EVIDENTIAL REASONING: AN IMPLEMENTATION FOR MULTISENSOR INTEGRATION

Technical Note 307

December 1983

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The work reported herein was partially supported by the Office of Naval Research under Contract N00014-81-C-0115 (SRI Project 2404) and by the Information Processing Techniques Office of the Defense Advanced Research Projects Agency and monitored by the Air Force Wright Aeronautical Laboratories (AFWAL/AAWP) under Contract F33615-80-C-1110 (SRI Project 1655).

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **DEC 1983**	2. REPORT TYPE	3. DATES COVERED **00-12-1983 to 00-12-1983**

4. TITLE AND SUBTITLE **Evidential Reasoning: An Implementation for Multisensor Integration**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **SRI International,333 Ravenswood Avenue,Menlo Park,CA,94025**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**116**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ABSTRACT

One common feature of most knowledge-based expert systems is that they must draw conclusions on the basis of evidential information. Yet there is very little agreement on how this should be done. Here we present our view of this problem and its solution for multisensor integration. We begin by characterizing evidence as information that is uncertain, incomplete, and sometimes inaccurate. On the basis of this characterization, we conclude that evidential reasoning requires both a method for pooling multiple bodies of evidence to arrive at a consensus and some means of drawing the appropriate conclusions from that consensus. We contrast our approach, which is based on a relatively new mathematical theory of evidence, with those that have their basis in Bayesian probability models. We believe that our method has significant advantages in its ability to represent and reason from bounded ignorance. We describe an implementation of these techniques by means of two kinds of memory: long- and short-term. This implementation provides for automated reasoning from evidential information at multiple levels of abstraction over time and space.

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INTRODUCTION

Reasoning from uncertain, incomplete, and sometimes inaccurate information is necessary whenever any system is to interact in an intelligent way with its environment. This follows directly from the fact that understanding the world is possible only by perceiving it through a set of knowledge sources that provide partially processed sensory information. Because of the limited capabilities of any sensor, the information is inherently "evidential." That is, perceptual information is not readily captured in terms of simple truths and falsities or in terms of probabilistic estimates, when the appropriate statistical data are lacking. Therefore, neither logical nor standard probabilistic reasoning techniques are uniformly applicable in this context.

This is exactly the case for most knowledge-based expert systems. More specifically, if an expert system is to be built for multisensor integration, where the information available from radars, ESM receivers, intelligence reports, and the like is inherently evidential, then it is has to reason according to degrees of partial belief. Yet, in this domain and others for which expert systems have been built, the appropriate statistical data for Bayesian reasoning are both unavailable and unobtainable. This dilemma has typically caused expert-system designers to either abandon formal approaches altogether or to modify a formal approach to reason with subjective estimates of probabilities. In either case, the advantages of a sound formal basis are largely lost. The problem is that the formalisms employed still require more information than is available. This leaves us with the need to develop new techniques that will allow us to reason effectively from truly available evidential information. Such techniques are essential if we are ever to construct systems capable of true perception.

Our recent work in the area of multisensor integration, building upon our previous work in this area [Garvey, Fischler 1980; Garvey, Lowrance, Fischler 1981; Lowrance

1982], has led us to take a closer look at evidential reasoning. Our interests lie in the development of a computational theory of evidential reasoning and its application to knowledge-based systems. Here we present our working definitions of evidence and evidential reasoning, describe the basis of our current approach to the construction of a suitable computational model, contrast this approach with the more traditional Bayesian approach, discuss some open problems, and describe the specific system we have implemented for multisensor integration.

We shall focus this discussion on the specific multisensor integration problem faced by an aircraft attempting to compile and monitor an air defense order of battle in support of a penetration mission. This involves integrating the information provided by sensors onboard the aircraft with knowledge of air defense operations, to form a composit picture of what (ground-based) air defense elements are present, where they are located, and what they are doing.

THE NATURE OF EVIDENCE

What characterizes the information provided by a knowledge source? Consider the problem of integrating information provided by multiple, disparate sources with prior knowledge of a situation in which each knowledge source is observing a portion of the electromagnetic environment and attempting to locate and classify physical objects in that environment on the basis of the observed electromagnetic activity. This presupposes that each knowledge source (partially) understands which observables could be linked with each type of object. However, this is not a straightforward task. At times, discriminating among these various types of objects will require making some fine distinctions from noisy data. A typical knowledge source might consist of a radar and its operator. The operator arrives at judgments about what is and is not in the environment according to the information displayed before him on the radar screen. His resulting beliefs constitute a body of evidence.

We have identified three characteristic features of evidence. First of all, evidence is generally **uncertain**. A knowledge source probing an environment does not usually reveal precisely what that environment contains. Instead, it typically leads one to attribute varying degrees of belief to several environmental possibilities. These degrees of belief reflect the relative strength of the contributing evidence as it bears on each possibility. In the case of the radar operator, he is frequently unwilling to make definite statements about what is in the environment. Yet he is willing to state that some possibilities seem more likely than others.

Second, the information a knowledge source can provide is almost always **incomplete**. That is, the precise degree of belief that should be accorded every environmental possibility generally cannot be known on the basis of a single body of evidence. Any single body of evidence might determine the degree to which one possibility should be believed, while remaining totally noncommittal with respect to another. This is to say that ignorance (as a bounded quantity) is an important component of evidential information. Understanding what remains unknown is just as important as understanding what is known. The radar operator may have determined that there very likely is an object at a particular location, yet have little opinion as to its type—and little or no opinion at all about what might be found at other locations.

Third, at times these evidential beliefs will be **incorrect**. We may characterize these errors along a scale from minor "measurement" errors, increasing in severity, to "gross" errors. If a knowledge source's information is largely correct except for some minor miscalculations, as might naturally occur near its bounds of resolution, then its conclusions will contain some measurement errors. On the other hand, if the information is largely incorrect, as might be expected because of some qualitative error, then it contains gross errors. This is further complicated by the fact that any body of evidence might be largely correct about some things, yet incorrect to varying degrees about other things.

REPRESENTING EVIDENCE

Bearing these three characteristic features in mind, we can begin to consider how evidence might be represented. Since evidence is typically uncertain, it is clear that something beyond a purely logical approach is necessary. Boolean expressions of propositional truth and falsity are inadequate because they fail to capture any notion of the relative strength of partial beliefs. Nevertheless, there are times when evidence is well expressed in terms of certain truths and falsities. Therefore, although a Boolean representation is not adequate, Boolean expressions must be represented.

Partial beliefs are frequently represented by probabilities. A Bayesian probability model would thus seem a likely candidate for representing evidential information. In fact, the Bayesian probability model is the basis for much of the work in expert systems [e.g., Duda, Hart, Nilsson 1976; Duda, Hart, Konolige, Reboh 1979; Lemmer, Barth 1982; Pearl 1982]. However, this approach has some inherent limitations—most significantly, its inability to capture the incompleteness of evidence.

Let us consider the radar operator in more detail. Suppose that there are a fixed set of environmental possibilities,

$$\Theta = \{\theta_1, \theta_2, ..., \theta_n\},$$

with every proposition of interest either true or false relative to each possibility. Then each proposition is completely defined by the subset of Θ containing exactly those environmental possibilities where the proposition is true. For example, the proposition "a SAM (surface-to-air missile system) is at location (x, y)" corresponds to the subset of environmental possibilities where some kind of SAM is at (x, y), (Figure 1). Θ should be chosen to preserve just those details that are essential. If two elements of Θ cannot be distinguished in terms of at least one proposition of interest, those elements should be replaced by a single one. This is the conventional way of expressing a propositional space in terms of sets to the required level of detail.

Now the radar operator can express his partial beliefs through a Bayesian distribution over Θ. This is done by distributing a unit of belief among the elements of Θ, attributing commensurately greater amounts to the more likely elements. Let us designate this distribution by the mapping dist:

$$\mathit{dist} : \Theta \mapsto [0, 1],$$

$$\sum_{\theta \in \Theta} \mathit{dist}(\theta) = 1.$$

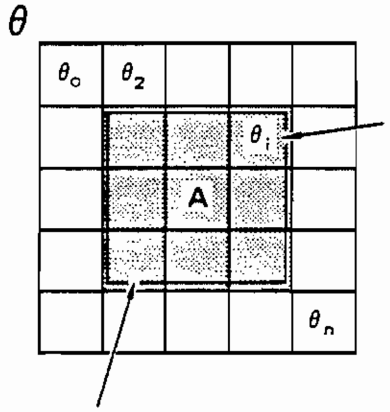
This induces a probability on every proposition A defined over this space (Figure 2),

$$\text{for all } A \subseteq \Theta, \quad \mathit{Prob}(A) = \sum_{\theta \in A} \mathit{dist}(\theta),$$

and it follows that

$$\mathit{Prob}(A) = 1 - \mathit{Prob}(\neg A).$$

The problem with this approach is that the radar operator has to determine a precise probability for every proposition in the space no matter how impoverished the evidence. This would not be such a problem if there were a rich source of statistical data for this domain from which these probabilities could be estimated. However, in a domain as expansive and dynamic as this one, the appropriate statistical data are not only unavailable, but unobtainable.

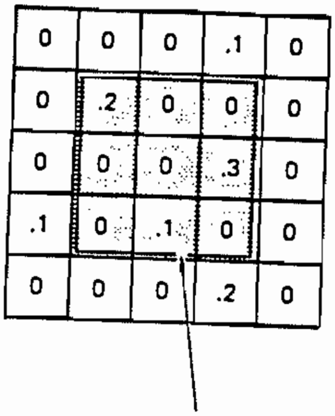


Each θ_i represents a description of a possible environmental situation, including the type, location, and activity of all air defense entities.

Each proposition A corresponds to the set of possible situations in which A is true. If proposition A states "a SAM is at location (x,y)", then A is the subset of θ containing all of those situations in which some kind of SAM is at location (x,y).

FIGURE 1 A FRAME OF DISCERNMENT

$$\text{dist:}\ \theta \rightarrow [0, 1];\ \sum_{\theta_i \in \theta} \text{dist}(\theta_i) = 1$$



0	0	0	.1	0
0	.2	0	0	0
0	0	0	.3	0
.1	0	.1	0	0
0	0	0	.2	0

$$\text{Prob}(A) = \sum_{\theta_i \in A} \text{dist}(\theta_i) = .2 + .3 + .1$$

$$= .6$$

$$\text{Prob}(\neg A) = \sum_{\theta_i \in \neg A} \text{dist}(\theta_i) = .1 + .1 + .2$$

$$= .4$$

$$\text{Prob}(A) = 1 - \text{Prob}(\neg A)$$

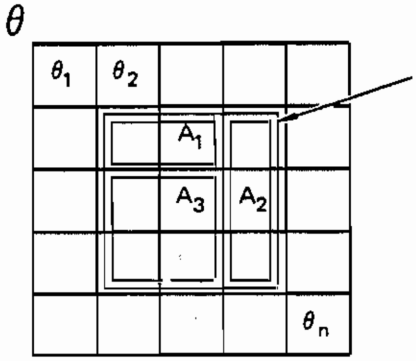
FIGURE 2 BAYESIAN DISTRIBUTIONS AND PROBABILITIES

Reasoning based on subjective estimates of these probabilities is similarly intractable. Consider the difficulty in estimating the chance that a highly mobile SAM is in a given location at a given time. How do we interpret a low probability? Does it mean we have not observed that location and have no particular reason to believe the SAM is present, or is it that we have made a direct observation and have a strong reason to disbelieve its presence? The difference takes on considerable significance in this domain if current plans call for an aircraft to be flying over that location at that time. The point is that intuition is destined to fail at this level of detail, leading to an inconsistent, unjustifiable, and unverifiable model. Point estimates of probabilities are incompatible with the available precision!

The fundamental problem with a Bayesian representation of evidence is that there is no adequate representation for ignorance. However, satisfactory results can be obtained in some cases by employing the *principle of indifference*. The essence of this principle is as follows: (1) we recognize that a probability assignment is a means of describing a state of knowledge; (2) if the available evidence gives us no reason to consider one proposition either more or less likely than another, then the only reasonable way we can describe our state of knowledge is to assign them equal probabilities. Thus, if our evidence suggests that the disjunction of the mutually exclusive propositions A_1, A_2, and A_3 should be assigned a probability of .6, and if there is no reason to prefer any one of these to another, then, according to the principle of indifference, one should assign them each a values of .2. As a result, there is no way to decide among A_1, A_2, and A_3 on the basis of their probabilities. Unfortunately, there is a distinct preference for the disjunction of any two of these propositions over the third, since the probability of the disjunction is .4, twice the probability of the third. If the evidence in fact provides no reason to prefer these disjunctions to the singletons, there are several incompatible ways in which the principle might be applied. The problem is compounded even further if these propositions are themselves disjunctions of other, more primitive, propositions (Figure 3). Of course, this presents a problem only if we are simultaneously interested in choosing among all these propositions, but this is frequently the case. For example, the radar operator will be simultaneously interested in knowing whether or not objects are present, whether they are friend or foe, what actions they are taking, and whether they present any immediate danger.

This confusion is avoided in *A Mathematical Theory of Evidence*, originally conceived by Arthur Dempster [Dempster 1968] and further developed by Glenn Shafer [Shafer 1976]. In this theory, the belief in a proposition A is represented by an interval $[Spt(A), Pls(A)]$. Each such "evidential interval" is a subinterval of the closed real interval $[0, 1]$. The lower bound $Spt(A)$ represents the degree to which the evidence **supports** the proposition; the upper bound $Pls(A)$ represents the degree to which the evidence fails to refute the proposition, i.e., the degree to which it remains **plausible**; and the difference $Pls(A) - Spt(A)$ represents the residual ignorance. When this technique is used, complete ignorance is represented by the unit interval $[0, 1]$ while a precise-likelihood assignment is represented by the "interval" collapsed about that point. Other degrees of ignorance are captured by evidential intervals with widths greater than 0 and less than 1. The above dilemma is avoided when this theory is applied, since the singleton propositions and their disjunctions can all be assigned identical intervals simultaneously. Thus, the principle of indifference holds, but over intervals instead of probabilities.

These intervals are induced by a "mass distribution," which differs only slightly from a Bayesian distribution. A Bayesian distribution distributes a unit of belief across a set of mutually exclusive and exhaustive propositions. Then the probability of any given proposition A is just the sum of the belief attributed to those propositions that



Prob (A)
= Prob $(A_1 \cup A_2 \cup A_3)$
= .6
Prob (~A) = .4

$$\text{Given} \quad \text{Prob}\,(A) = \sum_{\theta_i \epsilon A} \text{dist}\,(\theta_i) = .6$$

$$\text{then} \quad \text{dist}\,(\theta_i) = ?$$
$$\text{Prob}\,(A_i) = ?$$

FIGURE 3 FROM INCOMPLETE INFORMATION, WHAT DISTRIBUTION?

imply A (or conversely, one minus the sum of the belief attributed to those propositions that imply not A, $\neg A$). The probability of A plus the probability of $\neg A$ is constrained to equal one. A mass distribution also distributes a unit of belief over a set of propositions, but these focal propositions need not be mutually exclusive. Mass can be attributed to any propositions in the space.

$$mass : 2^{\Theta} \mapsto [0,1],$$

$$\sum_{F \subseteq \Theta} mass(F) = 1,$$

$$mass(\emptyset) = 0.$$

Therefore, the sum of the mass attributed to propositions that imply A (i.e., $Spt(A)$) plus the sum of the mass attributed to propositions that imply $\neg A$ (i.e., $Spt(\neg A)$) do not necessarily equal one, since some mass might be attributed to propositions that imply neither one. An interval is induced thereby on the probability of A (Figure 4).

$$Spt(A) = \sum_{F \subseteq A} mass(F),$$

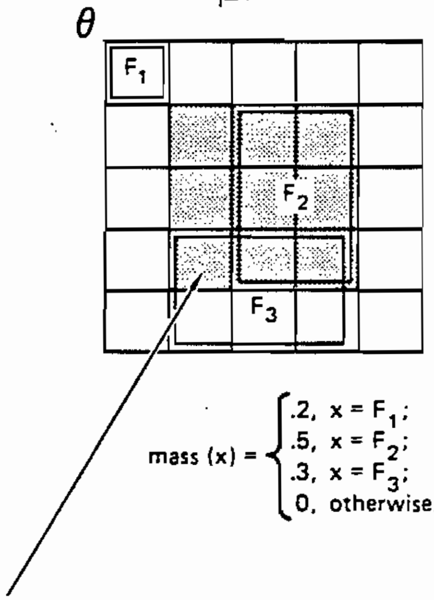
$$Pls(A) = 1 - Spt(\neg A) = 1 - \sum_{F \subseteq \neg A} mass(F),$$

Thus, relative to any mass distribution, there is a nonempty set of Bayesian distributions, each of which satisfies the following:

$$\text{for all } A \subseteq \Theta, \quad Spt(A) \leq Prob(A) \leq Pls(A).$$

Viewed intuitively, mass is attributed to the most precise propositions a body of evidence supports. If a portion of mass is attributed to a proposition, it represents a minimal commitment to that proposition as well as to all the propositions it implies. Additional mass suspended "above" that proposition—i.e., at propositions that neither imply it nor imply its negation—represents a potential commitment. This mass neither

$$\text{mass}: 2^{\theta} \rightarrow [0, 1]; \quad \sum_{F_i \subseteq \theta} \text{mass}(F_i) = 1; \quad \text{mass}(\phi) = 0.$$



$$\text{mass}(x) = \begin{cases} .2, & x = F_1; \\ .5, & x = F_2; \\ .3, & x = F_3; \\ 0, & \text{otherwise.} \end{cases}$$

$$\text{Spt}(A) = \sum_{F_i \subseteq A} \text{mass}(F_i) = \text{mass}(F_2) = .5$$

$$\text{Spt}(\neg A) = \sum_{F_i \subseteq \neg A} \text{mass}(F_i) = \text{mass}(F_1) = .2$$

$$\text{Pls}(A) = 1 - \text{Spt}(\neg A) = 1 - .2 = .8$$

$$\text{Evidential Interval for } A = [\text{Spt}(A), \text{Pls}(A)] = [.5, .8]$$

FIGURE 4 MASS DISTRIBUTIONS AND EVIDENTIAL INTERVALS supports nor denies that proposition at the moment, but might later shift either way on the basis of additional information. The amount of mass so suspended above a proposition accounts for the relative ignorance remaining about it, that is, the residual latitude in its probability according to all considered evidence. Thus, if mass is associated with the disjunction of mutually exclusive propositions A and B, this represents potential commitments to A and to B that have not yet been realized, as well as an immediate commitment to their disjunction and all that it implies. If more information were available, this mass would be distributed between A and B rather than being attributed to their disjunction. Mass attributed directly to the disjunction of all propositions (i.e., Θ), is neutral with respect to all propositions, providing an equal potential for each, and representing the degree to which the evidence fails to determine anything.

The primary advantage of this approach is that each knowledge source can express itself at a level of detail of its own choosing. When there is no clear reason to prefer one proposition to another, that judgment can be suspended. Thus, a radar operator can express some belief that an object is at a given location without having to speculate as to that object's type. A Bayesian approach would require that a precise probability be assigned to each type, no matter how noisy the sensory data, and no matter how little statistical data are available from which to make justifiable estimates.

This ability to represent ignorance reduces the likelihood of erroneous knowledge-source reports. A knowledge source can represent exactly what it believes without having to speculate about things for which it has little or no pertinent information. Since the representation does not elicit unsupported statements, the likelihood that the reports are correct is enhanced. Of course, there is nothing to prevent a knowledge source from being fundamentally mistaken, but at least the representation itself does not introduce additional errors.

