SMART FRAME PROJECT INTRODUCTORY DOCUMENT

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(A custom solution for the product CASTLE of Microflown-Avisa; Calculating translation and rotation of AMMSs with respect to internal coordinate axes referenced by primer and seconder GPS headings located on the first and the second AMMS sensor posts)

1- PROJECTS PURPOSE

The project aims to calculate AMMS positions easily and quickly for different configurations and deployments of each four AMMSs in a CASTLE product. When a new configuration of deployment is introduced to the system, the mission file should be updated in order to provide a correct internal localization to the AMR. The calculation and measurement of distance and angle between sensors can be difficult for some sensor configurations. Therefore, the company uses a solid frame with cross sticks. That helps keeping the sensors in a pre-defined position. The heading positions such as 180°, 90° or 270° are sufficient to integrate and calculate manually by the engineers during a demo or integration operation.

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1.  [DEVICE] id=AMMSHP-01-00001; role=none; source=gps; location=(lat,lon,alt); orientation(yaw,
pitch,roll); rotation=(-180,0,0); translation=(-0.15,0.00,0);

2.  [DEVICE] id=AMMSHP-01-00002; role=none; source=gps; location=(lat,lon,alt); orientation(yaw,
pitch,roll); rotation=(0,0,0); translation=(-0.15,1.00,0);

3.  [DEVICE] id=AMMSHP-01-00003; role=none; source=gps; location=(lat,lon,alt); orientation(yaw,
pitch,roll); rotation=(0,0,0); translation=(-1.15,0.00,0);

4.  [DEVICE] id=AMMSHP-01-00004; role=none; source=gps; location=(lat,lon,alt); orientation(yaw,
pitch,roll); rotation=(0,0,0); translation=(0.85,0.00,0);
```

Figure 1: Currently used solid frame

Figure2: Mission file example which is introduced to the AMR

However, when the deployment area is limited or customers want to deploy sensors in a different configuration, it becomes very confusing and takes too much time to measure and calculate their position with respect to True North created by GPS headings. Also, calculating the yaw of sensors is difficult when we have an imaginary axis. Smart Frame comes up with a proper solution to that situation. More additional benefits will be explained in the 5th section of this document and the company can decide whether those benefits and opportunities will be considerable or not.

2- SYSTEM DETAILS

The system is composed of two main parts, these are hardware and software. Main idea is to measure distance and the angle of a virtual line which can be drawn in between the centers of two AMMS posts. Hardware is deployed such that it covers all around the windcap of the sensor posts. Platform is deployed as it looks to the heading of sensor post (that means, the system takes the 180 degrees opposite direction of the plugs located on the sensor posts as reference in the beginning). Hardware includes two twin towers. One is deployed to the first AMMS post which also has a primer GPS unit. The other is deployed on second, third and fourth AMMSs in order. It takes almost 5 min. to complete that measurement process. When we get the angles and distances between AMMS posts, the software calculates and locates sensor positions with respect to True North introduced by primer and seconder GPS headings and sensor post headings. The mission file can be created directly by only one click in an instant.

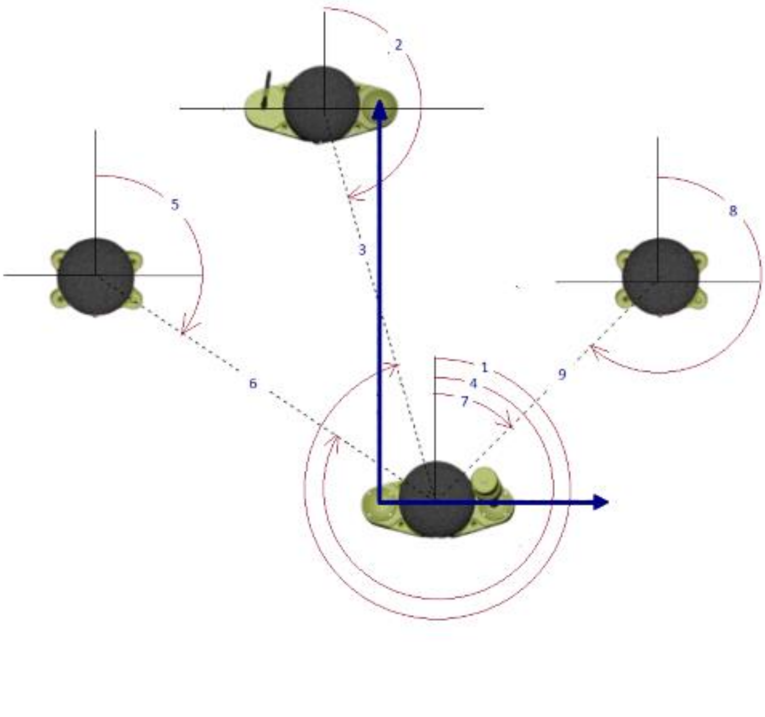


Figure 3: The measurement principles and parameters of the system. Sensor headings are drawn with black lines, angles measured by system according to software reference are drawn with claret red and GPS headings are drawn with blue

A) Hardware

System includes some electrical and structural components. They are listed below with their mission:

Cameras: Two identical cameras are located in two pair structures. They are used to recognize the spherical red bulb object located on the center of the system, and to align centers of moving parts on the system.

