SELENODETIC CONTROL DERIVED FROM APOLLO METRIC PHOTOGRAPHY *

RAYMOND J. HELMERING  
Defense Mapping Agency Aerospace Center, St. Louis, Mo., U.S.A.

(Received 16 February, 1973)

Abstract. The data reduction of the metric photography from the Apollo missions is progressing in an orderly fashion within the Defense Mapping Agency (DMA). The data from all three Apollo missions is ultimately to be utilized for development of a lunar control network covering approximately 20% of the lunar surface. In this paper, the status of the data reduction from the Apollo 15 mission is summarized. More specifically, the evaluation of system parameters, proposed control generation plan, and the anticipated characteristics of the network are discussed.

1. Introduction

The data acquisition and reduction of the Metric Camera System photography from Apollo 15 and 16 missions is currently being performed within the Defense Mapping Agency (DMA). The assignment of work on Apollo 15 materials was made in October 1971 to the DMA Aerospace Center (DMAAC). Recently a similar assignment has begun at the DMA Topographic Center (DMATC) with the photographic materials from Apollo 16. The ultimate aim of the National Aeronautics and Space Administration (NASA) in making the above assignments to DMA is to incorporate the Metric Camera System photography from Apollo missions 15, 16, and 17 into one mathematic solution which would compute the coordinates of selected lunar surface features with respect to the center of mass of the Moon. This system of coordinates, called the Apollo Control Network, would cover approximately 20% of the lunar surface and would be used as a basis for studies of selenodesy.

The Apollo 15 data reduction assignment is due to be completed in April 1973. The objectives of the Apollo 15 assignment are (1) to produce various types of precise measurement data, and (2) to combine reduced measurement data with other supporting information to compute the coordinates of surface features by employing the fundamental principles of analytical photogrammetric triangulation. This paper will discuss the status of the Apollo 15 Control Network reduction. The triangulation method, the available data, the evaluation of data, and the anticipated characteristics of the computed network of coordinates will be stated in the following pages.

2. Photogrammetric Method

The data included in the conventional mathematical model of analytical photo-

grammetric triangulation are the position of camera at each exposure time, the 
orientation of the camera at each exposure time, measurements of the photo images 
of lunar surface features (each feature measured on two or more photographs) and, 
if available, lunar surface features, the coordinates of which have known values. The 
mathematical model can, of course, be expanded to take advantage of data provided 
by other system components such as precise exposure time or altimeter observations. 
Least-squares estimation techniques are employed to compute the best estimates of 
the above parameters. Statistical variance-covariance estimates may be applied to 
each of the modeled data types.

![Diagram of geometric relation of two photographs](image)

Fig. 1. Geometric relation of two photographs as used in analytical photogrammetry.

Analytical photogrammetric techniques are used in practice primarily to intensify 
the number of known coordinates in an area. Surface positions may be computed 
if the position and orientation of the camera are known for each photograph on 
which images were measured. The assurance associated with the computed surface 
position will naturally depend on the accuracies of the position and orientation 
elements as well as the accuracy of image measurements. Figure 1 shows a schematic 
of the geometry of the mathematical model for analytical triangulation of a pair of 
photographs. Additional photographs may be included in the solution in an analogous 
manner.

3. Metric Camera System

The Metric Camera System consists of a mapping camera which records the lunar 
surface, a stellar camera which simultaneously photographs a star field, and a laser 
altimeter and precise relative timing equipment. The mapping camera has a 76 mm 
focal length with a 115 mm photograph format. Reseau marks with a spacing of 
10 mm are recorded on every photograph in order to compensate for film deformation. 
This camera has the capability to compensate for forward motion and to automatically