EVIDENTIAL REASONING

Given several bodies of evidence, there are two distinct reasoning processes that must be carried out. One of these takes a single body of evidence at a time and extends its scope from those propositions that the evidence directly bears upon to those it indirectly bears upon, allowing the confidences of some propositions not explicitly mentioned to be inferred from those that are. The basis for this **extrapolation** process is that belief in some propositions entails belief in others. If one believes that proposition A is likely true and that A logically implies proposition B, then one can conclude that B is likely true. Based on an understanding of the logical dependencies in an environment, this process allows one to predict the ramifications of one's beliefs.

If a source of evidential information is prone to occasional errors, so will be the conclusions based upon that information. Since the consensus of several independent opinions is generally more reliable than any one of them individually, conclusions should be based upon the combined views of several disparate sources. This suggests the other essential reasoning process—one that **pools** multiple bodies of evidence, thus culminating in a single body of evidence that represents the consensus of these disparate opinions. This process needs to be sensitive both to the degrees of dependence among the bodies of evidence and to the types of errors they might contain, since the appropriate method of compensation depends on these factors.

In a number of existing expert systems [Shortliffe, Buchanan 1975; Duda, Hart, Konolige, Reboh 1979; Lemmer, Barth 1982; Pearl 1982], these two reasoning processes are not differentiated. One finds instead a single reasoning process that performs the same computation no matter what the source of the initial beliefs. Thus, the result is the same—whether the initial beliefs all represent the opinion of a single source or the distinct opinions of several disparate sources. Clearly, this confusion needs to be avoided.

TECHNIQUES FOR EVIDENTIAL REASONING

Based on either a Bayesian or Shafer-Dempster approach, the extrapolation process is theoretically simple. As has been previously discussed, the probability of any proposition A, based on a body of evidence represented by a Bayesian distribution *dist*, is just the total belief attributed by *dist* to propositions that imply A; or, conversely, one minus the total belief attributed to propositions that imply $\neg A$. This picture is only slightly more complicated for the Shafer-Dempster approach. The support for a proposition A is the total belief attributed by the *mass* distribution to propositions that imply A and its plausibility is one minus the total belief that *mass* attributes to propositions that imply $\neg A$. Thus, the Bayesian approach requires a single computation, for which there are two alternative methods—whereas the Shafer-Dempster approach requires that two distinct computations be performed.

In either case, the computations are based on an understanding of the propositional dependencies that exist within the environment. Formally, this was captured by defining all propositions of interest with respect to a space of environmental possibilities Θ. Then there was a direct correspondence between propositional dependence in the environment and propositional relationships within Θ. If the domain of application is large and complex, the computational requirements of Θ can be prohibitive. This certainly would be the case for the real-world domain of identification of the sources of electromagnetic signals.

When Θ is both large and complex, it is computationally infeasible to generate and maintain a complete model. An incomplete model has to suffice, probably in the form of a deductive model [Konolige 1983] consisting of a base set of axioms and a procedure for deducing consequences from the base set. But this creates a problem for the Bayesian approach. What can be done when entailment can be neither proved nor disproved because of the incompleteness of the model? If some belief has been attributed to proposition A by a Bayesian distribution and, because of the model's incompleteness, it is unknown whether A implies B or whether A implies $\neg B$, then the probability of B cannot be determined. This is the same dilemma as before. The Bayesian theory requires that all belief be divided between a proposition and its negation, leaving no room for ignorance.

Just as before, this dilemma is avoided with the Shafer-Dempster approach. If mass has been attributed to some proposition A and it is not known whether A implies B or whether A implies $\neg B$, then judgment can be suspended. The mass attributed to A neither increases the support for B nor decreases the plausibility of B, but contributes to their difference, representing what remains unknown. Once again the ability to represent ignorance gives Shafer-Dempster a clear advantage over the Bayesian approach.

Unfortunately, neither approach has a completely satisfying method of pooling evidence. Both have a combination rule, but their applicability is limited. For the Bayesian approach, *Bayes' rule of conditioning* is the combination rule. It describes how a Bayesian distribution $dist$ is transformed into a distribution $dist'$ that reflects the additional information that some proposition A is true. The new Bayesian distribution $dist'$ is formed by restricting the domain of $dist$ to elements of A, discarding any belief attributed to other elements, and normalizing.

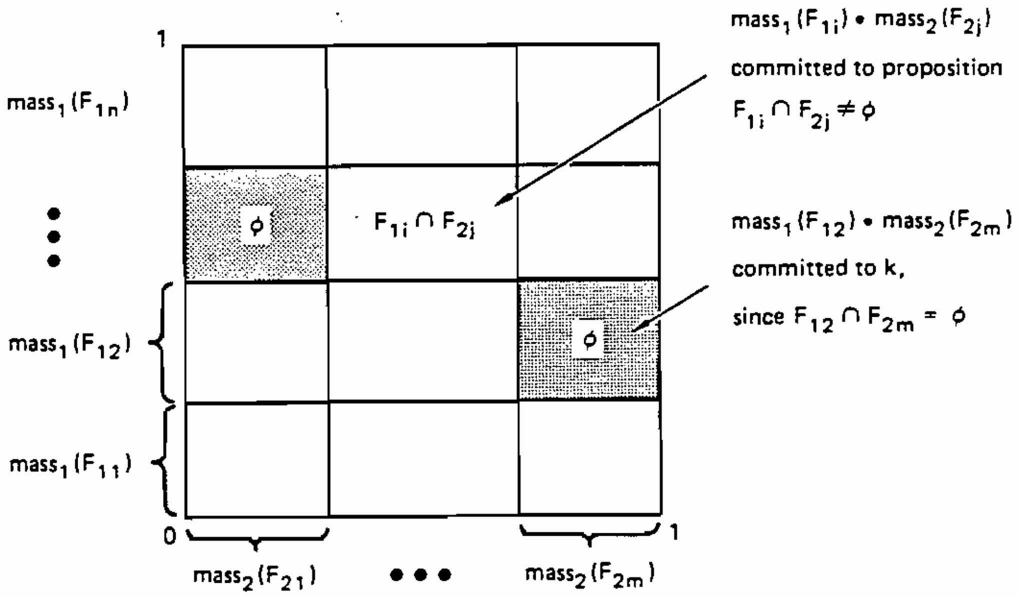
$$\text{For all } \theta \in \Theta, \quad dist'(\theta) = \begin{cases} 0, & \text{if } \theta \notin A; \\ (1-k)^{-1}\, dist(\theta), & \text{if } \theta \in A; \end{cases}$$
$$k = \sum_{\theta \notin A} dist(\theta) < 1.$$

As a result, all belief is confined to those propositions that support A, while the relative belief among those propositions remains the same. However, this does not address the general question of how to combine two distinct bodies of evidence, each represented by a Bayesian distribution, to form a third. Bayes' rule is useful, as far as it goes, but it just does not go far enough, since evidence generally is not expressible in terms of absolute belief in a single proposition.

Dempster's rule of combination pools multiple bodies of evidence represented by mass distributions. Like Bayes' rule, Dempster's rule moves belief towards propositions that are supported by both bodies of evidence and away from all others. In fact, it can be viewed as a direct generalization of Bayes' rule, since it produces the same results when given the same information. However, unlike Bayes' rule, it does not require that one body of evidence support a single proposition with certainty. It takes arbitrarily complex mass distributions $mass_1$ and $mass_2$ and, as long as they are not completely contradictory with respect to each other (i.e., there is at least one proposition that they both partially support), produces a third mass distribution $mass_3$ that represents the consensus of those two disparate opinions (Figures 5 and 6).

$$\text{For all } F_1, F_2, F_3 \subseteq \Theta, \quad mass_3(F_3) = (1-k)^{-1} \sum_{F_1 \cap F_2 = F_3} mass_1(F_1) mass_2(F_2),$$
$$k = \sum_{F_1 \cap F_2 = \emptyset} mass_1(F_1) mass_2(F_2) < 1.$$

There are several interesting computational aspects of Dempster's rule. To begin with, it is both commutative and associative. Therefore, the order and the grouping of combinations are immaterial. This permits results to be obtained through hierarchical combinations of partial results, with whatever degree of parallelism the host hardware

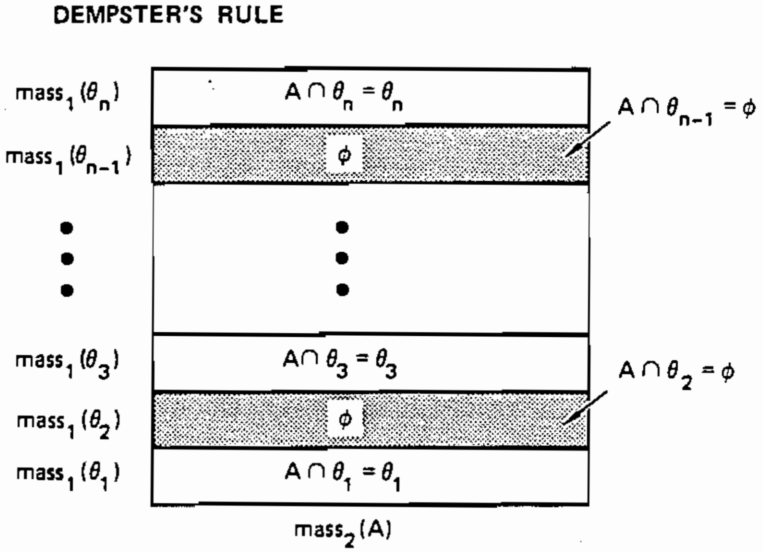


For all $F_1, F_2, F_3 \subseteq \theta$

$$\text{mass}_3(F_3) = (1-k)^{-1} \sum_{F_1 \cap F_2 = F_3} \text{mass}_1(F_1) \bullet \text{mass}_2(F_2)$$

$$k = \sum_{F_1 \cap F_2 = \phi} \text{mass}(F_1) \bullet \text{mass}(F_2)$$

FIGURE 5 DEMPSTER'S RULE OF COMBINATION



For all $\theta_j \in \theta$,

$$\text{mass}_3(\theta_j) = (1 - k)^{-1} \sum_{\theta_i \in A} \text{mass}_1(\theta_i)$$

$$k = \sum_{\theta_i \in A} \text{mass}_1(\theta_i)$$

For all $F_3 \subseteq \theta$,

$$\text{Prob}(F_3 | A) = \sum_{\theta_i \in F_3} \text{mass}_3(\theta_i)$$

FIGURE 6 BAYES' RULE AS A SPECIAL CASE OF DEMPSTER'S RULE can support. The mathematical load is insignificant. The logical load, which consists of resolving various conjunctions, depends on the complexity and completeness of the model. Whenever a conjunction cannot be resolved immediately, because of either the incompleteness of the logical model or some computational limit, judgment can be suspended by reserving the appropriate portion of mass for that unresolved conjunction, thereby preventing it from influencing the support or plausibility of any propositions. If the conjunction should later be resolved, this mass can be redistributed in the appropriate place(s) and the existing restriction of its influence upon other propositions removed.

While Dempster's rule is applicable in a wider range of situations than Bayes' rule, it is still limited. Dempster's rule requires that the bodies of evidence to be combined be independent (explained below) and that their errors be restricted to measurement errors. If the bodies of evidence are somewhat dependent or their errors cannot be accurately described as measurement errors, the available theory is insufficient. Unfortunately, these conditions are frequently difficult to avoid.

However, there are means of dealing with these problems. Dempster's rule also provides some information, over and above the resulting pooled evidence, that helps solve the problem of dealing with gross errors. This additional information, in the form of a measure of "conflict," is a by-product of the combination. This value k can be interpreted intuitively as the degree to which the combined opinions are contradictory. We use this value as a distance measure between bodies of evidence. Given several bodies of evidence, we expect that those containing gross errors will tend to be farther away from the other bodies of evidence than those with measurement errors.

Consequently, one can employ clustering algorithms, like those used in computer vision, to sort out those bodies of evidence containing gross errors. Each remaining cluster represents a set of basically commensurate opinions that differ only by virtue of measurement errors. If more than one cluster remains, they can each be interpreted as a distinct point of view on the environment. Presumably, each must be conditioned by at least one assumption that is contradictory to those assumptions conditioning the others. It is therefore appropriate to explore each of these alternatives separately, trying to either prove or disprove the validity of each through additional information.

The other condition for the application of Dempster's rule, evidential independence, is not as readily overcome. We say that two bodies of evidence are independent if the likelihood of one being in error is unrelated to the likelihood of the other being in error. Say we combine two bodies of evidence E_1 and E_2 to form a third $E_{1\oplus 2}$, and we also combine E_2 with another body of evidence E_3 to form $E_{2\oplus 3}$. $E_{1\oplus 2}$ and $E_{2\oplus 3}$ are evidentially dependent, since the accuracy of E_2 affects both of them (Figure 7). If E_2 is in error, so are $E_{1\oplus 2}$ and $E_{2\oplus 3}$. The problem is that, even when we know that $E_{1\oplus 2}$ and $E_{2\oplus 3}$ are dependent through E_2, there is no current method for combining $E_{1\oplus 2}$ and $E_{2\oplus 3}$ to get the cumulative benefit of all of the evidence. If we used Dempster's rule despite this partial dependence, the result would be overly weighted towards the opinion expressed by E_2. Without the ability to correctly combine bodies of evidence with known dependencies, we must maintain each body of evidence independently at a substantial cost. It seems likely that an approximate method could be developed for the combination of evidence with known dependencies. Although it is unlikely that the effect of these dependencies could be totally eliminated, the ability of the base theory to reason with limited information (bounded ignorance) fosters some hope.

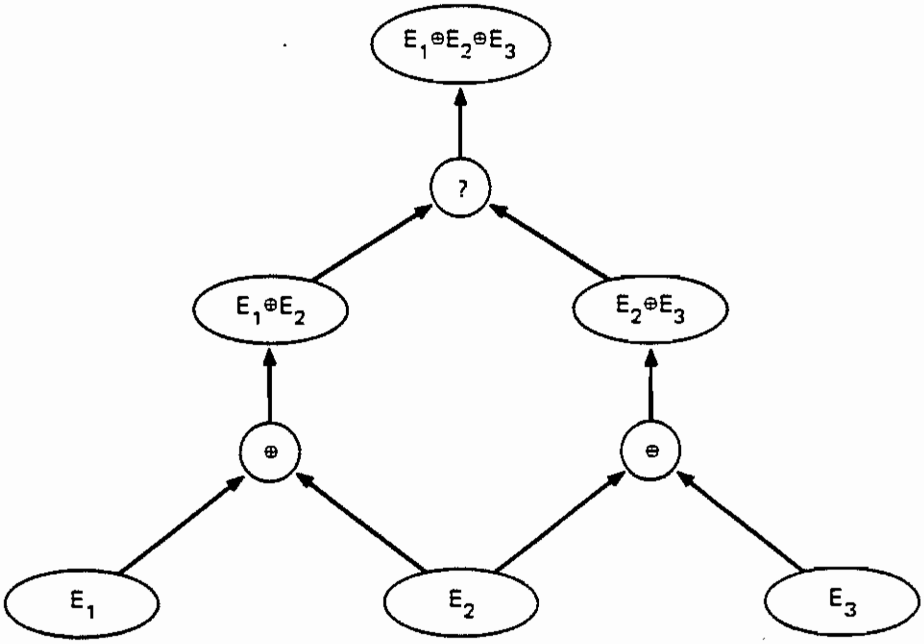


FIGURE 7 PARTIALLY DEPENDENT EVIDENCE

LONG-TERM MEMORY

For one to reason evidentially, one must first be able to reason about possibilities—that is, one must know what world events are possible and how they might be interrelated. We represent this possibilistic knowledge in a structure called long-term memory (LTM) [Williams, Lowrance 1977; Hanson, Riseman 1978]. It describes the generic classes of entities that exist potentially in the world, the various states they can assume, and how these entities and their states are interrelated.

A standard production-rule approach to representing this possibilistic information would seem to be a likely prospect. However, there are several significant problems entailed in its application. The foremost is that it is extremely difficult to select and coordinate all of the potentially relevant rules. Not only does the knowledge that an SA-4 (a specific type of surface-to-air missile system) is currently in acquisition mode allow one to infer that it might next go into target-tracking mode (if a possible target is approaching), but the knowledge that an SA-4 is in target tracking mode also leads one to conclude that it might next go into acquisition mode (since the target might be moving away). The fact that potentially relevant information is often highly interrelated makes it impossible (or, at least, undesirable) to preselect the "direction" in which the information should flow; the roles of evidence (i.e., stimulus) and hypothesis (i.e, response) may become reversed, depending on the given situation. This confounds the description of knowledge in terms of localized directed rules; a more highly integrated description is required. Other problems with a standard rule-based approach stem from the Bayesian-based nature of the rule strengths and the likelihoods of the hypotheses. The use of Bayesian point probabilities leads to a number of difficulties, as previously discussed.

A fragment of LTM describing an SA-4 appears in Figure 8. Each node in this graph represents a state that an SA-4 can assume. These particular states were chosen because the SA-4's electromagnetic emissions and its lethality are characteristically different in each of them. In other words, these states distinguish the critical differences in "appearance" of an SA-4 throughout its operational cycle. The arcs between these nodes represent the possible state transitions. For example, the TTR (target-tracking) node is connected to the ML (missile launch) node by an outpointing arc labeled with a gating condition that requires the range to be less than 3500 meters. This represents the idea that an SA-4 will move from target tracking mode to missile launch mode when the range to its target drops below 3500 meters. The other arcs are similarly interpreted.

If we know there is an SA-4 in TTR mode, then, on the basis of the information in this graph, we can predict that it will either remain in TTR mode, or move to ML or ACQ (acquisition) mode. This prediction can be made more precise if some range information is available. For example, from a rough estimate of the location of the SA-4 and a precise location for the aircraft it is tracking, the range might be known to be somewhere between 3250 and 4000 meters. In which case, the SA-4 could not move to ACQ mode, but must either remain in TTR mode or move to ML mode. Other operational constraints can be similarly captured and utilized to refine predictions.

An SA-4 is one example of a threat system. Other such systems are similarly described in LTM. Collectively, they form the TS (threat system) level. At lower levels of abstraction in LTM, the E (emitter) level contains operational descriptions of the various types of emitters that might be encountered, while the S (sensor) level describes the types of sensors that are aboard the aircraft. Above the TS level is the BG (battle group) level. Together these levels form a hierarchy of abstraction. Each sensor is

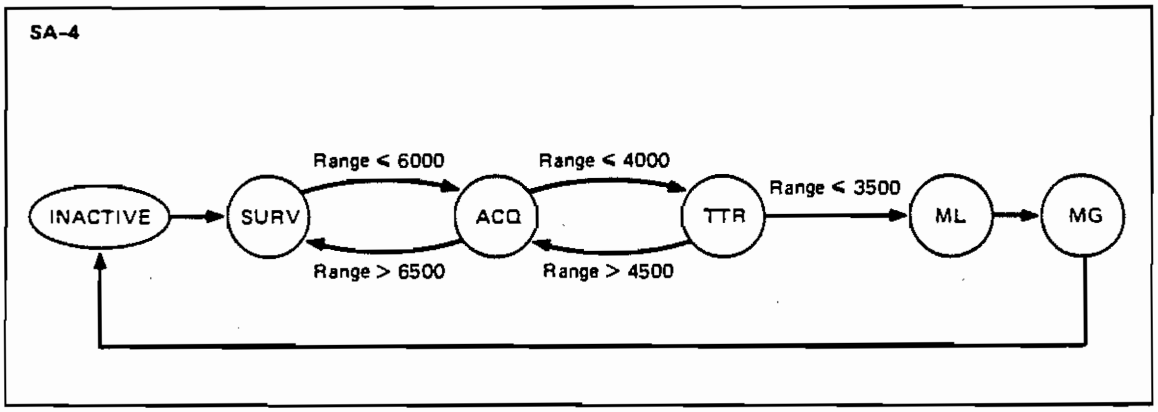


FIGURE 8 REPRESENTATION OF AN SA-4 IN LTM

capable of detecting a subset of the emitters, each emitter may be part of one or more different types of threat systems, and each threat system can participate as a component of one or more battle groups. These interlevel relationships are represented by connecting arcs. Thus, in Figure 9 we see that an SA-4 system might consist of both a Long Track and a Pat Hand (NATO code names for specific types of radars), that these are both detectable by an RWR (radar warning receiver) and that an SA-4 can participate as part of either a BG1 or BG2 battle group. Here too it is the possible interrelationships that are captured.