Lidar: It is used to measure distance between pair centers. It provides ± 1 cm accuracy in range 0-3 m.

Continuous Feedback Servo Motors: System includes two pairs of continuous feedback servo motors. They are used to align distance sensors and cameras to each other. In order to get a healthy measurement, cameras and distance sensors should look at each other when they are totally parallel and they must be aligned to their centers. Having a feedback servo motor gives the opportunity to get the exact position of the motor shaft as an angle with an accuracy ± 1°.

Red Bulb: Red bulb is used to easily recognize video processing. When it is recognized, a blue line is drawn in the center of the bulb in the GUI and motors can be directed to align cameras to that line. In order to satisfy center selection, it must be a spherical object to recognize its center from all instances before alignment.

Electronics Box: it includes most of the cables, PCB, USB HUB etc.

Solid Parts: They are designed to place the system on the right center of the AMMS posts and provide consistent measurement between pair structures.

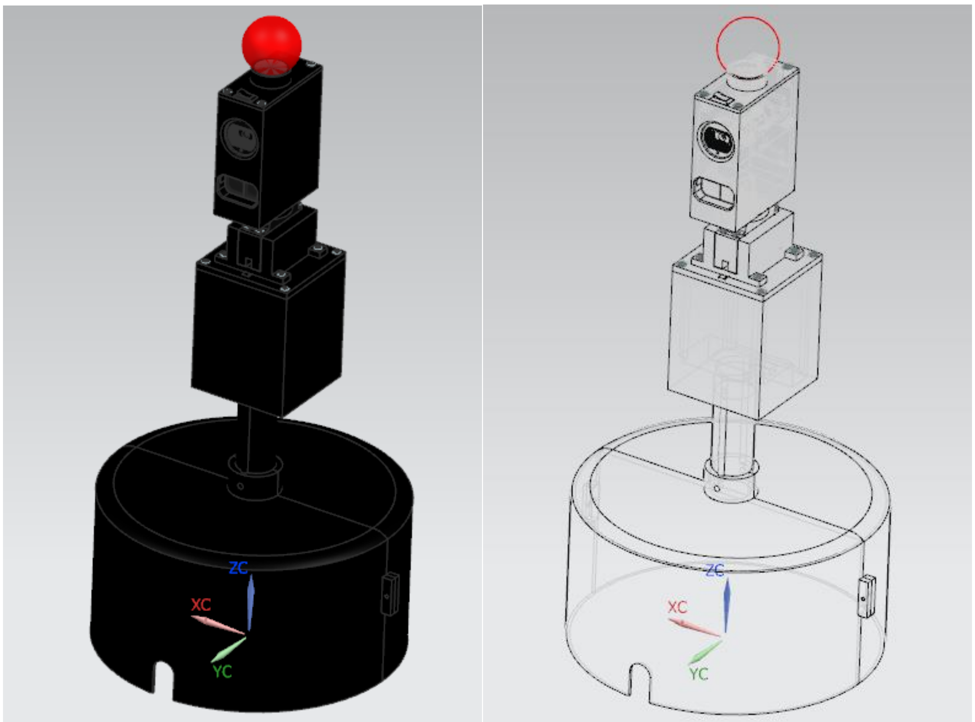


Figure 4: Some 3D model visuals for the first pair, all components are assembled in drawing program

Figure 5: Real prototypes of two pairs, both are assembled with all components

B) Software (GUI)

A simple user interface is developed with different options, helpful visuals and extra tools in order to ease the measurement and calculation process for the users. After two pairs are connected to the laptop via USB hubs (USB 3.0 or higher ports) the software becomes ready to run. It has necessary helpful directions in all tools. It mainly consists of two camera frames, motor control buttons, AMMS relation options, saving measurement button, visual deployment check window, zoom camera window, video processing on/off buttons, settings window, instantaneous data observation consoles and manual calculation tool.

