratchet wrench," says the mission commander during her second space walk to service the International Space Station (ISS) solar power array. Her autonomous teammate — robotic astronaut "Robonaut 2" — extends the requested tool.

"ESEX-82-27-10," R2's electronic voice says in her headset, confirming the specific ratchet wrench.

"Won't budge," reports the commander after five minutes spent pushing the ratchet.

"The engineers say to force it," replies Mission Control. "Put R2 on it. You'll overwork trying to do it."

"Copy that," she acknowledges, reclipping her safety tether so the robot can maneuver into her place.

There's nothing sci-fi about this scenario. Robonaut 2 not only exists, but it is already on the ISS undergoing trials. Astronauts plus R2 should form optimum work teams by combining what robots do best (complete precise, specific repetitive tasks, carry items, monitor without distraction, etc.) with what humans do best (observe, question, create, innovate, adapt to the unexpected).

So, if it works for astronauts, why not divers? At least, that's the thinking behind the CADDY project (for Cognitive Autonomous Diving Buddy). Backed by the European Community's Seventh Framework Programme FP7 Challenge 2 (cognitive systems and robotics), the CADDY Partners project team envisions a robotic dive "buddy" that has an autonomous surface component and an autonomous underwater component, according to the CADDY website (http://www.caddy-fp7.eu).

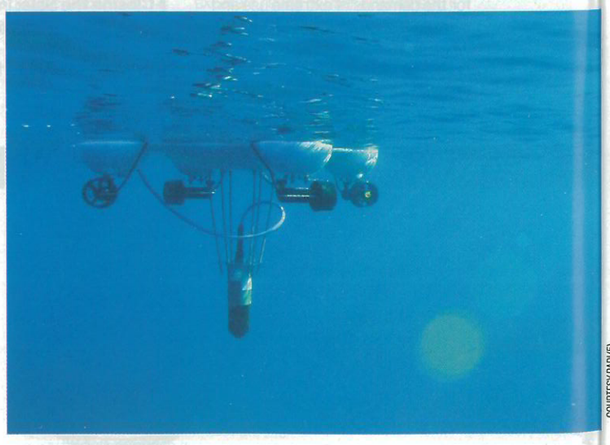
Using wireless telemetry, the surface unit communicates with the underwater unit, providing navigation information and communication with surface personnel. The underwater unit interacts with the diver. Both travel with the diver autonomously, serving three primary functions: observer, slave and guide.

As a buddy *observer*, CADDY monitors the diver. According to Costantino Balestra of CADDY Partner DAN Europe, it should be possible to have the robot track diver physiology and behaviorisms. Potentially, CADDY could warn the diver if it identifies stress behavior or other problems. The robot could also call for help if the diver appears to be incapacitated and direct rescuers to the diver.

As a buddy *slave* — suggestion to the CADDY group: *servant* sounds more positive — CADDY can carry tools, capture images, provide light by which to work, maintain a known location or carry out other programmable tasks.

As a buddy *guide*, CADDY's navigation system can lead divers to a precise location, along a desired path or to safety in the case of an emergency. On large projects, CADDY can bring a diver to a specific place where a previous diver left a task in progress.

In all of these roles, the divers have control and can command changes to the task or mission, or tell CADDY to perform tasks. Divers do this the same way they communicate with human buddies — using hand signals. CADDY programming will include optical recognition of hand signals and gestures.



COURTESY PADI (5)

CADDY AT WORK

The project's validation scenarios, by which the CADDY Partners will demonstrate system effectiveness, show what CADDY brings to the table. The first is a search-and-recovery task. CADDY should be able to guide divers through a conventional search pattern without lines, reels or compasses.

The second is underwater archaeology. CADDY should be able to provide site documentation without the large grid normally used. Based on diver commands, CADDY should shoot photos/video of key finds, create imagery for a mosaic, do some of the heavy lifting and provide light.

