Report on Implementation of the management information system for the acquisition of the UUV

Activity 4.1 - Mission planning, data acquisition and storage

WP4 - Implementation of the Georeferenced Open Access Database

SUSHI DROP project (ID 10046731)

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Abstract

WP4 is focused to UUV mission planning, data acquisition and storage. This deliverable describes the synergies between the mission planning environment and the acquisition management. The result of this operation materializes in the accurate description of Ground Station interface which consists of a coherent and efficient control environment for UUV missions. A standard geodetic reference frame is used both for planning phase and acquisition management phase, in order to maintain a consistent link with spatial-temporal navigation information. A comprehensive mission checklist is also described to allow a correct mission planning and management.

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Overview

An overview of all UUV system is given by the following subsystem – sensor table, describing the acquired data and unit of measurement for each installed component.

Subsystem	Sensor	Data	Unit of measurements
Guidance, Navigation and Control	Inertial Navigation System	Attitude (°): Heading Roll Pitch	°
		Attitude rates : Heading rate Roll Rate Pitch Rate	°/s
		Latitude	90° S to 90° N
		Longitude	180° E to 180° W
		Linear Acceleration	g
		Speed (North and East)	Knot
	Doppler Velocity Log (DVL)	Linear Speed	cm/s
		Linear Acceleration	cm/s^2
	On board GPS Attitude & Reference System (GPS AHRS)	Latitude	90° S to 90° N
		Longitude	180° E to 180° W
	Altimeter	Distance from Bottom	m
	Sound Velocity Sensor - Pressure Conductivity Temperature	Sound Velocity	m/s
		Pressure	dBar

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		Conductivity	mS/cm
		Temperature	°C
		Depth	m
	Ultra Short Baseline System (USBL)	Relative Distance (AUV- Vessel)	m
		Relative Velocity (AUV - Vessel)	m/s
		Relative Attitude	°
		Latitude AUV	180° E to 180° W
		Longitude AUV	90° S to 90° N
	Propulsion Controller	RPM	r/min
	Batteries	Cells voltage	volt
		Temperature	celsius
		Residual charge	%
Ground Station	GPS Receiver	Latitude Vessel	90° S to 90° N
		Longitude Vessel	180° E to 180° W
		Speed (North and East)	m/s
		Acceleration	m/s^2
	Ultra Short Baseline System (USBL)	Relative Distance (AUV- Vessel)	m
		Relative Velocity (AUV - Vessel)	m/s
		Relative Attitude	°
Scientific Payloads	Pilot Camera	Video Streaming	MBps
	Photogrammetric Camera (bottom Looking)	Image sequence	MBps
		Live View	MBps
	Multibeam	Bathymetry	MBps

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		Water Column	MBps
	Sound Velocity Sensor - Pressure Conductivity Temperature	Sound Velocity	m/s
		Pressure	dBar
		Conductivity	mS/cm
		Temperature	°C
		Depth	m

Figure 1: Sushi Drop Data subsystem-sensor Table

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Ground Station interface description

The Ground Station (GS) is composed by a portable computer system with rugged hardware designed to operate reliably in harsh environment on board the mission boat. The GS is equipped with an internal and an additional external monitor, input interfaces and dedicated software developed for UUV management. The following paragraphs describe in detail the software interface that allow the UUV mission planning through the use of 3D waypoints and further parameters. The interface of the GS has been studied to allow full overview of available telemetry. The operator can control the scientific payload of the submarine survey. The GS interface consists of a series of screens dedicated to specific functions.

Navigation information

This main GS screen (Figure 2) shows overlapped and georeferenced navigation map layers. Each layer can be switched on/off depending on the specific UUV mission. The following information can be displayed:

- Oriented home point position (latitude, longitude, bearing) updated in real-time and obtained from GNSS receiver installed on boat
- Real time UUV position
- UUV trajectory (actual) and survey trajectory (planned)
- Distance between home point (boat – GS) and UUV expressed both in nautical miles and meters
- Compass
- Attitude indicator
- Scalebar and geographic (latitude, longitude) and/or cartographic coordinates
- Background map(s):
  - Official aerial map: used for near-coast operations
  - Bathymetry (from local official repositories and/or General Bathymetric Chart of the Oceans)
  - Data from previous UUV surveys
- Georeferenced register of fishermen's alerts