Each entity in LTM, regardless of its level, is represented by a state transition graph (Figure 10). These states represent a partitioning of the various ways in which sensors can be tuned. Just as the entities at each level are connected to the compatible entities above and below, so are the states similarly connected to compatible states above and below. Consequently, not only can it be determined that a Pat Hand might be part of an SA-4, but, if it is also known that that Pat Hand is in TTR mode, then that SA-4 must also be in TTR mode; furthermore, one way of detecting that Pat Hand in TTR mode is to task an RWR in MODE6 (a sensor mode corresponds to a particular setting of the sensor's control variables).

LTM can be viewed as an axiomatic database, with a graphical indexing structure, that supports efficient possibilistic reasoning. It allows propositional statements about the possibilities at one abstraction level to be transferred to other levels or be projected either forward (or backwards) in time. Because a single possibility can—and frequently does lead to multiple possibilities while moving between levels or through time, the "inverse" operation is not guaranteed to return just the original possibility. For example, from knowledge of a Pat Hand, one can infer that there might be an SA-4, and, from an SA-4, that there is either a Long Track or a Pat Hand. Of course, this is

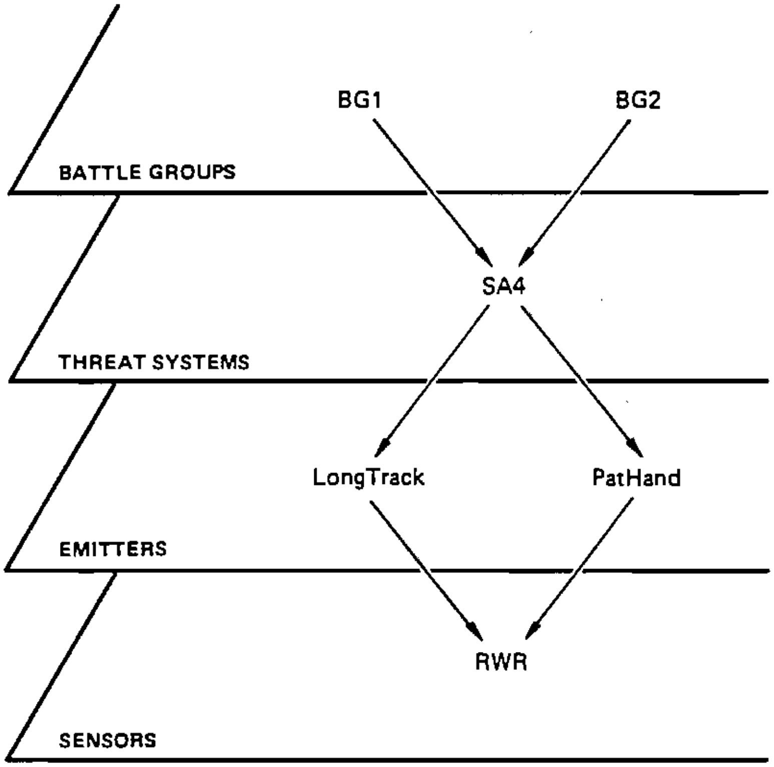


FIGURE 9 THE HIERARCHICAL LEVELS OF LTM

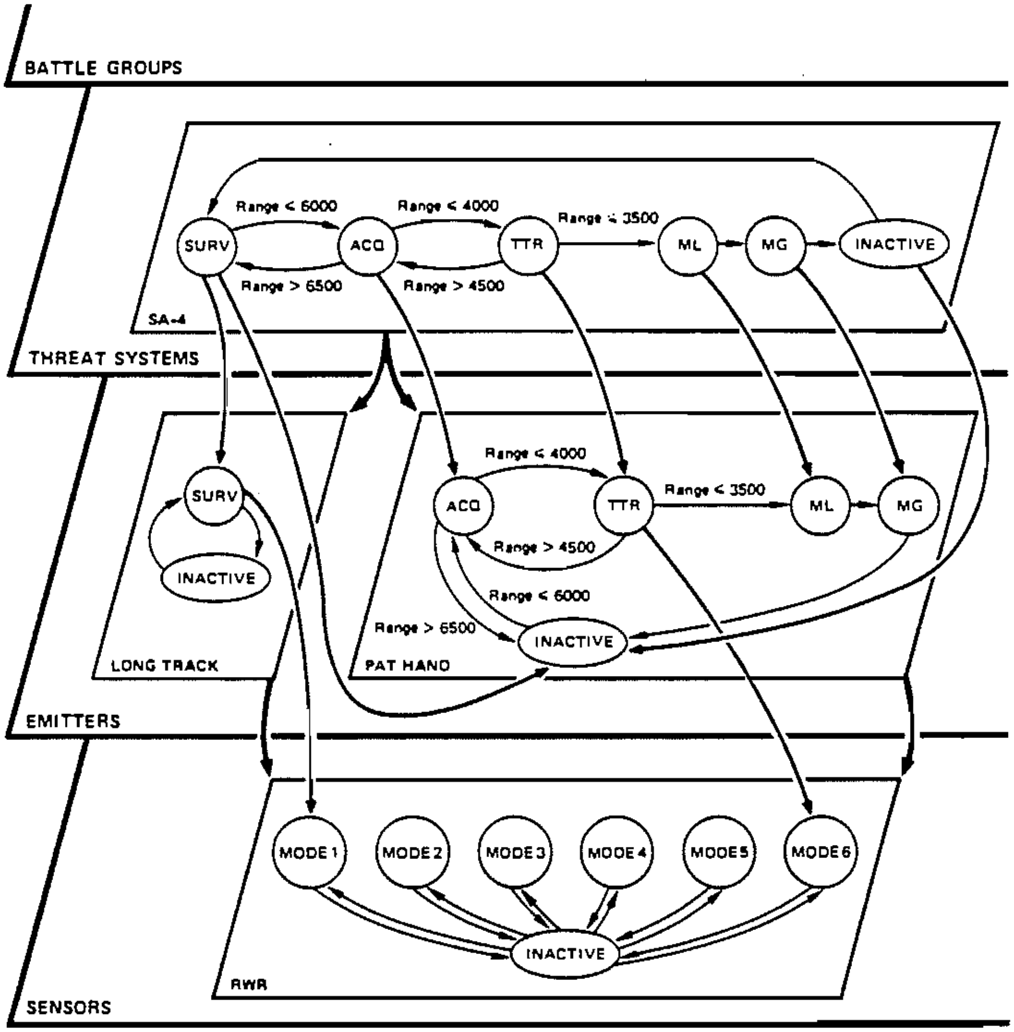


FIGURE 10 A FRAGMENT OF LTM

true. There is either a Long Track or a Pat Hand, but, if one has not been careful, one might not be aware that this conclusion has been drawn directly from knowledge of the Pat Hand. However, if proper care has been exercised, this might suggest that a Long Track should be sought to verify the presence of the SA-4.

EVIDENCE OVER LTM

In essence, LTM serves as an incomplete, axiomatic model of Θ, that is sufficient for limited evidential reasoning. A complete model of Θ would distinguish some cases that LTM does not, but would be computationally intractable. For example, it is not clear from LTM whether an SA-4 always includes both a Long Track and a Pat Hand. It will accept the possibility that an SA-4 consists of just a Long Track, just a Pat Hand, or both. We give up some precision for the sake of computational simplicity. But this is not the problem it might seem at first. This follows since this multisensor integration system is imbedded within a perceptual-reasoning system that actively cues sensors, seeking confirming or refuting evidence relative to hypothesized entities. It is designed to correct for errors and is equally effective regardless of the source of the error, be it the sensors or the deductive component of LTM.

Bodies of evidence are represented as mass distributions over the possibilities embodied in LTM. For example, let us suppose that an RWR, operating in MODE6, concludes unambiguously that it has detected a Pat Hand. However, on the basis of the current environmental conditions (such as high signal densities) it cannot be absolutely certain. This might be represented by a mass function that attributes .9 to the possibility of a Pat Hand, with the remaining mass being attributed to Θ. In some instances, the RWR could be more specific. For example, the nature of the received signal might strongly suggest a Pat Hand in either TTR or ACQ mode, with TTR being about twice as likely as ACQ. Then, instead of attributing the entire .9 to Pat Hand, .6 might be distributed between the suspected modes—.4 going to TTR mode, .2 to ACQ mode–with the residual .3 remaining at Pat Hand (Figure 11).

$$Mass(x) = \begin{cases} .3, & x = PatHand; \\ .4, & x = PatHand.TTR; \\ .2, & x = PatHand.ACQ; \\ .1, & x = \Theta; \\ 0.0, & otherwise. \end{cases}$$

To determine the impact of this body of evidence, we want to ascertain the support and plausibility of the relevant propositions. As previously discussed, this **extrapolation** process requires the ability to determine logical entailment. For the case at hand, let us focus on the proposition of a Pat Hand in TTR mode. We begin by determining which of the mass function's focal propositions (i.e., those propositions to which non-zero mass has been attributed) imply the proposition and which imply its negation. This is a fairly simple calculation, given LTM. *PatHand.TTR* clearly implies it, since it is one and the same proposition. *PatHand.ACQ* implies the negated proposition since it is represented by a distinctly different node. *PatHand* implies neither the proposition nor its negation, since it is compatible with either the presence or absence of a Pat Hand in TTR mode, as both the node representing that mode and nodes representing other modes are included within it. Finally, Θ implies nothing other than Θ and is compatible with anything. Thus,

$$Spt(PatHand.TTR) = .4,$$

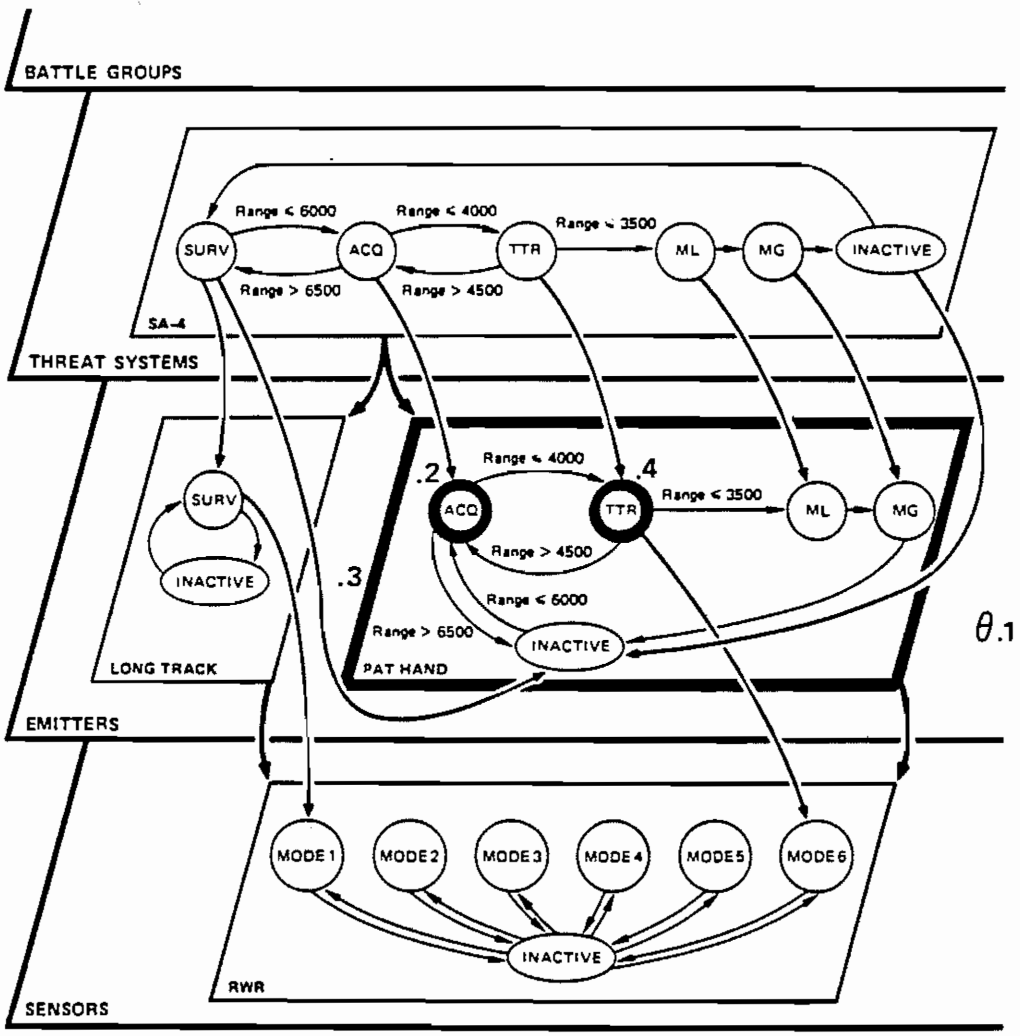


FIGURE 11 A MASS DISTRIBUTION AT THE EMITTER LEVEL OF LTM

$$\begin{aligned} Pls(PatHand.TTR) &= 1 - Spt(\neg PatHand.TTR) \\ &= 1 - .2 \\ &= .8, \end{aligned}$$

giving $[.4, .8]$ as the evidential interval for a Pat Hand in TTR mode.

Through a similar analysis we find that *PatHand.TTR*, *PatHand.ACQ*, and *PatHand* all imply *PatHand*, and that no focal propositions imply $\neg PatHand$. Therefore, the evidential interval for a Pat Hand is $[.9, 1.0]$. This body of evidence can also be interpreted relative to nonfocal propositions. For example, the interval for a Pat Hand in ML mode is $[0, .4]$, since both *PatHand.ACQ* and *PatHand.TTR* imply $\neg PatHand.ML$ and no focal elements imply *PatHand.ML*; the interval for a Long Track is $[0, .1]$, as all focal elements except Θ refute it.

Now let us suppose that some small amount of time has passed and we want to reinterpret this same body of evidence relative to the new time. Let us further suppose that we have determined that the range from the aircraft to this probable Pat Hand is bounded by the interval [3300,4200]. Using LTM, we project each focal element of the mass distribution into the future. The proposition *PatHand* does not change, since a radar's type does not vary with time. *PatHand.TTR* either remains at *PatHand.TTR* or becomes *PatHand.ML*, based on the range limits. Similarly, *PatHand.ACQ* becomes $PatHand.ACQ \vee PatHand.TTR$. Θ remains Θ. Thus, the projected mass distribution is

$$Mass(x) = \begin{cases} .3, & x = PatHand; \\ .4, & x = PatHand.TTR \vee PatHand.ML; \\ .2, & x = PatHand.ACQ \vee Pathand.TTR; \\ .1, & x = \Theta; \\ 0.0, & otherwise. \end{cases}$$

Now this mass distribution can be used as the basis for calculating evidential intervals, just as before—except that this time the resulting intervals represent the impact of the evidence on a future time. Some propositions and their associated intervals follow:

$$\begin{array}{cc}
PatHand = [.9, 1.0] & LongTrack = [0.0, .1] \\
PatHand.TTR = [0.0, 1.0] & PatHand.TTR \vee PatHand.ML = [.4, 1.0] \\
PatHand.ML = [0.0, .8] & PatHand.ACQ \vee PatHand.TTR = [.2, 1.0] \\
PatHand.ACQ = [0.0, .6] & PatHand.ACQ \vee PatHand.TTR \vee PatHand.ML = [.6, 1.0]
\end{array}$$

Here we see that the evidential interval associated with *PatHand* remains unchanged, but the intervals associated with the various possible modes of operation have widened. This reflects our inability to predict the Pat Hand's future behavior with perfect accuracy.

Just as we can project a mass distribution through time, based upon LTM, we can also project it up or down through the various levels of abstraction. This is accomplished in much the same way. Each focal proposition is projected independently. If a proposition projects to multiple propositions at the next level, then the mass is associated with the disjunction of those propositions. For a disjunctive focal element, each disjunct is projected independently and the mass is associated with the disjunction of all of the resulting propositions. Projecting the previous mass distribution up to the TS level yields the following:

$$Mass(x) = \begin{cases} .3, & x = SA4; \\ .4, & x = SA4.TTR \vee SA4.ML; \\ .2, & x = SA4.ACQ \vee SA4.TTR; \\ .1, & x = \Theta; \\ 0.0, & otherwise. \end{cases}$$

This is a fairly simple example, since each of the Pat Hand modes mentioned in the distribution maps to a single SA-4 mode, but this is not always the case. For example, the INACTIVE mode of a Pat Hand maps to both the INACTIVE and SURV modes of an SA-4. Once this projection has been made, the resulting mass distribution can be interpreted relative to any proposition at the threat system level:

$$\begin{array}{cc} SA4 = [.9, 1.0] & SA6 = [0.0, .1] \\ SA4.TTR = [0.0, 1.0] & SA4.TTR \vee SA4.ML = [.4, 1.0] \\ SA4.ML = [0.0, .8] & SA4.ACQ \vee SA4.TTR = [.2, 1.0] \\ SA4.ACQ = [0.0, .6] & SA4.ACQ \vee SA4.TTR \vee SA4.ML = [.6, 1.0] \end{array}$$

Thus, to predict both the likely type and future activity of a threat system, we have taken a body of evidence at the emitter level, projected it forward in time and then up a level of abstraction.

So far, we have considered only how to represent and extrapolate from a single body of evidence at a time. To handle multiple bodies of evidence , we need to apply Dempster's rule of combination. Suppose we are given a second body of evidence at the TS level. It gives fairly strong support to the existence of an SA-4, but acknowledges some weak (conflicting) evidence in support of an SA-6. Furthermore, if this suspected threat is an SA-4, there is strong reason to believe that it is in target-tracking mode. This might be represented by the following mass distribution:

$$Mass(x) = \begin{cases} .2, & x = SA4; \\ .4, & x = SA4.TTR; \\ .2, & x = SA6; \\ .2, & x = \Theta; \\ 0.0, & otherwise. \end{cases}$$

This leads to the following evidential intervals:

$$\begin{array}{cc}
SA4 = [.6, .8] & SA6 = [.2, .4] \\
SA4.TTR = [.4, .8] & SA4.TTR \vee SA4.ML = [.4, .8] \\
SA4.ML = [0.0, .4] & SA4.ACQ \vee SA4.TTR = [.4, .8] \\
SA4.ACQ = [0.0, .4] & SA4.ACQ \vee SA4.TTR \vee SA4.ML = [.4, .8]
\end{array}$$

Before we can use Dempster's rule to **pool** this new body of evidence with the previous one, we need to be assured of three things: (1) that they represent independent opinions, (2) that they are referring to the same entity, and (3) the time at which the information pertains. Let us assume that the bodies of evidence are based upon two distinctly different sensor reports, thereby satisfying the first requirement. Let us further assume that they are referring to the same threat system, since the sensors observed the same location (although we will challenge and possibly reject this assumption in subsequent operations). Finally, let us assume that the second body of evidence is based upon sensory information obtained at that same moment in time to which we projected the first body of evidence forward. Therefore, Dempster's rule can be applied at the TS level after the first body of evidence has been projected both forward in time and up one level of abstraction, just as we have already done.

