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Data Management Architecture for Tele-operated UAV System

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Abstract: Nowadays, more frequently than ever, the unmanned aerial vehicles (UAVs) are used effectively as mobile sensor platforms. The UAV system equipped with an airborne camera and special sensors is a valuable source of various important information helping to build an actual overview of an environment. It can take place like an observer in disaster situations as well as a special mobile monitoring device which is able to collect required data from a predefined area. This paper introduces our approach to design effective data management architecture to be able to manage, reliably distribute and represent different types of measured data with taking many aspects and limitations of the tele-operated UAV system to consideration.

1. INTRODUCTION

In the last few years various UAV systems became very popular as an effective platform to observe particular areas and collect the data using specific sensors. The UAVs enable us to obtain a bird's eye view of the environment, having access to areas, where often only incomplete and inconsistent information is available. To get actual and precise information or data from a desired place is important in many situations of a modern crisis management or plenty of inspection or data acquisition tasks. Proper utilization of collected data usually varies according to the purpose of the required mission of the UAV system. The main task of the mission normally forces to use specific, narrow focused type of sensors that need to be carried by the UAV. For this reason we decide to develop a modular, service based data management architecture, which can provide all desired functionality to complete the mission successfully and enable the operator to control the UAV system reliably and comfortably.

Management and distribution of data provide an interesting field of research in different domains, ranging from hardware architecture over communication and network architecture, resource awareness to categorization, deployment, flow control and representation of data.

This paper is organized as follows. In the first part the overview and the desired functionality of our system is described. The main limitations which need to be taken to consideration by design are presented as well. In the second part the system architecture as our base hardware (HW) and software (SW) platform is detailed and the engineering tradeoffs considered by specification are mentioned. The categorization and deployment of data measured by the airborne sensors is discussed in the third section. The fourth part explains the main data flow control between the HW/SW modules itself and the base station and shows the process of the representation of data. In the last part our experiences with measuring data by using a laser scanner as a new additional on-board sensor are described.

2. OVERVIEW OF OUR UAV SYSTEM FUNCTIONALITY AND LIMITATIONS

At our department we are focused on the development of an autonomous flying airship. We use a robotic airship (BLIMP) filled with helium which is 9 meters long with maximal 2.5 meters diameter and its payload is about 5 to 6 kilograms.

Fig. 1. Robotic Airship during a field test in Hemer, Germany, 2009

The required task of the mission has a big influence on the desired functionality of an UAV system. The functionality of an UAV system and its data management architecture from various aspects could be split into several levels.

The first and base level of the main functionality of an UAV system and its data management architecture is of course to provide the possibility to be controlled by the operator during the flight. This requirement is closely coupled with communication capabilities and the on-board autonomy of the system. Depending on the increasing on-board autonomy there appear three possible control modes.

- Remote Control
- Teleoperation
- Automatic mode

In the remote control mode the data management architecture provides to transmit primer and necessary data or commands from the operator to UAV's actuator system. In this case the level of autonomy is very low and the operator has to control the UAV manually using a remote control. This flying mode delivers many constraints depending on a potential application of the UAV. In our case one of the main limitations is that controlling the airship manually via remote control is a quiet difficult task for the pilot. It assumes to have some skills to keep the airship flying smoothly by rough weather conditions. Moreover the airship has to be visible for the pilot permanently during the flight. On the other hand this type of control is useful for some maneuvers which could be problematic for the autonomous control algorithms as well as a very important backup control system by any unexpected failure of the on-board systems.

The teleoperation mode increases the on-board autonomy into a semi-autonomous control, which means that the operator is able to control the UAV via joystick with support of basic automatic control algorithms to assure the desired course and altitude during the flight. The operator doesn't need to promptly react on each disturbance appeared during the flight and doesn't need to keep a visual contact with the UAV as well. It effects also the data management architecture, because it is necessary to deliver and intuitively represent an information of the actual position and many additional information from UAV's sensor system, which can give the operator feedback and a better overview of the environment. In this mode it is very important to provide and keep reliable communication with low latency between the UAV and the operator, because the system is usually not able to make any decision itself. In fact many UAV systems are working properly on semi-autonomous mode of control, because it enables them to complete many types of missions successfully.

