The Stabilized Radiometer Platforms (STRAPs): Description and Planned Upgrades

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1) Introduction

• A pair of STabilized RAdiometer Platforms (STRAPs; Fig. 2) were collaboratively developed in the mid-2000s by the Naval Research Laboratory (NRL), the Naval Postgraduate School Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS), and the Sandia National Laboratories

• The STRAPs were designed and built by L-3 Sonoma EO (formerly Sonoma Design Group)

• Their potential to provide higher quality aircraft measurements of solar/IR irradiance has been shown, but reliability has been an ongoing issue

• The DOE ARM Aerial Facility is therefore funding the maturation/hardening of the STRAPs

• Here we present:

- The motivation behind the development of the STRAPs
- A brief description of the STRAPs
- An illustration of the performance capability of the STRAPs
- A brief description of the planned upgrades to make the STRAPs more reliable and robust

2) Motivation

• Measurements of solar and IR irradiance by instruments rigidly mounted to an aircraft have historically been plagued by the introduction of offsets into the data that are solely due to the pitch, roll, and heading changes of the aircraft

• These offsets arise because irradiance instruments have a hemispheric field of view with a cosine response, i.e. the measured signal is a function of the cosine of the angle of the incoming radiation wrt the normal of the instrument

• Any tilt in the instruments causes an offset in the measured signal

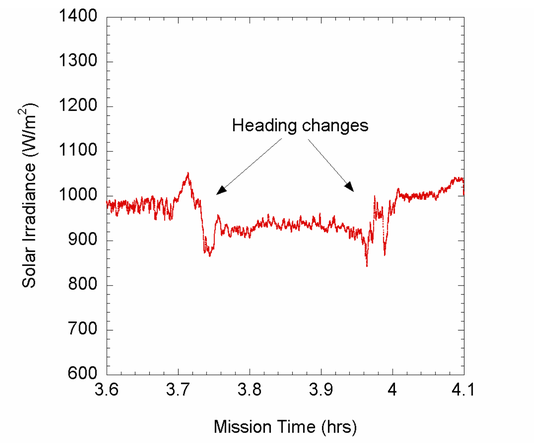

Figure 1. Effect of Heading Changes on Measured Solar Irradiance
Typical example of the systematic change in the measured solar irradiance with changes in heading when using radiometers rigidly mounted to the aircraft. The aircraft remained at a constant altitude for this whole flight segment.

3) Description of STRAPs

• Two STRAPs were developed to address this offset problem with aircraft irradiance measurements

• The STRAPs utilize a self-contained Inertial Navigation System-GPS pair to **actively** keep radiometers horizontally level

➢**to within +/- 0.02 deg**

➢**for pitch/roll range of +/- 10 deg**

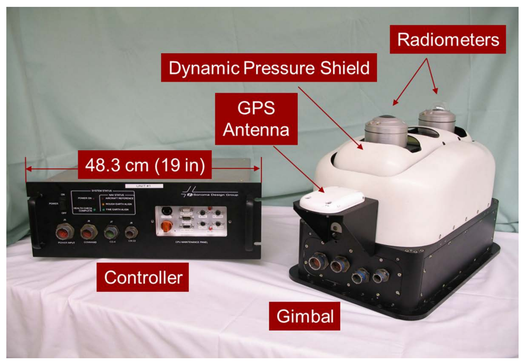

Figure 2. Major Components of STRAP
The Controller on the left is mounted inside the aircraft on a standard 19 inch rack. The Gimbal on the right is mounted on top of the aircraft.

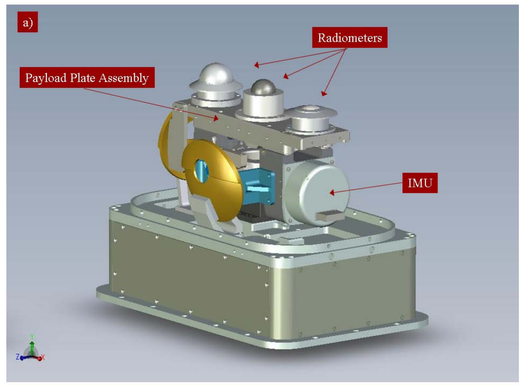

Figure 3. Interior of Gimbal.
An Inertial Measurement Unit (IMU) is mounted directly to the plate holding the radiometers for utmost leveling accuracy

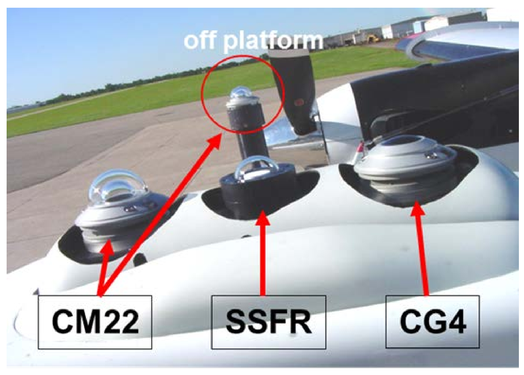

Figure 4. Close-up View of Radiometers on STRAP on the CIRPAS Twin Otter.
The CG4 is a modified Kipp & Zonen (K&Z) IR pyrgeometer. The SSFR (Solar Spectral Flux Radiometer) is a hyperspectral radiometer (courtesy NASA Ames). The CM22s are modified K&Z solar pyranometers, one on STRAP and one hard-mounted to the aircraft.

