cell once the voltage of the cell reaches the established limit. By use of this unit, multiple Li-ion cells connected in series within a battery pack can be charged from a single current source, and yet the charging of each cell is controlled independently of the other cells. More specifically, by use of this unit:

- Each cell in the series string is charged at full current until the cell voltage reaches the limit;
- Once the voltage of a given cell reaches the limit, the voltage is held at that limit and the current through that cell is tapered off so that the cell continues to gain some charge without becoming overcharged; and
- Even after some cells have reached voltage limit, other cells that are at lower states of charge continue to be charged at full current until they reach the voltage limit (see Figure 2).

The unit consists of electronic circuits and thermal-management devices housed in a common package. It also includes isolated annunciators to signal when the cells are being actively bypassed. These annunciators can be used by external charge managers or can be connected in series to signal that all cells have reached maximum charge. The charge-control circuitry for each cell amounts to regulator circuitry and is powered by that cell, eliminating the need for an external power source or controller. A 110-VAC source of electricity is required to power the thermal-management portion of the unit. A small direct-current source can be used to supply power for an annunciator signal, if desired.

This work was done by Concha M. Reid, Michelle A. Manzo, and Robert M. Button of Glenn Research Center and Russel Gemeiner of QSS Group, Inc. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17703-1.

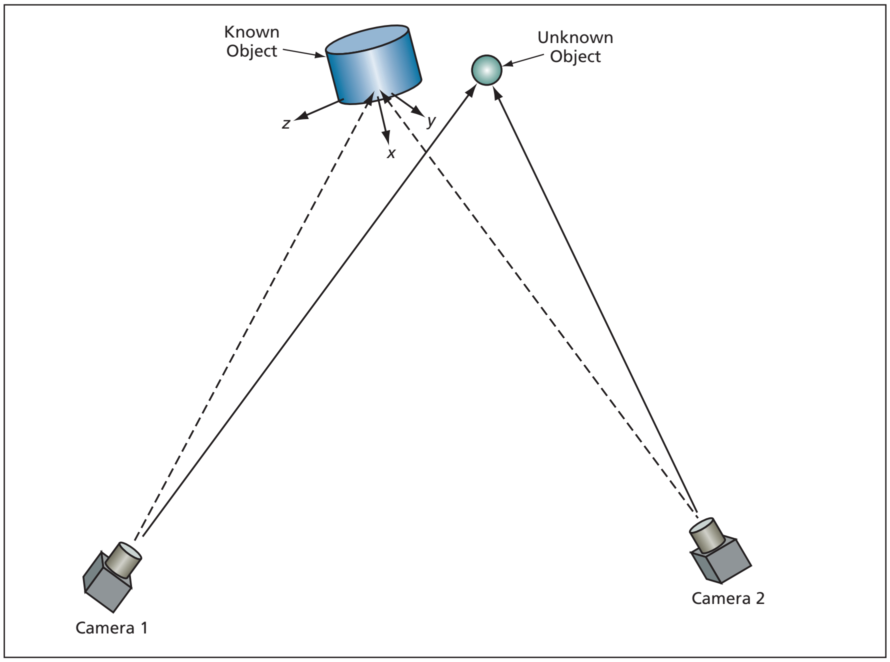
Measuring Positions of Objects Using Two or More Cameras

This method could determine the causes of accidents.

John F. Kennedy Space Center, Florida

An improved method of computing positions of objects from digitized images acquired by two or more cameras (see figure) has been developed for use in tracking debris shed by a spacecraft during and shortly after launch. The method is also readily adaptable to such applications as (1) tracking moving and possibly interacting objects in other settings in order to determine causes of accidents and (2) measuring positions of stationary objects, as in surveying. Images acquired by cameras fixed to the ground and/or cameras mounted on tracking telescopes can be used in this method.

In this method, processing of image data starts with creation of detailed computer-aided design (CAD) models of the objects to be tracked. By rotating, translating, resizing, and overlaying the models with digitized camera images, parameters that characterize the position and orientation of the camera can be determined. The final position error depends on how well the centroids of the objects in the images are measured; how accurately the centroids are interpolated for synchronization of cameras; and how effectively matches are made to determine rotation, scaling, and translation parameters.



Two Cameras Are Aimed at a pair of possibly moving objects, at least one of which is known. The positions and orientations of the cameras relative to the known object need not be known initially: instead, they are determined by means of photogrammetric computations.

The method involves use of the perspective camera model (also denoted the point camera model), which is one of several mathematical models developed over the years to represent the relationships between external coordinates of objects and the coordinates of the objects as they appear on the image plane in a camera. The point camera model is implemented in a commercially available software system for three-dimensional graphics and animation used in television, film, industrial design, architecture, and medical imaging.

The method also involves extensive use of the affine camera model, in which the distance from the camera to an object (or to a small feature on an object) is assumed to be much greater than the size of the object (or feature), resulting in a truly two-dimensional image. Using a technique common in photogrammetry as practiced in aerial surveying, depth information is obtained from a combination of image data acquired from two or more cameras. Synchronized image data from two or more cameras are combined following an error-minimization approach. Precise measurements are obtained by synchronizing data by use of linear interpolation and a dual-camera trajectory solution. Velocities of objects are also estimated in this model.

The affine camera model does not require advance knowledge of the positions and orientations of the cameras. This is because ultimately, positions and orientations of the cameras and of all objects are computed in a coordinate system attached to one object as defined in its CAD model.

