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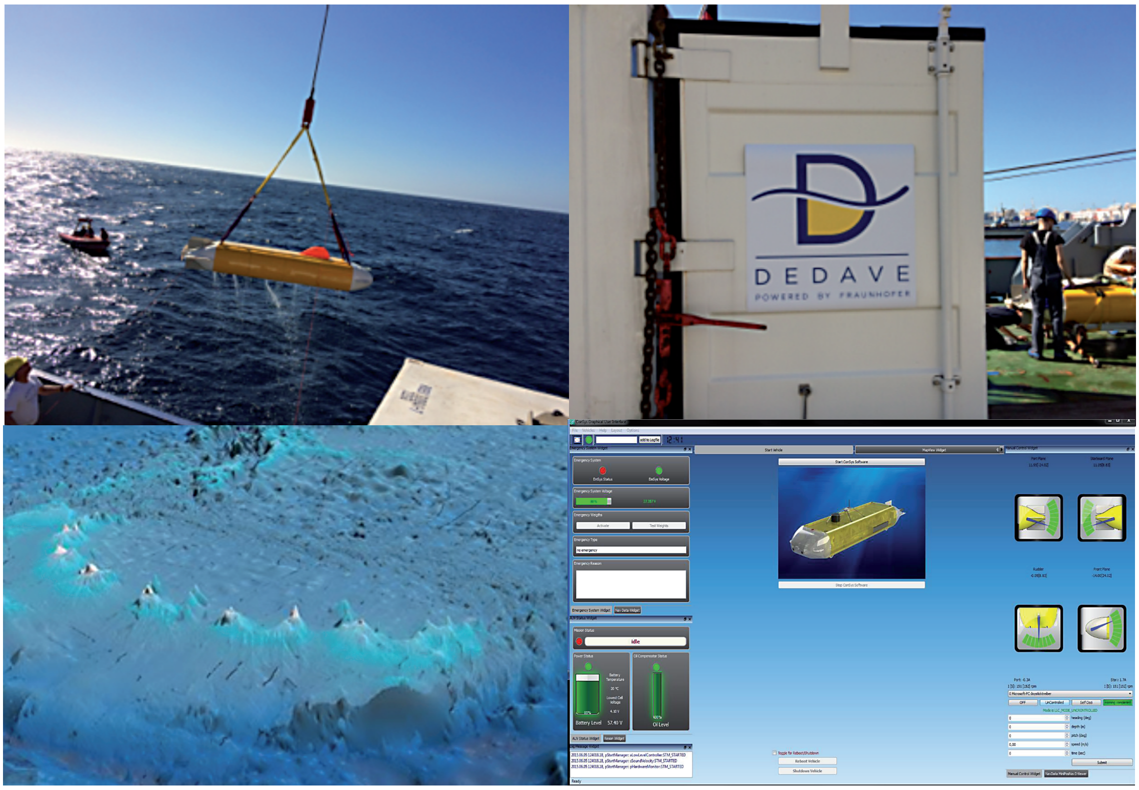
Helmholtz-Zentrum für Ozeanforschung Kiel

RV POSEIDON
Fahrtbericht / Cruise Report
POS493

AUV DEDAVE Test Cruise

Las Palmas - Las Palmas (Spain)
26.01.-01.02.2016



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Test cruise for AUV “DeDAvE” around the Canary Islands

Edited by K.S. Lackschewitz

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Pfützenreuter, Torsten	Fraunhofer Gesellschaft
Rauschenbach, Thomas	Fraunhofer Gesellschaft
Renkewitz, Helge	Fraunhofer Gesellschaft
Weber, Daniel	Fraunhofer Gesellschaft
Woock, Philipp	Fraunhofer Gesellschaft