4) Performance of STRAPs

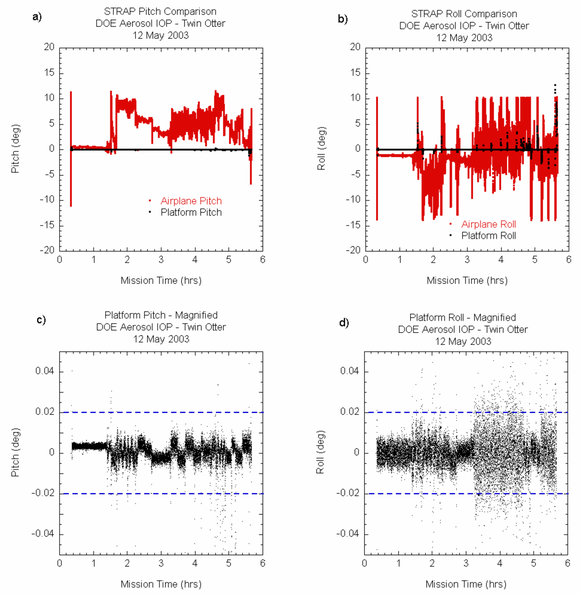

Figure 5. Illustration of the Excellent Stability and Accuracy of the STRAPs
(Top) Comparison of the (a) pitch and (b) roll of the aircraft (red lines) with the pitch and roll of STRAP (black lines) for a complete 5 hour flight of the CIRPAS Twin Otter. (Bottom) Magnified views of the platform (c) pitch and (d) roll showing it remained level to better than +/- 0.02 deg for most of the flight.

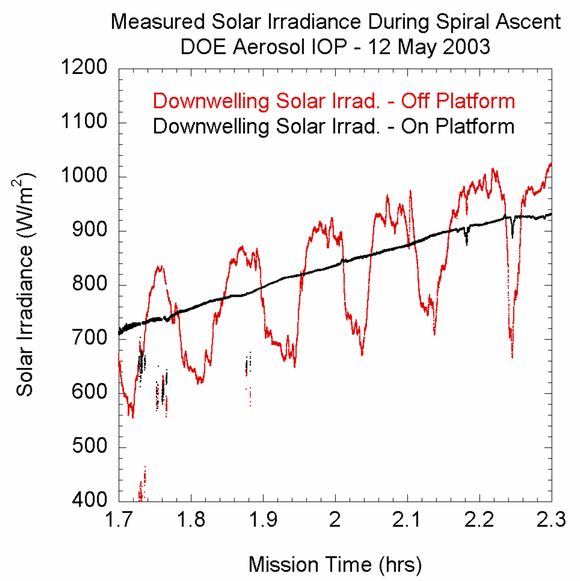

Figure 6. STRAP Enables Radiometer Irradiance Measurements in Spiral Ascents and Descents

• Comparison of the downwelling solar irradiance measured during a spiral ascent of the CIRPAS Twin Otter during the DOE Aerosol IOP flight on 12 May 2003. The black line is the irradiance measured by the radiometer on STRAP, while the red line is the irradiance measured by the radiometer rigidly mounted to the aircraft.

• In the past, none of the radiometer measurements in such a spiral would have been used because the pitch and roll angles would have been out of range and the offsets would have been too big to correct for. With STRAP, good measurements were obtained throughout the spiral.

5) Reliability Issues

• The STRAPs have flown in a handful of field studies that illustrated their potential for providing high quality solar and IR broadband irradiance measurements

• However, the STRAPs also experienced various hardware and software failures that highlighted the need for increased reliability

• Testing has revealed that the major limitation to reliability lies with:

1) the **INS solution** currently employed by the STRAPs (i.e. the hardware and software that control and level the platform)
2) the **Windows based operating system**

6) Planned Upgrades

• **The DOE ARM Aerial Facility (AAF) is funding the maturation and hardening of the STRAPs**

• **Planned upgrades include:**

- Upgrade to the navigational computer hardware components
- Upgrade of the platform control software
- Upgrade of the operating system to a Linux based system

• **Schedule:**

- Upgrades will be complete by the end of 2012

7) Reference

• For a complete description of the STRAPs see:

- Bucholtz et al, (2008): The Stabilized Radiometer Platform (STRAP) - An Actively Stabilized Horizontally Level Platform for Improved Aircraft Irradiance Measurements, JTECH, 2161-2175, DOI:10.1175/2008JTECHA1085.1

• For a successful application of the STRAPs see:

- Guan H, B. Schmid, A. Bucholtz, R. Bergstrom (2010). The sensitivity of shortwave radiative fluxes, forcing, and heating rates to the aerosol vertical profile. J. Geophys. Res., 115, D06209, doi:10.1029/2009JD012907.