HIGH ACCURACY DIRECTIONAL/HEMISPHERICAL MEASUREMENT SYSTEM FOR LARGE SAMPLES

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OBJECTIVES

- Address the need of calibration and validation of space-borne sensors;
- Facilitate directional/hemispherical characterization of large (~45 cm on a side) space diffusers;
- Able to measure horizontal samples – powders, liquids;
- Addition to BRDF calibration capabilities;
- Complement spectrophotometric measurements;
- Support the ongoing on-orbit calibrations in UV-VIS-NIR-SWIR.

BACKGROUND

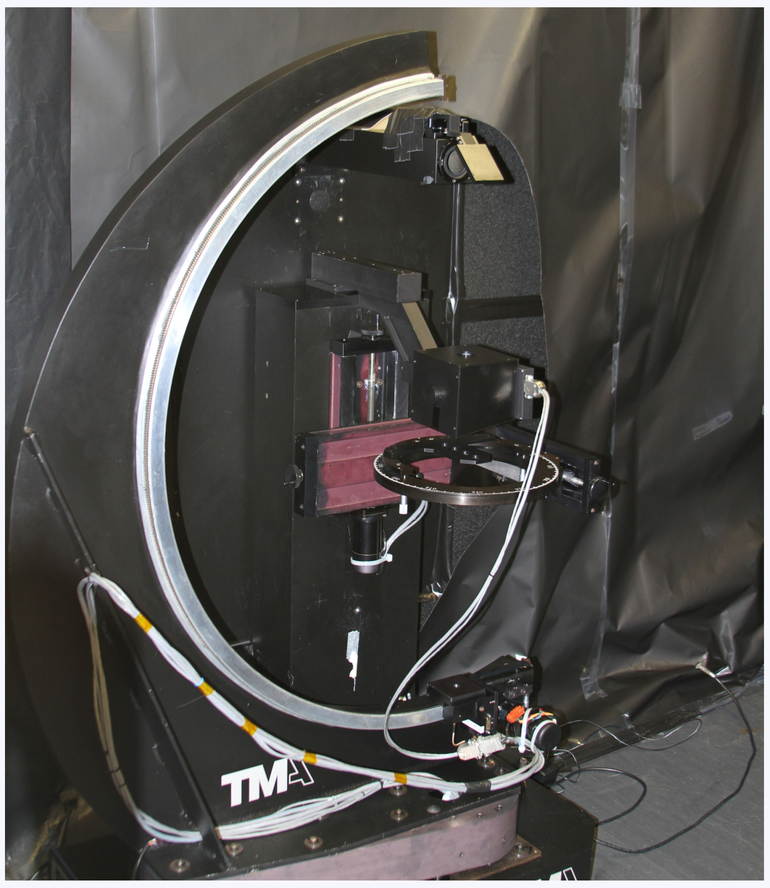
The total flux incident over the entire integrating sphere surface expanded to an infinite power series is:

$$\frac{\Phi_i \rho(1-f)}{1-\rho(1-f)}$$

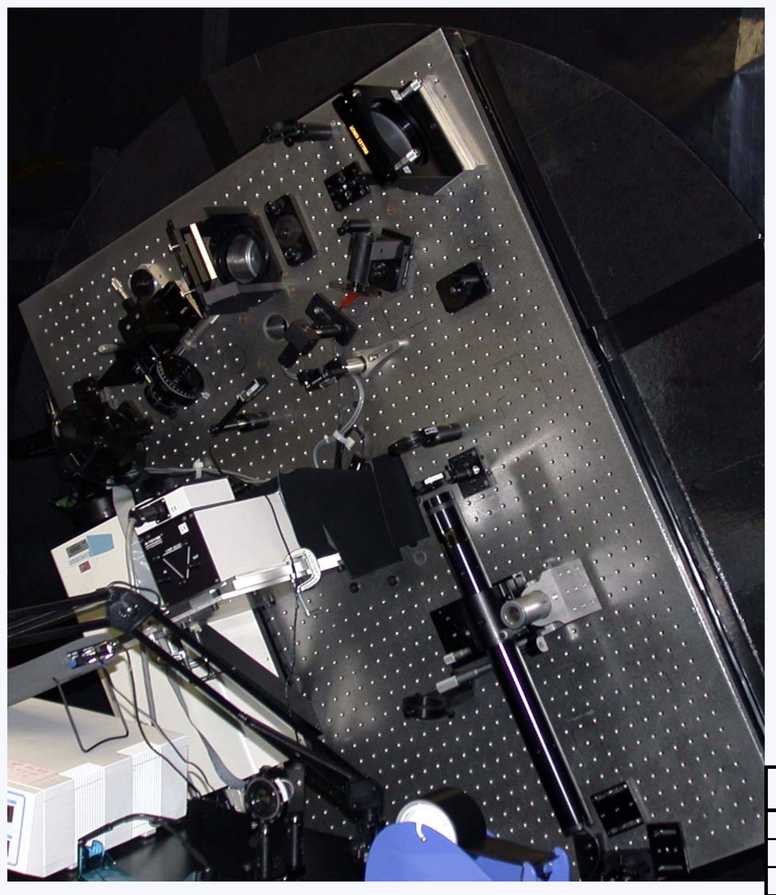
where φi is the incident flux, ρ is the reflectance, $f=(Ai+Ae)/As$ is the port fraction. The sphere surface radiance is given by:

$$L_s = \frac{\Phi_i}{\pi A_s}\frac{\rho}{1-\rho(1-f)}$$

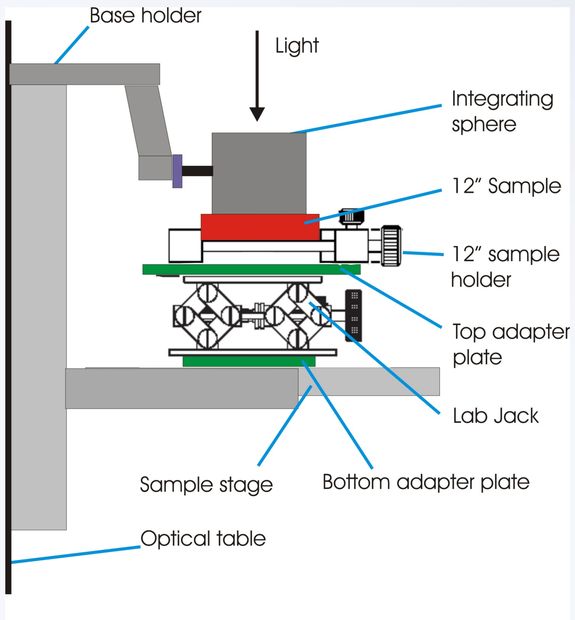
DIRECTIONAL/HEMISPHERICAL MEASUREMENT SETUP

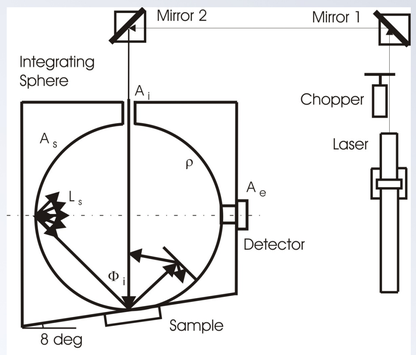


The goniometer with integrating sphere



The vertical optical table rotated 30°





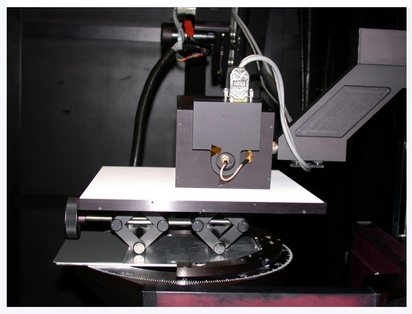
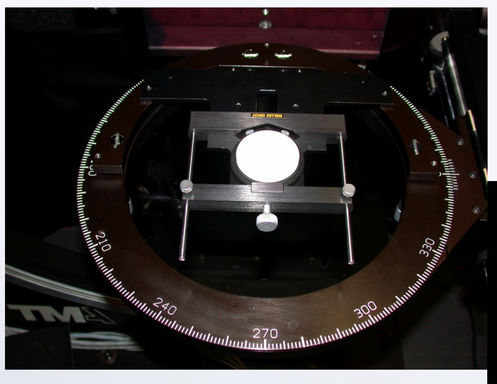