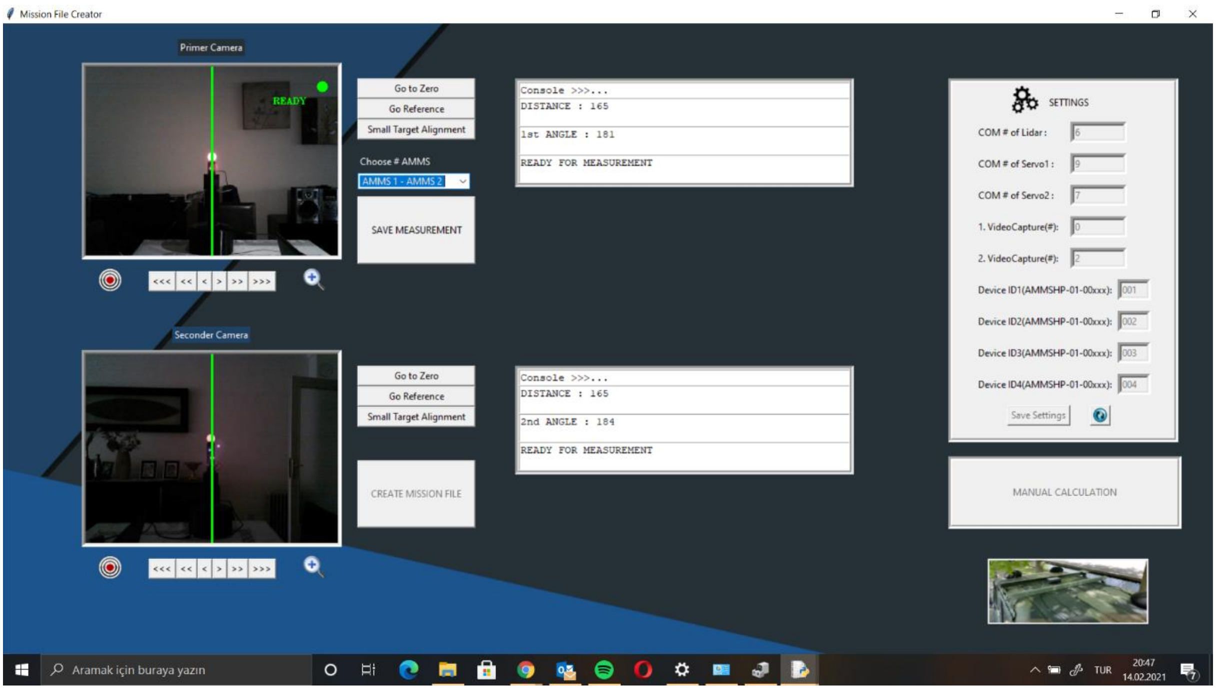


Figure 6: Graphical user interface

Settings window includes usb COM port entries for two servos and lidar. When a different laptop is used to perform, it can be arranged according to new port numbers of those components. In addition there are video capture number entries. Laptops give 0 or 1 to their own webcams to perform video capture functions at the back end. The user can arrange cameras which are going to be displayed on the GUIs camera frames. In addition, the settings window includes AMMS id number entry parts. They are listed in the mission file when all measurements are done. If the save settings button is clicked the window is locked and the system starts. When there is no proper data access via the ports the system gives warning. The user can unlock the settings window by clicking the blue refresh button.

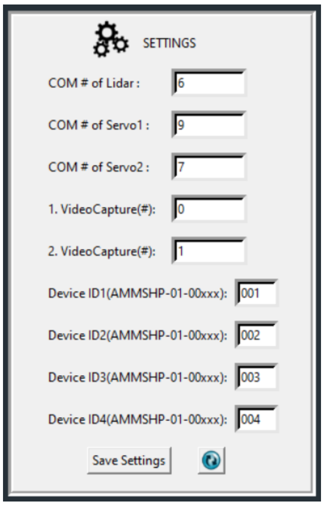


Figure 7: Settings window

Manual calculation tool is added in order to calculate and visualize the system setup configuration by entering angle and distance values by hand without connecting the pairs to the laptop. It also has a guidance picture on the right.

