AUTOASSESS
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D4.1 DEFINING AN INTERFACE TO THE MAP SERVER
25/06/2024

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Grant Agreement No.: 101120732
Call: HORIZON-CL4-2022-DIGITAL-EMERGING-02
Topic: HORIZON-CL4-2022-DIGITAL-EMERGING-02-07
Type of action: HORIZON-IA

D4.1 DEFINING AN INTERFACE TO THE MAP SERVER

Work package	WP 4
Task	4.1
Type deliverable	R – Report
Dissemination Level	PU – Public
Due date	30/06/2024
Submission date	25/06/2024
Deliverable lead	NTNU
Version	1.0
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Reviewers	Stefan Leutenegger (TUM)
Keywords	Interfaces, Mapping

DOCUMENT REVISION HISTORY

Version	Date	Description of change	List of contributor(s)
0.1	17/06/2024	Initial Version	Luca Zanatta, Mihir Rahul Dharmadhikari, Konstantinos Alexis
0.2	24/06/2024	Revised Version	Luca Zanatta, Mihir Rahul Dharmadhikari, Konstantinos Alexis
1.0	25/06/2024	Final Version	Luca Zanatta, Mihir Rahul Dharmadhikari, Konstantinos Alexis

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EXECUTIVE SUMMARY

This deliverable outlines the communication protocols for data exchange between the Unmanned Autonomous Systems (UAS) and offline map server employed in our activities:

- UAS Sensor Suite: The UAS is equipped with standard sensors (LiDAR, IMU, camera) for navigation, mapping, and visual inspection. Additionally, it carries specialized sensors for Non-Destructive Testing (NDT) measurements.
- Data Formats: Sensor data is collected in rosbag format on the UAS and converted into various formats (PCD, CSV, JPEG, etc.) suitable for digital twin on the server. Details on these formats are provided in a separate deliverable (D1.2).
- Communication Pipeline: Data flows from the UAS to the Ground Station (GS) and then to the server. The server stores both raw (rosbag) and processed data.
- Data for Inspection Missions: The Inspection UAS (IUAS) and Tethered IUAS (TIUAS) can retrieve processed maps (semantic, volumetric, localization) and trajectories from the server for mission planning.
- Communication Protocols: Secure communication protocols (SSH, HTTPS, etc.) are employed over a WiFi network for data exchange between the UAS, GS, and server.

The deliverable also identifies potential risks associated with data security, corruption, and transfer delays, along with proposed mitigation strategies.

TABLE OF CONTENTS

1 LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

UAS: Unmanned Autonomous System

EUAS: Exploration Unmanned Autonomous System

IUAS: Inspection Unmanned Autonomous System

TIUAS: Tethered Inspection Unmanned Autonomous System

NDT: Non-Destructive Testing

ROS: Robot Operating System

GS: Ground Station

GUI: Graphic User Interface

HTTPS: Hypertext Transfer Protocol Secure

SSH: Secure Shell

IMU: Inertial Measurement Unit

FPV: First-Person View

2 UAS

The Unmanned Autonomous Systems (UAS) that we will employ for our activities are primarily equipped with:

- LiDAR for high-precision distance measurement and mapping.
- Inertial Measurement Unit (IMU) for accurate navigation and stabilization.
- Cameras for high-resolution imaging and navigation.

In addition to these standard sensors, the UAS is also equipped with specialized sensors for Non-Destructive Testing (NDT) measurements.

These components collectively enhance the UAS's ability to perform complex and extended missions in various challenging environments.

3 DATA FORMAT

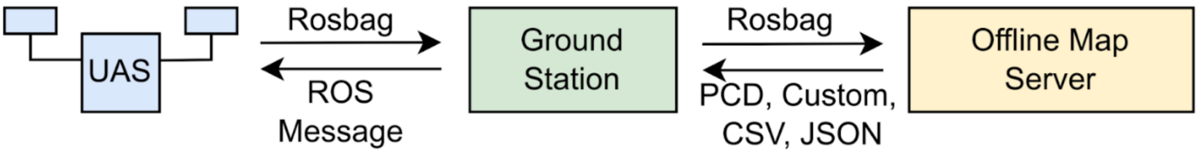

FIGURE 1: THIS FIGURE REPRESENTS THE FORMAT OF THE MESSAGES THAT WILL BE USED TO COMMUNICATE AMONG THE UAS, THE GS, AND THE SERVER.

During the mission, the UAS is tasked with collecting various types of data from its multiple sensors, including LiDAR, IMU, cameras (e.g., depth, RGB, and events), and NDT equipment. Each sensor generates data in its unique format, which will be converted appropriately on the server (task: T7.3). A comprehensive description of the data formats used by each sensor is provided in deliverable D1.2. A brief summary is presented in Table 1. The communication pipeline is illustrated in Figure 1.

Throughout the mission, the UAS stores the collected data in a rosbag file onboard the UAS. Once the mission concludes and the robot returns to the communication range of the ground station, this file will be transmitted to the Ground Station (GS). Previous experimental tests have indicated that a 6-minute mission typically collects a rosbag file of approximately 10GB including LiDAR, raw cameras, and IMU data, or 3GB if compressed image files are used. The GS serves as the communication bridge between the UAS and the server. Data is uploaded from the GS to the server, where it is converted into the final formats used for digital twinning. The server is responsible for storing both the raw data (rosbag) and the processed data.