The full automatic mode is the highest level of autonomy. The autonomy of an UAV relieves the operator of controlling the UAV and enables him to concentrate just on the main task of the mission. The operator just pickups the desired points to fly, the system calculates a flight path and flies it over. In this mode the control system is enhanced with a supervisory control and decision algorithms with support of various integrated modules like a path planner and collision avoiding algorithms. Although all information, which give a feedback for the operator like an actual position, are still important, this level of autonomy allows the system to make some pre-programmed decision by itself. With the support of a more advanced on-board intelligence, a short communication delays or disconnections between the UAV and base station communication does not necessary lead to any critical situation or damage of the UAV. Such a sophisticated control system enables the UAV to complete also some kind of missions successfully, where the capability of low latency communication is limited or restricted. On the other hand, in this mode various HW and SW modules are coupled together. These modules normally depend on each other and for the correct functionality of the whole system the effective exchange of actual data or the event messages between these collaborative modules is one of the major challenges for the data management architecture.

The second level of the functionality of an UAV system and its data management architecture is to enable the whole system to fulfill the required task of the mission successfully. As we mentioned in the introduction part of this paper, generally the tasks could be focused on monitoring some areas like an observer or any data acquisition tasks. For the data management architecture it usually means that various additional data from third-party sensor systems need to be transferred online to some operation centre or collected to be post-processed and analyzed after the mission. Our department was a member of two research projects: *International mine detection and removal (iMR)* and *International forest fire combat (iWBB)*. In the first project the role of our airship was to be used as an inspection vehicle to ensure the total destruction of mines by a high-energy laser system. Therefore, it was equipped with a remote camera system (Gerke 2009). This camera system is able to stream the video signal online to the base station and even to remote control the camera's viewpoint by the operator.

Fig. 2. The view on a destroyed dummy landmine which is captured by the on-board camera system during a test flight in Hemer, Germany, 2009

In the second project our airship was used as a mobile sensor platform for the third-party heat, smoke, gas detection and pollution monitoring sensoric systems. Another important aspect of our research was the establishment of redundant communication links between the airship and the base station, and to create a data interface to the project operation centre (Gerke 2009).

Fig. 3. The detection and monitoring of fire using the third-party sensoric system during the test flight in Hemer, Germany, 2010

The airship equipped with such a sensoric system is a valuable source of information about the actual situation for the firemen. As you can see in Figure 3 the airship was measuring data using these sensors to detect and monitor the fire and these data were online transferred to the project operation centre using the communication link of the airship's data management architecture.

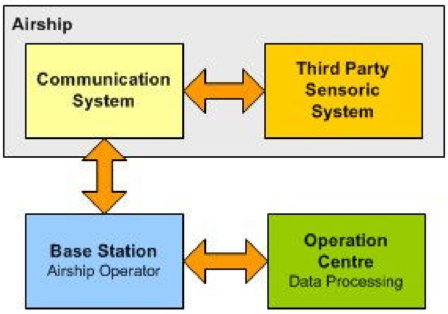

Fig. 4. Schematic of the data flow between the airborne sensoric system and the operation and data processing centre on the ground.

3. SYSTEM ARCHITECTURE AND ENGINEERING TRADEOFFS

During the design of our system architecture some limitations have to be taken to consideration. Our airship is powered by electric energy. The source of this power is just the battery system of the airship. Minimizing the power consumption of all embedded systems is a strict requirement. In order to save the energy that could be used to power the airship actuators and to maximize the time of flight as much as possible. The second very important limitation is the restricted payload of the airship.

The primary components of the hardware platform consist of a few modules. The first module represents an appropriate pre-designed control board with a DSP processor to handle a low level control of the airship in real-time. It has very low power consumption and it is optimized to minimal size and weight. Moreover it enables a rapid prototyping using the Matlab development environment. It includes the navigation system, which couples various sensors like GPS and an inertial measurement unit (IMU), which uses a combination of accelerometers and gyroscopes. This board is the main source of telemetric data for the operator as well as the superior system to process his commands. It is the most important node in the data management architecture.

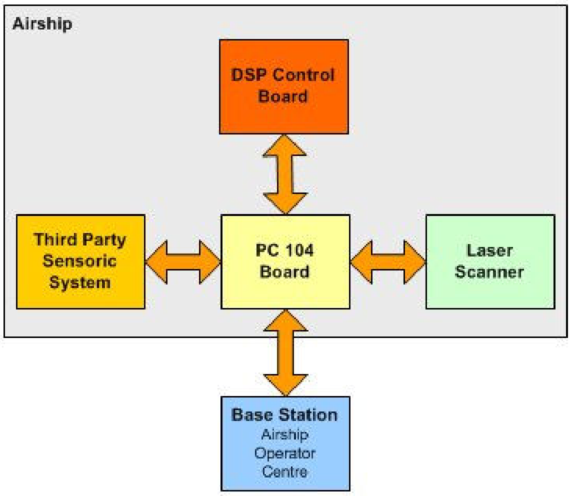

Fig. 5. The primary components of the hardware platform.