CADDY IN TEC

While the CADDY Partners envision primarily working tasks for the project, one can see applications in all forms of diving, including tec diving:

- Return navigating: If divers find something they want to revisit later; CADDY remembers where it is.
- Telemetry with diver's CCR. The robot provides warnings apart from the onboard systems by monitoring PO_2, CO_2 and deco status.
- Carrying tools and emergency gear.
- "Baby sitting" decompressing divers for safety, prompting upcoming gas changes, stop-depth changes, calling down support divers, etc.
- Shuttling equipment to the surface (spent cylinders, cameras/tools not needed during deco, etc.).
- Taking video/photos of the dive.
- Facilitating communication between surface support and divers.
- Providing back-up navigation to location of staged cylinders or other gear.

CADDY IN INSTRUCTION

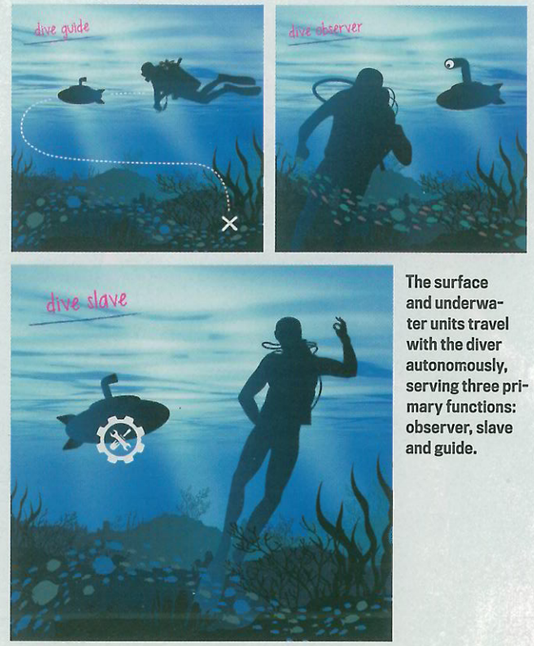
CADDY may well be the ultimate *second* certified assistant. You'll still want your trusted human PADI Divemasters and Assistant Instructors, but CADDY's instructional roles could include:

- Leading or following the group to help keep everyone together.
- Carrying (perhaps) some extra weights.
- Assisting navigation to keep staff attention on the divers.
- With physiological/behavior programming, alerting staff of student stress indicators before something becomes a situation.
- Facilitating communication between the staff and the dive boat/shore.
- "Sheep herding" buddy teams that start to stray away from the group.
- For indirect supervision (e.g., underwater photography), accompanying students to record video for additional performance assessments.
- Providing general reminders of depth, time, gas and no-stop limits.

"The robot will be able to observe divers, thus serving as a dive guide for a group of students, to detect if someone of them is getting separated from the group or swept away by the current," says Dr. Alessandro Marroni, CEO of DAN Europe, which is involved with the CADDY project. "It will also be able to guide a group of divers through planned itineraries, or to help [divers] find their way back to the boat, for example. Finally, in case of emergency, it will be possible to use it as an assistance tool — an underwater transportation means."

This isn't wishful thinking. The CADDY development team, which includes high-level experts in robotics, dive medicine, underwater tasks and telemetry (see sidebar) has already launched, with the project slated to continue through 2016. The team has completed initial tests and is well into development.

"Although the project is set to last a few years," explains Marroni, "it will produce its effects in the future to the benefit of the entire diving industry ... It will generate a base of knowledge that will enable us to build underwater [autonomous robots] able to cooperate with the diver. It is about creating a new paradigm for underwater robots."



The surface and underwater units travel with the diver autonomously, serving three primary functions: observer, slave and guide.

Watch the future unfold. Follow progress on the CADDY website (http://www.caddy-fp7.eu) and its YouTube channel (http://www.youtube.com/channel/UCQvWV7Eub1qyS0qE6xJuzvQ).

WHO ARE THE CADDY PARTNERS?

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