military installations, military land vehicles, and weapons facility construction. It would also be important to identify changes from one observation pass to the next, in order to identify a process or motion. Cruise missiles should also be observed. Current remote sensing technology is capable of observing them on the ground, but, because of their mobility and small size, they can easily be hidden in conventional-looking buildings. Furthermore, they require a much smaller "logistics trail" than ICBMs. Thus the cruise missile verification issue is controversial and probably cannot be addressed solely by technical means.[4,10] A number of other targets have been recommended; for example, nuclear reactors and uranium enrichment facilities could be observed to ascertain compliance with production limits of fissile material for nuclear weapons.[14]

Satellites with sensitive receivers that are able to cover large portions of the communications spectrum and large, high-gain antennas can intercept or "eavesdrop on" ground-to-ground and ground-to-space communications. While an international verification organization could technically do this, unless all parties—including the two superpowers—agreed to such monitoring it would not be practial diplomatically. In addition, there would be severe technical challenges due to the sophistication of equipment and the resources required to process and decode the data.

Any surveillance system for the late 1980's and 90's must be designed with the recognition that the environment which led to the treaties of the 1960's and 70's has changed. Monitoring strategic arms limitations and test bans between the US and USSR is still vital, but other targets must also be covered. Many nations and groups have increased their potential for initiating world crisis through limited military action, weapons build-up, guerrilla activity and terrorism. Consequently the system would have to be capable of observing all areas of the world, and objective presentation, interpretation and distribution of the data would be crucial.

WHAT DATA AND RESOLUTION ARE REQUIRED?

For some surveillance tasks it is adequate to detect merely the presence of an object or activity, while others require identification or even assessment of the target's dimensions. Table 1 shows the ground resolution (in metres) required for various targets, considering different tasks.[2]

Observing troop movements, especially in small groups, requires more precise resolution than for vehicles. For many targets "spectral" resolution (the ability to differentiate between particular wavelengths of light or other electromagnetic radiation) is as important as "spatial" ground resolution. Infrared detectors must be able to distinguish differences in temperature levels which are meaningful to the process under observation, and this usually requires resolution on the order of a few degrees.

TABLE 1 Resolution (in metres) Required for Different Verification Tasks

	TASK		
TARGET	*Detection*	*General Identification*	*Description*
Radar	3	1	0.15
Aircraft	5	1.5	0.15
Surface ships	8	5	0.3
Vehicles	1.5	0.6	.06
Roads	9	6	0.6
Submarines	30	6	0.6
ICBMs	3	1.5	0.3
SLBMs	30	6	1
Cruise missiles (estimated)	1.5	0.6	.06

FUNDAMENTALS OF A SATELLITE VERIFICATION SYSTEM

There are six key elements of a verification system:

- satellites
- satellite control and tracking station
- data receiving station
- data processing centre
- analysis and interpretation group
- information distribution network

The number of satellites and orbit selection is a trade-off among coverage requirements, resolution requirements, system lifetime and cost. Polar orbits have been used most often for surveillance missions because they allow coverage of the entire earth. Depending on the instruments' field(s)-of-view and the orbit altitude it usually takes several days, or even weeks, to observe everything. Other orbits such as equatorial and inclined elliptical orbits are useful for specific requirements. For example the USSR frequently uses "Molniya" orbits which are elliptical, inclined at sixty-five degrees or so, and have their apogees in the Northern hemisphere; they allow a good view of the North. As more satellites are added to the system, the time between repeated viewings of targets decreases and, depending on the orbits chosen, the global coverage can improve. With any orbit, instrument resolution improves if the altitude is lower; however the coverage area—or "swath width" per satellite pass—decreases, as does lifetime. As noted earlier, photo-reconnaissance satellites have very low orbits and short lives but they can