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Günther, Matthias	Captain
Korte, Detlef	1st mate
Nannen, Hero	2nd mate
Kröger, Kurre Klass	First engineer
Pieper, Carsten	Second engineer
Blunck, Voler	Electrician
Wieden, Wilhelm	Cook
Gerischewski, Bernd	Steward
Mischker, Joachim	Bosun
Meyer, Felix	Ship mechanic
Heyne, Roland	Ship mechanic
Von Keller, Magnus	Seaman
Kuhn,Ronald	Seaman
Rauh, Bernd	Ship mechanic

1 Introduction

K.S. Lackschewitz and T. Rauschenbach

The 493st cruise of the research vessel *POSEIDON* had purely technical aims, testing the newly-developed, Autonomous Underwater Vehicle (AUV) by the Fraunhofer Gesellschaft. The vehicle was funded by the Fraunhofer Gesellschaft 4D-Program “Discover, Define, Develop and Deploy”.

Maritime technologies will play an important economic and scientific role in the deep sea. With the general rise in raw material procurement costs will increase the importance of deep-sea deposits. Their development requires the exploration and surveying (mapping) and their operation requires a regular monitoring (inspection). The same applies to transport of raw materials to lines and cable for information and energy transfer. The study of flora and fauna and the geological structures of the oceans, especially under the influence of climate changes on earth, also requires the use of suitable deep sea autonomous underwater vehicles. The technologies needed for exploration and inspection especially in the deep sea are not yet developed enough and too expensive. Up to this point are only a few highly specialized, very expensive underwater vehicles available, although many tasks are automatically executable routine activities. It lacks cost-effective modular systems that can be adapted to the tasks to be solved. Especially lacking efficient energy storage, high-resolution sensors, effective method for evaluating the sensor data and control systems for a wide range of responsibilities of future underwater vehicles.

The aim of the 4D-Program is to provide technologies for the development of pressure-neutral and therefore more cost-effective, modular AUVs for use in the deep sea to reduce the above deficits. Pressure neutrality means that all functional units (computers, sensors, energy storage device, drives) to the prevailing ambient pressure are directly exposed and no pressure resistant hull consists. Intelligent multi-sensor imaging and ultrasonic sensors, which provide information are fused, the AUV for inspection and exploration abilities. The new technologies will be developed until a state of production. With DeDAvE (Deep-water AUV for Exploration) the technological leadership will be sought in the field of development of modular, autonomous underwater vehicles for exploration tasks. The results for the achievement of the ambitious project goals per required innovation from many years' experience of partners in the development and implementation of industrial components for underwater vehicles.

Based on targeted strategic investment measures in advance of the complainants was an infrastructure (pressure chamber, two underwater vehicles, vehicle testing pool) created that fosters the success of the 4D-Program much. The consortium now has a unique base in Germany for the proposed project, which will increase the leverage of the already made significant strategic investments.

For testing purposes several working areas close to the Canary Islands (Spain) were chosen that span water depths between 50m and 3500m (Fig. 1).