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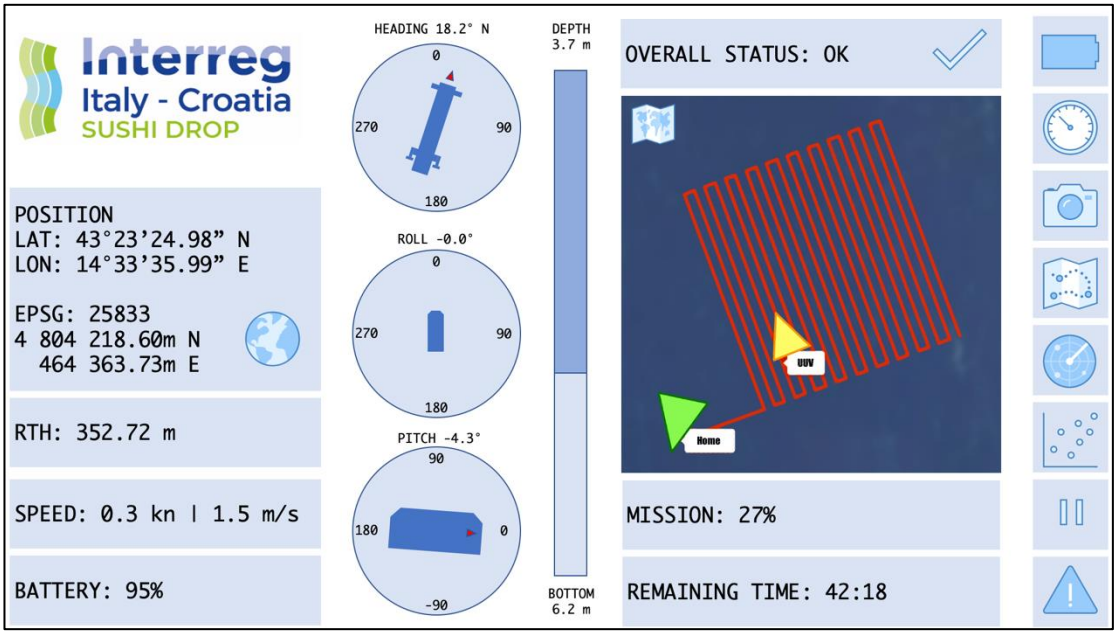

Figure 2: example of mission planning and UUV control in GS interface

3D Waypoint navigation planning

Navigation planning using 3D waypoints is one of the crucial components of the UUV system. It is therefore essential to define a consistent reference system for the navigation phase and for the subsequent co-registration of the acquired data. A convenient system for global geolocation is then indicated: World Geodetic System (WGS84) with reference EPSG:4326. The adoption of this universal system will allow the activity of the UUV platform for navigation in any area of the globe by setting 3D waypoints as latitude and longitude coordinates to combined with depth as a third dimension. It also guarantees the possibility of converting these coordinates in real time into a local cartographic system for the benefit of the GS user with information consistent with the investigated area for a more immediate understanding of the distance between GS and UUV. Within SUSHI DROP project the whole survey area is between 12°E and 18°E longitude (Figure 3) corresponding to European Terrestrial Reference System 1989 – UTM zone 33N (EPSG:25833).

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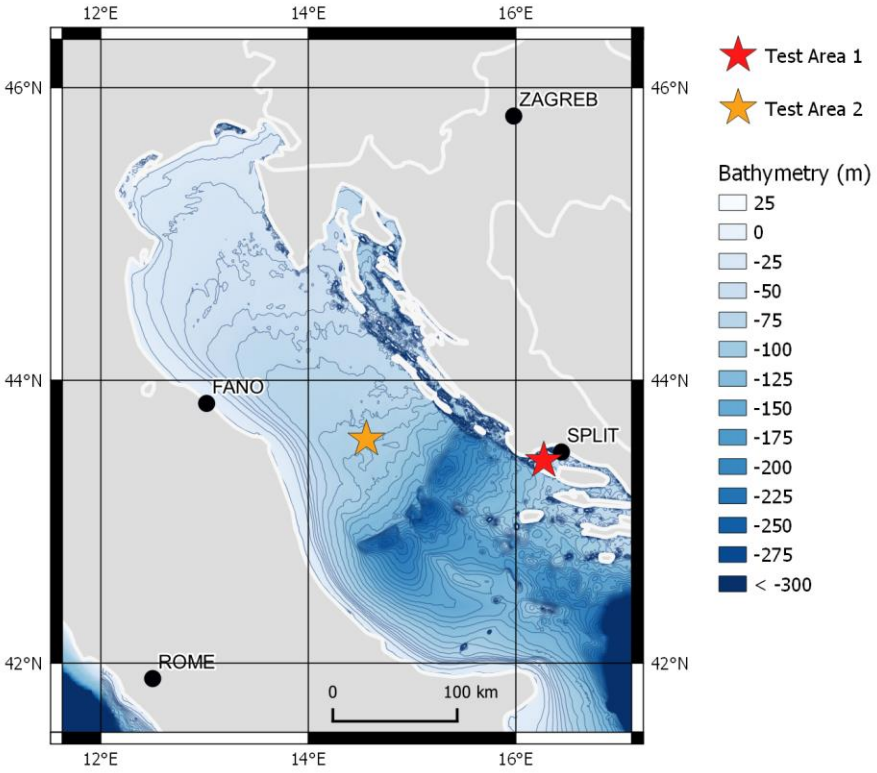

Figure 3: location of the UUV surveyed areas

In the following list, the main controls, settings and parameters displayed on the GS interface are described:

- Mission planning and editing of 3D waypoints directly on Ground Station
- Previously planned mission import from external computer to Ground Station
- Sync and upload from Ground Station to UUV
- 3D waypoint settings (geometric proximity tolerance for autopilot) and triggers (depth, speed, hold, camera trigger, attitude holding, LED switch on/off, etc)
- Mission briefing parameters: time of mission, total distance following mission plan, estimated time of arrival (ETA), depth between waypoints, maximum distance from home point
- Scalebar and geographic (latitude, longitude) and/or cartographic coordinates
- Trigger power on/off for top LED lights for UUV recovery at mission end

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Camera video streaming

The live view camera video streaming is always displayed in real time on external monitor, when available. Additional telemetry is displayed on screen over the video frames in order to provide a overview for the operator.