The next module is the embedded PC 104 board, which is dedicated to manage the data flow control and reliable distribution of data between all the collaborative modules and the base station on the ground. It is based on the Intel x86 processor architecture and uses a 500 MHz AMD Geode processor with 1 GB of RAM. The system uses a 32 GB compact flash card (CF) for storage and has many HW interfaces like dual Ethernet, RS232 or USB ports, to be able to connect additional third-party sensors or devices. This platform is a balanced trade-off between the needed resources and power consumption. Nowadays mostly expanding boards are based on Intel Atom platform with more resource capability, but also coupled with higher power consumption, which can be in some cases 4 times more like our board. For the purpose of a data flow manager, communication router and data collector we rather took the less powerful variant.

The base station, as an airship operator centre, is located on the ground. This module consists of a powerful mobile workstation PC equipped with pre-developed SW modules to keep the reliable communication between the airship and the base station and a special control panel module for the airship.

Our last tested additional module is the laser scanner UTM-30LX produced by Hokuyo Automatic CO., LTD. It is a relatively small type of a laser scanner. It weights just about 210 grams and its power consumption is less than 8 W, so it is an ideal device for a middle-sized UAV like our airship. It is intented to be used for the purpose of making 3D scans of the environment the airship is flying over and for obstacles detection as an information source for the collision avoiding algorithms.

4. CATEGORIZATION AND DEPLOYMENT OF DATA

By design of data management and communication architecture for tele-operated UAV system it is very important to specify all the data sources. The main source of data is of course the navigation system of the airship which delivers information of the actual position, altitude, orientation and velocities of the airship. As a second source of information and event messages the control panel module is located on the base station. It fires control commands and event messages from the operator to the airship's on-board control system. The next source of valuable information is the battery and actuator system status observer that gives an information of the actual battery capacity, voltage, current and propellers rpm. Other sources of data are also the laser scanner system and third-party sensoric systems, which usually use our communication platform just to transfer or collect measured data.

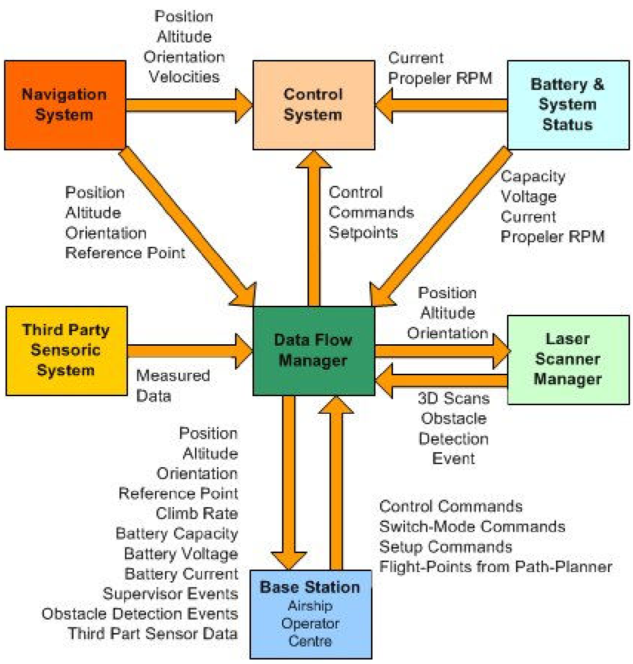

Fig. 6. Schematic of the data relations between the system components.

We can categorize the data to different types based on their utilization. Some applications like navigation and control system need to execute their calculations in real-time. For these applications a continuous exchange of their data in real-time is necessary. This real-time requirement is realized by joining and executing these application modules on the same real-time platform.

Real-time delivery: Some applications require that a message must be delivered within a specified time, otherwise the message becomes useless or its information content is decreasing after the time bound. (Kansal 2010)

Another type of data represents event based messages. These messages can be usually invoked by the operator like a control, setup commands or path-planner recalculated flight-points or any obstacle detection event fired by collision avoiding system. These messages usually don't appear in every real-time sample, but a low latency delivery is necessary to keep their relevancy. Moreover their delivery status has to be checked. This approach is used also for the main exchange of information between airship on-board systems and the base station on the ground.

The next type of data is usually collected and stored on a storage device of the PC 104 board. These data are further used for post processing and analysis. The source of these data is the laser scanner system and any third-party sensoric system. It often handles large amounts of data. In some cases it is required to transfer these data online to the base station or any mission operation centre on the ground. The communication link needs to handle larger amounts of data, but the low latency by data delivery is not critical.

