

AUTOMATED CLASSIFICATION, IDENTIFICATION,
AND INFORMATION SYSTEM: An Integrated
Systems Approach to Automated Target
Recognition in a Multiple Sensor Multiple
Platform Environment

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ABSTRACT

The *Automatic Classification, Identification, and Information (ACII)* System is a project designed for Automated Target Recognition in a multiple sensor, multiple platform environment, implemented as a collection of integrated rule based system modules that learn according to the platform type needs. The design concept includes introduction, background, systems and concepts, overall system operation, initial design of a platform level system, description of major information flows, other applications of the system, and conclusions. The appendices contain the design of a platform level system using the *CASE* tool named *Software through Pictures (StP)*TM. The design consists of data flow diagrams, annotations, level drawings, and structure charts of the major systems.

The ACII system is designed for a combined theater area, local operating area, and unit target correlation system. The individual units perform the collection of target information using their sensors. The unit attempts identification before sending the information to the local area coordinator. The local area coordinator attempts identification using all the information in the area before sending it to the theater system. The theater system uses all the information in the theater for identification. The identification, if completed, is returned to all units within the local operating area.

The ACII system can be adapted for numerous other non-military uses including Air Traffic Control, industrial process monitoring, industrial robotics, weather forecasting, seismographic evaluation, and financial systems. The number of military uses are vast including weapons systems, propulsion systems, damage assessment systems, safety systems, manpower evaluation systems, and numerous others.

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I. INTRODUCTION

The title of this project defines several concepts that are significant. In order to understand what is being designed, you need to know the definitions of the concepts related to the project. The first concept is *Integrated Systems*. In this project, *Integrated Systems* refers to developed systems that are combined based on the specific need of the platform. An Army Mechanized Headquarters group does not need a module that evaluates Sonar information, but a Navy Anti-submarine airplane does. Each type of platform has a general system requirement and a specific set of unique sensor and tracking modules. A ship would have a general system. A ship protecting against submarines would have specific Sonar modules based on its inherent system (convoy protection sonar equipment is different from battle group protection sonar equipment). A high speed aircraft requires a significantly faster tracking module.

The next concept is *Target Recognition*. In radar systems *Target Recognition* involves (i) correlation of targets to ensure spurious targets are not generated and (ii) targets that split (e.g., a missile launch) are detected. In optical systems the target must be separated from the terrain prior to classification and identification attempts. The meaning of *Target Recognition* in the system being defined is classification and identification. The system being defined will take the output (a target) of the sensor fused evaluation unit and classify or identify it. Identification means the target is known (e.g., a T-72 Tank, a Backfire bomber, or an Echo class submarine). Classification is a level below identification and defines attributes of the contact (e.g., airborne, bomber-size, and propeller driven). An example of the classification technique would be combining a radar target course and speed from one platform, an electronic warfare intercept from another platform, and a passive sonar bearing from another platform to classify the target as a type of enemy platform with a probability of certainty level.

The term *Multiple Sensor* means there can be both several sensors of the same type and the sensors can be mixed (e.g., air search radar, surface search radar, active sonar, passive sonar, others). The information from sensors of the same type must be fused first. The term *Multiple Platform* means more than one unit of a platform type or multiple platform types (e.g., ships, airplanes, helicopters, and land forces) can be operating together.

The system being developed is called the *Automatic Classification, Identification, and Information* (ACII) system. Information is added because the system relies on rapid information retrieval, so that capability is extended to the user. The following sections define the system.

II. BACKGROUND

The next generation of *Combat Information Center* or *Combat Control Center* will require rapid, secure, fully evaluated information before receipt by decision makers. The development of a very reliable, rapid automatic system to coordinate information flow, produce evaluated information, and provide recommendations requires the application of intelligent rule based systems, advanced data retrieval techniques, and secure reliable communications. The next generation warfare environment must have fast, reliable local area and theater exchange of combat information.

There are large amounts of information generated by fixed and non-fixed sensors throughout an operating theater that must be shared. Examples include:

1. Ship, aircraft, and submarine movements via reporting systems.
2. Contact information from submarines, surface ships, and aircraft using internal sensors (includes *AWACS*, *KC-130*, and other classified systems).
3. Intelligence photographs of non-friendly nation vessel movements out of ports.
4. Commercial ships and aircraft movement reporting.
5. Other intelligence sources.