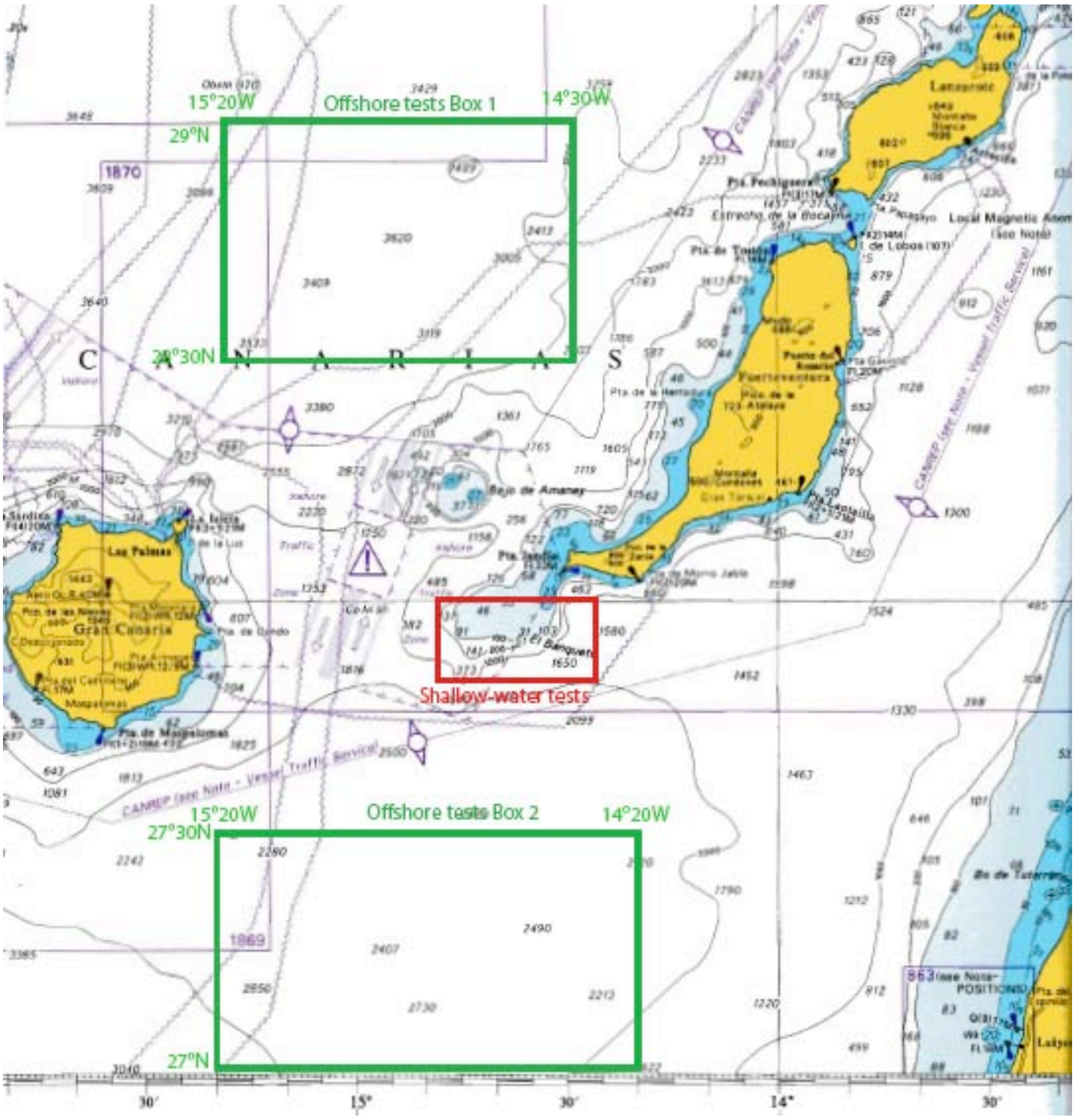

Fig. 1: Location of the shallow-water test area south of Fuerteventura and the two proposed mid-water offshore test areas.

2 Cruise Narrative and Event List

K.S. Lackschewitz and T. Rauschenbach

RV POSEIDON left Las Palmas at 9:30 on 26.01.2016 and took course to the working area, initially designated as being around 27°57´N/14°39´W. The area has about 80m water depth with some rocky areas rising to 50m. As the trimming of the AUV was the first aim work was begun already during the stay in the harbour. Two deployments during the daylight hours were carried out at the 27th as listed in the event table. On 28.01.16 another two dive missions took place in shallow water working area at 27°57´N/14°39´W. Shallow-water tests (ca. 60m water depth) were carried out for the remainder of the cruise in order to test system integrity and sensor functionality. On 29.01.16 the last dive mission were carried out in the shallow water area. Due to strong winds and high sea state we couldn't launch the vehicle in the planned deepwater area during the last two days of our cruise. RV POSEIDON left the working area on January 31th and sailed back to Las Palmas where she arrived in the early morning of February 1th. The container was unloaded shortly after the arrival and the scientists left POSEIDON in the early afternoon of February 1th.