5. FLOW CONTROL AND REPRESENTATION OF DATA

In the previous few sections the primary requirements and constraints of data management architecture, system architecture and data categorization have been discussed. But the most important part of data management architecture is to provide a reliable communication between all of these collaborative modules. This capitol explains the main concept of the communication architecture.

5.1 Communication Architecture

The communication architecture was designed as follows. In the beginning the best concept has been searched. Several communication approaches have been tested to find out the best results. The main criteria of a wireless network structure are reliability of a communication channel, communication range, baud rate and latency by transferring data packets. Moreover all the devices have to be certified by European Regulations.

The ad-hoc network structure was chosen as the first communication approach. In this case the network is decentralized and does not rely on a pre-existing network infrastructure. Communication between the nodes in the network is realized just like a point-to-point data link. This type of wireless network structure fits the requirements of communication architecture for the UAV system, because there are just two nodes which need to communicate with each other. It is the communication node located on the base station on the ground and the on-board communication node of the UAV system. As the first type of wireless network a popular Wi-Fi IEEE 802.11 b/g standard transmitting in the 2.4 GHz frequency band with allowed transmit power of 100 mW has been chosen. Several tests have been realized to prove our main criteria. The best result was the baud rate around 10 Mbit/s and very low latency by transferring data packets, but even in the line of sight the communication range was just about a 100 to 190 meters by using 9 dB Omni-directional antennas. As a second difficulty by using this wireless network type appears a problem with the reliability of a communication channel. After disconnection caused by coming out of the communication range and returning back into it, the Wi-Fi device was not able to establish the communication link before reaching a very near bound of about a 50 meters from base station. It means that a save operation area for a flying UAV to keep reliable communication channel has to be restricted even to a half of the available communication range. As a second type of wireless communication a radio-modem transmitting in ISM 868 frequency band with 250 mW transmit power (by European regulations is allowed up to 500 mW) was applied. During some tests the same criteria have been evaluated. In this case the baud rate was just 28.8 kbit/s with latency about 120 to 250 ms, but the communication range in the line of sight was about 1500 meters by using 5 dB Omni-directional antennas. The reliability of the communication channel was excellent.

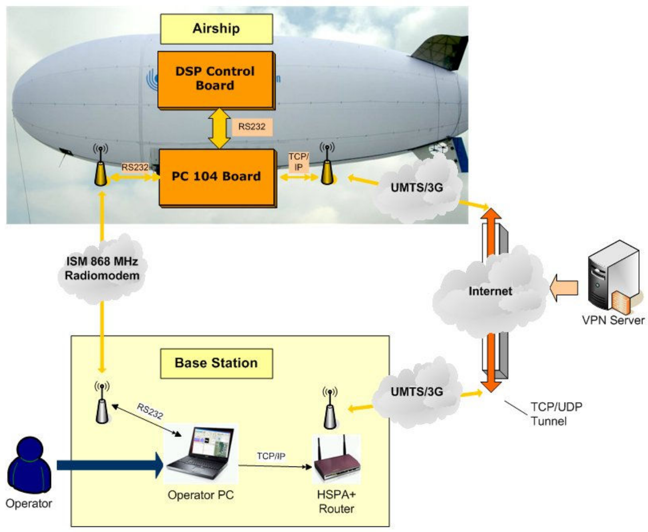

Fig. 7. Schematic of the Communication Architecture.

For the second approach we decided to use an already existing network infrastructure of the Universal Mobile Telecommunications System (UMTS). This type of 3G network infrastructure is nowadays provided by any mobile telecommunication operator. The client is able to connect to internet using resources of this infrastructure. On the other hand this internet connection is provided by the telecommunication operator as a paid service and there is no direct possibility to make a point-to-point data link. To be able to communicate from one UMTS network device on the base station to another device connected to the PC 104 board on the airship a virtual private network (VPN) has to be established. For this purpose a VPN server with a public IP address is used. The same criteria have been evaluated as well as in the case of ad-hoc networks. The baud rate, reliability of communication channel and data delivery latency depends of the actual signal coverage and of network type. The typical values are presented in the table Tab. 1. Especially the data delivery latency varies depending on the actual network link capacity and of course on the delays caused by overhead of the necessary VPN network, which routes the data via VPN server.

	Downlink	Uplink	Latency
HSDPA	7.2 Mbit/s	3.6 Mbit/s	100-300 ms
UMTS	384 kbit/s	128 kbit/s	200-1000 ms
EDGE	236 kbit/s	59.2 kbit/s	300-2500 ms
GPRS	60 kbit/s	40 kbit/s	400-3000 ms

Tab. 1. Typical downlink, uplink and latency values of most used GSM standards.