The external information could be consolidated, continuously updated and evaluated, tailored to specific operating area need, and exchanged for use in decision making. Internal information could also be evaluated using rules developed by the most experienced military experts available.

Besides the improved information flow, an automatic system could solve other problems. If a Navy ship or aircraft detects a sub-surface contact, the automatic system would already know whether to classify it as friendly or unknown. If the contact is friendly, prosecution is not attempted, preventing hostile forces from detection by elimination (i.e., the enemy knows the location of its submarines). Target acquisition reports are automatically generated and submitted, eliminating the need for the existing manual, time-consuming contact reporting system. Additionally, movement reporting would also be eliminated as vessels periodically update their position to the central information center. The position reports would also be very helpful for search and rescue operations on aircraft. Numerous other manual reports are eliminated, changed, or enhanced by this system.

III. SYSTEMS AND CONCEPTS

This section introduces the systems and general concepts of the combat system being defined. The first two sections include descriptions of systems being developed at Auburn University that are relevant to this project. The following sections discuss the technical aspects of the design.

III.1 Rule Based Systems

The ultimate goal of research at Auburn is to produce a family of integrated, rule based learning systems that can easily be adapted to solve any information evaluation problem. A significant amount of research has been completed in this area¹⁻⁵. Figure 1 lists the systems under development and their interoperability. The major emphasis in the ACII system development is on solving combat or tactical classification and identification problems. In order to understand the complexity of the system being developed, an understanding of the type of knowledge systems that must be created is required.

Rule based systems are conventionally defined as computer programs that solve classes of problems. They can be used to acquire new knowledge by a person familiar with the subject area. A rule based system is used to discover non-obvious knowledge, thereby eliminating database systems with obvious inference schema. Belev⁶ identified the five components of a rule based system as a user friendly interface, model base, rule base, text base, and data base. In the Belev scheme, the model base defines the method for deducing new knowledge from the rule base and data base. The text base contains instructions for

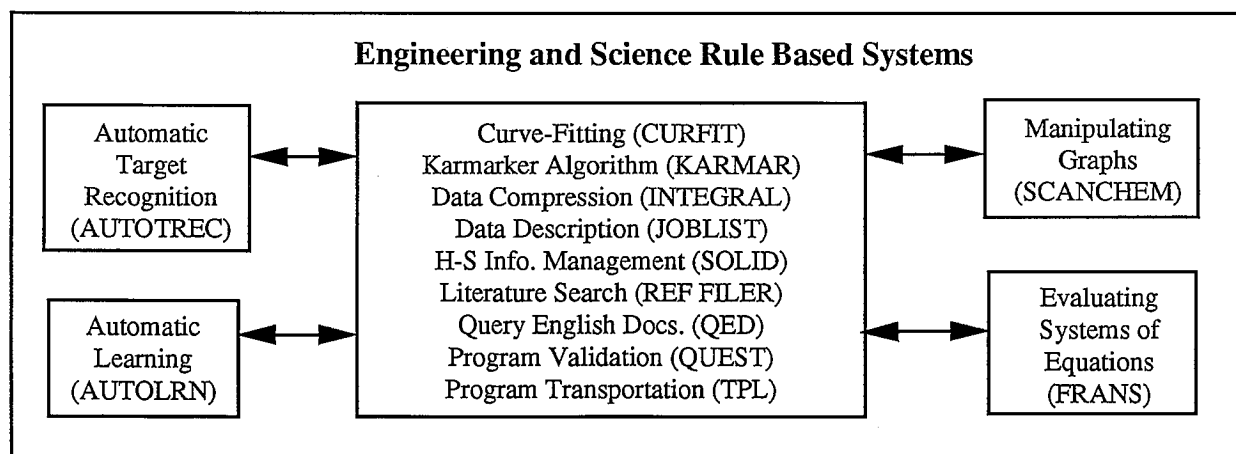


Figure 1. Relationships between the component Rule Based Systems for the planned Engineering and Science Rule Based Systems Package. The nine systems in the central box are the Artificial Intelligence System Support Tools (AISST) each of which can be used on a stand-alone basis. The AUTOTREC and AUTOREC will be used extensively in the ACII system.

communicating with the user interface in an easily understood, familiar language.