To apply Dempster's rule, we need to resolve the conjunctions of the focal propositions (Figure 12). These are all resolved simply by referring to LTM. Any proposition conjoined with itself or with Θ is itself; a type conjoined with one or more of its modes is those modes, e.g., $SA4 \wedge (SA4.ACQ \vee SA4.TTR) = (SA4.ACQ \vee SA4.TTR)$; types conjoined with distinct types or modes of distinct types are nonexistent, e.g., $SA6 \wedge (SA4.TTR \vee SA4.ML) = \emptyset$. The resulting mass distribution and evidential intervals follow:

θ	.1	SA4	SA4.TTR	SA6	θ
SA4.ACQ v SA4.TTR	.2	SA4.ACQ v SA4.TTR	SA4.TTR	φ	SA4.ACQ v SA4.TTR
SA4.TTR v SA4.ML	.4	SA4.TTR v SA4.ML	SA4.TTR	φ	SA4.TTR v SA4.ML
SA4	.3	SA4	SA4.TTR	φ	SA4
		.2	.4	.2	.2
		SA4	SA4.TTR	SA6	θ

$$\text{mass}(x) = \begin{cases} .17 = .14\,(1-k)^{-1}, & x = \text{SA4}; \\ .49 = .40\,(1-k)^{-1}, & x = \text{SA4.TTR}; \\ .20 = .16\,(1-k)^{-1}, & x = \text{SA4.TTR} \vee \text{SA4.ML}; \\ .10 = .08\,(1-k)^{-1}, & x = \text{SA4.ACQ} \vee \text{SA4.TTR}; \\ .02 = .02\,(1-k)^{-1}, & x = \text{SA6}; \\ .02 = .02\,(1-k)^{-1}, & x = \theta; \\ 0.0, & \text{otherwise}; \end{cases}$$

where $k = .18$

FIGURE 12 APPLICATION OF DEMPSTER'S RULE

$$Mass(x) = \begin{cases} .17, & x = SA4; \\ .49, & x = SA4.TTR; \\ .20, & x = SA4.TTR \vee SA4.ML; \\ .10, & x = SA4.ACQ \vee SA4.TTR; \\ .02, & x = SA6; \\ .02, & x = \Theta; \\ 0.0, & otherwise. \end{cases}$$

$$\begin{array}{rr} SA4 = [.96, .98] & SA6 = [.02, .04] \\ SA4.TTR = [.49, .98] & SA4.TTR \vee SA4.ML = [.69, .98] \\ SA4.ML = [0.0, .39] & SA4.ACQ \vee SA4.TTR = [.59, .98] \\ SA4.ACQ = [0.0, .29] & SA4.ACQ \vee SA4.TTR \vee SA4.ML = [.79, .98] \end{array}$$

In this case, the consensus is likely valid, since the conflict generated during the combination was relatively small ($k = .18$). The result includes increased support for an SA-4 and decreased support (and plausibility) for an SA-6. Moreover, there is significant support for the SA-4's being in ACQ, TTR, or ML mode, with TTR the most likely of the three.

SHORT-TERM MEMORY

Thus far, we have seen how possibilistic knowledge is stored in LTM, how evidence can be expressed relative to LTM, and how evidence extrapolation and pooling can be performed. Next we need some means for keeping track of bodies of evidence. We need to know their origin, their impact at each level of abstraction, the locations and times to which they pertain, and, their heritage when they are a product of the combination of other bodies of evidence.

All of this information is stored in a structure called STM, for short-term memory. Whereas LTM contains generic information that is constant across multiple missions, STM contains information related specifically to a single mission. LTM describes Pat Hands and SA-4s as generic types; STM describes specific Pat Hand and SA-4 installations, including their locations and their activities over time.

The basic framework of STM is the same hierarchy of levels used for LTM (Figure 13). Each level consists of a set of nodes connected to the nodes on the adjacent levels. In STM, however, these nodes represent bodies of evidence, not generic types and states. If a node is connected to a single node at the next lower level of abstraction, it represents the upwards projection of the body of evidence represented by that lower node. If a node is connected to more than one node at the next lower level, it represents the combination of those lower bodies of evidence after they have been projected to the higher level.

Associated with each node in STM is a mass distribution represented by a vector of pairs, each pair consisting of a focal proposition and a number representing the mass assigned to it by the distribution. The focal propositions refer to concepts at the same level in LTM. In effect, a node in STM hypothesizes the existence of an entity at its level. For example, a node at the emitter level hypothesizes the existence of an emitter. Its associated mass vector provides evidential information concerning that emitter's type and current state.

Whenever a sensor produces a new report, it is recorded in STM. A node is created at the sensor level to represent that particular sensing. Its associated mass vector describes what type of sensor produced the report as well as the mode it was in at the time of the sensing. Since this is presumably known with certainty, the mass

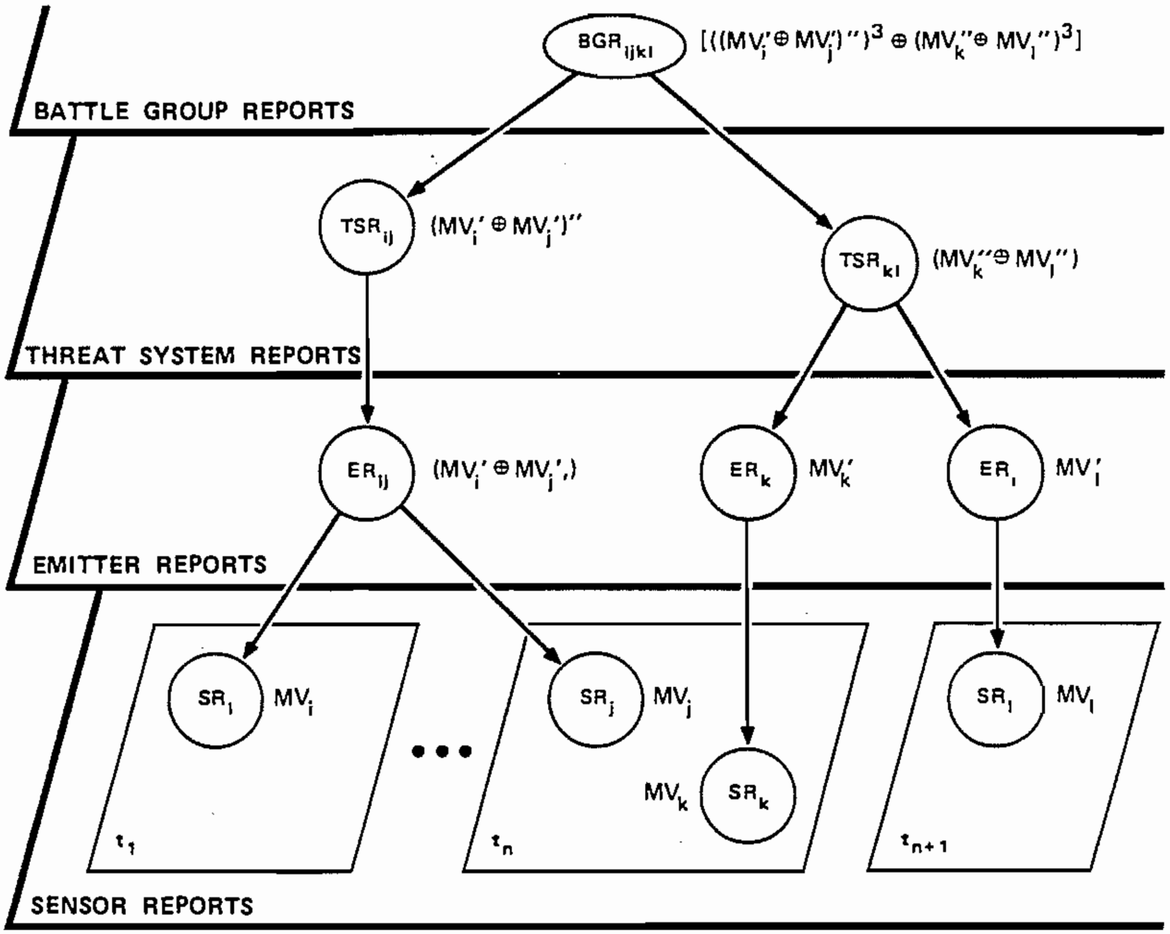


FIGURE 13 A FRAGMENT OF STM

distribution attributes all of its mass to a single proposition, the one denoting the appropriate sensor type and mode.

If one were to project this mass distribution up to the emitter level, the result would be a mass distribution that attributes all of its belief to the disjunction of all the emitter types and states that could be detected by that particular sensor, operating in that mode. This is exactly what one would know after having been told that the sensor, so tasked, has something to report. Of course, a sensor will usually have provided more information, in the form of a mass vector at the emitter level, describing in more detail what type of emitter it suspects that it has detected. In either case, a node is created at the emitter level, connected to the node at the sensor level, and the appropriate mass vector attached. If one knew that this was a distinctly different emitter from those already detected and recorded, then one would continue to project this information upwards, recording the result at the threat system level. There one would again need to determine whether this was a distinctly different threat system from those already recorded. If so, one would project it on upwards to the battle group level.

On the other hand, the sensor might be reporting on an emitter that had already been detected and recorded in STM. In that case, we would want to merge this new report with what was already there. This involves using Dempster's rule to combine this new mass vector with the one already stored at the appropriate node at the emitter level. The resulting mass vector replaces the previous one and an additional downward arc, pointing to the node that represents this most recent sensing, is created. Next, the mass vectors associated with nodes above this modified emitter node will have to be updated, so as to reflect the newly formed opinion regarding this emitter. If the new report did not refer to the same emitter, but did refer to the same threat system, then the combination would take place at the system level and be projected upwards from there. Mechanically, it is the same process, but simply takes place at a different level.

Thus, STM is a forest. The root of each tree in this forest represents a distinct battle group; the sons represent the threat systems that are part of the groups; the grandsons are the emitters that make up the threat systems; and the leaf nodes are the individual sensings. Note that, as long as the sensings remain evidentially independent, so will be all the combinations represented by the higher nodes. The tree structures guarantee evidential independence, which is one of the preconditions for using Dempster's rule.

To construct STM properly, one must be able to distinguish between reports that are talking about the same entities and those that are talking about distinctly different entities. This determination is based upon the compatibility of the reports. Could two reports be referring to the same entity? One important means of answering this question involves the compatibility of locational information. At any instant in time each entity is at exactly one location. Therefore, two reports could be talking about the same entity only if they support common possible locations. Towards this end, a polygon, bounding a set of possible (x,y) locations, is appended to each propositional statement in each mass vector. In this way, uncertain statements about an entity's location are directly integrated with the uncertain statements about its type and state. If a report has been generated by a sensor that is capable of locating emitters accurately, then the associated bounding polygons in the mass vector are small. If a sensor has little or no locating capability, the polygons are large, perhaps reaching the full detectable range of the sensor.

Reasoning with these locational estimates requires that we be able to reason about their conjunctions and implications. The conjunction of two polygons is simply their intersection. That is, two bounding estimates of possible locations conjoin, yielding the locations contained in both of them. One polygon implies another if it is fully contained within the latter and implies the negation of another if the two are nonintersecting. These are the fundamental determinations that are needed to drive the pooling and extrapolation processes.

Besides location, if two reports are referring to the same entity, they should agree basically on its type and state. Since all of this information (including location) is encoded in the mass vectors, we can use Dempster's rule to arrive at a consensual opinion, then use the resultant k value as a measure of compatibility. We suggested earlier that this value can be used to isolate bodies of evidence containing gross errors. What we are suggesting here is essentially the same as that. If two bodies of evidence are largely incompatible, it might be because each pertains to a different entity. Since it is a gross error to consider them to be referring to the same entity if in fact, they are referring to distinct entities, it should not be surprising that they are grossly incompatible. Hence, the k value can be used to separate bodies of evidence with grossly different opinions, whether the differences are due to processing errors made during the collection and initial interpretation of the evidence or are due to the fact that the bodies of evidence pertain to distinctly different portions of the environment.

The projection of propositions is somewhat complicated by the presence of the locational information. Each entity is considered to be located at a point, even though each entity actually occupies an area. The point selected (relative to the entity) is not important as long as it is consistent. When moving from one level to the next, say, from the emitter level to the system level, one needs to reason about how the system's location is constrained by the emitter's location. For our purposes, a relative bounding distance d is sufficient. That is, if an emitter's possible locations are represented by a bounding (convex) polygon, then the possible locations of the system, of which the emitter is part, are bounded by an enlargement of that emitter polygon whose sides are exactly d away from the original polygon. From an estimate of the emitter's location and the knowledge that the system must be within d distance from the emitter, we can concluded the possible locations of the system.

Of course, the distance d depends on the type of emitter and the type of system. These distances are stored in LTM on the arcs connecting emitter types with system types. If, in fact, the emitter-level proposition contains a disjunction of emitter types and/or the emitter type(s) projects to more than one system type, there might be several applicable distances. In this case, one could make a separate prediction based on each of the distances, associate the appropriate projected polygon with each projected system type, and then take the disjunction of all of them as the result. However, a simpler method can be utilized if some precision can be sacrificed. This simpler method is to just use the largest d, which projects the largest polygon, then to associate that polygon with the disjunction of all the possible system types.

Projection through time is similar, except that one uses mobility as the constraint when transforming the bounding polygon. For this application, the air defense entities move such a short distance in the time it takes the aircraft to pass through the area that no changes in the bounding polygons are typically necessary. Any errors this might introduce are overshadowed by the inaccuracies of the sensors themselves.

Although the polygons are not altered during forward projections, the state information (typically) is. We assume that the aircraft for which we are performing multisensor integration is the only one in the immediate vicinity. Therefore, any state changes are presumably in response to its presence. Since the location of the aircraft is known and the locations of possible air defense entities are bounded by polygons, a range of possible distances from the aircraft to each air defense entity can be easily determined. These ranges are calculated and used to limit the possible state transitions of the air defense entities. As time passes, the reports in STM are projected forward in unison. Thus, when new reports enter, the information in STM has already been advanced to the current time and is ready to be combined with new information.

To obtain the full value of all the evidence entered into STM, at all levels throughout the run, it is sometimes necessary to recalculate some of the combinations. This occurs, for example, when some new evidence pertains to an emitter that has been combined with another emitter at the threat system level. Any change in the identity of the first emitter influences both the threat system in which it participates and the other emitter. If one were not concerned about obtaining the full value of this information for all these entities the new report would be combined with the first emitter in its original form; it would be projected to the threat system level and combined with the report already at that node; it would be projected upwards, then back down to the emitter level and combined with the mass vector associated with the second emitter. This could overlook some of the synergistic effects of the new evidence in combination with the previous evidence concerning that first emitter.

For example, let us consider the situation in which an emitter of type ET_1 projects to a system of type ST_1, an emitter of type ET_2 projects to system types ST_1 and ST_2, and an ET_3 emitter projects to an ST_2 system (Figure 14). If the original information about the first emitter includes the possibilities of its being of either type ET_1 or ET_2, then the system in which it participates could be either type ST_1 or ST_2. Suppose the new information about this first emitter is that it is an ET_1 or an ET_3. This also projects to system types ST_1 and ST_2. However, if these two emitter reports are combined at the emitter level, the result is that the emitter must be type ET_1. From this it follows that the system must be type ST_1. On the other hand, if we had simply projected the second

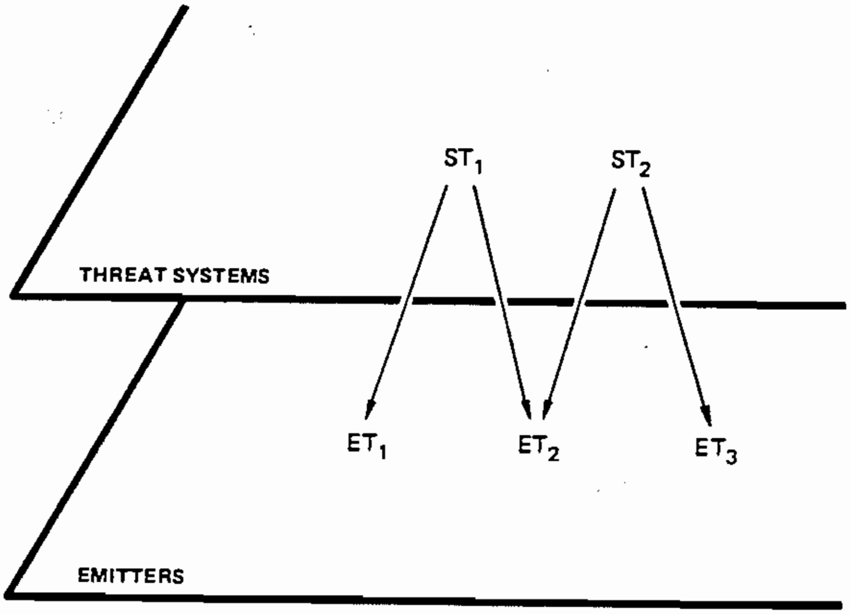


FIGURE 14 A FRAGMENT OF LTM

body of evidence up to the system level and combined it with the information already at that level, the result would have supported both possibilities, ST_1 and ST_2. The synergistic effect has been lost. Once again let us emphasize that, while both results are correct, the first is more precise and will potentially have a greater effect on the identity of the second emitter.

To be assured of obtaining all the available precision at a node in STM, all related bodies of evidence must be combined at the level at which their combination is recorded and projected as directly as possible to that node, where the final combination is effected. In the foregoing example, if there is a body of evidence that directly supports the second emitter and another that directly supports the system besides the two that are in direct support of the first emitter, then the most precise information about the first emitter would be obtained by (1) projecting the evidence pertaining to the second emitter up to the system level, (2) combining that with the evidence directly pertaining to the system, (3) projecting the result back down to the emitter level, and (4) combining that projected result with the two bodies of evidence pertaining to the first emitter. For the second emitter, the process is basically reversed: first one takes the combination at the first emitter, projects and combines at the system level, then projects and combines at the second emitter. For the system, the combination at the first emitter is projected upwards, as is the evidence at the second emitter, then the two projected bodies of evidence are combined with the one that pertains directly to the system.

To remain as flexible as possible, the seed bodies of evidence must be retained. These can be recorded in STM as nodes of a different type (and drawn with a different shape). Each node would have its body of evidence represented by a mass vector and have an arc connecting it to the STM node to which it contributes directly. In the situation discussed above, there would be two of these nodes connected to the first emitter node: one to the second emitter node, one to the system node (Figure 15). It is a meta issue to determine how much computational effort should be expended at each node towards obtaining the greatest possible precision. Similar meta issues involve the method used and the effort expended in determining when two bodies of evidence are referring to the same entity; determining when the combination structure is no longer appropriate and should be modified, since some bodies of evidence, previously presumed to be referring to the same entity, are no longer so presumed; determining when a body of evidence, together with any of its associated projections and combinations, should be discarded because it has not been properly confirmed after some effort in that direction.

To the extent that the complexities introduced by these meta issues can be limited by simplifying assumptions and approximations, the computational aspects of the problem can be kept within reasonable limits. And since this evidential reasoning process is manifest as a subprocess within the perceptual-reasoning cycle, which is designed to aggressively seek confirmation of the results of evidential reasoning, any errors generated by these simplifying assumptions and approximations will likely be discovered and overwhelmed.