This type of network connection is in our communication architecture primary used as a redundant communication channel. So the whole communication architecture, illustrated on the figure 7, consists of the communication channel based on point-to-point communication via radio-modem, and as a second redundant channel the communication via UMTS is used.

5.2 Data Flow and Reliability

The data management architecture has to manage and to keep reliable data flow with the base station using the pre-designed communication architecture. Various data have to be routed via these two communication channels by specific criteria. The very important telemetric data, control commands from the operator with a higher priority needs to be transferred with low latency. These information and messages are usually smaller data-packets which are transferred via a point-to-point radio-modem communication channel. For the data, which low latency is not such a limiting factor like data measured by third-party sensors or large amounts of collected data, the second UMTS communication channel will be used. The UMTS communication channel will be used also as a backup system in situations by radio-modem communication interruption. The pre-developed data router manager (in testing phase) handles this functionality. The data flow between the components is realized as a service oriented architecture (SOA). It is based on a pre-developed lightweight protocol applied mainly over TCP protocol, so it uses primary a TCP socket interface.

When some component needs a functionality not provided by itself, it asks the system for the required service. If other component of the system has this capability, their location will be provided and finally the client component can consume the service using the common interface in the provider component. The interface of a SOA component must be simple and clear enough to be easily implemented in different platforms both hardware and software. (Pastor 2006)

On the base station is also a pre-developed data hub server as a service provider for multiple clients on the ground like control panel component on the base station or any third-party clients, which use a service to become the data from its sensoric system located on the airship as it is illustrated on the figure 4. The data hub server checks also a delivery status of each message and control the network delay measuring the message delivery with time constraints.

5.3 Data Representation

The next challenge for the data management architecture is the effective and intuitive representation of distributed data for the operator. For this purpose a special control panel module for the airship as a graphical user interface (GUI) has been developed. It is the important module in the system architecture used for interaction between the operator and the airship. The main goal of such an interaction is an effective operation and control of the airship. Moreover, the feedback from the airship sensors aids the operator in making operational decisions.

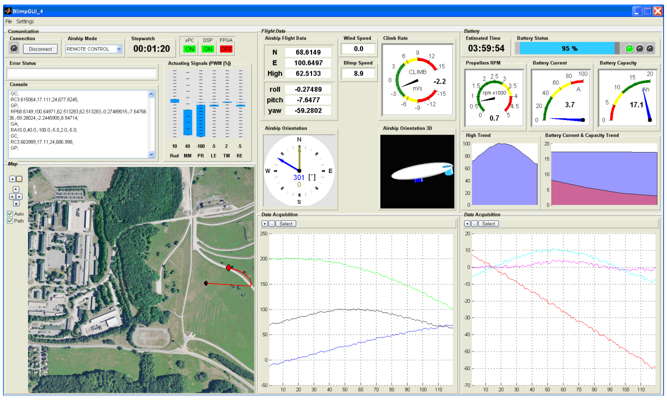

Fig. 8. GUI of the airship's control panel module.

The control panel provides the input and output capabilities. The input functionality allows the operator to control the airship. It enables him to select the airship control mode, setup some system options. The output functionality provides the indication of important data like information about the actual position, altitude and orientation of the airship. For a better overview for the operator the airship orientation is visualized with the help of a three-dimensional virtual reality model. The actuating signals are indicated as well as the information of the airship systems and batteries state. There is also a possibility to record the measuring data using the pre-developed data acquisition module.

The actual position is displayed in the two-dimensional (2D) map, which is georeferenced in Universal Transverse Mercator (UTM) geographic coordinate system. It is a very practical grid-based 2D Cartesian coordinate system. The position on the Earth is referenced in the UTM system by the UTM zone, and the easting (E) and northing (N) coordinate pair. (Wikipedia) The navigation system of the airship calculates the actual position in local north, east, down (NED) coordinates as it is illustrated in Figure 9. This local coordinate system needs to be referenced to specify its location on the surface of the Earth. For this purpose the navigation system sets the reference location in Earth-Centered-Earth-Fixed (ECEF) conventional terrestrial coordinate system and this information is sent to the control panel. The reference point is displayed on the map of the control panel. The transformation from ECEF coordinate system to UTM is necessary. As a first step the position needs to be converted from ECEF to geodetic coordinates WGS84 (latitude ϕ, longitude λ, height h) using the Kaplan algorithm.

