Conversions To The Lidar Atmospheric Sensing Experiment (LASE) Instrument for Nadir and Zenith Measurements

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1 Introduction

The Lidar Atmospheric Sensing Experiment (LASE) Instrument uses a Differential Absorption Lidar (DIAL) technique that is uniquely suited for making precise water vapor measurements in the troposphere (Browell et al. 1979; Browell 1983; Ismail et al.1989). Measurement of aerosols and clouds in the troposphere are also made. Water vapor measurements made with the LASE instrument have been validated with results showing an accuracy with less than 6% of error for water vapor profiles across the troposphere (Browell et al. 1996). No other instrument can provide the spatial coverage and accuracy of LASE. Water vapor is the most radiative active gas in the troposphere, and the lack of understanding about its distribution provides one of the largest uncertainties in modeling climate change. LASE has demonstrated the necessary potential in providing high resolution water vapor measurements that can advance the studies of tropospheric water vapor distributions.

LASE was initially a downward looking instrument that has flown aboard a NASA/Ames ER-2 aircraft at altitudes from 16-21 km. It weighs 520 kg and has a volume of approximately 1 m^3. The proven operating pressure is from standard atmosphere to 1/4 atmosphere. The temperature range is from 15°C to 40° C. After power is applied, the operation of LASE is totally autonomous when operating onboard the ER-2 (Moore et al.1996). LASE has data storage capacity of continuous operation for maximum ER-2 flight time of 8.5 hours.

LASE uses a double-pulsed Ti:Sapphire laser for the transmitter with a 30 ns pulse length and 150 mJ/pulse. The laser beam is "seeded" to operate on a selected water vapor absorption line in the 815-nm region using a laser diode and an onboard absorption reference cell (J. Barnes et al. 1993, N. Barnes et al 1993, J. Barnes et al. 1993). A 40 cm diameter telescope collects the back-scattered signals and directs them onto two detectors. LASE was designed to collects DIAL data at 5 Hz. The Control and Data Acquisition Subsystem (CDS) controls the overall instrument functions and formats the collected data into a data stream that is stored on a recorder. This data is later processed by the Data Processing Station (DPS) on the ground.

The LASE Instrument has flown over 30 successful flights in a 2 year period. The demand for LASE has made it credible to increase the availability of LASE in supporting the agency's Earth Science Enterprise by adapting it to other NASA aircraft such as the P-3 and DC-8. This adaption requires converting a nadir instrument into a nadir and zenith instrument. The electronics to accomplish the conversion follows.

2 Describing the Zenith channel addition

Significant upgrades had to be made with the CDS and DPS computer systems to handle the existing nadir channel plus the additional load of adding a zenith channel. In figure 1, the boxes above the dashed line are the added hardware. The electronic upgrades were accomplished during the preparations for a deployment in the summer of '97 aboard the NASA P-3 aircraft. The CDS computer was upgraded to an Intel 486-PC from a PDP-11. The 486-PC was housed in a STD-32 chassis which also houses several other commercial-off-the-shelf (COTS) printed circuit boards (PCB). The chassis supports PCB such as SCSI disk controller for interfacing data storage units; a network card to interface the DPS, a Laptop PC and other communicators; an Arinc-429 aircraft parameters interface card; two Quad-serial cards; a Floppy drive; and two custom built cards providing housekeeping data and communications with the CAMAC crate science modules.

The CAMAC crate continues to house all original science modules. Moving the computer related items to the STD-32 chassis, made room available for a Signal Processing Module, three new Transient A/D digitizers, and a crate control module to connect the CAMAC crate and the STD-32 chassis together.