With the Belev scheme, rule based systems can be classified as being in one of three principal categories defined as follows:

1. *Conventional Rule Based Systems* - The rule base is constructed using current knowledge to predict events within the defined expertise. The conventional rule based system must be continually updated to maintain current knowledge.
2. *Automatic Deductive Systems (ADS)* - An ADS is a special class of rule based system. Its model base is a mathematical model, and its rule base is either an integral, indistinguishable part of the mathematical model or generated by the system itself from the fundamental laws of science like the Conservation of Mass/Energy.
3. *Automatic Adaptive Learning Systems* - Automatic learning systems are used to classify or identify objects and entities. The model base is one or more clustering algorithms used to compute classification parameters for a known set which is then used to classify unknown sets. Adaptive learning systems augment known sets with unknown sets that have been classified. The classification parameters are recomputed to improve the predictive capabilities. There are two types of automatic adaptive learning systems. The automatic learning system does not require human input to determine classification parameters or to identify objects and entities. The automatic target recognition system typically requires a description of the object or entity for recognition.

There are two related adaptive learning systems, *AUTOLRN* and *AUTOTREC*¹, presently being designed at Auburn University. The two independent systems are implementations of general automatic adaptive learning systems for determining controlling parameters, classification, and identification.

III.2 Artificial Intelligence Support Systems

There are also two related *Artificial Intelligence Support Systems* (AISS) being investigated at Auburn University, *JOBLIST* and *SOLID*²⁻⁵. *JOBLIST* and *SOLID* combine to form a high speed data management system that has bounded search times, i.e. the amount of time to process any query is small, independent of the size or number of different databases and the form of the question asked. The *JOBLIST* system creates, maintains, and manipulates the related data structure. It constructs the internally used data form and executes all arithmetic and manipulative operations. The *JOBLIST* system uses the *SOLID* system to retrieve and update information in the databases. The *SOLID* system manages information and processes both retrieval and update requests received from the *JOBLIST* system. Its mathematical basis is the *JOBLIST* data structure. *SOLID* has three

interdependent files (*REGFILE*, *AFILE*, and *MFILE*) that can be accessed independently. *MFILE* contains the referenced information in compressed form. *AFILE* is a keyed-entry file that yields the machine address of the compressed items in the *MFILE*. *REGFILE* is a simulated communications network whose information paths are described by the queries (i.e. there is no directory). A prototype of the *SOLID* system was used as part of the highly successful *PENNRAMS*⁷ system for processing patient health-care information.

III.3 Communications

Communications provide the vital link that forms the foundation of the ACII system. Without rapid, secure intermodule, intersystem, interplatform, and theater communications, the ACII system would be ineffective. In order to understand the communications system requirements, consider the level of computing power of the university LAN and its interconnections. Prior to connection, a *SUN* workstation (the single platform) is a powerful computer system. The workstation's power grows rapidly when it is connected to the local network and to a server. Further, the connection to the university network is another rapid growth, because the university network is connected to the university's computers, the Alabama Supercomputer, other Supercomputers, and *InterNet*. The same principal exists in combat communications systems, but the connections are not quite as easy. The military is starting to design strategic systems with interconnections to the entire DoD and intelligence community. The Integrated Tactical Data Network⁸ is a system being developed to interconnect existing military packet switching networks. A system similar to the ITDN system will provide the backbone for the Theater ACII system communications concept, at least for the higher echelons of command.

The communications requirements of the ACII system are diverse. The Theater to platform tactical communications will be via satellite networks with High Frequency networks as backups. The communications networks must be distributed⁹ for greater survivability against physical and electronic attacks. New technology is being developed for satellites¹⁰⁻¹³, High Frequency¹⁴, Ultra High Frequency¹⁵, and Very Low Frequency¹⁶ (submarine) communications. New packet switching routing and interconnection techniques¹⁷⁻²¹ are completing their definition phase and becoming on-line systems. Multimedia²²⁻²⁵ systems (voice, data, and video) are available for use on some platforms (aircraft carriers are receiving SAFENET II²⁶), with other platforms to have new systems in this century.

