THE INTEGRATED ATMOSPHERIC CHARACTERIZATION SYSTEM

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1. INTRODUCTION

The Georgia Tech Research Institute (GTRI) is developing a transportable three-lidar system to characterize the laser beam propagation environment during the testing of laser-based electro-optical systems. This three-year project started during the summer of 2008 with a detailed definition of the system requirements, and the project is currently in the design phase.

2. REQUIREMENTS OVERVIEW

The Integrated Atmospheric Characterization System (IACS) is required to characterize laser beam propagation paths in terms of three parameters: 1) the strength of refractive turbulence; 2) absorption due to water vapor; and 3) absorption due to aerosols. Three wavelengths are of interest: 1.07 microns (fiber laser), 1.318 microns (chemical oxygen-iodine laser), and 1.625 microns (free electron laser). The ground-based system must be transportable so that it can be deployed at various test ranges, and it must be capable of pointing at any elevation angle from the horizon to the zenith, in order to support ground-to-ground, air-to-ground, and ground-to-air engagement scenarios. The system must provide profiles of the three desired parameters at ranges of 0 – 10 km, and it must operate during both day and night.

3. APPROACH

In order to minimize technical risk, IACS will be based on proven technology as much as possible. There is only one documented technique for day and night profiling of refractive turbulence, the differential image motion lidar developed by the GTRI lidar team [1]. This technique uses a high-power tripled Nd:YAG laser operating at 355 nm wavelength along with a fairly large (~1/2 m) receiving telescope. The concentration of water vapor can be profiled by using either differential absorption lidar (DIAL) or Raman lidar. The Raman technique was chosen for IACS because it can be implemented with the same 355 nm laser and large receiving telescope that are used for the turbulence profiler, thereby simplifying the overall system. The water vapor lidar will be based on technology developed at the NASA Goddard Space Flight Center (GSFC) [2].

Measuring atmospheric absorption at the three wavelengths of interest is problematical, because the chemical oxygen-iodine laser (COIL) is on the edge of a water vapor line. This means that a lidar designed to emulate the COIL would have to employ a laser with the same center wavelength and the same line width. Such a laser (suitable for lidar) is not commercially available. In lieu of lidar measurements at 1.318 microns, IACS will profile water vapor (using 355 nm) and measure aerosol absorption at both 1.06 and 1.625 microns, spanning the COIL wavelength. Absorption due to water vapor will then be calculated, and absorption due to aerosols will be interpolated. The 1.06 micron laser light will be provided by an Nd:YAG laser that also pumps a type of optical parametric oscillator known as the rotated image singly-resonant twisted-rectangle cavity (RISTRA) [3] to generate the 1.625 micron laser wavelength.

4. EXPECTED PERFORMANCE

Detailed simulations as well as previous experience have shown that IACS will be able to meet the requirements listed above, providing profiles from 0-10 km with turbulence strength uncertainties on the order of +/- 20% and aerosol absorption uncertainties on the order of a few percent. Water vapor profiles are an exception, with a maximum range of perhaps 5-6 km during daytime. The performance envelope of IACS is still being assessed through simulations.

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[3] A.V. Smith and D.J. Armstrong, "Nanosecond optical parametric oscillator with 90^0 image rotation: design and performance," *J. Opt. Soc. Am. B* **19**, 1801-1814 (2002).