- Live view from pilot (frontal) bullet camera
- Live view from photogrammetric (bottom) camera
- Overview of telemetry
  - Distance from home point
  - UUV speed (knots and m/s)
  - Depth
  - Battery status
  - REC button
  - Camera REC settings
  - Free space on local memory

Scientific payload

This GS screen is dedicated to the display of the output received from available scientific payload. Each sensor acquisition is spatial-temporally synced thanks to on-board navigation data.

- Photogrammetry camera
  - Trigger and setting software, based on PTP (Picture Transfer Protocol) and PTP/IP protocol implemented within the window
    - Camera live view
    - Survey settings (ISO, Aperture, Speed, etc.)
    - REC button (automatic trigger geolocated on 3D waypoint proximity)
    - Free space on local memory
    - Total n° of imagery surveyed/residual
  - Power on/off for LED lights
    - 2 front
    - 2 bottom
- Multibeam
  - Settings from control software R2Sonic on board in multibeam-computer
  - Information obtained from R2Sonic software
  - Trigger from waypoint to R2Sonic software for survey
- CT probe (conductivity and temperature)
  - Always on (1 Hz): feedback indicator (green, yellow, red) for data recording
- SVS-P probe (sound velocity sensor)

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- Always on (1 Hz): feedback indicator (green, yellow, red) for data recording

Telemetry

In this GS screen a graphical and numerical feedback is shown for the main telemetry values received in real time from the UUV.

- Graphical plot for main parameters, custom on temporal scale
- Joystick thrusters (lever position, buttons mapping)
- Thrust: raw data obtained from each UUV motor
- FOG
  - roll, pitch, heading
  - compass
  - GNSS fix flag
- Speed: data fusion of multiple sensors
- USBL (oriented head)
  - Relative distance from drone (D + oriented arrow)
- Altimeter
  - Distance from bottom
- CT+SVS-P
  - Computed depth
- Battery voltage
  - Residual charge
  - Navigation residual time estimate (based on variable power requirements)
- Feedback lag radio transmission
  - Signal bars + time delay (Es. WiFi, Radio, Acoustic)
  - Bandwidth saturation
- Onboard computer
  - CPU (load)
  - SSD (capacity and read/write feedback)
  - Optical fiber transmission

Mission checklist

Preliminary – dry operations

- Weather control up to 48 hours in advance
- 3D waypoint mission planning
- Mission duration estimate: boat navigation, UUV survey, boat re-entry
- Port authority communication
- Equipment to be loaded on board
- Charged batteries
- Free space on memory archives (SSD and SD cards)
- Mission authorization for UUV operators
- Handheld transceiver (walkie-talkie) for on boat verbal communications
- UUV handling on board using appropriate safety structure

Pre-mission

- Onboard instruments check
  - USBL install. The instrument stays in water only during mission, not during boat navigation.
  - GNSS receiver install. The boat antenna is fixed and stays in place.
  - Winch install for UUV handling
  - GS install: rugged notebook and external monitor
  - Communication node install: optical fiber mux-demux, GNSS receiver, USBL
- UUV inspection
  - Free propeller
  - Visual inspection
  - Check connection of subsystems and batteries
  - Check of cleaning and cap removal from sensors
  - Check for automatic safety system for Return To Home (RTH) and return to surface with release of weights in case of failure or empty battery
- Power and system control
  - Communication check
    - Radio
    - Wi-Fi
    - Optical fiber
  - Power on for onboard computers
    - Multibeam computer
    - Mission control computer (GNC: Guidance Navigation and Control)
    - Health computer system

- GNC sensors initialization routine
  - USBL
  - DVL
  - FOG
  - GNSS fixed position
  - AHRS
  - CT probe
  - SVS-P probe
- Scientific payload initialization routine
- Motors check
- Check LED lights power
- Ground Station check
- Battery status check
- 3D waypoint mission and trigger upload

Mission

- Instrument calibration (dry or wet)
- UUV deploy in water
- Buoyancy check and weights setting
- Crane release
- Operators ready
  - 2 operators for Ground Station
  - 1 operator for visual check and cable check (communications using walkie-talkie)
- Check health status
- GNC sensor start-up
- Mission begin recorded on logbook
- First manoeuvres in manual mode to check command response
- Start mission
- Instructions to boat Captain for UUV following
- Instructions for winch control
- Verification of the progressive completion of the mission
- Return To Home and winch cable rewind

Post-mission

- Crane connection
- Mission end recorded on logbook
- Recovery of the UUV on board
- UUV cleaning with fresh water

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- Preliminary visual inspection for UUV integrity
- Data download via optical fiber
- Direct access to removable memories if needed
- Power off
- UUV movement on safety support for boat navigation

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