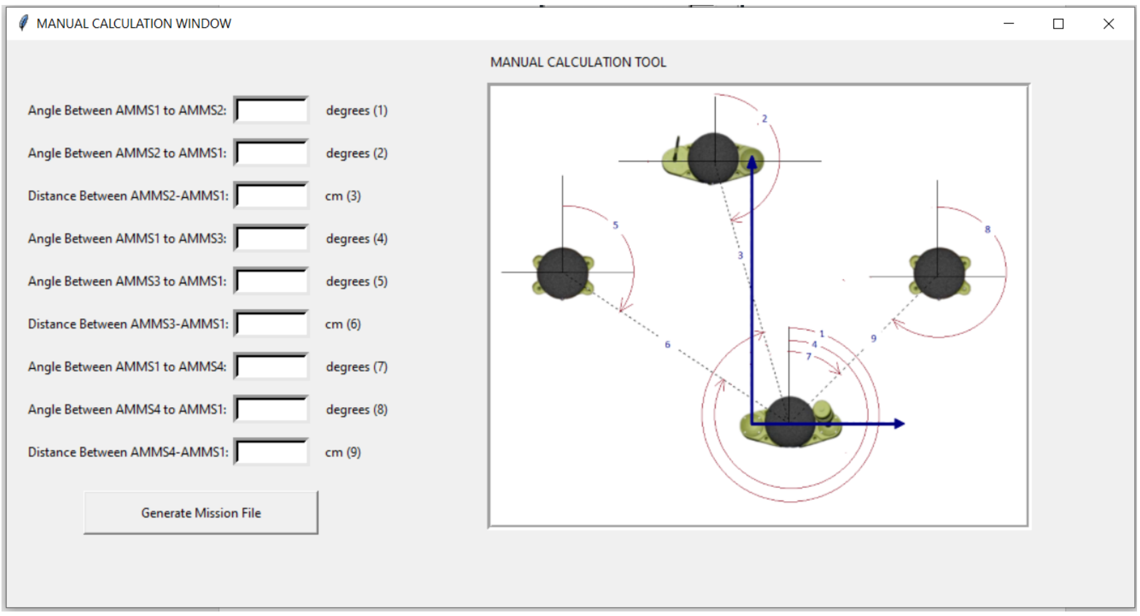
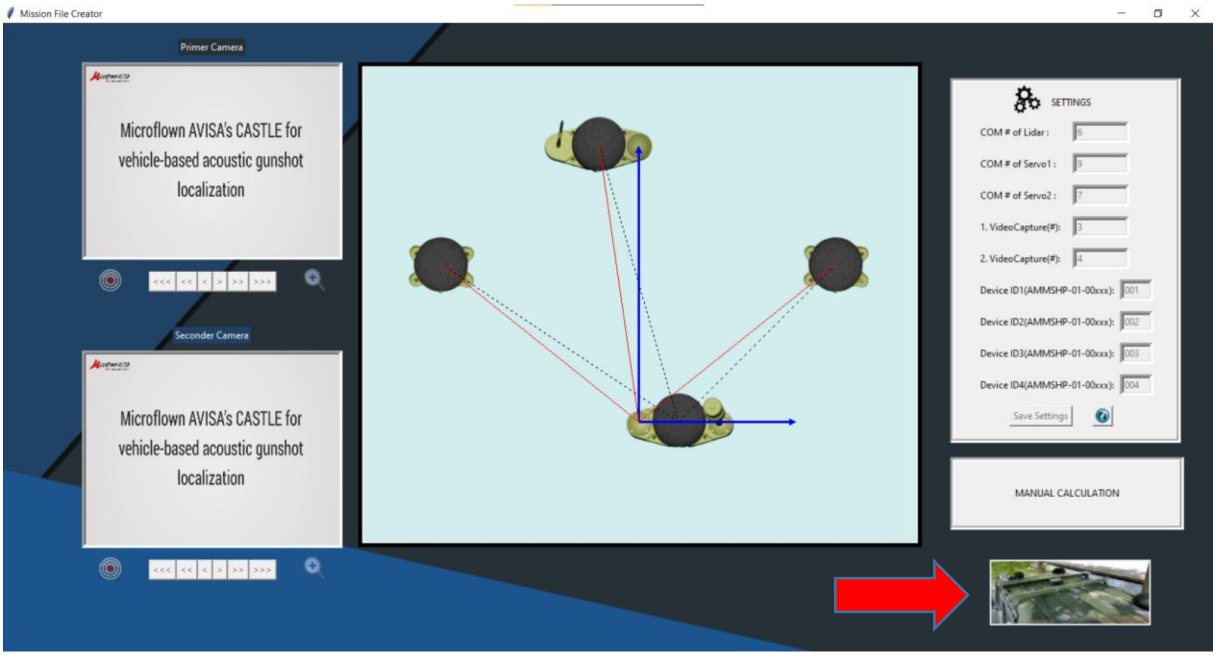


Figure 8: Manual calculation tool window

It is also possible to check the measurements or manual entries visually by hovering to the right bottom image of the armored vehicle top.



