

Responses to Reviewers

Response to Reviewer 1 Comments

1. Summary

We sincerely thank you for taking the time to review this manuscript. Please find the detailed responses below and the corresponding revisions in the re-submitted files.

2. Questions for General Evaluation

Reviewer's Evaluation

Does the introduction provide sufficient background and include all relevant references?	Yes
Is the research design appropriate?	Yes
Are the methods adequately described?	Yes
Are the results clearly presented?	Can be improved
Are the conclusions supported by the results?	Can be improved
Are all figures and tables clear and well-presented?	Must be improved

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: Figure 1 totally is not visible due to super small fonts in the block diagram. Increase the font.

Response 1: We accept this suggestion. However, although the font size in this figure is small, it can still be clearly seen when magnified. Due to the width constraints of the figure, we can only present it at this size. Below is the figure we have attached.

Automated Microwave Scatterometer with Digital Twin

System Architecture Block Diagram

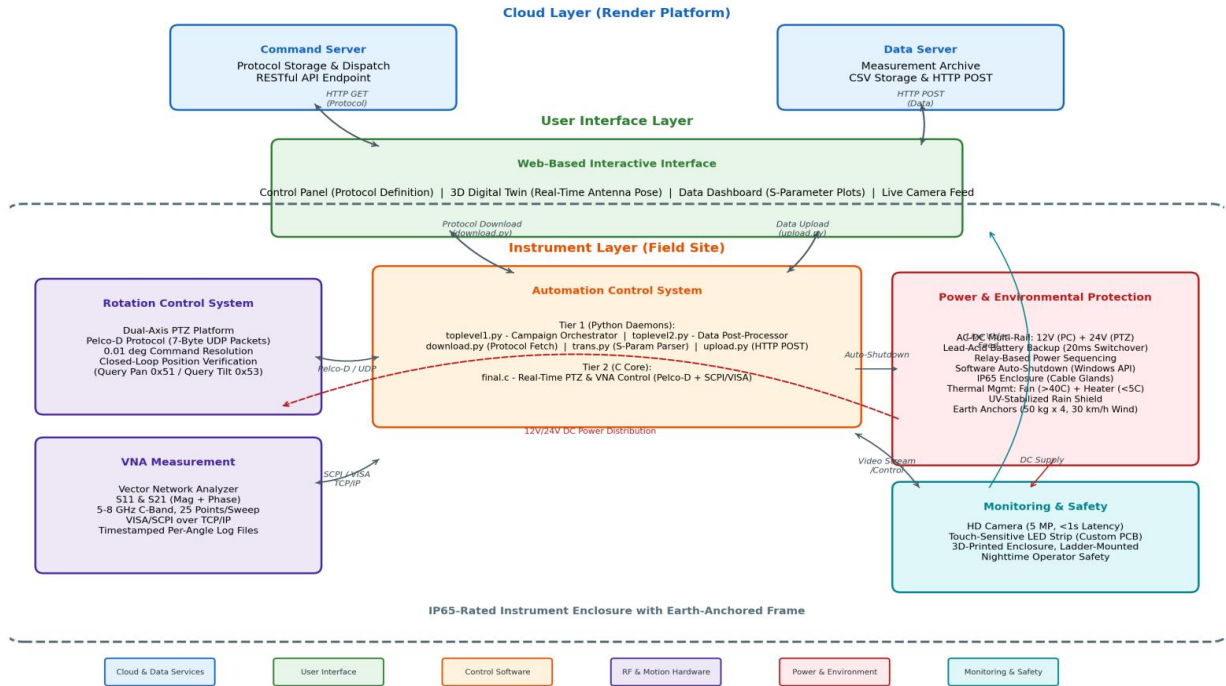


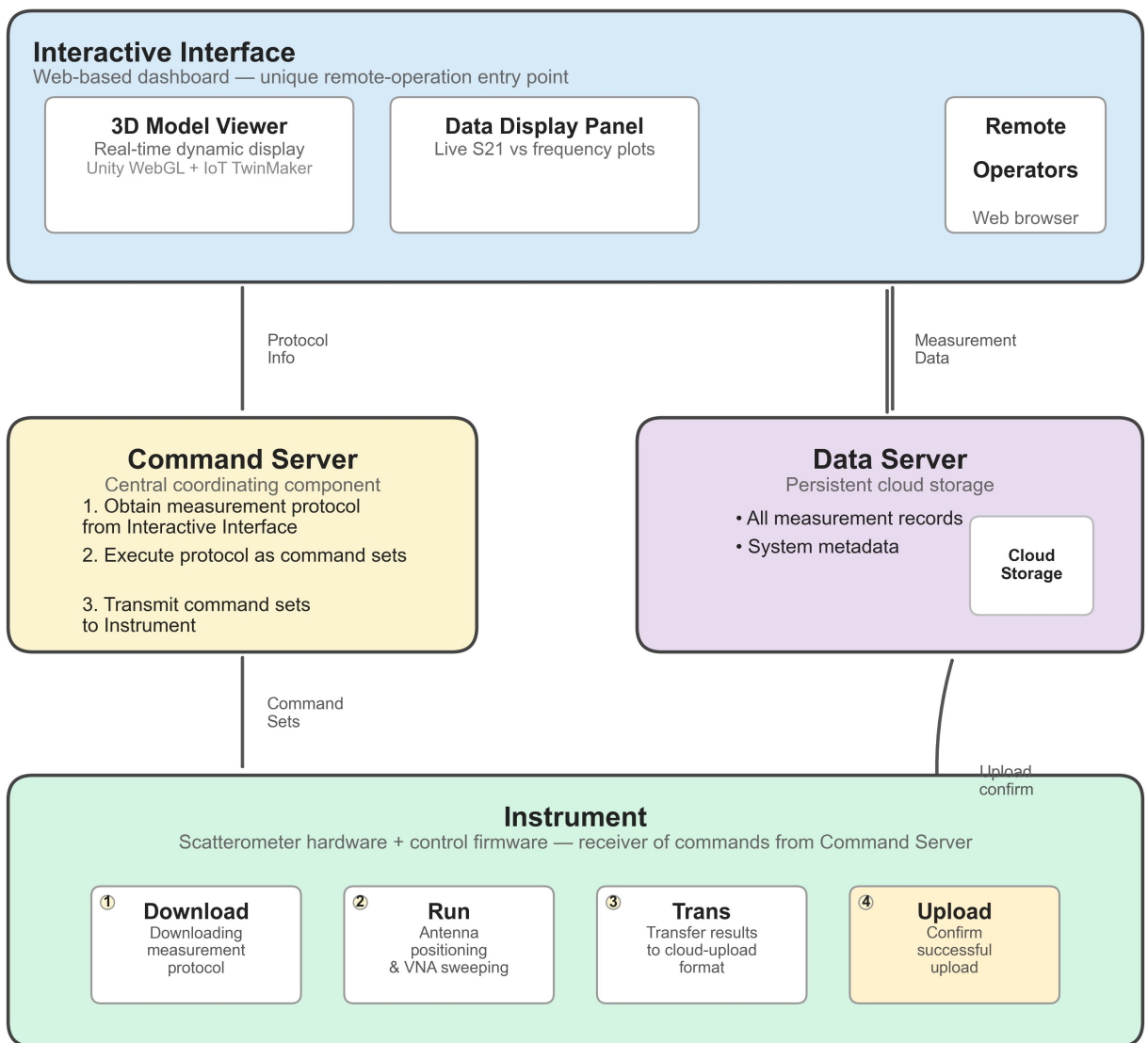
Figure 1: Block diagram of the Automated Microwave Scatterometer and its digital twin showing the integration of all subsystems.

Comments 2: Figure 2 totally is not visible due to super small fonts in the block diagram.

Increase the font.

Response 2: We sincerely thank the reviewer for this detailed assessment. We realize that the block diagram is very difficult to read. We adjust the structure of the block diagram so that we have more space to write down our words. And we increase the font in the diagram to make the graph more clear.

a



Comments 3: Discuss the requirements for a user-friendly motion-capable robotic assistant.