III.3.1 Theater-wide Communications

The Theater ACII system requires global communications to link platforms (data collectors) to the central control facility. With satellite communications, platforms can send information to the central collection facility which returns evaluated information. Decisions on whether individual platforms send the information directly to the central facility or the information is consolidated on one of the locally operating platforms for transmission will be based on the tactical environment. Much of the research being done is focused on the network environment. The determination of the best communications protocol, link interconnection scheme, routing algorithm, and congestion control algorithms will require on-going investigation.

The satellite network problems are simple compared to the situation when satellite communications are lost. The backup to satellite communications for airborne and seaborne platforms is HF communications, a significantly less capable method. Although new technology is improving the speed of information exchange on HF networks^{14,26}, HF communications will require information consolidation for each local operating area. Land based platforms would also have to consolidate information when changing locations. The consolidated information could then be passed by microwave, packet radio, or telephone lines to the central facility. Development of contingency plans, in addition to research on the best network architecture, is required for the non-satellite environment. Higher speed Modems²⁶ are evolving, and millimeter wave and optical communications⁹ are receiving increased attention. These technologies are not ready for system deployment in the near future.

III.3.2 Local Operating Area Communications

Local area communications provide another vital link in the system. A packet switched network architecture is required for platforms operating as a functioning group, like an armored division or battle group. The local communications network permits a single warfare commander, independent of the platform, to determine and order engagements of all targets in that area. The network for the ACII system can effectively use existing packet radio networks employing various types of radio systems.

III.3.3 Internal Platform Communications

Intermodule communications on the individual platform will use *JOBLIST/SOLID* for the passing of pointers (kernel addresses). By establishing a processing language that can

be used throughout the platform system, only the individual user-interface and external communications require translation. Of course, research will be required on the best methods of process management, flow analysis, response time, and bottleneck analysis for this system.

III.4 Multiple Platform Environment

In order to understand the ACII system, the designer must know the environment. There are numerous military systems that presently exchange information of a tactical nature²⁶⁻³⁰. An Air Force *AWACS* aircraft using the Tactical Air Control System (TACS) exchanges tactical and engagement information with Naval Tactical Data System (NTDS) equipped platforms (aircraft, ships, and submarines). Army platforms coordinate via a Direct Air Support Center (DASC) to establish radio links to the other armed services for Close Air Support and Naval Gunfire Support. The multiple platform environment requires the exchange of information between all capable platforms regardless of the organization. Platforms owned by the Treasury Department, Drug Enforcement Agency, FBI, and others will interconnect with the ACII system as necessary.

The potential for greater interaction of services and allied forces in the future is significant. As advanced tactical communications systems mentioned above reach the operating forces, airborne sensors will become the Over-the-Horizon eyes of the ground forces²⁷. As these improvements in the exchange of information develop, the potential for flooding the present state-of-the-art combat system exists²⁸. New systems being designed must have the capability to automatically adjust the amounts of information sent to the display module as the battle situation changes. The ACII system will not display targets that have no bearing on the host platform. Additionally, it will automatically adjust the sensor displays to eliminate targets that are outside the immediate threat area (e.g., it might adjust the scale on the display unit from 200 miles to 50 miles based on the threat situation).

The only method of effectively controlling the magnitude of information in the next generation combat system is via an Intelligent System. As combat systems expand their sensor capabilities and incorporate advanced information exchange capabilities, smart information consolidation and correlation systems must be employed. Without the ACII System or a related system, combat systems will become so good that they are detrimental to the combat environment.