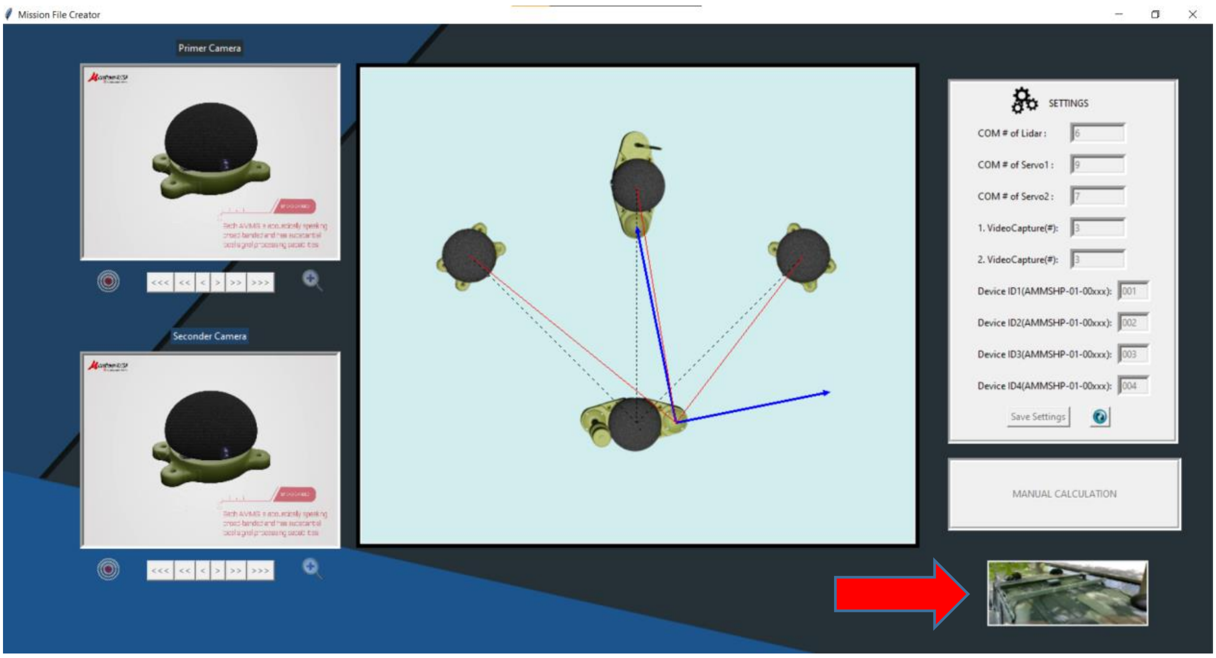


Figure 9 & 10: Two visual check window examples. First is the default one and second one is created after a mesaruments.

When the measurement process is done it is possible to create a mission file and save it to the desired directory. The system can be restarted and be ready for measurement when the system settings window is refreshed and the settings are saved.