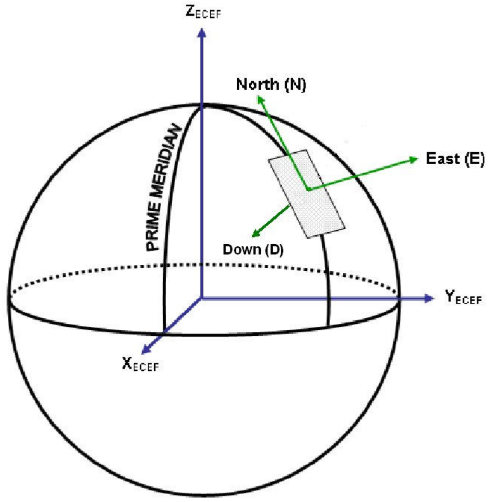

Fig. 9. NED Coordination system.

Afterwards the conversion from geodetic coordinates (latitude ϕ, longitude λ) to UTM coordinates pair (E,N) and the UTM zone is calculated.

6. 3D SCANNING OF THE EARTH SURFACE BY A LASER SCANNER

A typical data acquisition task for our airship could be a scanning of the Earth's surface by a laser scanner. The laser scanner is an additional sensor installed on-board. A basic principle is based on measuring the distance of the scanned points from chosen reference point that is usually placed over the surface. Knowing its exact position and having a possibility to measure its distance precisely to all points of the scanned surface and direction of the measurement, it is possible to calculate exactly their positions.

6.1 Choice Of The Measurement Method

A 3D scanning of the surface based on reflection of waves can be carried out in several ways: By sonar using ultrasonic waves, or by radar working with electromagnetic waves. The distance from a reference point may also be determined using stereoscopy, whereby it is evaluated by comparing two pictures of an object made from two reference points. This leads to different angles of view. Precision of all these systems is given by the used wave lengths and by their propagation. Systems like sonar have a relatively slow response speed and a relatively low resolution not enabling to see details of the scanned surface. A reasonable improvement was brought by laser technology guaranteeing high linearity of the ray movement, its fast speed (above 300 000 m/s) and measurement of details in range of millimeters. After bringing reflectors to Moon by Apollo missions, by using laser technology it was e.g. possible to measure that the Moon is spiraling away from Earth at a rate of 38 mm per year (Espenak 1994), whereby its mean distance is about 384.467 kilometers and the round pulse trip time is about 2½ seconds. So, the laser systems are able to give precise measurement information over a long distance.

By scanning the Earth's surface, the resulting precision depends highly on precision of the reference point localization and orientation of the beam. The final resolution will directly depend on the density of emitting and orientation of the beams.

6.2 Measurement Principle

Assume a laser device emitting laser beams oriented in a plane. That means that this system is able to scan just information about a curve lying in this plane. When wishing to scan the entire space, such scan must be repeated in infinitely many other planes. In order to get stereoscopic information the measurement must be repeated at least from one additional place. Such a measurement can e.g. be based on a translation movement, when the laser moves its reference position and the beam falls to the surface from other reference positions.

During the measurement, the reference position and orientation of the beam must be measured in order to enable the calculation of the points of reflection. This information is usually achieved by a measurement and recording system completing the laser measurement by information about the laser reference position in 3D coordinating system [x,y,z], as well as angular orientation of the beam in all three axes X, Y, Z denoted usually as Roll, Pitch, and Yaw.

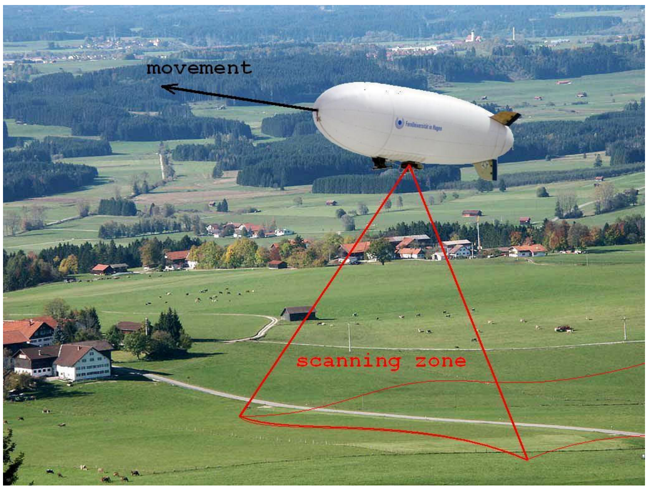

Fig. 9. Earth's surface scanning illustration by a laser scanner.

6.3 Data Identification

For this task two frames are given: navigation frame (FRAME) and body frame (BODY). Data acquisition is considered in body frame. For following representation of measured data, they have to be transformed into a global navigation frame.

The body frame may freely move and rotate in the navigation frame, i.e. it may change the coordinates of its origin in navigation frame, as well as orientation of its axes. The navigation frame is usually considered to be static.