CONCLUSIONS

We believe that evidential reasoning will prove to be an essential capability of any artificially intelligent, perceiving entity. Our initial work with the Shafer-Dempster approach to evidential reasoning has proved successful and there is reason to believe that continued work in this direction will be equally productive. The strength of the approach lies in its ability to work with limited information in a very flexible way. Multiple bodies of evidence, associated with different levels of abstraction, can be pooled

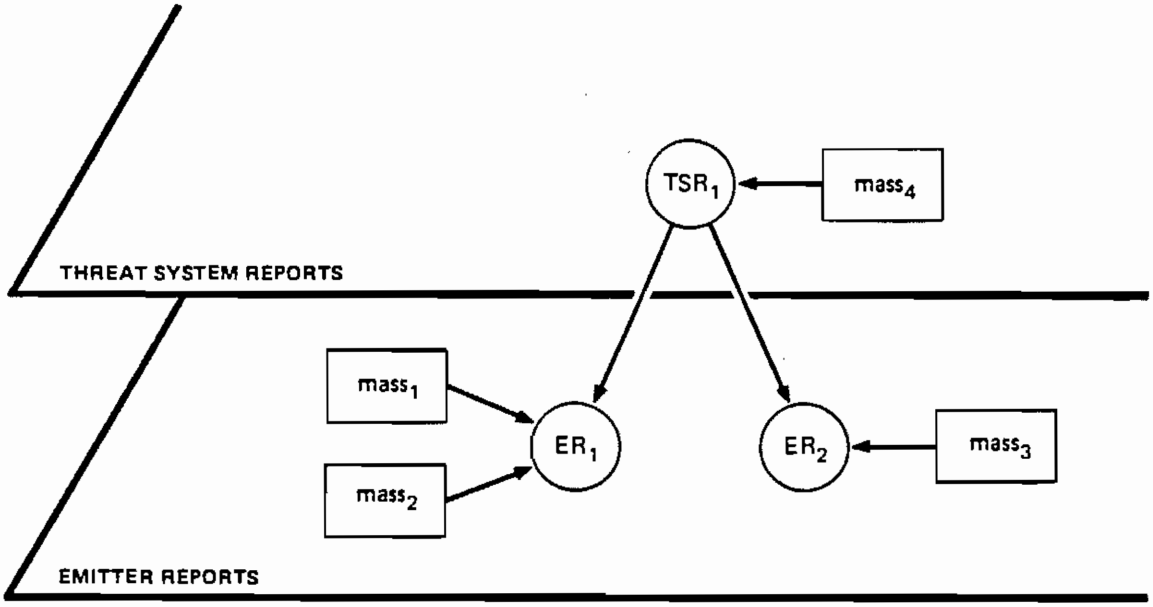


FIGURE 15 A FRAGMENT OF STM WITH SEED MASS DISTRIBUTIONS

to produce consensual opinions, which can then be interpreted with respect to any related propositions at any levels. There are no restrictions as to where information enters or is extracted. In addition, these techniques make it possible to address the meta issues that involve computationally limited comparisons and interpretations of entire bodies of evidence.

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Appendix A

THE MSI EVIDENTIAL-REASONING SYSTEM

APPENDIX A

THE MSI EVIDENTIAL-REASONING SYSTEM

An evidential-reasoning system for multisensor integration has been implemented in INTERLISP [Teitelman 1978], with support from a graphical database package GRASPER [Lowrance 1978], on a DEC 20. This system realizes the previously described design with just a few exceptions. The battle group level of LTM and STM has not been implemented, although this would require only definition and entry of the appropriate battle-group types and states. Locational projections are implemented as identity projections (i.e., all distances *d* are assumed to be zero). This is not a significant handicap, since emitters and threat systems are usually collocated, and battle groups that would require nonzero distances because they consist of spatially distributed multiple threat systems are not included.

This implementation can be run as either a stand-alone system or a subsystem. Its initialization procedure and its commands are described below.

INITIALIZATION

1. MSI.EXE = initializes the system to use data stored on a file. The file name is the value of the atom *MSI-INPUT-FILE. Its default value is MSI.DATA. If the value of the atom *USER? is non-NIL, the user is allowed to interact with the system as it runs. If this non-NIL value is an atom, then whenever a new report is processed, the user is informed by means of a message and is given an opportunity to look around through an evaluation loop. The default value for *USER? is T. On the other hand, if

this non-NIL value is a list, this list is evaluated sequentially after each new report has been processed. In either case, anything can be evaluated; the following, however, are of particular significance:

(SUMMARIZE:BRANCH) - prints a summary of the THREAT-SYSTEMS information contained in the branch of STM that includes the most recent report.

(PRINT:BRANCH) - prints the entire branch of STM that includes the last report.

*BRANCH - is the branch that includes the last report.

*TIME - is the simulation clock.

*AIRCRAFT-LOC - is the location of the aircraft at the current simulation time.

(SETQ *USER? NIL) - will prevent this evaluation loop from being entered again.

(SETQ *USER? '($sexp_1 \ldots sexp_n$)) - substitutes this loop by the evaluation of $sexp_1$ through $sexp_n$.

(SETQ *SPT-THRESH n) - resets the amount of support needed before a summary report goes into detail about the possible states the threat might be in; initially this is .8.

(SETQ *PLS-THRESH n) - resets the amount of plausibility required before a summary report contains any information about a threat or its states; initially this is .2.

GO - causes the evaluation loop to terminate and the processing to resume.

2. After initializing the system as in (1) and loading the server creation routines, execute (CREATE:MSI-FORK). This causes the system to initialize itself and execute (SERVER.SAVE 'MSI-SERVER). This initialization includes setting *MSI-INPUT-FILE and *USER? to NIL.

3. An uncompiled version of the system (initialized as in (1)) can be obtained by (LOAD 'MSI.LSP). Similarly, a complied version can be loaded from the file MSI.COM. Both of these cause a multitude of files to be loaded, including both programs and data.

COMMANDS

Once the system has been initialized, it will respond to the following commands.

STOP - This causes the MSI system to halt and return the current simulation time.

RESTART - This causes the system to reinitialize itself, resetting the simulation time, aircraft location, and GENNUM, and clearing STM.

SUMMARIZE - This causes the system to write a summary report containing an individual summary of every node on the THREAT-SYSTEMS level of STM. Each summary consists of a location, a review of each plausible type of threat (as defined by the current value of *PLS-THRESH), and a list of the sensor report nodes that have led to this threat system hypothesis. Each threat-type summary begins with the threat type being summarized and its support and plausibility interval. If the support for the type is greater than or equal to *SPT-THRESH, then the threat-type summary concludes with a summary of each plausible state (as per *PLS-THRESH). These each consist of the state paired with its support and plausibility interval.

PROCESS - This causes the system to summarize those reports that have been entered since the last PROCESS or SUMMARIZE command. It is exactly like SUMMARIZE, except that it restricts its summary to newly created or updated threat hypotheses.

(ENVIRONMENT (*time*(*xy*))) - This updates the system's environmental information, including the time and location of the aircraft. In turn, this causes the system to update STM to reflect these changes. This command is ignored if the given time equals *TIME.

(REPORT $(stmlevel_1 \, source_1 \, massvector_1) \ldots (stmlevel_n \, source_n \, massvector_n)$) - This causes each of these n reports to be entered into STM, hypothesizing n distinct entities. That is, the system will not attempt to fuse any of these reports. If this is not desirable, a separate REPORT command should be given for each one. The *stmlevel* is the level at which the report is entered. The *source* describes the sensor responsible for the information. It should include a description of where the sensor was looking, the sensor-type, and, optionally, the sensor state. (Actually, the system will accept anything as the source, since no processing is currently done with it.) This information is recorded at the SENSORS level of STM. Finally, the *massvector* pairs propositions (concerning the appropriate level of STM) with mass assignments. The total mass assigned must equal one, with the residual assigned to NIL (i.e., Θ).

(EVAL $sexp_1 \ldots sexp_n$) - This command causes the s-expressions to be evaluated in turn, and the value of the last s-expression to be written.

Anything else will cause an error.

Appendix B

AN ANNOTATED SAMPLE RUN OF THE MSI EVIDENTIAL-REASONING SYSTEM

APPENDIX B

AN ANNOTATED SAMPLE RUN OF THE MSI EVIDENTIAL-REASONING SYSTEM

In the sample run that follows, the right-hand columns are the commands to the system and the left-hand columns are the system's responses. The parenthetical numbers refer to the annotations. This run was generated with *USER? set to a list of commands. The list is executed every time a new report is entered in STM. This includes the execution of PRINT:BRANCH and SUMMARIZE:BRANCH. PRINT:BRANCH prints a description of each node in the branch of STM containing the new report and SUMMARIZE:BRANCH prints a summary of the body of evidence stored at the threat system node in that branch. The first and last commands in this list print beginning and ending banners, respectively, that serve to bracket the output of the other commands in the list. Other responses are not so bracketed. All other system variables remained at their default values.

For this sample run, LTM contained thirteen (13) possible emitters (GUNDISH, LANDROLL, STRAIGHTFLUSH, LONGTRACK, PATHAND, A3F-23/2-OA-FC, A3F-35/2-RADAR, A3F-35/2-OA-FC, SF-3-MM, SF-3-OA-FC, ZSU-23/4-OA-FC, SA-9-OA-FC, SA-9-LASER-FC), nine (9) possible threat systems (EARLYWARNING, ZSU-23/4, A3F-23/2, A3F-35/2, SF-3, SA-4, SA-6, SA-8, SA-9), and there were three (3) different sensors onboard the aircraft (EO, OA, RWR). On average, there were five (5) possible modes associated with each sensor, emitter, and threat systems. What these various code names and abbreviations denote, need not be known to follow the example.

```
--------------------BEGIN-------------------

(3)  SR.0003 = ((SECTOR ((331 16 6708 4708)))
        ED ED.MODE2)

         <-DOWN-- ER.0002

         <-CONTAINS-- SENSORS


     ER.0002 = (((((PAR POLYGON (568669 4199134)
                               (568293 4200061)
                               (567296 4199551)
                               (567827 4198704))
          STRAIGHTFLUSH))
         .8947477)
        ((((PAR POLYGON (568669 4199134)
                 (568293 4200061)
                 (567296 4199551)
                 (567827 4198704))
          LONGTRACK)
         ((PAR POLYGON (568669 4199134)
                 (568293 4200061)
                 (567296 4199551)
                 (567827 4198704))
          PATHAND)
         ((PAR POLYGON (568669 4199134)
                 (568293 4200061)
                 (567296 4199551)
                 (567827 4198704))
          STRAIGHTFLUSH))
         .1052523))

         --DOWN-> SR.0003

         <-DOWN-- TSR.0001

         <-CONTAINS-- EMITTERS


     TSR.0001 = (((((PAR POLYGON (568669 4199134)
                                (568293 4200061)
                                (567296 4199551)
                                (567827 4198704))
          SA-6))
         .8947477)
        ((((PAR POLYGON (568669 4199134)
                 (568293 4200061)
                 (567296 4199551)
                 (567827 4198704))
          SA-4)
         ((PAR POLYGON (568669 4199134)
                 (568293 4200061)
                 (567296 4199551)
                 (567827 4198704))
          SA-6))
         .1052523))

         --DOWN-> ER.0002

         <-CONTAINS-- THREAT-SYSTEMS

(4) ((PAR POLYGON (568669 4199134)
          (568293 4200061)
          (567296 4199551)
          (567827 4198704))
     [(SA-6 (.8947477 1.0)
          (SA-6.ACQ (0.0 1.0))
          (SA-6.ED-ACQ (0.0 1.0))
          (SA-6.ED-MG (0.0 1.0))
          (SA-6.ED-ML (0.0 1.0))
          (SA-6.ED-SURV (0.0 1.0))
          (SA-6.ED-TTR (0.0 1.0))
          (SA-6.INACTIVE (0.0 1.0))
          (SA-6.MG (0.0 1.0))
          (SA-6.ML (0.0 1.0))
          (SA-6.RADAR-SURV (0.0 1.0))
          (SA-6.TTR (0.0 1.0]
     (SR.0003))
---------------------END--------------------

--------------------BEGIN-------------------
```

```
(1) (ENVIRONMENT (0 (570707 4194107)))
(2) [REPORT (THREAT-SYSTEMS ((SECTOR ((331 16 6708 4708)))
                              ED ED.MODE2)
                             ((((PAR POLYGON (568669 4199134)
                                      (568293 4200061)
                                      (567296 4199551)
                                      (567827 4198704))
                                SA-6)
                               .8637)
                              (((PAR POLYGON (568669 4199134)
                                      (568293 4200061)
                                      (567296 4199551)
                                      (567827 4198704))
                                (OR SA-4 SA-6))
                               .1016)
                              (NIL .03574]
```

(1) This ENVIRONMENT command initializes the position of the aircraft at time zero.

(2) The first REPORT is from the EO sensor. While operating in its MODE2 observing sector (331 16 6708 4708), it detected what it strongly believes to be an SA-6, but that might conceivably be an SA-4. Since this is an optical sensor, it makes reports directly in terms of threat systems. The report also includes a PARametric description of a POLYGON that bounds this SAM's location.

(3) As a result of the report from the EO sensor, this branch (printed by PRINT:BRANCH), which includes nodes SR.0003, ER.0002, and TSR.0003, is created in STM. The first node in this branch SR.0003 represents this sensing. The value of this node indicates the sensor, its mode, and where it was looking when this event occurred. The SENSORS node is connected to this one by a CONTAINS arc, representing that this node is contained at the sensor level of STM. The node ER.0002 is connected by a DOWN arc, representing that one must go down one level of STM from node ER.0002 to arrive at node SR.0003. Below this information, printed by PRINT:BRANCH about node SR.0003, are descriptions of the connected emitter node ER.0002 and threat system node TSR.0001. ER.0002 is CONTAINed at the EMITTERS level and TSR.0001 at the THREAT-SYSTEMS level of STM. From TSR.0001 one goes DOWN to ER.0002. The value of TSR.0001 is the original report, except that the .03574 originally attributed to Θ has been thresholded out as an unimportant detail. If a significant amount of mass had been attributed to Θ, it would have been retained upon being entered into STM. The mass vector at node ER.0002 is the downward projection of the threat system mass vector.

(4) SUMMARIZE:BRANCH prints a summary of this branch at the threat system level, including the polygon bounding the threat system's location, the evidential

interval for its being an SA-6 (since its plausibility is greater than *PLS-THRESH at .2), the evidential intervals for each possible state this SA-6 might be in (since the support for an SA-6 is greater than *SPT-THRESH at .8), and a list of the sensings that have been pooled, thereby leading to these conclusions (in this case it is just the one sensing represented by node SR.0003). No other threat system types were included in the summary, since their plausibilities were all below *PLS-THRESH.

```
(6)  SR.0006 = ((SECTOR ((320 40 2231 1231)))
        OA OA.MODE3)

        <-DOWN-- ER.0005

        <-CONTAINS-- SENSORS


     ER.0005 = (((((PAR POLYGON (570150 4195801)
                            (570138 4195835)
                            (570078 4195814)
                            (570091 4195780))
          LANDROLL LANDROLL.ED-MG)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          LANDROLL LANDROLL.ED-TTR))
        .49)
       ((((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          A3F-23/2-OA-FC A3F-23/2-OA-FC.ACTIVE)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          A3F-35/2-OA-FC A3F-35/2-OA-FC.ACTIVE)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          LANDROLL LANDROLL.ED-MG)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          LANDROLL LANDROLL.ED-TTR)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          SA-9-OA-FC SA-9-OA-FC.ACTIVE)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          SF-3-OA-FC SF-3-OA-FC.ACTIVE)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          STRAIGHTFLUSH STRAIGHTFLUSH.ED-MG)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          STRAIGHTFLUSH STRAIGHTFLUSH.ED-TTR)
         ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
          ZSU-23/4-OA-FC ZSU-23/4-OA-FC.ACTIVE))
        .46)
       (NIL .05))

        --DOWN-> SR.0006

        <-DOWN-- TSR.0004

        <-CONTAINS-- EMITTERS


      TSR.0004 = ((((((PAR POLYGON (570150 4195801)
                              (570138 4195835)
                              (570078 4195814)
                              (570091 4195780))
           SA-8 SA-8.ED-MG)
          ((PAR POLYGON (570150 4195801)
                (570138 4195835)
                (570078 4195814)
                (570091 4195780))
           SA-8 SA-8.ED-TTR))
```

```
(5) [REPORT (THREAT-SYSTEMS ((SECTOR ((320 40 2231 1231)))
                              OA OA.MODE3)
                             ((((PAR POLYGON (570150 4195801)
                                      (570138 4195835)
                                      (570078 4195814)
                                      (570091 4195780))
                                 (OR (SA-8 SA-8.ED-TTR)
                                     (SA-8 SA-8.ED-MG)))
                               .49)
                              (((PAR POLYGON (570150 4195801)
                                      (570138 4195835)
                                      (570078 4195814)
                                      (570091 4195780))
                                 (OR (SA-6 SA-6.ED-TTR)
                                     (SA-6 SA-6.ED-MG)
                                     (SA-8 SA-8.ED-TTR)
                                     (SA-8 SA-8.ED-MG)
                                     (SA-9 SA-9.IR-TTR)
                                     (SA-9 SA-9.IR-MG)
                                     (SF-3 SF-3.ED-TTR)
                                     (SF-3 SF-3.ED-MG)
                                     (ASF-35/2 A3F-35/2.ED-TTR)
                                     (ASF-35/2 A3F-35/2.ED-MG)
                                     (ASF-23/2 A3F-23/2.TTR)
                                     (ASF-23/2 A3F-23/2.FIRE)
                                     (ZSU-23/4 ZSU-23/4.ED-TTR)
                                     (ZSU-23/4 ZSU-23/4.ED-FIRE)))
                               .46)
                              (NIL .05]
```

(5) The next report is from the OA sensor operating in MODE3. It has detected a threat system that it suspects is an SA-8 in EO-TTR or EO-MG mode, but it also suspects that it might be one of several other types in various modes.

(6) This second report results in a distinctly different branch being formed in STM. Although theses first two threat system reports pertain to overlapping areas, they are not combined, since they disagree considerably regarding the type of system detected. Therefore, two distinct threat systems are presumed.

```
        .49)
       ((((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         A3F-23/2 A3F-23/2.FIRE)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         A3F-23/2 A3F-23/2.TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         A3F-35/2 A3F-35/2.ED-MG)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         A3F-35/2 A3F-35/2.ED-TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-6 SA-6.ED-MG)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-6 SA-6.ED-TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-8 SA-8.ED-MG)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-8 SA-8.ED-TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-9 SA-9.IR-MG)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SA-9 SA-9.IR-TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SF-3 SF-3.ED-MG)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         SF-3 SF-3.ED-TTR)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         ZSU-23/4 ZSU-23/4.ED-FIRE)
        ((PAR POLYGON (570150 4195801)
               (570138 4195835)
               (570078 4195814)
               (570091 4195780))
         ZSU-23/4 ZSU-23/4.ED-TTR))
        .46)
       (NIL .05))

        --DOWN-> ER.0005

        <-CONTAINS-- THREAT-SYSTEMS

(7) ((PAR POLYGON (570150 4195801)
           (570138 4195835)
           (570078 4195814)
           (570091 4195780))
     ((SA-8 (.49 1.0))
      (A3F-23/2 (0.0 .51))
      (A3F-35/2 (0.0 .51))
```

(7) Note that this summary includes no state information, since no threat system type is sufficiently supported.

```
     (SA-6 (0.0 .51))
     (SA-9 (0.0 .51))
     (SF-3 (0.0 .51))
     (ZSU-23/4 (0.0 .51)))
    (SR.0006))
  --------------------END--------------------

(9)  (((PAR POLYGON (568669 4199134)
            (558293 4200061)
            (567296 4199551)
            (567827 4198704))
       [(SA-6 (.8947477 1.0)
               (SA-6.ACQ (0.0 1.0))
               (SA-6.ED-ACQ (0.0 1.0))
               (SA-6.ED-MG (0.0 1.0))
               (SA-6.ED-ML (0.0 1.0))
               (SA-6.ED-SURV (0.0 1.0))
               (SA-6.ED-TTR (0.0 1.0))
               (SA-6.INACTIVE (0.0 1.0))
               (SA-6.MG (0.0 1.0))
               (SA-6.ML (0.0 1.0))
               (SA-6.RADAR-SURV (0.0 1.0))
               (SA-6.TTR (0.0 1.0]
       (SR.0003))
      ((PAR POLYGON (570150 4195801)
            (570138 4195835)
            (570078 4195814)
            (570091 4195780))
       ((SA-8 (.49 1.0))
        (A3F-23/2 (0.0 .51))
        (A3F-35/2 (0.0 .51))
        (SA-6 (0.0 .51))
        (SA-9 (0.0 .51))
        (SF-3 (0.0 .51))
        (ZSU-23/4 (0.0 .51)))
       (SR.0006)))
  --------------------BEGIN--------------------

(12)  SR.0009 = ((SECTOR ((330 16 6502 4502)))
         ED ED.MODE2)

         <-DOWN-- ER.001

         <-CONTAINS-- SENSORS


      ER.001 = (((((PAR POLYGON (568490 4199031)
                                (568173 4199768)
                                (567489 4199420)
                                (567897 4198729))
                 STRAIGHTFLUSH))
               .8947478)
              ((((PAR POLYGON (568490 4199031)
                        (568173 4199768)
                        (567489 4199420)
                        (567897 4198729))
                 LONGTRACK)
                ((PAR POLYGON (568490 4199031)
                        (568173 4199768)
                        (567489 4199420)
                        (567897 4198729))
                 PATHAND)
                ((PAR POLYGON (568490 4199031)
                        (568173 4199768)
                        (567489 4199420)
                        (567897 4198729))
                 STRAIGHTFLUSH))
               .1052523))

         --DOWN-> SR.0003

         --DOWN-> SR.0009

         <-DOWN-- TSR.0011

         <-CONTAINS-- EMITTERS


      TSR.0011 = (((((PAR POLYGON (568490 4199031)
                                  (568173 4199768)
                                  (567489 4199420)
                                  (567897 4198729))
                   SA-6))
```

```
(8)  SUMMARIZE

{10}  (ENVIRONMENT (1 (570544 4194258)))
{11}  [REPORT (THREAT-SYSTEMS ((SECTOR ((330 16 6502 4502)))
                               ED ED.MODE2)
                              ((((PAR POLYGON (568490 4199031)
                                      (568173 4199768)
                                      (567489 4199420)
                                      (567897 4198729))
                                 (OR SA-6 SA-4))
                               1.0]
```

(8) At this point, a request is made to SUMMARIZE the threats that have been detected.