Sensor	Data Format – UAS	Data Format - Server
LiDAR	Rosbag	OBJ, LAS, and Rosbag
IMU	Rosbag	CSV, JSON, and Rosbag
Cameras	Rosbag	JPEG, PNG, TBD (Events), and Rosbag
NDT Equipment	Rosbag	CSV and Rosbag

TABLE 1 : DATA FORMATS FOR STORING SENSOR DATA ON THE UAS AND THE SERVER

In detail, before the exploration mission, if previous maps are available on the server, the Ground Station (GS) can retrieve them in their processed format (as specified in Table 2) and send them to the UAS using ROS. After the mission, the data collected by the UAS is sent to the GS in a rosbag file, which is then transferred from the GS to the server.

Prior to the inspection mission, the GS must retrieve previous maps and mission-relevant coordinates from the server (formats specified in Table 2) to plan the inspection trajectory. These maps are transmitted from the GS to the UAS as ROS messages. After the mission, the UAS sends the collected data back to the GS in a rosbag file, which is finally sent to the server for processing and storage.

This structured pipeline ensures that all data collected by the UAS during its missions is effectively managed, converted, and utilized, facilitating seamless operations and data integrity throughout the mission lifecycle.

Data	Type of Data	Format of the Data	Communication: Server to GS	Communication: GS to IUAS
Maps	Semantic Map, Volumetric Map, Point Cloud (with color), Visualization Map, Mesh	OBJ, LAS, and Custom	GUI	ROS Message
Inspection Mission	Sets of Coordinates	CSV and JSON	GUI	ROS Message

TABLE 2 : FORMATS OF THE DATA COMMUNICATED FROM THE SERVER TO THE IUAS.

4 DATA PROTOCOLS

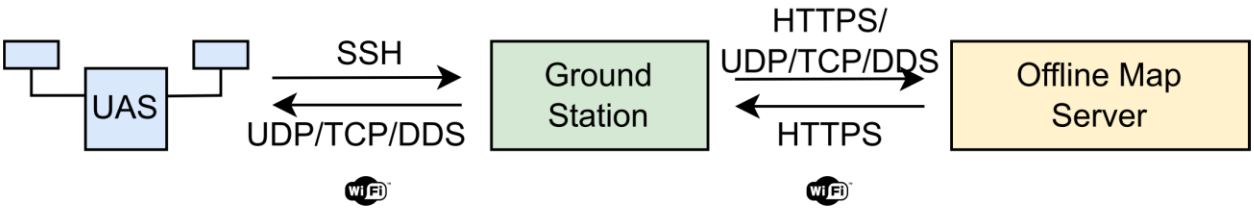

FIGURE 2: THIS FIGURE ILLUSTRATES THE PROTOCOLS AND MEDIUMS USED FOR COMMUNICATION BETWEEN THE UAS, THE GS, AND THE SERVER.

Figure 2 demonstrates the communication protocols utilized among the UAS, GS, and the Server. Specifically, all communications will be conducted over a WiFi network. The protocols are as follows:

- UAS to GS Communication:
    - Protocol: SSH (Secure Shell).
    - Purpose: To transfer data collected during the mission (e.g., rosbag files) from the UAS to the GS.
- GS to UAS Communication:
    - Protocol: UDP/TCP/DDS with ROS (Robot Operating System) Interface

- Purpose: To send mission data from the GS to the UAS (e.g., point clouds, inspection mission, etc.). To send high-level commands (e.g., start mission).

- GS to Offline map server:
  - Protocol: HTTPS (Hypertext Transfer Protocol Secure) with Graphical User Interface (GUI) and/or UDP/TCP/DDS with ROS (Robot Operating System) Interface
  - Purpose: To facilitate secure data transfer between the GS and the server.
- Offline map server to GS
  - Protocol: HTTPS (Hypertext Transfer Protocol Secure) with Graphical User Interface (GUI)
  - Purpose: To facilitate secure data transfer between the GS and the server using a GUI for downloading maps/paths for UAS missions.

These protocols ensure secure and efficient data exchange, maintaining the integrity and confidentiality of the mission data throughout the communication process.

5 RISK ANALYSIS

Security Threats:

Risk: The use of WiFi and the internet exposes the system to potential security threats such as unauthorized access, data breaches, and cyber-attacks.

Mitigation: Use strong encryption methods (e.g., SSH, HTTPS) and secure authentication protocols. Regularly update and patch all systems and software.

Data Corruption or Loss:

Risk: Data may be corrupted or lost during transfer, especially for large files like rosbags.

Mitigation: Implement robust error-checking and correction mechanisms. Use reliable file transfer protocols with built-in integrity checks (e.g., SCP for SSH). Always maintain a copy of the file on the source machine until the transferred file is verified to be correct.

Data Transfer Delays:

Risk: The WiFi network may not always provide consistent and high-speed connectivity, potentially causing delays in data transfer between the GS and server.

Mitigation: Use high-bandwidth, low-latency WiFi networks and consider implementing redundant communication paths. Have backup communication methods.