III.5 Multiple Sensor Environment

Many platforms contain more than one sensor. Most of these platforms have sensors like radar, electronic warfare, and submarine detection equipment, and they have more than one type of each sensor. An anti-submarine ship can have three radars, two electronic warfare systems, and three submarine detection systems. It is possible to detect the same target on five or six of the systems. Target correlation is critical to system performance. Present research into Kalman filtering, gating, and data association techniques have solutions to individual sensor target correlation, especially radars²⁹⁻³³, and can be extended to the multiple sensor environment. In optical recognition systems, factor analysis, logistic regression, and linear least squares regression³⁴ techniques look promising. Honeywell also has developed the KMBAA algorithm adaptation technique for optical systems³⁵.

The ACII system does not perform individual sensor fusion. The system takes information from the sensor correlation module and determines if the target is unique. If the target is unique, the system attempts to create a classification and/or identification. It also produces a target symbol structure that can be used throughout the ACII network. Section III.8 on data fusion covers the subject in more detail.

III.6 Integrated Systems

Another key to the ACII system is the integrated systems concept. In order to have a combat system operate properly, each type of platform must have the capability to effectively use the information. Each individual module must be usable on any platform with only minor modifications like installing its unique training set. The individual military branches must also have the foresight to realize that developing a single system is the most efficient way to meet their combat systems goals³⁶. The ACII system will integrate several learning modules. The user organizations will develop their own training sets for their learning systems, their own Knowledge Bases (e.g., list of facts, classification criteria, expert decision matrix, etc.), and the set of modules required for their environment (a land based staff does not submit a continuous position report). Each platform has unique system requirements and training sets. The combat system requirements for an *AWACS* aircraft are significantly different from those on a submarine, so hardware requirements are different. However, as functions of the combat system modules do not change, the module software differs only slightly for those platforms. Once the software modules are developed, only minor modifications will be needed for the ACII system to be operational in different environments.

III.7 Security

A primary concern with any defense software system is security of the information. Individual pieces of information may have one security level, but combinations of equally classified material might have a higher security level. An example could be the word *HUMINT*. Used separately, the word is unclassified. Put it together with the method of identification of a target, and the word is classified information. Making every word or phrase the highest security level possible is not a solution³⁶.

The ACII system solution to the problem involves developing a closed, limited access system with only *TEMPEST* approved computers exchanging information. Neither the technique nor information used to determine an identification or classification is accessible. Bulk encryption devices are used for the transfer of information over communications networks. The information management system, *JOBLIST/SOLID*, ensures proper security and access are maintained internally. (The information management system has dynamic and static security locking codes that prevent illegal access to information.) There is very limited access to internal information. Both the individual and the display terminal must meet security requirements for information to be displayed. (A hardware security code will be installed in the terminal with some type of user identification code inserted via a number pad or plastic card reader when the user commences operation of the terminal.) Additionally, some classified information may be locked until certain situations exist and multiple unlocking codes are required (two individuals have unique codes that must be entered).

The storage of backup software is a problem. It can be stored in a safe with other materials of equal security classification provided the safe meets the requirements for storing disks. The ACII software should be protected based on its abilities to interface with other equipment. Only the Knowledge Base will have any intelligence information that would require high security classification.

Other methods of security should be investigated, to solve the combinational security problem without having to rely on the extremely drastic measures used in this system. Present systems employing some type of combinational security require tremendous overhead.

III.8 Data Fusion

The ACII system is essentially a data fusion system. It obtains data from a variety of sources, internal and external to the platform. The data fusion is then done in several

stages. The first stage occurs when information from the sensors is fused using probabilistic methods. The most common methods employed for classification and identification are Bayesian, Dempster/Shafer, Fuzzy Set Theory, and Cluster Analysis²⁸, depending on the sensor and its function. Similar methods are used in evaluating tactical information and developing new strategies during knowledge acquisition procedures. After target correlation is complete, target information moves to the next stage which attempts multiple sensor data fusion techniques like the *Blackboard*²⁸ data structure for identification. The information moves to the third stage where further identification techniques are employed, if required. At this stage the system uses its special tracking module and knowledge acquisition capability to determine the identity. At this stage the information is also sent out to other locally operating platforms via an automatic reporting system. The locally operating platforms attempt identification by using fusing techniques to collate the targets to their sensor generated targets. The final stage is the automatic report sent to a theater-wide central control facility which contains all the information in the theater of operations to attempt further fusion and/or identification.