Event list for POS493

Day	Time (LT)	Plan	Result
25.01.16	13:00 13:30	Start trim test in the harbour Stop trim test in the harbour	Sucessfull
26.01.16	09:30	Leave harbour of Las Palmas	
	14:30	Arrive in shallow water working area at 27°57´N/14°39´W	
26.01.16	all day	Working on the vehicle software	
27.01.16	08:00	**Test deployments 01 and 02**; deploy vehicle for several missions at the surface to test the control system at different engine speeds and the data recording of the different sensors. The AUV completed several straight-ahead and curving runs. Instruments used: Pressure sensor, DVL, GPS, IMU, sound velocity	Vehicle runs at different engine power.
27.01.16	11:15	**Recover vehicle**	Sucessfull
27.01.16	14:45	**Test deployments 03 and 04**; deploy vehicle for several missions at the surface to test the manual control with WLAN, to perform the directional control, to test the depth control. The course control while driving various control parameters were tested.	The vehicle has performed several runs with preset courses autonomously.
		Recover vehicle	Succesfull

Day	Time (LT)	Plan	Result
28.01.16	09:00	**Test dive 01**; deploy the vehicle for diving tests; The depth control while driving various control parameters were tested. Vehicle state data was locked for detailed investigations of control behavior During the test 48 diving manoeuvers were carried out	Data for optimization of control parameters was stored and investigated.
	16:00	Recover vehicle	Succesful
29.01.16	09:00	**Test deployment 05**; deploy the vehicle for several dive missions. The cruise and depth controller were tested during 52 diving manoeuvers with a duration between 2 and 10 minutes	Cruise and depth controller were tested successfully. This is a fundamental base for the following exploration missions.
	16:30	Recover vehicle	Succesful
30.01.16		No test dives, because the sea state is too high for launch and recover. Implementation of new features in the mission control system. Checking the functionality of the iridium modem for use in the emergency module. Fixing a problem of the DC power supply.	New features in the mission control system successfully tested. Problem of the DC power supply is fixed.
31.01.16		No test dives, because the sea state is too high for launch and recover. Mounting the repaired DC power supply in the vehicle. Changing the iridium antenna. Integrate a new control algorithm in the vehicle control system	DC power supply works well in the AUV. New iridium antenna is more sensitive than the old one.
01.02.16	8:00	Arriving at Las Palmas	End of cruise

3 AUV Functions and Capabilities

T. Rauschenbach

The AUV DeDAvE was designed and built by the Fraunhofer Institut für Optronik, Systemtechnik und Bildauswertung (IOSB), Fraunhofer IOSB- AST, and Fraunhofer-Institut für Siliziumtechnologie (ISIT).