(9) In response to the SUMMARIZE command, the system summarizes each node at the threat system level in STM.

(10) This ENVIRONMENT command causes *TIME to be changed from time zero to time one, the location of the aircraft to be updated to the given coordinates, and all the emitter and threat system reports in STM to be projected forward in time.

(11) This REPORT is the second one from the EO sensor and represents a locational update for the previously reported threat system. It includes exactly the same types as in the first report, with more precise locational information. No preference is expressed between the types because the sensor has no new information on which to base such a judgment. The preferences expressed in the first report are not repeated, since they would be misinterpreted as independent judgments based upon newly acquired information.

(12) Even though this second report from the EO sensor is not explicitly tagged to identify it as a locational update on the first report, the two reports are properly combined in STM. This combination is selected because, the k value between the two reports being zero, they are completely compatible. The sensor node representing this new sensing SR.0009 and the one representing the previous sensing SR.0003 are both connected to the same emitter node ER.001, which is in turn connected to a single threat-system node TSR.0011. Thus, the system has concluded that the two reports are referring to the same threat system and to the same emitter (that was hypothesized on the basis of the first report). The appropriately pooled mass vectors are stored at ER.001 and TSR.0011.

```
          .8947478)
         ((((PAR POLYGON (568490 4199031)
                 (568173 4199768)
                 (567489 4199420)
                 (567897 4198729))
            EARLYWARNING)
           ((PAR POLYGON (568490 4199031)
                 (568173 4199768)
                 (567489 4199420)
                 (567897 4198729))
            SA-4)
           ((PAR POLYGON (568490 4199031)
                 (568173 4199768)
                 (567489 4199420)
                 (567897 4198729))
            SA-6))
          .1052523))

          --DOWN-> ER.001

          <-CONTAINS-- THREAT-SYSTEMS

(13)   ((PAR POLYGON (568490 4199031)
             (568173 4199768)
             (567489 4199420)
             (567897 4198729))
        [(SA-6 (.8947478 1.0)
               (SA-6.ACQ (0.0 1.0))
               (SA-6.ED-ACQ (0.0 1.0))
               (SA-6.ED-MG (0.0 1.0))
               (SA-6.ED-ML (0.0 1.0))
               (SA-6.ED-SURV (0.0 1.0))
               (SA-6.ED-TTR (0.0 1.0))
               (SA-6.INACTIVE (0.0 1.0))
               (SA-6.MG (0.0 1.0))
               (SA-6.ML (0.0 1.0))
               (SA-6.RADAR-SURV (0.0 1.0))
               (SA-6.TTR (0.0 1.0]
        (SR.0003 SR.0009))
       --------------------END--------------------


       -------------------BEGIN-------------------

         SR.0014 = ((SECTOR ((317 40 2024 1024)))
            OA OA.MODE3)

            <-DOWN-- ER.0015

            <-CONTAINS-- SENSORS


         ER.0015 = (((((PAR POLYGON (570122 4195820)
                                    (570092 4195812)
                                    (570097 4195795)
                                    (570127 4195803))
             LANDROLL LANDROLL.ED-MG)
            ((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
             LANDROLL LANDROLL.ED-TTR))
           .49)
          ((((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
             ASF-23/2-OA-FC ASF-23/2-OA-FC.ACTIVE)
            ((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
             ASF-35/2-OA-FC ASF-35/2-OA-FC.ACTIVE)
            ((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
             LANDROLL LANDROLL.ED-MG)
            ((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
             LANDROLL LANDROLL.ED-TTR)
            ((PAR POLYGON (570122 4195820)
```

```
(14) [REPORT (THREAT-SYSTEMS ((SECTOR ((317 40 2024 1024)))
                               OA OA.MODE3)
                              ((((PAR POLYGON (570127 4195803)
                                      (570122 4195820)
                                      (570092 4195812)
                                      (570097 4195795))
                                  (OR (SA-8 SA-8.ED-TTR)
                                      (SA-8 SA-8.ED-MG)
                                      (SA-6 SA-6.ED-TTR)
                                      (SA-6 SA-6.ED-MG)
                                      (SA-9 SA-9.IR-TTR)
                                      (SA-9 SA-9.IR-MG)
                                      (SF-3 SF-3.ED-TTR)
                                      (SF-3 SF-3.ED-MG)
                                      (ASF-35/2 ASF-35/2.ED-TTR)
                                      (ASF-35/2 ASF-35/2.ED-MG)
                                      (ASF-23/2 ASF-23/2.TTR)
                                      (ASF-23/2 ASF-23/2.FIRE)
                                      (ZSU-23/4 ZSU-23/4.ED-TTR)
                                      (ZSU-23/4 ZSU-23/4.ED-FIRE)))
                               1.0]
```

(13) Notice that the summary of node TSR.0011 is identical to the previous summary of node TSR.0001, with the exception of the locational information and the list of supporting sensings that now includes both SR.0003 and SR.0009.

(14) This report is basically a locational update from the OA sensor for the threat system previously reported by it.

```
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
      SA-9-OA-FC SA-9-OA-FC.ACTIVE)
     ((PAR POLYGON (570122 4195820)
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
      SF-3-OA-FC SF-3-OA-FC.ACTIVE)
     ((PAR POLYGON (570122 4195820)
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-MG)
     ((PAR POLYGON (570122 4195820)
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-TTR)
     ((PAR POLYGON (570122 4195820)
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
      ZSU-23/4-OA-FC ZSU-23/4-OA-FC.ACTIVE))
    .46)
   ((((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      A3F-23/2-OA-FC A3F-23/2-OA-FC.ACTIVE)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      A3F-35/2-OA-FC A3F-35/2-OA-FC.ACTIVE)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      LANDROLL LANDROLL.ED-MG)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      LANDROLL LANDROLL.ED-TTR)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      SA-9-OA-FC SA-9-OA-FC.ACTIVE)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      SF-3-OA-FC SF-3-OA-FC.ACTIVE)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-MG)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-TTR)
     ((PAR POLYGON (570127 4195803)
           (570122 4195820)
           (570092 4195812)
           (570097 4195795))
      ZSU-23/4-OA-FC ZSU-23/4-OA-FC.ACTIVE))
    .05))

    --DOWN-> SR.0006

    --DOWN-> SR.0014

    <-DOWN-- TSR.0016

    <-CONTAINS-- EMITTERS


TSR.0016 = (((((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
      SA-8 SA-8.ED-MG)
```

```
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-8 SA-8.ED-TTR))
 .49)
((((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-23/2 A3F-23/2.FIRE)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-23/2 A3F-23/2.SURV)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-23/2 A3F-23/2.TTR)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-35/2 A3F-35/2.ED-FIRE)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-35/2 A3F-35/2.ED-SURV)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   A3F-35/2 A3F-35/2.ED-TTR)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-6 SA-6.ED-MG)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-6 SA-6.ED-TTR)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-8 SA-8.ED-MG)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-8 SA-8.ED-TTR)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-9 SA-9.ACQ)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-9 SA-9.IR)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-9 SA-9.IR-MG)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-9 SA-9.IR-ML)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
   SA-9 SA-9.IR1)
  ((PAR POLYGON (570122 4195820)
        (570092 4195812)
        (570097 4195795)
        (570127 4195803))
```

```
   SA-9 SA-9.SURV)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SA-9 SA-9.TTR)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SF-3 SF-3.ED-ACQ)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SF-3 SF-3.ED-MG)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SF-3 SF-3.ED-ML)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SF-3 SF-3.ED-SURV)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   SF-3 SF-3.ED-TTR)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   ZSU-23/4 ZSU-23/4.ED-FIRE)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   ZSU-23/4 ZSU-23/4.ED-SURV)
  ((PAR POLYGON (570122 4195820)
         (570092 4195812)
         (570097 4195795)
         (570127 4195803))
   ZSU-23/4 ZSU-23/4.ED-TTR))
 .46)
((((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-23/2 A3F-23/2.FIRE)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-23/2 A3F-23/2.SURV)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-23/2 A3F-23/2.TTR)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-35/2 A3F-35/2.ED-FIRE)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-35/2 A3F-35/2.ED-SURV)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   A3F-35/2 A3F-35/2.ED-TTR)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
         (570097 4195795))
   SA-6 SA-6.ED-MG)
  ((PAR POLYGON (570127 4195803)
         (570122 4195820)
         (570092 4195812)
```

```
        (570097 4195795))
 SA-6 SA-6.ED-TTR)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-8 SA-8.ED-MG)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-8 SA-8.ED-TTR)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.ACQ)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.IR)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.IR-MG)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.IR-ML)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.IR1)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.SURV)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SA-9 SA-9.TTR)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SF-3 SF-3.ED-ACQ)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SF-3 SF-3.ED-MG)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SF-3 SF-3.ED-ML)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SF-3 SF-3.ED-SURV)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 SF-3 SF-3.ED-TTR)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 ZSU-23/4 ZSU-23/4.ED-FIRE)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
        (570097 4195795))
 ZSU-23/4 ZSU-23/4.ED-SURV)
((PAR POLYGON (570127 4195803)
        (570122 4195820)
        (570092 4195812)
```

```
              (570097 4195795))
         ZSU-23/4 ZSU-23/4.ED-TTR))
        .05))

        --DOWN-> ER.0015

        <-CONTAINS-- THREAT-SYSTEMS

(15)  ((PAR POLYGON (570122 4195820)
           (570092 4195812)
           (570097 4195795)
           (570127 4195803))
       ((SA-8 (.49 1.0))
        (A3F-23/2 (0.0 .51))
        (A3F-35/2 (0.0 .51))
        (SA-6 (0.0 .51))
        (SA-9 (0.0 .51))
        (SF-3 (0.0 .51))
        (ZSU-23/4 (0.0 .51)))
       (SR.0006 SR.0014))
      ----------------------END---------------------------

      (((PAR POLYGON (568490 4199031)
             (568173 4199768)
             (567489 4199420)
             (567897 4198729))
        [(SA-6 (.8947478 1.0)
             (SA-6.ACQ (0.0 1.0))
             (SA-6.ED-ACQ (0.0 1.0))
             (SA-6.ED-MG (0.0 1.0))
             (SA-6.ED-ML (0.0 1.0))
             (SA-6.ED-SURV (0.0 1.0))
             (SA-6.ED-TTR (0.0 1.0))
             (SA-6.INACTIVE (0.0 1.0))
             (SA-6.MG (0.0 1.0))
             (SA-6.ML (0.0 1.0))
             (SA-6.RADAR-SURV (0.0 1.0))
             (SA-6.TTR (0.0 1.0]
        (SR.0003 SR.0009))
       ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
        ((SA-8 (.49 1.0))
         (A3F-23/2 (0.0 .51))
         (A3F-35/2 (0.0 .51))
         (SA-6 (0.0 .51))
         (SA-9 (0.0 .51))
         (SF-3 (0.0 .51))
         (ZSU-23/4 (0.0 .51)))
        (SR.0006 SR.0014)))
      ---------------------BEGIN--------------------------

         SR.0019 = ((SECTOR ((329 16 6297 4297)))
            ED ED.MODE2)

             <-DOWN-- ER.002

             <-CONTAINS-- SENSORS

         ER.002 = (((((PAR POLYGON (568292 4199167)
                                  (568114 4199571)
                                  (567702 4199370)
                                  (567912 4198981))
                   STRAIGHTFLUSH))
                 .8947477)
                ((((PAR POLYGON (568292 4199167)
                          (568114 4199571)
                          (567702 4199370)
                          (567912 4198981))
                   LONGTRACK)
                  ((PAR POLYGON (568292 4199167)
                          (568114 4199571)
                          (567702 4199370)
                          (567912 4198981))
                   PATHAND)
                  ((PAR POLYGON (568292 4199167)
                          (568114 4199571)
                          (567702 4199370)
                          (567912 4198981))
                   STRAIGHTFLUSH))
                 .1052523))
```

```
SUMMARIZE

(16) (ENVIRONMENT (2 (570381 4194409)))
     [REPORT (THREAT-SYSTEMS ((SECTOR ((329 16 6297 4297)))
                               ED ED.MODE2)
                              ((((PAR POLYGON (568292 4199167)
                                        (568114 4199571)
                                        (567702 4199370)
                                        (567912 4198981))
                                 (OR SA-6 SA-4))
                                1.0]
```

(15) Merging sensor report SR.0014 with report SR.0006 has resulted in more sharply delineated locational information without affecting the type information.

(16) The time and the aircraft location are moved forward once again, followed by another locational update from the EO sensor.

```
      --DOWN-> SR.0009

      --DOWN-> SR.0003

      --DOWN-> SR.0019

      <-DOWN-- TSR.0021

      <-CONTAINS-- EMITTERS

  TSR.0021 = (((((PAR POLYGON (568292 4199167)
                          (568114 4199571)
                          (567702 4199370)
                          (567912 4198981))
        SA-6))
       .8947477)
      ((((PAR POLYGON (568292 4199167)
                (568114 4199571)
                (567702 4199370)
                (567912 4198981))
        EARLYWARNING)
       ((PAR POLYGON (568292 4199167)
                (568114 4199571)
                (567702 4199370)
                (567912 4198981))
        SA-4)
       ((PAR POLYGON (568292 4199167)
                (568114 4199571)
                (567702 4199370)
                (567912 4198981))
        SA-6))
       .1052523))

      --DOWN-> ER.002

      <-CONTAINS-- THREAT-SYSTEMS

((PAR POLYGON (568292 4199167)
      (568114 4199571)
      (567702 4199370)
      (567912 4198981))
 [(SA-6 (.8947477 1.0)
        (SA-6.ACQ (0.0 1.0))
        (SA-6.ED-ACQ (0.0 1.0))
        (SA-6.ED-MG (0.0 1.0))
        (SA-6.ED-ML (0.0 1.0))
        (SA-6.ED-SURV (0.0 1.0))
        (SA-6.ED-TTR (0.0 1.0))
        (SA-6.INACTIVE (0.0 1.0))
        (SA-6.MG (0.0 1.0))
        (SA-6.ML (0.0 1.0))
        (SA-6.RADAR-SURV (0.0 1.0))
        (SA-6.TTR (0.0 1.0]
 (SR.0009 SR.0003 SR.0019))
---------------------END---------------------


(((PAR POLYGON (570122 4195820)                                  SUMMARIZE
 -      (570092 4195812)
        (570097 4195795)
        (570127 4195803))
  ((SA-8 (.49 1.0))
   (A3F-23/2 (0.0 .51))
   (ASF-35/2 (0.0 .51))
   (SA-6 (0.0 .51))
   (SA-9 (0.0 .51))
   (SF-3 (0.0 .51))
   (ZSU-23/4 (0.0 .51)))
  (SR.0006 SR.0014))
 ((PAR POLYGON (568292 4199167)
        (568114 4199571)
        (567702 4199370)
        (567912 4198981))
  [(SA-6 (.8947477 1.0)
         (SA-6.ACQ (0.0 1.0))
         (SA-6.ED-ACQ (0.0 1.0))
         (SA-6.ED-MG (0.0 1.0))
         (SA-6.ED-ML (0.0 1.0))
         (SA-6.ED-SURV (0.0 1.0))
         (SA-6.ED-TTR (0.0 1.0))
         (SA-6.INACTIVE (0.0 1.0))
         (SA-6.MG (0.0 1.0))
         (SA-6.ML (0.0 1.0))
         (SA-6.RADAR-SURV (0.0 1.0))
```

```
          (SA-6.TTR (0.0 1.0]
   (SR.0009 SR.0003 SR.0019)))
 -------------------BEGIN-------------------


    SR.0024 = ((SECTOR ((328 16 6094 4094)))
       ED ED.MODE2)

        <-DOWN-- ER.0025

        <-CONTAINS-- SENSORS


    ER.0025 = (((((PAR POLYGON (568076 4199341)
                       (568033 4199438)
                       (567864 4199358)
                       (567911 4199263))
          STRAIGHTFLUSH))
        .8947478)
       ((((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
          LONGTRACK)
         ((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
          PATHAND)
         ((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
          STRAIGHTFLUSH))
        .1052523))

        --DOWN-> SR.0019

        --DOWN-> SR.0003

        --DOWN-> SR.0009

        --DOWN-> SR.0024

        <-DOWN-- TSR.0026

        <-CONTAINS-- EMITTERS


   TSR.0026 = (((((PAR POLYGON (568076 4199341)
                        (568033 4199438)
                        (567864 4199358)
                        (567911 4199263))
         SA-6))
       .8947478)
      ((((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
         EARLYWARNING)
        ((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
         SA-4)
        ((PAR POLYGON (568076 4199341)
               (568033 4199438)
               (567864 4199358)
               (567911 4199263))
         SA-6))
       .1052523))

       --DOWN-> ER.0025

       <-CONTAINS-- THREAT-SYSTEMS

((PAR POLYGON (568076 4199341)
      (568033 4199438)
      (567864 4199358)
      (567911 4199263))
 [(SA-6 (.8947478 1.0)
        (SA-6.ACQ (0.0 1.0))
        (SA-6.ED-ACQ (0.0 1.0))
        (SA-6.ED-MC (0.0 1.0))
        (SA-6.ED-ML (0.0 1.0))
```

```
(ENVIRONMENT (3 (570218 4194560)))
[REPORT (THREAT-SYSTEMS ((SECTOR ((328 16 6094 4094)))
                          ED ED.MODE2)
                         ((((PAR POLYGON (568076 4199341)
                                 (568033 4199438)
                                 (567864 4199358)
                                 (567911 4199263))
                            (OR SA-6 SA-4))
                           1.0]
```

```
        (SA-6.ED-SURV (0.0 1.0))
        (SA-6.ED-TTR (0.0 1.0))
        (SA-6.INACTIVE (0.0 1.0))
        (SA-6.MG (0.0 1.0))
        (SA-6.ML (0.0 1.0))
        (SA-6.RADAR-SURV (0.0 1.0))
        (SA-6.TTR (0.0 1.0]
 (SR.0019 SR.0003 SR.0009 SR.0024))
--------------------END--------------------


------------------BEGIN------------------

   SR.0029 = ((SECTOR ((308 40 1630 630)))
      OA OA.MODE3)

      <-DOWN-- ER.003

      <-CONTAINS-- SENSORS


   ER.003 = (((((PAR POLYGON (570122 4195820)
                    (570092 4195812)
                    (570097 4195795)
                    (570127 4195803))
       LANDROLL LANDROLL.ED-MG)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       LANDROLL LANDROLL.ED-TTR))
     .7655402)
    ((((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       A3F-23/2-OA-FC A3F-23/2-OA-FC.ACTIVE)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       A3F-35/2-OA-FC A3F-35/2-OA-FC.ACTIVE)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       LANDROLL LANDROLL.ED-MG)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       LANDROLL LANDROLL.ED-TTR)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       SA-9-OA-FC SA-9-OA-FC.ACTIVE)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       SF-3-OA-FC SF-3-OA-FC.ACTIVE)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       STRAIGHTFLUSH STRAIGHTFLUSH.ED-MG)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       STRAIGHTFLUSH STRAIGHTFLUSH.ED-TTR)
      ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
       ZSU-23/4-OA-FC ZSU-23/4-OA-FC.ACTIVE))
     .2344598))

     --DOWN-> SR.0014

     --DOWN-> SR.0006

     --DOWN-> SR.0029
```

```
(17)[REPORT (THREAT-SYSTEMS ((SECTOR ((308 40 1630 630)))
                            OA OA.MODE3)
                           ((((PAR POLYGON (570109 4195807)
                                   (570109 4195809)
                                   (570104 4195809)
                                   (570104 4195806))
                              (OR (SA-8 SA-8.ED-TTR)
                                  (SA-8 SA-8.ED-MG)))
                             .49)
                            (((PAR POLYGON (570109 4195807)
                                   (570109 4195809)
                                   (570104 4195809)
                                   (570104 4195806))
                              (OR (SA-6 SA-6.ED-TTR)
                                  (SA-6 SA-6.ED-MG)
                                  (SA-8 SA-8.ED-TTR)
                                  (SA-8 SA-8.ED-MG)
                                  (SA-9 SA-9.IR-TTR)
                                  (SA-9 SA-9.IR-MG)
                                  (SF-3 SF-3.ED-TTR)
                                  (SF-3 SF-3.ED-MG)
                                  (A3F-35/2 ASF-35/2.ED-TTR)
                                  (A3F-35/2 ASF-35/2.ED-MG)
                                  (A3F-23/2 ASF-23/2.TTR)
                                  (A3F-23/2 A3F-23/2.FIRE)
                                  (ZSU-23/4 ZSU-23/4.ED-TTR)
                                  (ZSU-23/4 ZSU-23/4.ED-FIRE)))
                             .46)
                            (NIL .05]
```

