OPTICAL SYSTEMS

INSTRUMENT	APERTURE (cm)	TIMING ACCURACY (msec)	DIRECTIONAL ACCURACY (arc seconds)	FAINTEST SATELLITE (magnitude)
Baker-Nunn tracking camera	50	0.1	2	12
Hewitt camera	63	0.2	1	7.5
BC-4 camera	12	0.1	2	6
PC-1000 camera	20	0.1	2	6
NAFA 3c/25 camera	10	2	5	4.5
MOTS-40 camera	20	2	2	5
Kinetheodolite photographic	20	10	20	4
Kinetheodolite photovisual	10	10	40	8
70-mm theodolite	7	100	110	8
7 x 50 binoculars	5	100	110	8
11 x 80 binoculars	8	100	70	9.5
20-cm telescope	20	100	70	11

OPTICAL SYSTEMS

Optical systems are those systems which utilize the visible part of the electromagnetic spectrum. This definition would encompass astronomical positioning using a theodolite or sextant and also laser ranging. However, we will not consider these techniques in this section. Conventional astronomical positioning has been discussed in Chapter 1, and laser ranging will be discussed later in this chapter.

Optical systems range in accuracy and complexity from simple binoculars to 60 cm tracking cameras. They have been used in the past for both satellite tracking (i.e., orbit determination) and terrestrial positioning but only the tracking cameras provided geodetically-useful results [Henriksen, 1977]. A tracking camera records a photographic image or a series of images of a satellite, either from a flashing beacon or via reflected sunlight, together with the images of background stars. The time of exposure is also precisely recorded. The positions of the satellite images on the processed film are subsequently measured with respect to stars in the field of view. If the positions of the stars are known, then the topocentric right ascension and declination of the satellite can be determined. Three such determinations combined with the known coordinates of the camera are sufficient for determining the orbit of the satellite. Additional observations can be used to improve the orbit's accuracy.

Alternatively, if the orbit of the satellite is known, it is possible to determine the geocentric coordinates of the camera. Two techniques have been used. In the ***geometric*** method, two or more cameras simultaneously record satellite images and the camera positions are then determined by triangulation. In the ***dynamic*** method, observations are not necessarily synchronized but precise knowledge of the satellite orbit is required. Several three-dimensional networks were established using these techniques [Henriksen, 1977]. One of them was the BC-4 worldwide satellite triangulation network, a network of 45 stations whose coordinates were established through observations of the balloon satellite PAGEOS, using Wild BC-4 cameras. The relative positions of the stations were determined with an estimated accuracy of about 5 m. Greater accuracy in position determination using satellite photography is not readily achievable due to a number of error sources. Chief among these are scintillations of the satellite due to atmospheric turbulence and distortions in the photographic emulsion. Consequently, in geodesy, satellite photography has been superseded by other techniques.

Optical systems are still an important source of information for satellite orbit determination and surveillance. They figure prominently, for example, in the U.S. Air Force's Spacetrack System and its Ground-based Electro-Optical Deep Space Surveillance (GEODSS) System.