Response 3: Thank you for your suggestion. Requirement and Verification SMS-4 is added to discuss the motion-capable robotic assistant. "User-friendly" is already reflected in the original Interactive Visualization Subsystem (IVS) part; rather than requiring users to write code to control the machine's operations, it allowed them to enter commands on the client side to control it remotely.

#	Requirement	Verification Process	Verification Result
SMS-4	<i>The robotic assistant shall execute smooth multi-axis movements with an angular positioning resolution of at least 1°.</i>	<i>Command the robotic joint to move to specific angular targets, e.g., 30°. Measure the actual mechanical displacement.</i>	<i>Passed. The recorded positioning deviation was within $\pm 0.15^\circ$.</i>

Response to Reviewer 2 Comments

1. Summary

We are truly grateful for the reviewer's insightful and constructive feedback, which has greatly enhanced the clarity and rigor of our work. In light of the reviewer's comments, we have thoroughly revised the manuscript. Detailed point-by-point responses are provided below.

2. Questions for General Evaluation

Reviewer's Evaluation.

Does the introduction provide sufficient background and include all relevant references? Yes

Is the research design appropriate? Can be improved

Are the methods adequately described? Yes

Are the results clearly presented? Can be improved

Are the conclusions supported by the results? Yes

Are all figures and tables clear and well-presented? Yes

3. Point-by-point response to Comments and Suggestions for Authors

Comments 1: Request: Discuss the design and implementation of the camera.

Response 1: We agree with the reviewer. We should add more description of the monitor camera. Although we didn't design the camera ourselves but we can still tell why we choose this type of camera and what is our criteria. And how we use the camera and what's the function of it.

[Camera design: A low power complementary metal oxide semiconductor (CMOS) image sensor was selected as the core visual component. This choice is motivated by its favourable

trade-off among resolution, energy efficiency, and compact form factor, which is essential for long term autonomous operation. To support sustained field deployment, the camera is powered by a high capacity rechargeable lithium ion battery (9800 mAh), enabling a standby duration of up to 200 days on internal power. Furthermore, the camera module integrates both Wi-Fi and 4G cellular connectivity, allowing remote status queries, on-demand image retrieval, and over-the-air firmware updates without physical access to the instrument.

Implementation: The camera is rigidly affixed to the scattermeter chassis with a wide-angle lens (120 ° field of view) to monitor both the instrument’s mechanical components and its surrounding environment. Real-time motion detection of the instrument is achieved through an embedded three-axis accelerometer combined with frame differencing algorithms; any physical displacement, vibration, or tilt event is automatically logged with a timestamp. Concurrently, ambient environmental monitoring is performed via scheduled image captures (e.g., one frame per hour) and event-triggered video streaming. This implementation enables post-acquisition identification of external perturbations such as wildlife interference, vegetation encroachment, or weather-induced movements.]

Comments 2: Discuss the power requirements for the LED safety lighting system

Response 2: Thank you for your suggestion. Requirement and Verification LLS-3 and LLS-4 are added to discuss the power requirements of the Ladder Lighting Subsystem.

#	Requirement	Verification Process	Verification Result
LLS-3	The power should integrate a DC-DC boost converter to step up the battery voltage (3.7V) to a regulated 5V output for the 4.8W LED array.	Measure the output voltage of the boost converter using a digital multimeter under maximum load (4.8W) while the battery discharges from full to depleted.	Passed. The boost converter maintained a stable 5.01V \pm 50mV output across the discharge cycle.
LLS-4	The onboard charging	Connect the depleted system	Passed. Charging

	<i>circuit shall restrict the charging current to 400mA via a USB-C interface.</i>	<i>to a 5V USB-C power source and series ammeter. Record the charging current profile and total time to reach full charge.</i>	<i>current was regulated at approximately 396mA. The full chage cycle finished successfully in approximately 1.25 hours without overheating.</i>
--	--	--	--