(17) After an initial estimate of a detected threat's type and location, the OA sensor has provided a locational update based on its ability to sharpen locational estimates through additional dwell time. Now, once again, it is able to make a judgment concerning the threat's type. This judgment is based on a distinctly different sighting from the previous judgment; otherwise it would not have been reported. However, since the mass vector is the same, it does appear that the sighting was very similar to the first.

```
                     (570127 4195803))
               SA-9 SA-9.IR-ML)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SA-9 SA-9.IR1)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SA-9 SA-9.SURV)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SA-9 SA-9.TTR)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SF-3 SF-3.ED-ACQ)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SF-3 SF-3.ED-MG)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SF-3 SF-3.ED-ML)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SF-3 SF-3.ED-SURV)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               SF-3 SF-3.ED-TTR)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               ZSU-23/4 ZSU-23/4.ED-FIRE)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               ZSU-23/4 ZSU-23/4.ED-SURV)
              ((PAR POLYGON (570122 4195820)
                     (570092 4195812)
                     (570097 4195795)
                     (570127 4195803))
               ZSU-23/4 ZSU-23/4.ED-TTR))
              .2344598))

              --DOWN-> ER.003

              <-CONTAINS-- THREAT-SYSTEMS

(18)   ((PAR POLYGON (570122 4195820)
             (570092 4195812)
             (570097 4195795)
             (570127 4195803))
        ((SA-8 (.7855402 1.0))
         (A3F-23/2 (0.0 .2344598))
         (A3F-35/2 (0.0 .2344598))
         (SA-6 (0.0 .2344598))
         (SA-9 (0.0 .2344598))
         (SF-3 (0.0 .2344598))
         (ZSU-23/4 (0.0 .2344598)))
        (SR.0014 SR.0006 SR.0029))
       ---------------------END---------------------

       (((PAR POLYGON (568076 4199341)                                SUMMARIZE
              (568033 4199438)
              (567864 4199358)
              (567911 4199263))
         [(SA-6 (.8947473 1.0)
                (SA-6.ACQ (0.0 1.0))
                (SA-6.ED-ACQ (0.0 1.0))
```

```
<-DOWN-- TSR.0031

<-CONTAINS-- EMITTERS

TSR.0031 = (((((PAR POLYGON (570122 4195820)
                  (570092 4195812)
                  (570097 4195795)
                  (570127 4195803))
      SA-8 SA-8.ED-MG)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-8 SA-8.ED-TTR))
    .7655402)
   ((((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-23/2 A3F-23/2.FIRE)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-23/2 A3F-23/2.SURV)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-23/2 A3F-23/2.TTR)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-35/2 A3F-35/2.ED-FIRE)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-35/2 A3F-35/2.ED-SURV)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      A3F-35/2 A3F-35/2.ED-TTR)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-6 SA-6.ED-MG)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-6 SA-6.ED-TTR)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-8 SA-8.ED-MG)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-8 SA-8.ED-TTR)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-9 SA-9.ACQ)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-9 SA-9.IR)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
      SA-9 SA-9.IR-MG)
     ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
```

(18) Since two independent judgments have been combined, each leaning towards identification of the threat as an SA-8, the result points even more strongly towards that conclusion.

```
        (SA-6.ED-MG (0.0 1.0))
        (SA-6.ED-ML (0.0 1.0))
        (SA-6.ED-SURV (0.0 1.0))
        (SA-6.ED-TTR (0.0 1.0))
        (SA-6.INACTIVE (0.0 1.0))
        (SA-6.MG (0.0 1.0))
        (SA-6.ML (0.0 1.0))
        (SA-6.RADAR-SURV (0.0 1.0))
        (SA-6.TTR (0.0 1.0]
 (SR.0019 SR.0003 SR.0009 SR.0024))
((PAR POLYGON (570122 4195820)
      (570092 4195812)
      (570097 4195795)
      (570127 4195803))
 ((SA-8 (.7655402 1.0))
  (A3F-23/2 (0.0 .2344598))
  (A3F-35/2 (0.0 .2344598))
  (SA-6 (0.0 .2344598))
  (SA-9 (0.0 .2344598))
  (SF-3 (0.0 .2344598))
  (ZSU-23/4 (0.0 .2344598)))
 (SR.0014 SR.0006 SR.0029)))
--------------------BEGIN--------------------


  SR.0034 = ((SECTOR ((322 16 7324 5324)))
     ED ED.MODE2)

      <-DOWN-- ER.0033

      <-CONTAINS-- SENSORS


  ER.0033 = (((((PAR POLYGON (568325 4201105)
                      (568142 4202088)
                      (566985 4201766)
                      (567335 4200830))
        LONGTRACK)
       ((PAR POLYGON (568325 4201105)
             (568142 4202088)
             (566985 4201766)
             (567335 4200830))
        PATHAND))
      .8367669)
     ((((PAR POLYGON (568325 4201105)
             (568142 4202088)
             (566985 4201766)
             (567335 4200830))
        LONGTRACK)
       ((PAR POLYGON (568325 4201105)
             (568142 4202088)
             (566985 4201766)
             (567335 4200830))
        PATHAND)
       ((PAR POLYGON (568325 4201105)
             (568142 4202088)
             (566985 4201766)
             (567335 4200830))
        STRAIGHTFLUSH))
      .1020082)
     (NIL .0612249))

      --DOWN-> SR.0034

      <-DOWN-- TSR.0032

      <-CONTAINS-- EMITTERS


   TSR.0032 = (((((PAR POLYGON (568325 4201105)
                       (568142 4202088)
                       (566985 4201766)
                       (567335 4200830))
         SA-4))
       .8367669)
      ((((PAR POLYGON (568325 4201105)
              (568142 4202088)
              (566985 4201766)
              (567335 4200830))
         SA-4)
        ((PAR POLYGON (568325 4201105)
              (568142 4202088)
              (566985 4201766)
              (567335 4200830))
         SA-6))
```

```
(19) (ENVIRONMENT (4 (570055 4194711)))
     (ENVIRONMENT (5 (569891 4194862)))
     (ENVIRONMENT (6 (569728 4195013)))
     (ENVIRONMENT (7 (569565 4195163)))
     (ENVIRONMENT (8 (569402 4195314)))
(20) {REPORT (THREAT-SYSTEMS ((SECTOR ((322 16 7324 5324)))
                              ED ED.MODE2)
                             ((((PAR POLYGON (568325 4201105)
                                     (568142 4202088)
                                     (566985 4201766)
                                     (567335 4200830))
                                SA-4)
                               .8367)
                              (((PAR POLYGON (568325 4201105)
                                     (568142 4202088)
                                     (566985 4201766)
                                     (567335 4200830))
                                (OR SA-4 SA-6))
                               .102)
                              (NIL .06122]
```

(19) Time passes without any further reports until time 8.

(20) At time 8, the EO sensor has detected a new threat system, in a new location, that it strongly believes to be an SA-4.

```
       .1020092)
      (NIL .0612249))

       --DOWN-> ER.0033

       <-CONTAINS-- THREAT-SYSTEMS

((PAR POLYGON (568325 4201105)
      (568142 4202088)
      (566985 4201766)
      (567335 4200830))
 [(SA-4 (.8367669 1.0)
        (SA-4.ACQ (0.0 1.0))
        (SA-4.INACTIVE (0.0 1.0))
        (SA-4.MG (0.0 1.0))
        (SA-4.ML (0.0 1.0))
        (SA-4.SURV (0.0 1.0))
        (SA-4.TTR (0.0 1.0]
 (SR.0034))
---------------------END--------------------


(((PAR POLYGON (568076 4199341)
       (568033 4199438)
       (567864 4199358)
       (567911 4199263))
  [(SA-6 (.8947478 1.0)
         (SA-6.ACQ (0.0 1.0))
         (SA-6.ED-ACQ (0.0 1.0))
         (SA-6.ED-MG (0.0 1.0))
         (SA-6.ED-ML (0.0 1.0))
         (SA-6.ED-SURV (0.0 1.0))
         (SA-6.ED-TTR (0.0 1.0))
         (SA-6.INACTIVE (0.0 1.0))
         (SA-6.MG (0.0 1.0))
         (SA-6.ML (0.0 1.0))
         (SA-6.RADAR-SURV (0.0 1.0))
         (SA-6.TTR (0.0 1.0]
  (SR.0019 SR.0003 SR.0009 SR.0024))
 ((PAR POLYGON (570122 4195820)
       (570092 4195812)
       (570097 4195795)
       (570127 4195803))
  ((SA-8 (.7655402 1.0))
   (ASF-23/2 (0.0 .2344598))
   (ASF-35/2 (0.0 .2344598))
   (SA-6 (0.0 .2344598))
   (SA-9 (0.0 .2344598))
   (SF-3 (0.0 .2344598))
   (ZSU-23/4 (0.0 .2344598)))
  (SR.0014 SR.0006 SR.0029))
 ((PAR POLYGON (568325 4201105)
       (568142 4202088)
       (566985 4201766)
       (567335 4200830))
  [(SA-4 (.8367669 1.0)
         (SA-4.ACQ (0.0 1.0))
         (SA-4.INACTIVE (0.0 1.0))
         (SA-4.MG (0.0 1.0))
         (SA-4.ML (0.0 1.0))
         (SA-4.SURV (0.0 1.0))
         (SA-4.TTR (0.0 1.0]
  (SR.0034)))
--------------------BEGIN--------------------


   SR.0037 = ((SECTOR ((321 16 7134 5134)))
      ED ED.MODE2)

       <-DOWN-- ER.0038

       <-CONTAINS-- SENSORS


   ER.0038 = (((((PAR POLYGON (568101 4201180)
                      (567934 4202018)
                      (567108 4201798)
                      (567381 4200988))
         LONGTRACK)
        ((PAR POLYGON (568101 4201180)
              (567934 4202018)
              (567108 4201798)
              (567381 4200968))
         PATHAND))
        .836767)
       ((((PAR POLYGON (568101 4201180)
```

```
(21)   SUMMARIZE
```

```
      (ENVIRONMENT (9 (569239 4195465)))
(22) [REPORT (THREAT-SYSTEMS ((SECTOR ((321 16 7134 5134)))
                               ED ED.MODE2)
                              ((((PAR POLYGON (568101 4201180)
                                          (567934 4202018)
                                          (567108 4201798)
                                          (567381 4200988))
                                 (OR SA-4 SA-6))
                                1.0]
```

(21) The summary now includes three distinct threat systems.

(22) The EO sensor provides a locational update on the newly detected threat.

```
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       LONGTRACK)
      ((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       PATHAND)
      ((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       STRAIGHTFLUSH))
     .1632331))

     --DOWN-> SR.0034

     --DOWN-> SR.0037

     <-DOWN-- TSR.0039

     <-CONTAINS-- EMITTERS


 TSR.0039 = (((((PAR POLYGON (568101 4201180)
                        (567934 4202018)
                        (567108 4201798)
                        (567381 4200988))
       EARLYWARNING)
      ((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       SA-4))
     .836767)
    ((((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       EARLYWARNING)
      ((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       SA-4)
      ((PAR POLYGON (568101 4201180)
            (567934 4202018)
            (567108 4201798)
            (567381 4200988))
       SA-6))
     .1632331))

     --DOWN-> ER.0038

     <-CONTAINS-- THREAT-SYSTEMS

((PAR POLYGON (568101 4201180)
      (567934 4202018)
      (567108 4201798)
      (567381 4200988))
 ((EARLYWARNING (0.0 1.0))
  (SA-4 (0.0 1.0)))
 (SR.0034 SR.0037))
--------------------END--------------------


------------------BEGIN--------------------

  SR.0042 = ((CIRCULAR (7500))
     RWR RWR.MODE1)

      <-DOWN-- ER.0043

      <-CONTAINS-- SENSORS


  ER.0043 = (((((PAR POLYGON (567831 4201825)
                         (567169 4201616)
                         (567381 4200988)
                         (567981 4201148))
        PATHAND PATHAND.SURV))
      .931775)
     ((((PAR POLYGON (568101 4201180)
```

```
(23) [REPORT (EMITTERS ((CIRCULAR (7500))
                        RWR RWR.MODE1)
                       ((((PAR POLYGON (568047 4200848)
                               (567831 4201825)
                               (566748 4201483)
                               (567130 4200559))
                          (PATHAND PATHAND.SURV))
                         .9195)
                        (NIL .08046]
```

(23) Still at time 9, the RWR has detected an emitter that it believes is almost surely a Pat Hand in SURVeillance mode. This is the first report that has entered at the emitter level.

```
                (567934 4202018)
                (567108 4201798)
                (567381 4200988))
          LONGTRACK)
         ((PAR POLYGON (568101 4201180)
                (567934 4202018)
                (567108 4201798)
                (567381 4200988))
          PATHAND))
        .06822505))

        --DOWN-> SR.0037

        --DOWN-> SR.0034

        --DOWN-> SR.0042

        <-DOWN-- TSR.0044

        <-CONTAINS-- EMITTERS


   TSR.0044 = (((((PAR POLYGON (567831 4201825)
                              (567169 4201616)
                              (567381 4200988)
                              (567981 4201148))
          SA-4 SA-4.SURV))
        .931775)
       ((((PAR POLYGON (568101 4201180)
                (567934 4202018)
                (567108 4201798)
                (567381 4200988))
          EARLYWARNING)
         ((PAR POLYGON (568101 4201180)
                (567934 4202018)
                (567108 4201798)
                (567381 4200988))
          SA-4))
        .06822505))

        --DOWN-> ER.0043

        <-CONTAINS-- THREAT-SYSTEMS

(24) ((PAR POLYGON (567831 4201825)
           (567169 4201616)
           (567381 4200988)
           (567981 4201148))
      [(SA-4 (.931775 1.0)
            (SA-4.SURV (.931775 1.0]
      (SR.0037 SR.0034 SR.0042))
     ---------------------END--------------------


     (((PAR POLYGON (568076 4199341)                              SUMMARIZE
            (568033 4199438)
            (567864 4199358)
            (567911 4199263))
       [(SA-6 (.8947478 1.0)
              (SA-6.ACQ (0.0 1.0))
              (SA-6.ED-ACQ (0.0 1.0))
              (SA-6.ED-MG (0.0 1.0))
              (SA-6.ED-ML (0.0 1.0))
              (SA-6.ED-SURV (0.0 1.0))
              (SA-6.ED-TTR (0.0 1.0))
              (SA-6.INACTIVE (0.0 1.0))
              (SA-6.MG (0.0 1.0))
              (SA-6.ML (0.0 1.0))
              (SA-6.RADAR-SURV (0.0 1.0))
              (SA-6.TTR (0.0 1.0]
       (SR.0019 SR.0003 SR.0009 SR.0024))
      ((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
       ((SA-8 (.7555402 1.0))
        (A2F-23/2 (0.0 .2344598))
        (A2F-35/2 (0.0 .2344598))
        (SA-6 (0.0 .2344598))
        (SA-9 (0.0 .2344598))
        (SF-3 (0.0 .2344598))
        (ZSU-23/4 (0.0 .2344598)))
       (SR.0014 SR.0006 SR.0029))
      ((PAR POLYGON (567831 4201825)
            (567169 4201616)
```

(24) Since the possible locations for this Pat Hand overlap those for the suspected SA-4 and a Pat Hand emitter is part of an SA-4 system, the report from the RWR has been combined with the previous two reports from the EO; the conclusion is that there is an SA-4 system in SURV mode within this area.

```
      (567381 4200988)
      (567981 4201148))
  [(SA-4 (.931775 1.0)
         (SA-4.SURV (.931775 1.0]
  (SR.0037 SR.0034 SR.0042)))
--------------------BEGIN--------------------

   SR.0047 = ((SECTOR ((318 16 4732 2732)))
      ED ED.MODE2)

      <-DOWN-- ER.0048

      <-CONTAINS-- SENSORS


   ER.0048 = (((((PAR POLYGON (568029 4199415)
                       (567910 4199380)
                       (567898 4199574)
                       (567920 4199301)
                       (568050 4199340))
         STRAIGHTFLUSH))
       1.0))

      --DOWN-> SR.0024

      --DOWN-> SR.0009

      --DOWN-> SR.0003

      --DOWN-> SR.0019

      --DOWN-> SR.0047

      <-DOWN-- TSR.0049

      <-CONTAINS-- EMITTERS


   TSR.0049 = (((((PAR POLYGON (568029 4199415)
                        (567910 4199380)
                        (567898 4199374)
                        (567920 4199301)
                        (568050 4199340))
         SA-6))
       1.0))

      --DOWN-> ER.0048

      <-CONTAINS-- THREAT-SYSTEMS
```

```
(26) ((PAR POLYGON (568029 4199415)
           (567910 4199380)
           (567898 4199374)
           (567920 4199301)
           (568050 4199340))
      [(SA-6 (1.0 1.0)
            (SA-6.ACQ (0.0 1.0))
            (SA-6.ED-ACQ (0.0 1.0))
            (SA-6.ED-MG (0.0 1.0))
            (SA-6.ED-ML (0.0 1.0))
            (SA-6.ED-SURV (0.0 1.0))
            (SA-6.ED-TTR (0.0 1.0))
            (SA-6.INACTIVE (0.0 1.0))
            (SA-6.MG (0.0 1.0))
            (SA-6.ML (0.0 1.0))
            (SA-6.RADAR-SURV (0.0 1.0))
            (SA-6.TTR (0.0 1.0]
      (SR.0024 SR.0009 SR.0003 SR.0019 SR.0047))
     --------------------END--------------------
```

```
(((PAR POLYGON (570122 4195820)
       (570092 4195812)
       (570097 4195795)
       (570127 4195803))
  ((SA-8 (.7655402 1.0))
   (A3F-23/2 (0.0 .2344598))
   (A3F-35/2 (0.0 .2344598))
   (SA-6 (0.0 .2344598))
   (SA-9 (0.0 .2344598))
   (SF-3 (0.0 .2344598))
   (ZSU-23/4 (0.0 .2344598)))
  (SR.0014 SR.0006 SR.0029))
 ((PAR POLYGON (567831 4201825)
```

```
     (ENVIRONMENT (10 (569076 4195616)))
(25) [REPORT (THREAT-SYSTEMS ((SECTOR ((318 16 4732 2732)))
                              ED ED.MODE2)
                             ((((PAR POLYGON (568050 4199340)
                                       (568029 4199415)
                                       (567897 4199376)
                                       (567920 4199301))
                                SA-6)
                               .8632)
                              (((PAR POLYGON (568050 4199340)
                                       (568029 4199415)
                                       (567897 4199376)
                                       (567920 4199301))
                                (OR SA-4 SA-6))
                               .1016)
                              (NIL .03574]
```

SUMMARIZE

(25) Yet another report is received from the EO sensor concerning the suspected SA-6, the first threat system detected.