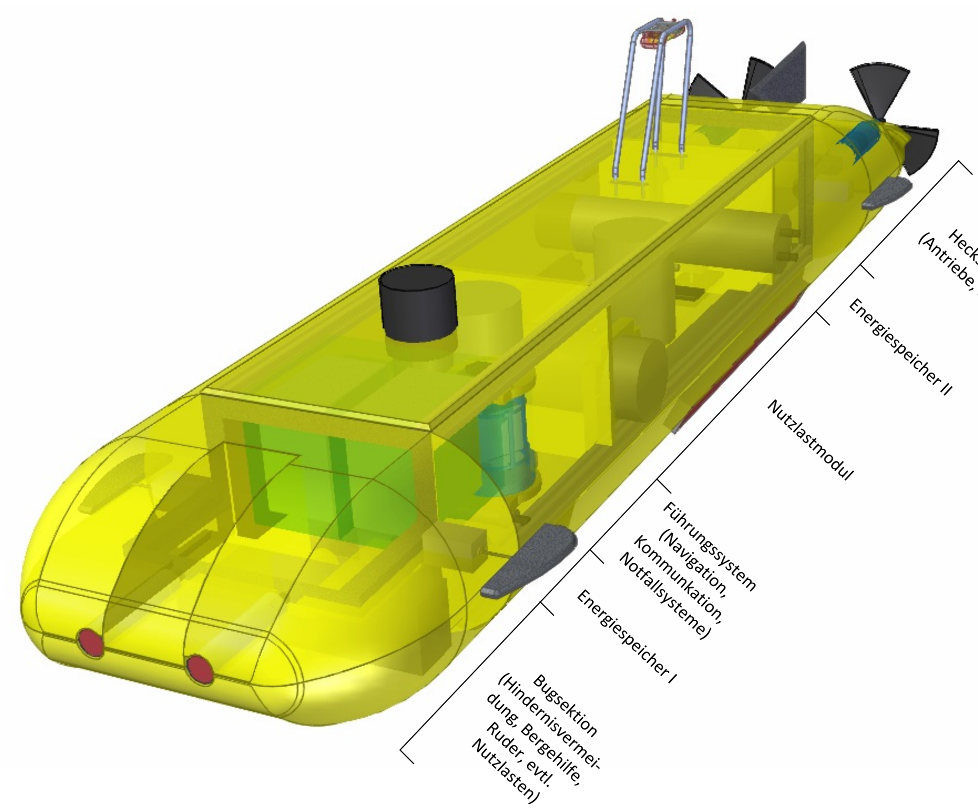

Fig. 2: Modules of AUV DEDAVE.

The vehicle consists of the following modules (see Fig. 2):

- Distance sensor module,
- Dive planes modules (bow and stern),
- Battery modules,
- Emergency module,
- Control module,
- Rudder module,
- Main drive modules,
- Payload module