Numerous techniques for data fusion have been researched²⁸. The techniques include:

1. Knowledge representations such as algorithms, hypotheses, rules, and frames.
2. Control strategies that include imperative, opportunistic, and forward/backward methods.
3. Numerical and symbolic uncertainty schemes used for inference.²⁸

As this is not a project on defining all the techniques of data fusion, I will not diverse. The combat system being defined has not developed to the point where decisions are being made on specific techniques or even whether new techniques are to be developed. The system will now be defined.

IV. OVERALL ACII SYSTEM OPERATION

The overall ACII system operation involves creating a central information storage and evaluation unit, the Theater ACII System, to feed specific information to operating units in their area of operations based on their need to know. If a Battle Group is operating in the Sea of Japan, it has access to all information on friendly and possible non-friendly contacts (not previously identified or known hostile) in that area and adjacent operating areas. The information would be transferred via a secure communications link to the unit's ACII Knowledge Base and Automated Tracking module for access by the operational unit and local commanders with access based on the individual's need to know.

Figure 2 is a block diagram of the Theater ACII System. It communicates with operational units, operational and tactical commanders, and headquarters commands. The military communications network is used to exchange information between the Theater ACII system and operational platforms. Contact and movement information from the operating units to the Theater Knowledge Base, Figure 3, is the foundation of the multiple platform information exchange concept. Operating platforms are the data collection module for the central unit. The Central Control System (CCS) coordinates information flow. The CCS determines the information needs of the individual platform or headquarters command based on location, readiness condition set, etc. The CCS handles queries, transfers reports to the appropriate agency, and coordinates new information development. The Knowledge Acquisition System (KAS) continuously evaluates information

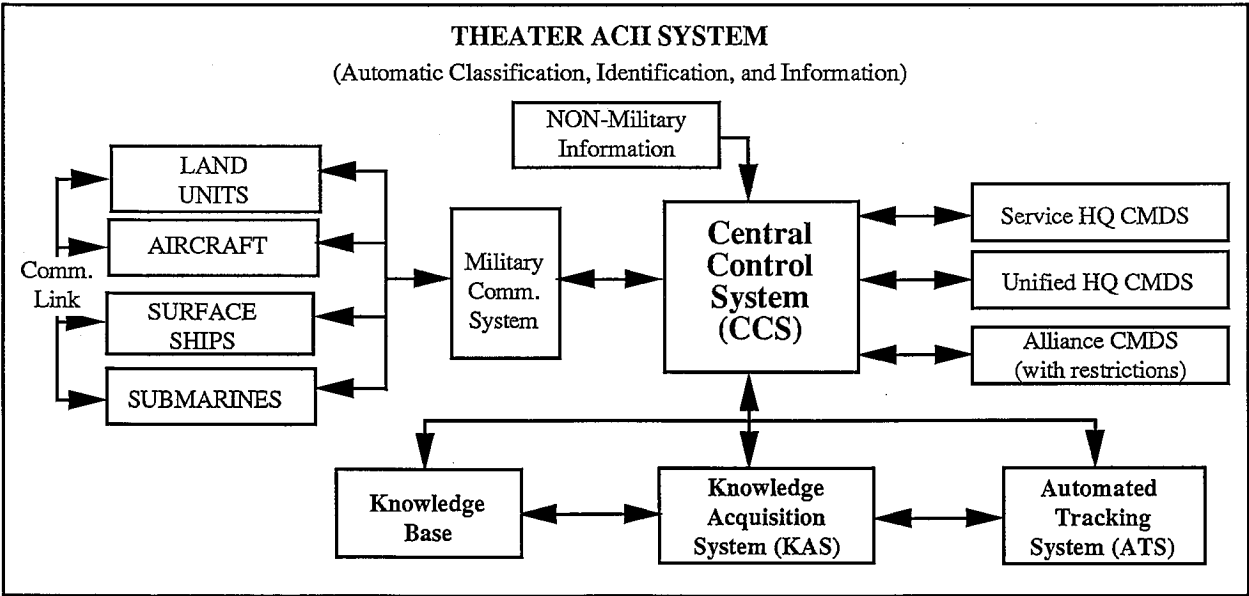


Figure 2. The Theater ACII System block diagram showing interoperability of system modules.