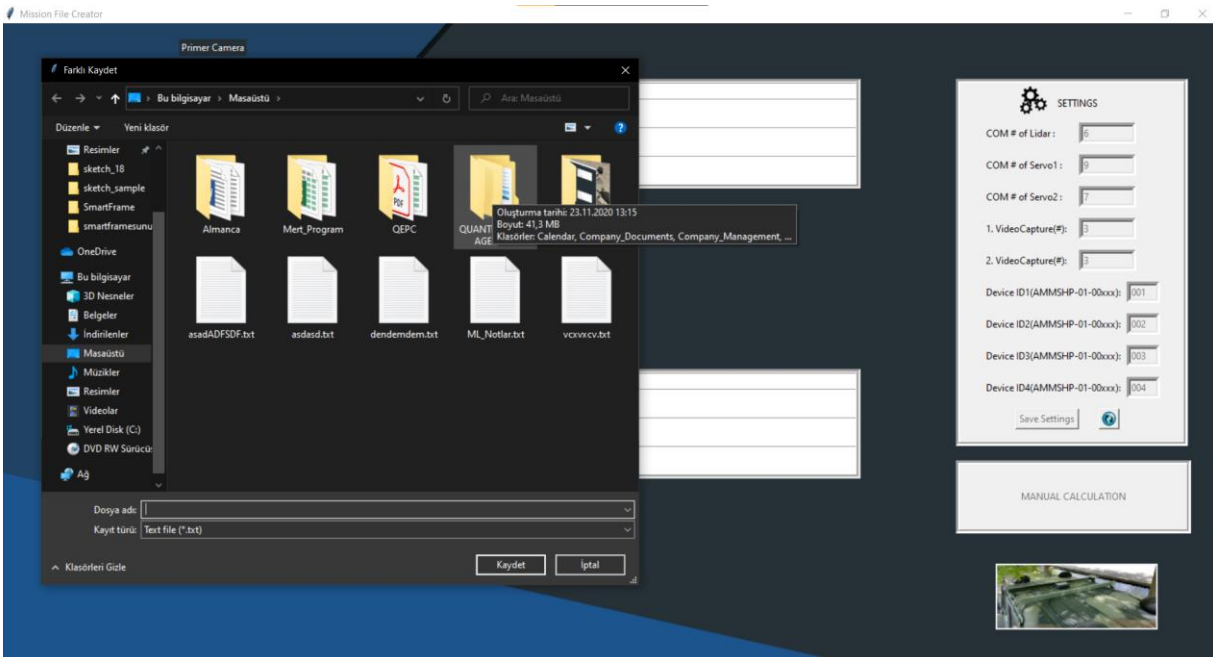


Figure 11: The mission file can be saved to the desired directory in the computer.

3- PROJECT CHALLENGES

The project had different problems to be solved. They are solved step by step during the design and development process. Those are:

- Determining measurement reference points:

It was very important to get healthy measurements and perform correct calculations. It is solved by designing some coverage platform which is fit for AMMS windcape. In addition adding spherical bulbs on the top of the pairs ended up a sufficient alignment of the system to the AMMS centers.

- Distance measurement:

Distance measurement seems easy by the engineering side. However, in this project it really differs when the system has less accuracy than 1 cm. Also spacing and parallel alignment is very important to get a correct measurement because of that reason using a lidar was a good option.

- Measuring angle:

Angle measurement is also an important parameter for the system. Using an accelerometer could be an option however small and cheap sensors are not working properly when the system moves back to previous positions. The solution was using a feedback servo.

- Controlling Continuous Servos:

Continuous Feedback servos get PWM signals in order to control only servo speed. It was a difficult challenge in that project to control those servos according to their angle positions considering cycle and signal parameters etc.

- Providing a proper motion to the necessary parts.
- Drawing 3D models for sensors and designed cases, holder parts for production and checking whether each component is fit.

- Designing sensor cages.
- Designing solid parts according to low weight, space and easy deployment purposes
- Arranging component placements considering future repairs and changes.
- Producing solid parts with few revisions and fastening them during the assembly.
- Software development for getting sensor data.
- Software development for correct position calculation w.r.t. True North.
- GUI development.

4- PROJECT BENEFITS

- Minimizing measurement and calculation time.
- Human mistakes are reduced.
- Being able to update sensor positions even if the sensors are configured by dummy angles or distances such as 53°, 134°, 321° etc.
- Considerable gain of time in integration and mounting process.
- It can provide an opportunity to change the configuration during a demonstration.
- The currently used solid frame can be eliminated by using this system.
- Even if a solid frame is used, this system can be used for a double check.
- In case of supplying that system with an order of CASTLE coming from customers, it can be a chance for the end user to mount it to a different platform by themselves without a necessary call from company engineers. That can supply a profit in the aspect of time, employee labor, flight and accommodation costs etc. when an update in the configuration is demanded by the end user.
- It can be used in internal developments and upgrades to save time and labor of engineers.
- The system components can be repaired or changed easily.
- Low weight and small space requirement.
- System software can always be updated, upgraded or combined with external options.

5- FUTURE OPORTUNITIES

. As all components and software are designed and developed by considering future upgrades and updates some future improvements can be predictable.

After some kinematic analysis and designs it can be possible to measure and calculate elevation in the Z axis and pitch and roll .

The distance and angle accuracy can be increased by some extra software development or using different components.

The solid holder parts can be redesigned and servo control codes can be improved for a better and sharper movement.

It can be possible to complete measurement by adding an extra step with end to end measurements between sensor posts even if there are visual obstacles such as RCWS, mast or other Payloads on the mounting platform.

6- SOME VISUALS OF COMPONENTS AND PROTOTYPE