For a photographic system, the resolution is also dependent on the emulsion. Under perfect conditions, an image of a satellite is a disk of diameter d, where

$$d = (2\lambda f)/D$$

For this calculation λ is the wavelength, f the focal length and D the diameter of the aperture of the camera. Thus, for a Baker-Nunn camera with a focal length of 500 mm and an aperture of 50 cm, the diameter of a point source will ideally be about 3 microns. However, because of the effect of the atmospheric visibility conditions, this diameter is increased by a factor of 10 so that d usually is about 20 to 40 microns for fast emulsions. Recent advances in remote sensing technology have reduced these values somewhat, so that good resolution of less than 10 microns, and often near 2 to 3 microns, can now be obtained. A Baker-Nunn camera can photograph stars of

$$m = 14.5 \text{ with a 20-second exposure.}$$

The field of a typical Baker-Nunn camera is about 30 by 5 degrees. The scale on the film is about 2.5 microns per second of arc. Therefore, the camera will theoretically be capable of photographing an object of

$$d = (2\lambda)/s$$

seconds of arc in diameter, where s is the scale. The minimum resolvable angle is therefore about 0.5 seconds of arc.

The resolution of radar tracking systems should also be considered. Although radar tracking systems, in contrast to photographic methods, are active rather than passive systems and although they utilize a different part of the electromagnetic spectrum, the basic principles are similar to those for photographic methods. For radar, resolution is defined by the relation:

$$r = 70(\lambda/D)$$

where r is the resolving power (the minimum separation in degrees of arc required to distinguish between two objects) and D is the antenna diameter. For a radar unit with an antenna diameter of 3 m and a typical wavelength of 3 cm, the beam width is 0.7 degrees of arc. For example, the maximum distance for a 3-m antenna would be about 250 m. Therefore, two objects side by side at distances greater than 250 m will appear to be one.

The resolution of a space object is dependent on several variables: 1) the wavelength used, 2) the optics, 3) the altitude of the object, 4) its size and shape, 5) its brightness, and 6) its angular velocity. It is obvious that, for example, a wavelength of 570 nanometres is not suitable for day-time or cloudy-day observations. The resolving capability of an optical system is dependent on its focal length and aperture, the system ideally having a focal length larger than the aperture width. It is also obvious that an object in a high geostationary orbit will be less easily tracked than one in a low reconnaissance orbit. The size of the object is directly related to its brightness, which is dependent upon its albedo as well as its phase angle. The phase angle will be dependent on its angular velocity, dependent in turn on its altitude. The problem of satellite observations is thus reduced to only two aspects: the observation system and the orbit (inherently, the *purpose*) of the satellite. Present optical and electro-optical systems are able to observe all types of satellites and contribute in real-time to the NORAD SPACETRACK satellite catalog. Giant Phased-Array Radars like the 13-storey-high structure at Elgin AFB in Florida are limited in their resolution of high-orbiting satellites, but capable of tracking a wealth of lower satellites with advanced data processors. Photometric and photographic systems, consequently, are vital for their abilities to complement radar observations. And, with an increasing number of payloads in orbit each year, the overloading of any one system must be avoided at all costs, for both military and navigational reasons.[17]

[17] See Wooding, B. and Spruson, T.A. *op. cit.*, note 9.