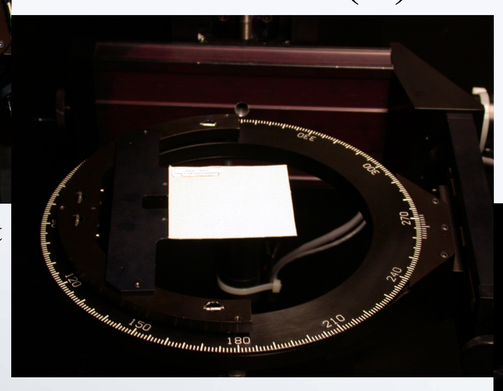
Table 1: Polynomial coefficients

Wavelength, nm	A	B	C	D
300	-9.82894×10^{-4}	0.29122	-0.02605	1.66337×10^{-3}
400	3.40319×10^{-3}	1.19252	-0.45747	0.10296
500	4.0201×10^{-3}	0.34171	-0.03957	2.58476×10^{-3}
600	4.90461×10^{-3}	0.38612	-0.05035	3.61316×10^{-3}
700	5.70006×10^{-3}	0.56125	-0.10729	0.01139
800	6.15911×10^{-3}	1.03389	-0.36472	0.07069
900	4.33566×10^{-3}	0.1615	-8.66674×10^{-3}	2.43788×10^{-4}

SAMPLES



2" diameter 99% white Spectralon target



Radiometric tarp witness piece of field deployable target

12" square 99% white Spectralon target

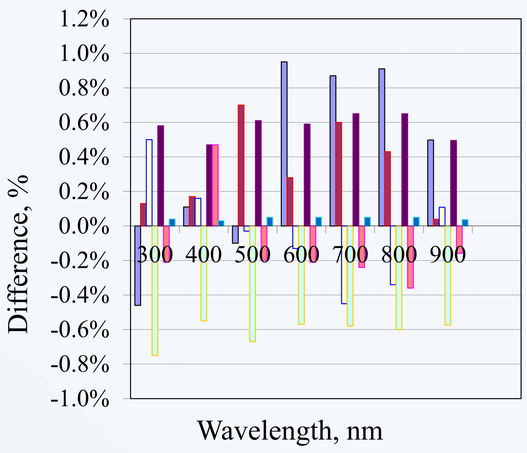
RESULTS

The dependence of the hemispherical reflectance versus receiver power is fitted using a third-degree polynomial regression:

$$R(P) = A + BP - CP^2 + DP^3$$

8° directional/hemispherical reflectance

Wavelength, nm	2" Spectralon	Tarp sample #1	12" Spectralon
300	0.974		
400	0.988		0.9909
500	0.989		0.9912
600	0.989		0.9914
632.8	0.989	0.673	
700	0.990		0.9904
800	0.989		0.9901
900	0.987		0.9884

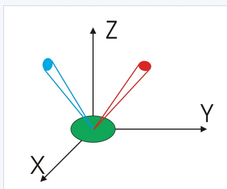


Difference between NIST standard and GSFC measured 7 Spectralon samples

Radiometric tarps 8° directional/hemispherical reflectance @ 632.8 nm

Sample	Hemispherical Reflectance
1	67.34%
2	49.65%
3	31.93%
4	4.35%

CONCLUSIONS AND FUTURE WORK

- Broadband and laser light sources were used in the UV, VIS and NIR spectral regions;
- 8 deg directional/hemispherical measurements of samples with different surface structure were performed to complement the Bidirectional Reflectance data;
- Demonstrated is the ability to measure 8° directional/hemispherical reflectance of large up to 45 cm on a side horizontally positioned samples as powders and liquids;
- The reported data were measured in clean room calibration facility and the results presented are NIST traceable trough calibrated standard plates.
- Future work: Expanding the measurements spectral range in SWIR up to 2.5 µm

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