Strawman Payload for the Unmanned Aerospace Vehicle Demonstration Flights

J. Vitko, Jr.
Sandia National Laboratories
Livermore, CA 94550

Introduction

The first phase of the Atmospheric Radiation Measurement-Unmanned Aerospace Vehicle (ARM-UAV) program is a demonstration phase meant to provide both scientific results and operational experience within the first year of the program. These UAV demonstration flights (UDF) will emphasize flux divergence measurements, a key building block in the longer term goals of ARM-UAV. The basic idea is to make up- and down-looking broadband flux measurements from a UAV and combine these with similar measurements made from the ground, other aircraft/UAVs, and satellites to obtain the flux divergence. Of necessity, the UDF will use "existing" equipment—both in terms of instrumentation and UAVs. A strawman UAV payload for this mission is heuristically shown in Figure 1.

This payload consists of three main groupings of instruments: small, accurate, flux radiometers which provide the critical flux measurements; an ancillary package which provides spectral radiances and visible imagery to aid in the interpretation of the flux divergence; and a meteorological package which characterizes the bulk state of the atmosphere. Selected portions of this payload are described briefly below.

Flux Radiometers

Francisco Valero of National Aeronautics and Space Administration (NASA) Ames has several flux radiometers that appear to be well suited to near-term UAV applications. These include both broadband hemispherical solar and IR flux radiometers (BBHSR and BBHIR), as well as the total direct diffuse radiometer (TDDR), which measures both the direct and diffuse solar radiation in each of seven narrow spectral channels. All three types of instruments have been flown extensively on aircraft and, in some cases, on balloons; typically weigh less than 5 kg; and can operate unattended and over wide temperature ranges (as low as -20°C).

From the onset, these instruments have been designed with calibration in mind. They have estimated accuracies as high as 1% in the solar and several percent (~3%) in the IR and appear to be well accepted in the climate community.

The current plan is to fly two each—one up-looking and one down-looking—of the BBHSR and BBHIR instruments. In addition, we will fly a single up-looking TDDR. While the TDDR does not measure the broadband flux, it does measure the direct and diffuse components of the solar radiation. This information is needed to attain the maximum accuracy in analyzing the solar broadband fluxes from the BBHSR.

Ancillary Package

The ancillary package provides spectral radiances and visible imagery to help interpret the flux divergence data. Spectral radiances help in two ways. First, they provide information on the spectral signature of the scene and therefore can be useful in relating the energy detected by a broadband radiometer to the actual energy incident on the instrument. Second, they can be used to infer cloud, aerosol and water vapor properties and, hence, can be used in conjunction with flux divergence measurements to test various radiative models.

Two spectral radiometers are under consideration. The first is the Scanning Spectral Polarimeter (SSP) now being developed by Graeme Stephens and co-workers at Colorado State University and first scheduled to fly this spring. The SSP is a nadir-looking spectral radiometer for measuring daytime cloud, aerosol and surface properties. It covers the spectral range from 0.4 to 2.4 microns in about