(26) Combining this report with the others leads to the certain conclusion that an SA-6 is present within these locational bounds.

```
              (567169 4201616)
              (567381 4200988)
              (567981 4201148))
(27)    [(SA-4 (.931775 1.0)
                (SA-4.ACQ (0.0 1.0))
                (SA-4.INACTIVE (0.0 1.0))
                (SA-4.SURV (0.0 1.0]
        (SR.0037 SR.0034 SR.0042))
       ((PAR POLYGON (568029 4199415)
              (567910 4199380)
              (567898 4199374)
              (567920 4199301)
              (568050 4199340))
        [(SA-6 (1.0 1.0)
                (SA-6.ACQ (0.0 1.0))
                (SA-6.ED-ACQ (0.0 1.0))
                (SA-6.ED-MG (0.0 1.0))
                (SA-6.ED-ML (0.0 1.0))
                (SA-6.ED-SURV (0.0 1.0))
                (SA-6.ED-TTR (0.0 1.0))
                (SA-6.INACTIVE (0.0 1.0))
                (SA-6.MG (0.0 1.0))
                (SA-6.ML (0.0 1.0))
                (SA-6.RADAR-SURV (0.0 1.0))
                (SA-6.TTR (0.0 1.0]
        (SR.0024 SR.0009 SR.0003 SR.0019 SR.0047)))
      -------------------BEGIN-------------------


         SR.0052 = ((SECTOR ((2 16 4546 2546)))
            ED ED.MODE2)

             <-DOWN-- ER.0053

             <-CONTAINS-- SENSORS


         ER.0053 = (((((PAR POLYGON (568043 4199329)
                             (568025 4199402)
                             (567899 4199368)
                             (567920 4199296))
               STRAIGHTFLUSH))
             1.0))

             --DOWN-> SR.0047

             --DOWN-> SR.0019

             --DOWN-> SR.0003

             --DOWN-> SR.0009

             --DOWN-> SR.0024

             --DOWN-> SR.0052

             <-DOWN-- TSR.0054

             <-CONTAINS-- EMITTERS


         TSR.0054 = (((((PAR POLYGON (568043 4199329)
                              (568025 4199402)
                              (567899 4199368)
                              (567920 4199296))
               SA-6))
             1.0))

             --DOWN-> ER.0053

             <-CONTAINS-- THREAT-SYSTEMS

      ((PAR POLYGON (568043 4199329)
            (568025 4199402)
            (567899 4199368)
            (567920 4199296))
       [(SA-6 (1.0 1.0)
               (SA-6.ACQ (0.0 1.0))
               (SA-6.ED-ACQ (0.0 1.0))
               (SA-6.ED-MG (0.0 1.0))
               (SA-6.ED-ML (0.0 1.0))
               (SA-6.ED-SURV (0.0 1.0))
               (SA-6.ED-TTR (0.0 1.0))
               (SA-6.INACTIVE (0.0 1.0))
               (SA-6.MG (0.0 1.0))
```

```
(ENVIRONMENT (11 (568929 4195774)))
[REPORT (THREAT-SYSTEMS ((SECTOR ((2 16 4546 2546)))
                          ED ED.MODE2)
                         ((((PAR POLYGON (568043 4199329)
                                 (568025 4199402)
                                 (567899 4199368)
                                 (567920 4199296))
                            (OR SA-6 SA-4))
                           1.0]
```

(27) Note that the almost certain belief that the SA-4 was in SURV mode has given way to belief in three possible modes at this new time.

```
      (SA-6.ML (0.0 1.0))
      (SA-6.RADAR-SURV (0.0 1.0))
      (SA-6.TTR (0.0 1.0]
 (SR.0047 SR.0019 SR.0003 SR.0009 SR.0024 SR.0052))
---------------------END---------------------


--------------------BEGIN--------------------

  SR.0057 = ((SECTOR ((337 40 1500 500)))
     OA OA.MODE3)

     <-DOWN-- ER.0056

     <-CONTAINS-- SENSORS


  ER.0056 = (((((PAR POLYGON (569090 4196664)
                     (569093 4196682)
                     (569061 4196687)
                     (569059 4196669))
      SF-3-OA-FC SF-3-OA-FC.ACTIVE))
     .49)
    ((((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      A3F-23/2-OA-FC A3F-23/2-OA-FC.ACTIVE)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      A3F-35/2-OA-FC A3F-35/2-OA-FC.ACTIVE)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      LANDROLL LANDROLL.ED-MG)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      LANDROLL LANDROLL.ED-TTR)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      SA-9-OA-FC SA-9-OA-FC.ACTIVE)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      SF-3-OA-FC SF-3-OA-FC.ACTIVE)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-MG)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      STRAIGHTFLUSH STRAIGHTFLUSH.ED-TTR)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
            (569061 4196687)
            (569059 4196669))
      ZSU-23/4-OA-FC ZSU-23/4-OA-FC.ACTIVE))
     .46)
    (NIL .05))

     --DOWN-> SR.0057

     <-DOWN-- TSR.0055

     <-CONTAINS-- EMITTERS


  TSR.0055 = (((((PAR POLYGON (569090 4196664)
                      (569093 4196682)
                      (569061 4196687)
                      (569059 4196669))
      SF-3 SF-3.ED-MG)
     ((PAR POLYGON (569090 4196664)
            (569093 4196682)
```

```
(28) [REPORT (THREAT-SYSTEMS ((SECTOR ((337 40 1500 500)))
                               OA OA.MODE3)
                              ((((PAR POLYGON (569090 4196664)
                                      (569093 4196682)
                                      (569061 4196687)
                                      (569059 4196669))
                                 (OR (SF-3 SF-3.ED-TTR)
                                     (SF-3 SF-3.ED-MG)))
                                .49)
                               (((PAR POLYGON (569090 4196664)
                                      (569093 4196682)
                                      (569061 4196687)
                                      (569059 4196669))
                                 (OR (SA-6 SA-6.ED-TTR)
                                     (SA-6 SA-6.ED-MG)
                                     (SA-8 SA-8.ED-TTR)
                                     (SA-8 SA-8.ED-MG)
                                     (SA-9 SA-9.IR-TTR)
                                     (SA-9 SA-9.IR-MG)
                                     (SF-3 SF-3.ED-TTR)
                                     (SF-3 SF-3.ED-MG)
                                     (A3F-35/2 A3F-35/2.ED-TTR)
                                     (A3F-35/2 A3F-35/2.ED-MG)
                                     (A3F-23/2 A3F-23/2.TTR)
                                     (A3F-23/2 A3F-23/2.FIRE)
                                     (ZSU-23/4 ZSU-23/4.ED-TTR)
                                     (ZSU-23/4 ZSU-23/4.ED-FIRE)))
                                .46)
                               (NIL .05]
```

(28) The OA sensor has detected a new threat system that it suspects to be an SF-3 in EO-TTR or EO-MG mode.

```
                (569061 4196687)
                (569059 4196669))
          SF-3 SF-3.ED-TTR))
         .49)
        ((((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          A3F-23/2 A3F-23/2.FIRE)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          A3F-23/2 A3F-23/2.TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          A3F-35/2 A3F-35/2.ED-MG)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          A3F-35/2 A3F-35/2.ED-TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-6 SA-6.ED-MG)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-6 SA-6.ED-TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-8 SA-8.ED-MG)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-8 SA-8.ED-TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-9 SA-9.IR-MG)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SA-9 SA-9.IR-TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SF-3 SF-3.ED-MG)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          SF-3 SF-3.ED-TTR)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          ZSU-23/4 ZSU-23/4.ED-FIRE)
         ((PAR POLYGON (569090 4196664)
                (569093 4196682)
                (569061 4196687)
                (569059 4196669))
          ZSU-23/4 ZSU-23/4.ED-TTR))
         .46)
        (NIL .05))

         --DOWN-> ER.0056

         <-CONTAINS-- THREAT-SYSTEMS

((PAR POLYGON (569090 4196664)
      (569093 4196682)
      (569061 4196687)
      (569059 4196669))
```

```
        --DOWN-> SR.0003

        --DOWN-> SR.0019

        --DOWN-> SR.0047

        --DOWN-> SR.006

        <-DOWN-- TSR.0062

        <-CONTAINS-- EMITTERS


    TSR.0062 = (((((PAR POLYGON (568043 4199329)
                        (568025 4199402)
                        (567899 4199368)
                        (567920 4199296))
          SA-6))
        1.0))

        --DOWN-> ER.0061

        <-CONTAINS-- THREAT-SYSTEMS

(29)  ((PAR POLYGON (568043 4199329)
           (568025 4199402)
           (567899 4199368)
           (567920 4199296))
       [(SA-6 (1.0 1.0)
              (SA-6.ACQ (0.0 1.0))
              (SA-6.ED-ACQ (0.0 1.0))
              (SA-6.ED-MG (0.0 1.0))
              (SA-6.ED-ML (0.0 1.0))
              (SA-6.ED-SURV (0.0 1.0))
              (SA-6.ED-TTR (0.0 1.0))
              (SA-6.INACTIVE (0.0 1.0))
              (SA-6.MG (0.0 1.0))
              (SA-6.ML (0.0 1.0))
              (SA-6.RADAR-SURV (0.0 1.0))
              (SA-6.TTR (0.0 1.0]
       (SR.0052 SR.0024 SR.0009 SR.0003 SR.0019 SR.0047 SR.006))
      ---------------------END---------------------


      --------------------BEGIN--------------------
```

```
(30) [REPORT (EMITTERS ((CIRCULAR (7500))
                        RWR RWR.MODE1)
                       ((((PAR POLYGON (567888 4200914)
                               (567682 4201892)
                               (566677 4201587)
                               (567050 4200659))
                          (PATHAND PATHAND.ACQ))
                         .9195)
                        (NIL .08046]
```

```
    SR.0065 = ((CIRCULAR (7500))
       RWR RWR.MODE1)

        <-DOWN-- ER.0066

        <-CONTAINS-- SENSORS


    ER.0066 = (((((PAR POLYGON (567705 4201785)
                       (567169 4201616)
                       (567381 4200988)
                       (567846 4201112))
          PATHAND PATHAND.ACQ))
        .8615308)
       ((((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          PATHAND PATHAND.ACQ)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          PATHAND PATHAND.INACTIVE)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          PATHAND PATHAND.ML)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          PATHAND PATHAND.SURV)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
```

```
 ((SF-3 (.49 1.0))
  (A3F-23/2 (0.0 .51))
  (A3F-35/2 (0.0 .51))
  (SA-6 (0.0 .51))
  (SA-8 (0.0 .51))
  (SA-9 (0.0 .51))
  (ZSU-23/4 (0.0 .51)))
 (SR.0057))
---------------------END---------------------


(((PAR POLYGON (570122 4195820)                                   SUMMARIZE
       (570092 4195812)
       (570097 4195795)
       (570127 4195803))
  ((SA-8 (.7655402 1.0))
   (A3F-23/2 (0.0 .2344598))
   (A3F-35/2 (0.0 .2344598))
   (SA-6 (0.0 .2344598))
   (SA-9 (0.0 .2344598))
   (SF-3 (0.0 .2344598))
   (ZSU-23/4 (0.0 .2344598)))
  (SR.0014 SR.0006 SR.0029))
 ((PAR POLYGON (567831 4201825)
       (567169 4201616)
       (567381 4200988)
       (567981 4201148))
  [(SA-4 (.931775 1.0)
         (SA-4.ACQ (0.0 1.0))
         (SA-4.INACTIVE (0.0 1.0))
         (SA-4.SURV (0.0 1.0))
         (SA-4.TTR (0.0 1.0]
  (SR.0037 SR.0034 SR.0042))
 ((PAR POLYGON (568043 4199329)
       (568025 4199402)
       (567899 4199368)
       (567920 4199296))
  [(SA-6 (1.0 1.0)
         (SA-6.ACQ (0.0 1.0))
         (SA-6.EO-ACQ (0.0 1.0))
         (SA-6.EO-MG (0.0 1.0))
         (SA-6.EO-ML (0.0 1.0))
         (SA-6.EO-SURV (0.0 1.0))
         (SA-6.EO-TTR (0.0 1.0))
         (SA-6.INACTIVE (0.0 1.0))
         (SA-6.MG (0.0 1.0))
         (SA-6.ML (0.0 1.0))
         (SA-6.RADAR-SURV (0.0 1.0))
         (SA-6.TTR (0.0 1.0]
  (SR.0047 SR.0019 SR.0003 SR.0009 SR.0024 SR.0052))
 ((PAR POLYGON (569090 4196664)
       (569093 4196682)
       (569061 4196687)
       (569059 4196669))
  ((SF-3 (.49 1.0))
   (A3F-23/2 (0.0 .51))
   (A3F-35/2 (0.0 .51))
   (SA-6 (0.0 .51))
   (SA-8 (0.0 .51))
   (SA-9 (0.0 .51))
   (ZSU-23/4 (0.0 .51)))
  (SR.0057)))
--------------------BEGIN--------------------


  SR.006 = ((SECTOR ((356 30 4328 2328)))
     EO EO.MODE3)

      <-DOWN-- ER.0061

      <-CONTAINS-- SENSORS


  ER.0061 = (((((PAR POLYGON (568043 4199329)
                     (568025 4199402)
                     (567899 4199368)
                     (567920 4199296))
        STRAIGHTFLUSH))
      1.0))

      --DOWN-> SR.0052

      --DOWN-> SR.0024

      --DOWN-> SR.0009
```

```
(ENVIRONMENT (12 (568927 4195996)))
[REPORT (THREAT-SYSTEMS ((SECTOR ((356 30 4328 2328)))
                         EO EO.MODE3)
                        ((((PAR POLYGON (568043 4199334)
                                (568025 4199402)
                                (567906 4199369)
                                (567927 4199301))
                           SA-6)
                          .8628)
                         (((PAR POLYGON (568043 4199334)
                                (568025 4199402)
                                (567906 4199369)
                                (567927 4199301))
                           (OR SA-4 SA-6))
                          .1015)
                         (NIL .03574]
```

(29) At this point, the SA-6 conclusion acts as a data reduction vehicle, absorbing all the additional reports concerning that SA-6.

(30) The RWR has detected the Pat Hand once again, but this time in ACQuisition mode.

```
                (567981 4201148))
          PATHAND PATHAND.TTR))
         .07538746)
        ((((PAR POLYGON (567682 4201892)
                (567133 4201725)
                (567391 4200988)
                (567846 4201112))
          PATHAND PATHAND.ACQ))
         .06308173))

         --DOWN-> SR.0042

         --DOWN-> SR.0034

         --DOWN-> SR.0037

         --DOWN-> SR.0065

         <-DOWN-- TSR.0067

         <-CONTAINS-- EMITTERS


    TSR.0067 = (((((PAR POLYGON (567705 4201785)
                             (567169 4201616)
                             (567381 4200988)
                             (567846 4201112))
          SA-4 SA-4.ACQ))
         .8615308)
        ((((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          SA-4 SA-4.ACQ)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          SA-4 SA-4.INACTIVE)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          SA-4 SA-4.ML)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (557981 4201148))
          SA-4 SA-4.SURV)
         ((PAR POLYGON (567831 4201825)
                (567169 4201616)
                (567381 4200988)
                (567981 4201148))
          SA-4 SA-4.TTR))
         .07538746)
        ((((PAR POLYGON (567682 4201892)
                (567133 4201725)
                (567381 4200988)
                (567846 4201112))
          SA-4 SA-4.ACQ))
         .06308173))

         --DOWN-> ER.0066

         <-CONTAINS-- THREAT-SYSTEMS

(31) ((PAR POLYGON (567705 4201785)
           (567169 4201616)
           (567381 4200988)
           (567846 4201112))
      [(SA-4 (1.0 1.0)
           (SA-4.ACQ (.9246125 1.0]
      (SR.0042 SR.0034 SR.0037 SR.0065))
     ---------------------END---------------------

(32) (((PAR POLYGON (570122 4195820)
            (570092 4195812)
            (570097 4195795)
            (570127 4195803))
       ((SA-8 (.7655402 1.0))
        (A3F-28/2 (0.0 .2344598))
        (A3F-35/2 (0.0 .2344598))
        (SA-6 (0.0 .2344598))
        (SA-9 (0.0 .2344598))
```

SUMMARIZE

(31) The addition of this report has led to the certain conclusion that an SA-4 is present and is almost certainly in ACQ mode. Before this report, the initial opinion that it was in SURV mode had expanded to encompass four possible modes.

(32) The final summary, prior to the STOP command, includes four threat systems hypothesized on the basis of 15 reports. Two of these systems, the SA-4 and the SA-6, have been identified with certainty. The current mode of operation of the SA-4 is known with near certainty, while the mode of the SA-6 remains completely unknown.

```
   (SF-3 (0.0 .2344598))
   (ZSU-23/4 (0.0 .2344598)))
  (SR.0014 SR.0006 SR.0029))
((PAR POLYGON (569090 4196664)
      (569093 4196682)
      (569061 4196687)
      (569059 4196669))
 ((SF-3 (.49 1.0))
  (A3F-23/2 (0.0 .51))
  (A3F-35/2 (0.0 .51))
  (SA-6 (0.0 .51))
  (SA-8 (0.0 .51))
  (SA-9 (0.0 .51))
  (ZSU-23/4 (0.0 .51)))
 (SR.0057))
((PAR POLYGON (568043 4199329)
      (568025 4199402)
      (567899 4199368)
      (567920 4199296))
 [(SA-6 (1.0 1.0)
        (SA-6.ACQ (0.0 1.0))
        (SA-6.ED-ACQ (0.0 1.0))
        (SA-6.ED-MG (0.0 1.0))
        (SA-6.ED-ML (0.0 1.0))
        (SA-6.ED-SURV (0.0 1.0))
        (SA-6.ED-TTR (0.0 1.0))
        (SA-6.INACTIVE (0.0 1.0))
        (SA-6.MG (0.0 1.0))
        (SA-6.ML (0.0 1.0))
        (SA-6.RADAR-SURV (0.0 1.0))
        (SA-6.TTR (0.0 1.0]
 (SR.0052 SR.0024 SR.0009 SR.0003 SR.0019 SR.0047 SR.006))
((PAR POLYGON (567705 4201785)
      (567169 4201616)
      (567381 4200988)
      (567846 4201112))
 [(SA-4 (1.0 1.0)
        (SA-4.ACQ (.9246125 1.0]
 (SR.0042 SR.0034 SR.0037 SR.0065)))

                                                              STOP
```