

Radiometer Stabilized Platform Testing during ARISTO-2016

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1. Purpose

A set of moveable platforms for preserving level attitude of broadband radiometers in the event of aircraft pitch and roll were designed and fabricated at RAF in 2014-2015. Platforms mounted on the top and bottom of the C130 compensate for angular variations about the pitch and roll axes of the aircraft. Preliminary tests of the stabilized platforms during ARISTO-2015 indicated that modifications and further testing were required. Specifically, the angular offset of the pitch component appeared to be incorrect following analysis of the ARISTO-2015 data, so the source of the discrepancy was to be investigated in ARISTO-2016. Additionally, anomalous behavior in the roll component of the bottom platform (in just one direction) was unexplained following ARISTO-2015, and needed to be corrected. Finally, there was no independent verification of platform position once it was mounted on the aircraft, so a video camera was purchased to observe movement of the platforms in flight.

2. Procedures

Extensive testing and troubleshooting in the lab prior to flights were conducted on the bottom platform. A problem discovered with a connector is thought to be the explanation for the anomalous behavior of the roll correction during ARISTO-2015.

Review of the microprocessor code which sends instructions to stepper motors to move the platforms revealed that a built-in offset to the pitch platform had not been properly taken into account. Training on the code was provided by Mike Spowart to John Munnerlyn and Julie Haggerty, so we were able to adjust coefficients to obtain the desired motion. After ensuring that the modified instructions were producing the desired results, a new set of calibrations was performed and applied in Nimbus.

A Go-Pro video camera was purchased, and Steve Rauenbuehler designed a mounting apparatus to attach it to the platform fairing. The video provides independent verification that the platforms are moving in the proper manner.

A set of flight maneuvers was designed to test the capabilities of the platform to level the radiometers. They were performed on RF03.

3. Results

Prior to installation, a failure in the circuit board of the bottom platform occurred. Repair or replacement was not possible in time for the project, so the bottom platform and radiometer pair were not flown. However, the top platform/radiometer measurements are actually more important

since they are most susceptible to variations in solar angle induced by aircraft pitch and roll. Fortunately, the top platform was functional when the project began.

Another problem occurred on RF03 and RF04 with the signal from the housing temperature of the IR radiometer. A problem with the channel used for that variable in the signal conditioning box was discovered and repaired before RF05. Again, though, the measurement from the visible radiometer is most important for testing the effect of variations in solar angle, so the loss of IR data on two flights did not significantly impact our objectives.

Video footage from the Go-Pro camera was quite useful for verifying that the platform adjusted angles of the radiometers in the proper directions. Adjustments compensating for aircraft roll and pitch changes were documented visually, giving us independent verification of proper movement by the platform.

The radiometer flight maneuvers were carried out on 8/9/16 during RF03. During clear skies and relatively low sun angle (SZA $\sim 43^\circ$), pitch maneuvers were performed with true heading pointing into the sun, and then (180°) away from the sun. If the platforms were keeping the radiometers exactly level, constant irradiance should have been measured throughout the pitch maneuvers and within the reverse heading legs. Preliminary analyses of irradiance data show that there were slight variations ($\sim 1\%$) in irradiance during pitch maneuvers, which might be explained by a slight time lag in the platform response. There is a larger discrepancy in irradiance between the segments pointing into and away from the sun. Differences of about 5% suggest an offset of the platform from level. The theoretical difference in the event the radiometers were not stabilized at all is on the order of 10%, so we can conclude that some adjustment by the platform was occurring. The irradiance measurements during roll maneuvers show very minor variations, indicating that the platforms were orienting correctly to compensate for aircraft roll.

Post-project measurements of the aircraft fuselage pitch angle vs. pitch angle of the Inertial Navigation System (INS) plate revealed a difference of about 1.9° . Since the platform is mounted flush with the aircraft fuselage while the instructions for platform movement are derived from INS data, this difference may explain why the platform was not entirely level during pitch maneuvers. Further investigation will be conducted prior to our next deployment.

4. Conclusions

ARISTO-2016 provided important information on the performance of the radiometer stabilized platforms. Specific findings are as follows:

- Video verifies that platform is moving in the proper directions
- Variation in irradiance of $\sim 5\%$ between “into sun” and “away from sun” flight segments indicates that the platform is not completely level along pitch axis
- Discrepancy is less than in ARISTO-2015 and less than that for a theoretical fixed platform ($\sim 10\%$)

- Stabilization with roll appears to be successful
- Anomalous behavior in bottom platform roll stabilization corrected in lab, although bottom platform not flown
- Some time lag apparent in both pitch and roll corrections
- Accuracy not as good as more complex and more costly platforms, e.g., HARP or STRAP stabilized platforms (tenths vs. hundredths of deg.)
- Offset in pitch platform due to aircraft vs. INS angles needs further investigation. May be able to account for offset in calibration.
- Microprocessor code that drives stepper motors now accessible and has been modified as needed
- New signal conditioning box tested; bad channel discovered and repaired
- Signal conditioning box and radiometers shown to be functional