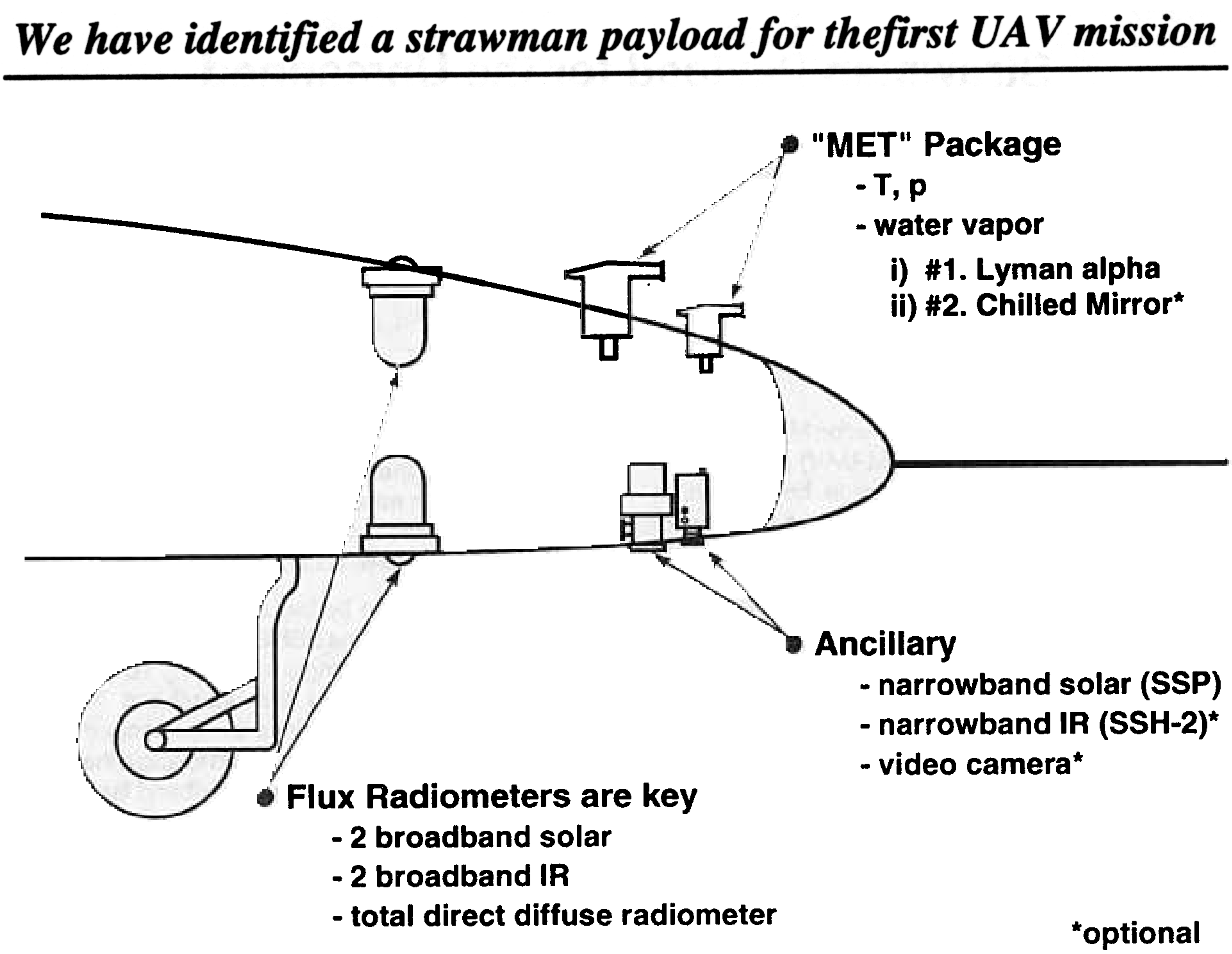

Figure 1. A stylized strawman payload for the UAV Demonstration Flight (UDF). (Instruments marked with an asterisk are optional and will be included only if schedule and budget allow.)

90 bands and includes polarization capability. The second is an IR spectral radiometer, the SSH-2, that was originally designed as a Defense Meteorological Support Program instrument to obtain temperature and water vapor profiles. The SSH-2 has recently been used for aircraft-based measurements in the First ISCCP[a] Regional Experiment (FIRE) intensive field observations in 1992.

Meteorological Package

The meteorological package measures such bulk atmospheric parameters as the temperature, pressure and water-vapor profiles. Commercially available instruments with appropriate characteristics are readily available for measuring the temperature and pressure profiles, though their configuration will need to be engineered. The measurement of upper tropospheric water vapor is less straightforward. We recommend two instruments if resources and time allow. Our first priority is a Lyman-alpha hygrometer. These instruments can measure dewpoints from -80°C to 50°C with an accuracy of about 0.5°C (or 2% in relative humidity) with millisecond response times. Our second priority is a chilled mirror hygrometer typically used in the community. These instruments provide relatively good accuracies in a small package, but do exhibit degraded response times and accuracies at low dew points.

(a) International Satellite Cloud Climatology Project.