alone becomes the optimal policy. As Red becomes more likely (but still far from certain) Decision-maker should use a satellite inspection and follow up with an on-site inspection when no evidence of violation is turned up. And if Red is likely enough, Decision-maker should Alarm without delay. As Figure 5 shows, a sequential scheme can indeed produce synergy; the resulting inspection protocols are optimal across a fairly broad range of circumstances.

As the characteristic values above indicate, the cost of gathering information sequentially depends on the true state. This is because the use of the expensive process (OSI) is contingent on the result of the free process (Satellite Inspection). Thus, the probability that OSI is used (and paid for) depends on the true state. In general, variable cost is easy to handle when it is a consequence of a contingent information-gathering procedure, as above. A somewhat different problem is presented by time cost, which is typically variable because delay in acting is a problem only when there is a genuine violation (i.e. when the true state is Red). Costs of this type will be considered next.

Verification with Delay Costs

Suppose that a suspect event occurs at time zero, and that Decision-maker must decide whether to act immediately or to seek out further information one or more times before acting. We assume that the information is essentially cost-free, except that in state Red (the event really was a violation) Decision-maker's costs increase the longer Decision-maker takes to act. This is a simplified model of a satellite inspection problem, in which the time between satellite passes may be substantial, resulting in extra risks.*

To build the Delay Verification Decision Model, modify the cost parameters of the Basic Verification Decision Model (Figure 2) as shown in Figure 6. The relative cost parameters, F, L, and M, retain their meanings, and satisfy the same inequalities

$$F > 0 ; \qquad L > 0 ; \qquad L > M .$$

The quantity k represents the delay time, i.e. the number of satellite passes ("looks") between the occurrence of the event and the choice of an action by Decision-maker; the parameter d represents an extra cost for each pass, provided the state is Red. Thus, delay is costly if, and only if, there is a violation. In the following, the example

$$L = 110 ; M = 20 ; F = 10 ; d = 10$$

will be discussed in detail. (Note that the numerical values of L, F, and M are not the same as in Figure 5. The new values, which make failure to detect an actual violation extremely costly, and a one-pass delay in detecting as costly as a false alarm, have been chosen to make Figure 8 clearer.) For this example, $p_0 = 0.10$, so if no satellite passes were available, Decision-maker would choose Accept if $p < 0.10$, and Alarm if $p > 0.10$.

The information source in the model represents satellite reconnaissance of a region in which one mobile weapon is permitted, but two (or more) are suspected. It is assumed that the satellite can view a randomly chosen 40 per cent of the area of the region on each pass, and that the interval between consecutive passes is long in comparison to the speed of movement of the weapon. Then, taking Green to represent the presence of one weapon, and Red the presence of two, the probability table of Figure 7 results.

As Figure 7 makes clear, satellite surveillance does not provide binary information in this case; there are three (or more) possible observations ("results"). Of these, 'Observe 2' convinces Decision-maker that the true state is Red, whereas the other two observations merely

* For a general introduction to satellite surveillance, see "Surveillance from Space: A Strategic Opportunity for Canada," by George Lindsey, Working Paper 44, Canadian Institute for International Peace and Security, June 1992. More details concerning the timing problems resulting from satellite kinetics can be found in the Annex to "Some Quantitative Aspects of Verification," presentation by George Lindsey to the International Amaldi Conference of Academies of Sciences and National Scientific Societies, Heidelberg, Germany, July, 1992.