Advantages of the upgraded CDS (in addition to providing space for Zenith science modules) includes

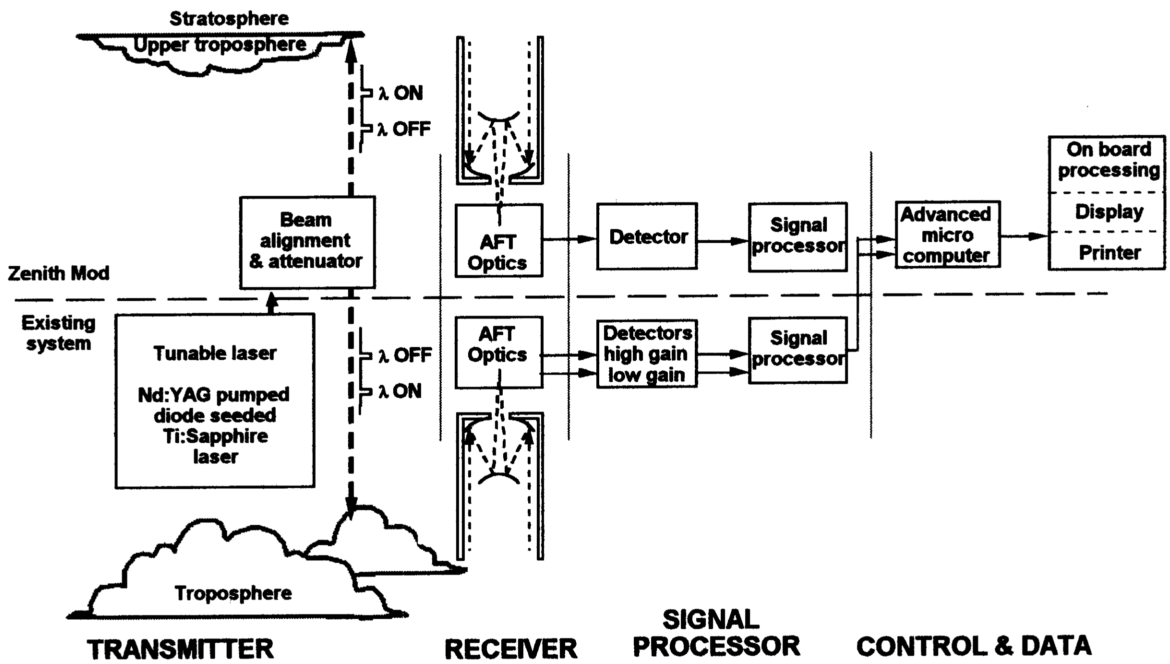

Fig 1. Block diagram of a zenith mod to the LASE Instrument for DC-8 type aircraft operations

having more "C" software language programmers available and COTS software modules and drivers. In addition, the STD-32 chassis is smaller, very rugged, and powered by standard aircraft power without requiring special power supplies.

The DPS (previously the ground station) was reduced to an equipment rack one-fourth in size with faster processing times and capable of being installed aboard various aircraft with the LASE instrument.

The new DPS is housed in two fifty inch high racks. The computing is done by a single Alpha based computer running a VMS operating system which was maintained to avoid massive software revision. The Alpha will run Windows NT if the decision is made to switch in the future because of increasingly less support for the VMS operating system. The single Alpha has much more power than the dual MicroVax-3800 configuration used before the upgrade. This speeds up daily operations and allows for the added data in the Nadir/Zenith set-up.

Advantages of the upgraded DPS are reduction of space and weight requirements, faster processing, and the switch to a more current product which is more easily serviced.

During the Mission in '97 onboard the P-3 aircraft, all post flight processing was completed before the plane landed as compared to six hours after the plane lands with the prior system.

A telescope has been added to the LASE Instrument to provide a zenith channel for up-looking during flights on aircraft such as the NASA DC-8. The science channel detector is one of the spare units from the nadir channel. Only structural hardware had to be designed to adapt COTS optical components to LASE.

3 Summary

LASE now has the advantage of being economically upgraded and customized with COTS hardware and software while using "C" software language. These changes are made so as not to destroy the form, fit and functional characteristics required for flights aboard the ER-2 aircraft. The LASE Instrument can now be quickly adapted to fly onboard ER-2, P-3, C-130 and DC-8 aircraft.

The adaptability of the CDS upgraded electronics compliments other modular subsystems like the laser optical bench in that it was designed to be a test bed for new technology lasers.

The CDS upgrade allows greater flexibility to accept changes required of various aircraft and provides higher processing speeds which are needed as the complexity of the task increases.

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