While scanning laser beams are emitted with the origin placed to the origin of body frame [0,0,0].

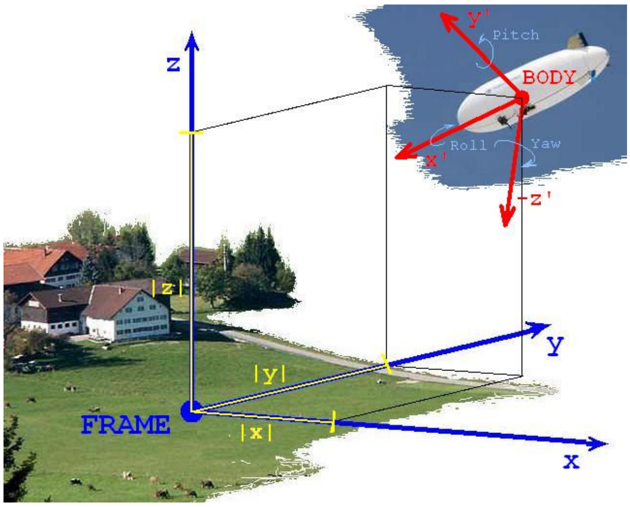

Fig. 10. Illustration of the coordinate systems BODY and FRAME.

These always lie in a plane YZ. After being reflected by the Earth's surface, its points are calculated according to:

$$y1 = d * \sin\alpha \quad (1)$$

$$z1 = d * \cos\alpha \quad (2)$$

d – Measurement of the scanned point from laser.
α – Angle between zero reference position and the emitted beam.

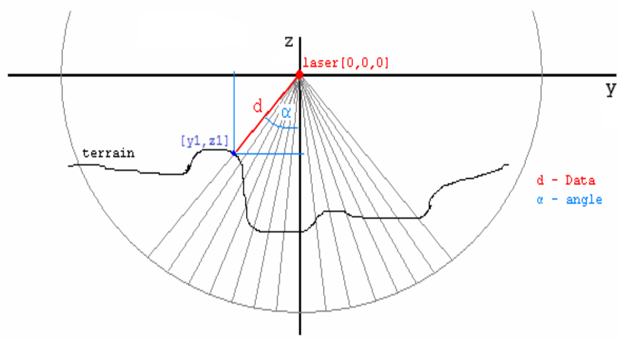

Fig. 11. Scanning principle.

Under zero reference position we will understand beam orientation parallel to axis Z, i.e. vertically to the Earth in direction of –Z. While looking into the X direction, deviation from the zero position do the right means deviation under a negative angle α. Deviation to the left corresponds to positive angles. This sign convention enables an easy calculation of Y coordinates. For such a measurement, the first X-coordinate will be zero, i.e. the measurement will be represented as [0,y,z].

Known coordinates in body frame are necessary to transform into navigation frame coordinates. The coordinate transformation is calculated by means of the direction cosine matrix (DCM). The DCM matrix performs the coordinate transformation of a vector in navigation frame axes (ox0, oy0, oz0) into a vector in body frame axes (ox3, oy3, oz3).

$$\begin{bmatrix} ox_3 \\ oy_3 \\ oz_3 \end{bmatrix}_{BODY} = DCM \begin{bmatrix} ox_0 \\ oy_0 \\ oz_0 \end{bmatrix}_{FRAME} \quad (3)$$

In the case of 3D space there exist in principle 12 different options how to describe a general body orientation by a sequence of three rotations. It could be demonstrated that the rotation according to X (Roll) axis, then with respect to Y(Pitch) axis and finally with respect to Z(Yaw) axis is different from that one with the same rotation in Roll, Pitch and Yaw carried out in different order. DCM transformation matrix is defined by combination of three axis transformation matrices M(X), M(Y), M(Z).

In our case the rotation angles in body frame are known and we need to carry out the inverse transformation into the navigation frame coordinates. This can be done according to:

$$\begin{bmatrix} ox_0 \\ oy_0 \\ oz_0 \end{bmatrix}_{FRAME} = DCM^{-1} \begin{bmatrix} ox_3 \\ oy_3 \\ oz_3 \end{bmatrix}_{BODY} \quad (4)$$

By translation movement of the body frame origin, the transformation is calculated as follows:

$$\begin{bmatrix} ox_0 \\ oy_0 \\ oz_0 \end{bmatrix}_{FRAME} = DCM^{-1} \begin{bmatrix} ox_3 \\ oy_3 \\ oz_3 \end{bmatrix}_{BODY} + \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{POSITION} \quad (5)$$

In the navigation frame the points are recorded in a way that corresponds to their position within the scanned surface.