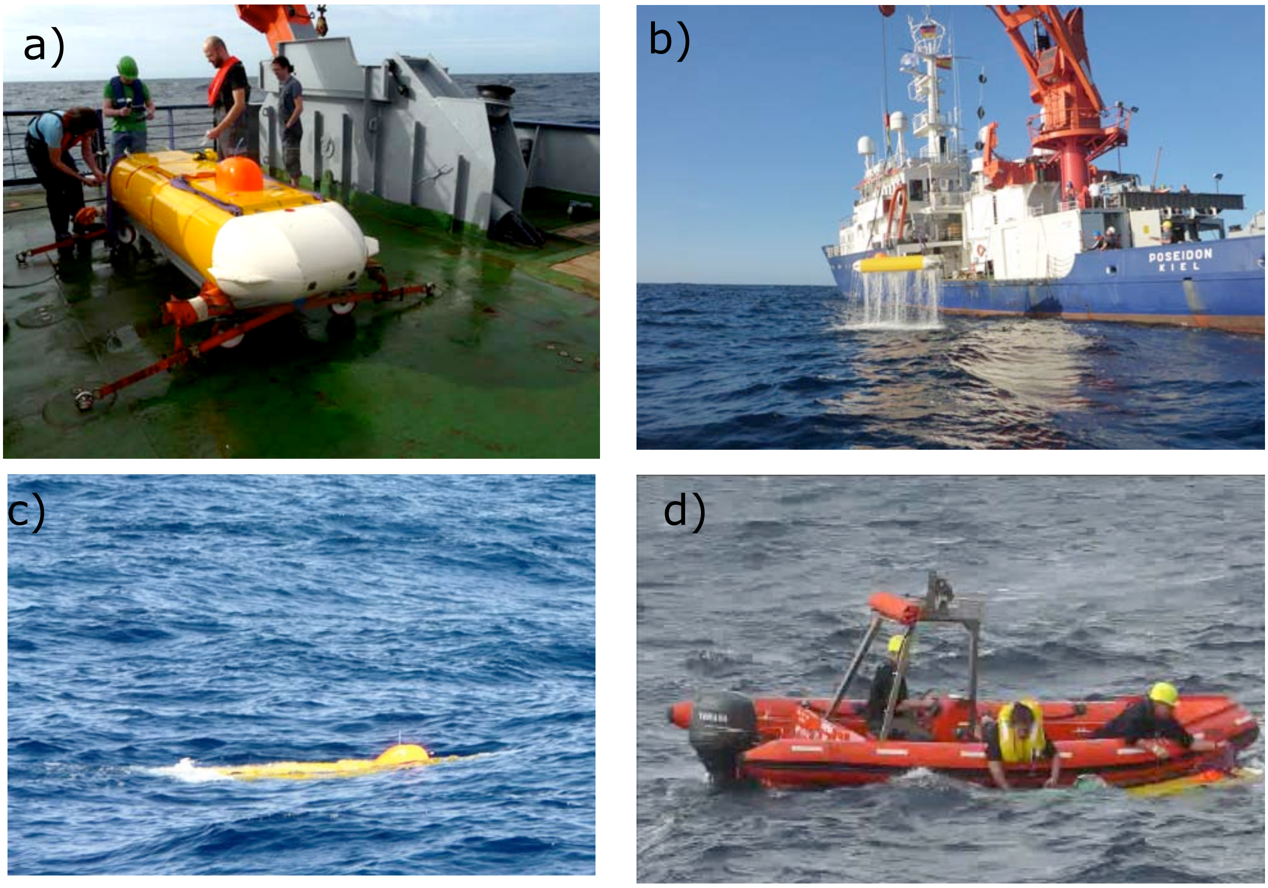

Fig. 3: AUV DEDAVE operations. a) AUV shortly before launch, b) AUV is being launched, c) AUV during the test d) The zodiac had to be used for launch and recovery of the vehicle.

The AUV DeDAvE is equipped with a wireless systems for communication with the operator when on the surface. This WLAN system is optimized for short range, in-water communications. It will often eliminate the need to recover the vehicle between missions. Typically, ranges between the ship and vehicle of 1000 meters are achieved.

Sensors of the base vehicle include a MBES (Reson T20) and Kraken SAS (synthetic aperture sonar). But the Kraken SAS is under repair and during the Poseidon mission it is not mounted in the vehicle.

All sensor information collected by the vehicle is marked with time, depth and latitude, and longitude as it is collected, facilitating the rapid and highly automated generation of maps and data profiles. An acoustic communication system permits the vehicle to send status messages to the surface ship containing information about the vehicle's health, its location, and some sensor data while it is performing a mission. The acoustic communication system is also used to send data and redirection commands to the vehicle. The AUV utilizes electronics, control software, and the laptop based operator interface software.

The vehicle navigates autonomously using a combination of navigation methods, depending on the mission objectives, conditions, and optional equipment enabled.

- GPS - Works only on the surface, GPS determines the vehicle's location on Earth. GPS determines the "initial position" before the vehicle submerges, and verifies or corrects the vehicle's position when it surfaces during the mission. GPS also plays a critical role during INS alignment.
- Inertial Navigation System (Xsens) - After alignment on the surface, INS continuously integrates acceleration in 3 axes to calculate the vehicle's position. It uses input from the DVL and the GPS to maintain its alignment.
- Doppler Velocity Log (DVL) - Continuously measures altitude and speed over ground whenever the vehicle can maintain bottom-lock. The DVL must be within range of the bottom to measure altitude and provide bottom-lock for the INS.

A Vehicle Interface Program (VIP), a LINUX and Windows®-based program (Fig. 5) manages every aspects of AUV operation, including the following tasks:

- Mission planning on electronic navigation charts (customizable, multi-format)
- Real-time mission monitoring through the acoustic modem
- Real-time support-vessel position and heading through GPS and compass feeds (from the AUV control container)
- Pre-mission system checkout
- Post-mission data analysis, mission play-back, and side-scan review

The VIP provides a convenient means of mission planning and programming.

Fig. 4: Screenshot of the LINUX- and Windows®-based vehicle interface program software handling the AUV operations.

4 Acknowledgments

K. Lackschewitz and the Fraunhofer AUV-team thanks the officers and crew of RV POSEIDON for their help, advice and the friendly working environment during the test cruise. The entire AUV team thank the Fraunhofer Gesellschaft for providing the funds to design and built the AUV "DEDAVE".

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