Initially, the software developed to solve the equations of the affine camera model implemented a gradient-descent algorithm for finding a solution of a matrix · vector equation that minimizes an error function. Whereas photogrammetric analyses typically entailed weeks of measurements and computations to obtain accurate results from a given set of images, this software yielded solutions in times of the order of minutes. A more recent version of the software solves the affine-camera-model equations directly by means of a matrix inversion in a typical computation time of the order of a second.

This work was done by Steve Klinko, John Lane, and Christopher Nelson of ASRC Aerospace for Kennedy Space Center. KSC-12665/3/705

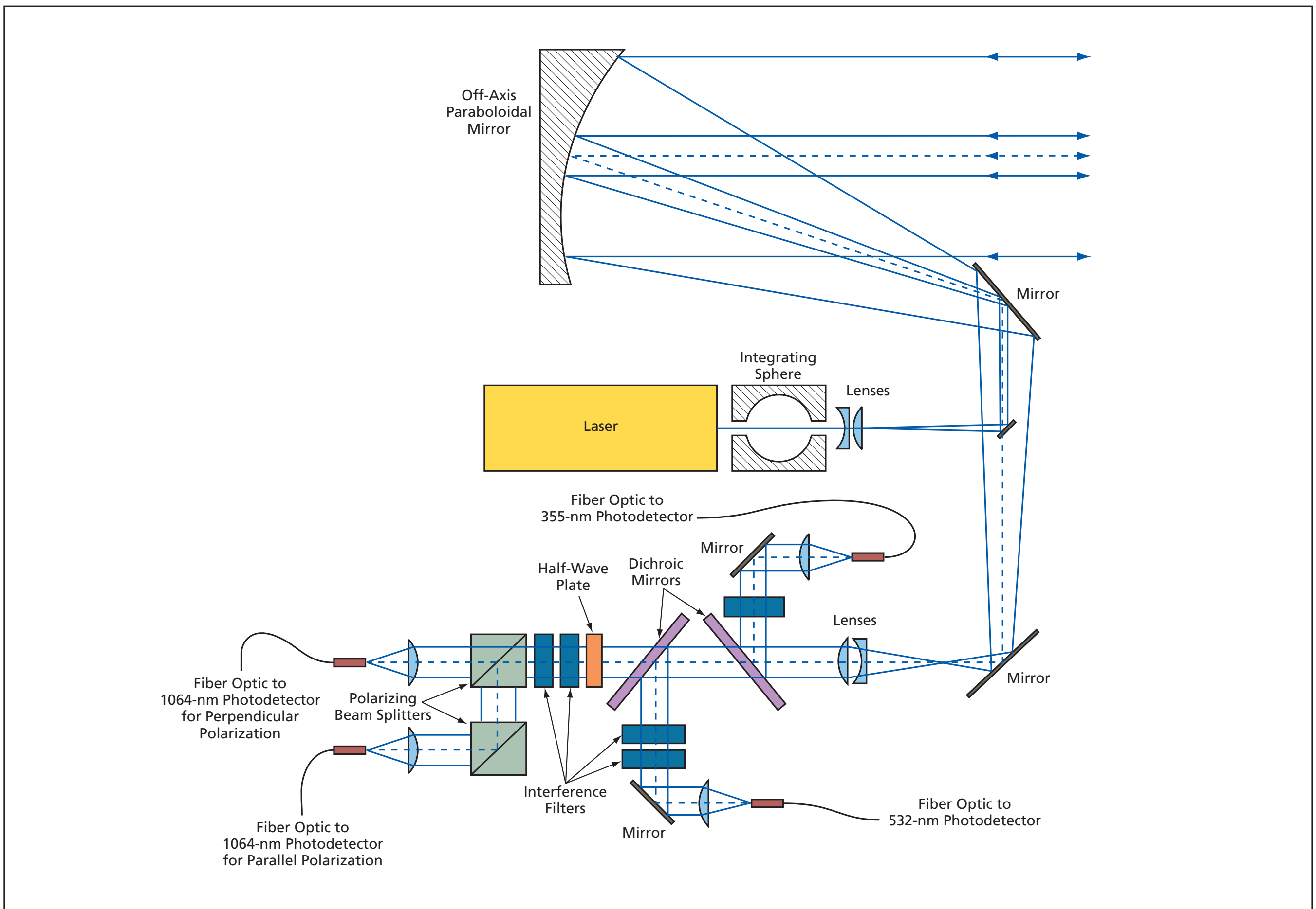
Lidar System for Airborne Measurement of Clouds and Aerosols

This is an eye-safe, rugged, all-solid-state system.

Goddard Space Flight Center, Greenbelt, Maryland

The figure schematically depicts a lidar system for measuring optical properties of clouds and aerosols at three wavelengths. The system is designed to be operated aboard the NASA ER-2 aircraft, which typically cruises at an altitude of about 20 km — above about 94 percent of the mass of the atmosphere. The system can also be operated aboard several other aircraft, and a version for use on Unmanned Aerial Vehicles (UAVs) is presently under construction. In addition to the requirement for fully autonomous operation in a demanding airborne environment, three other main requirements have governed the design: (1) to make the system eye-safe at the operating altitude; (2) to make the system as lightweight as possible, yet rugged; and (3) to use solid-state photon-counting detectors fiber-coupled to the receiver.

The laser transmitter is based on a Nd:YVO_4 laser crystal pumped by light coupled to the crystal via optical fibers



This **Simplified Optical Layout** (not to scale) shows the main optical components of a lidar system designed for measuring selected optical properties of clouds and aerosols at three wavelengths.