6.4 System Implementation

The type of used laser scanner was briefly described in the section 3. Up to now a few first tests have been done mostly in laboratory conditions. The laser scanner enables a measurement in the range from 30 to 60 meters (m). The final results depend on the surface reflection capability, whereby precision given by the producer is for measurement up to 10 m in range of 0.03 m, and for measurement up to 30 m in the range up to 0.05 m. The first statement was partially confirmed by a measurement repeated several times in laboratory conditions, whereby the maximal difference of two measured samples was 28 mm. Of course, this does not yet guarantee the absolute measurement precision, but characterizes repeatability of the measurement

During the tests the laser scanner was installed 1.35 m over the surface on a moving platform which enables to control the translation in axis X. The position x values in body frame X axes was incrementally preset in range of -0.9 m up to 0.9 m. Laser beam was emitted in the plane YZ. Pitch was changed in the range from -32° up to 32°. It corresponds to changes of Y value within the range from -0.81 m up to 0.81 m for the given distance of the body frame origin respectively laser scanner over the scanned surface.

These tests were carried out by scanning two boxes and one box with banked surface and decreasing height from 0.245 m, 0.18 m to 0.075 m. The results, displayed in Figure 13, illustrate a relatively correct reproduction of the scanned surface distorted partially by the measurement noise.

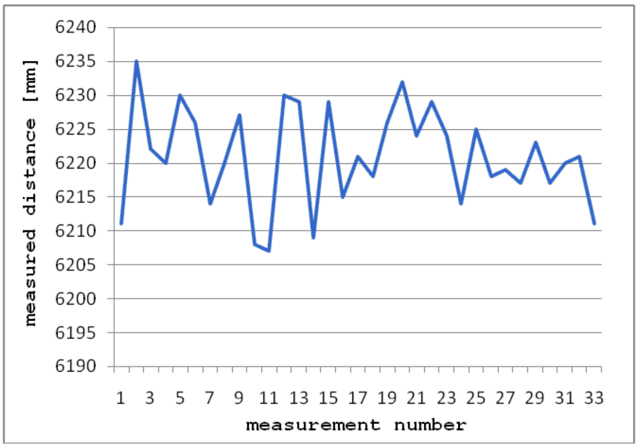

Fig. 12. Results of the measurement precision for 33 realized experiments.

For noise elimination some various filtration procedures may be applied.

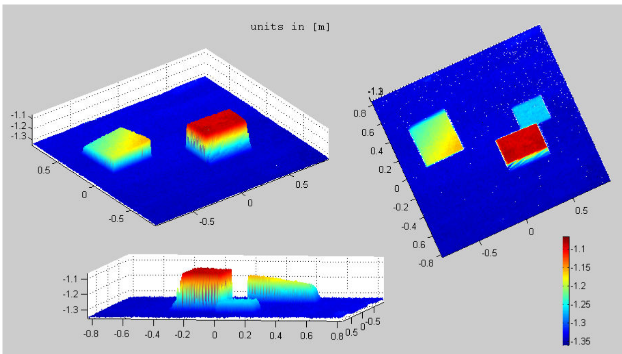

Fig. 13. Results of scanning.

The determination of the laser position respectively the body frame origin and its rotation angles (roll, pitch, yaw) has a dominant influence on the final measurement precision.

7. CONCLUSION

This paper has introduced our approach to design a modular, service based data management architecture for our UAV system, in our case the robotic airship, to provide the data management and routing as well as a reliable distribution of information between all the collaborative system modules. For this purpose the system and communication architecture has been described. As a very important component of the complex system the control panel module for intuitive data representation and control has been developed. Such an architecture enables to establish a robust communication structure, comfortable control capability for the operator and even to provide a service based interface for a mission operation centre with an opportunity of online distribution of important data from the airborne sensoric system as a valuable source of information. The main constraints and experiences by the design and practical experiments have been mentioned as well. The most valuable experiences were gained by fulfilling the major tasks in our two research projects, where design and development of the architecture was formed by the real constraints and problems, which appear during the tests.

As a future work some enhancement of communication data flow and a more robust reliability are planned. The communication structure could be used as a source of information to any leashing algorithms.

Leashing is then performed by having the robot react to low message rates by moving towards the base in order to improve the communication. (Hauert 2010)

The data throughput by a communication channel with low band rate like our radio-modem data link could be enhanced by any real-time data compression methods.

Huffman style compression scheme exploits temporal locality and delta compression to provide better bandwidth utilization, thus reducing latency for real time applications. (Szalapski 2010)

The next interesting mission for our airship is a 3D scanning of the Earth surface by the new additional sensor system, the laser scanner. The last section introduces the measurement method and our first results in this problem.

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