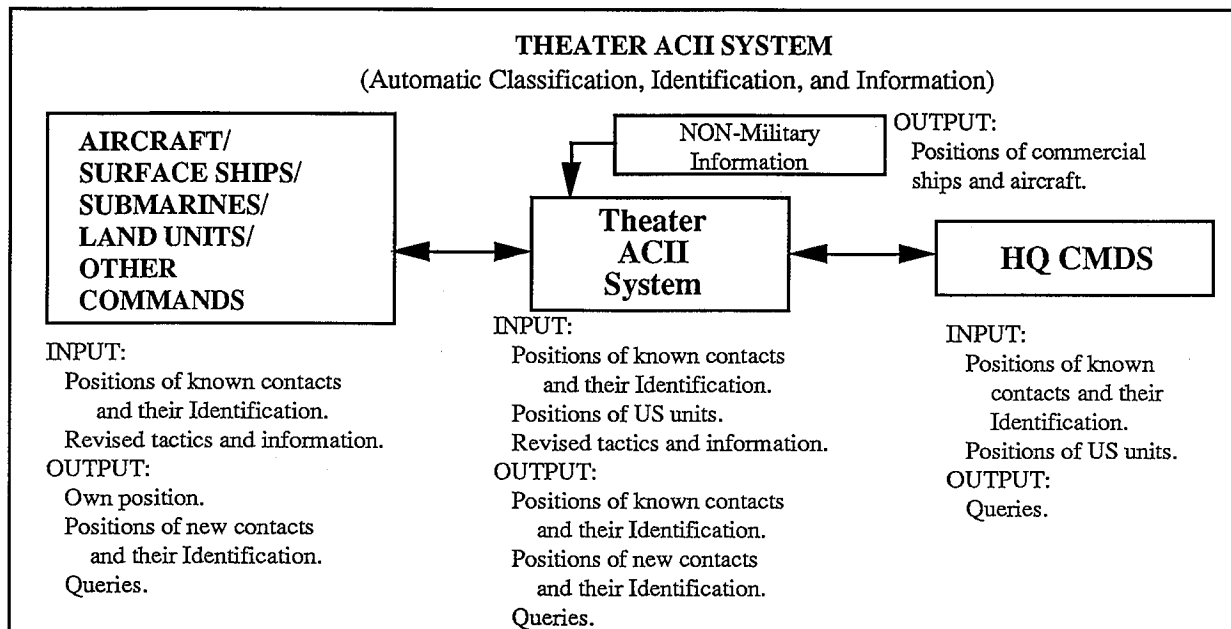


Figure 3. The Theater ACII System information flow diagram defining major inputs and outputs within the system.

to determine new tactical patterns like type of enemy platform operating in a specific area, special tactics employed, or new types of equipment (new vehicles, tanks, ships, aircraft, etc.). The Theater Knowledge Base contains all known relevant information including aircraft, ships, submarines, vehicles, equipment, and military tactics. The Theater Automated Tracking System (ATS) tracks all types of major platforms including military and commercial surface ships and aircraft, troop movements, major vehicle group movements, and submarines. It also provides a combinatorics matrix of course and speed changes for contacts being tracked for use in identification of sensor detected contacts.

An example of information flow would be the CCS taking information from the ATS and Knowledge Base, developing contact reports for a Navy Battle Group in an area with probability location and search area defined. The low probability contacts would be stored in the individual platform's Knowledge Base. The medium to high probability contacts would be added to the platform's Automated Tracking module based on the contacts highest probability location or last confirmed location. All contacts within the platform's sensor detection range are also displayed on the platform's threat matrix display console.

The Theater ACII System would require a large multi-processor computer system and communications network. As each Theater commander (i.e., Unified Commander) already has major computer systems and the military communications system has adequate networks, specific hardware requirements are not provided. If the computer system in

place could be slowed by the massive computing requirements, the Theater's system could be further subdivided or a separate computer could be added. The software for the Theater System would use algorithms similar to those developed for the platform system.

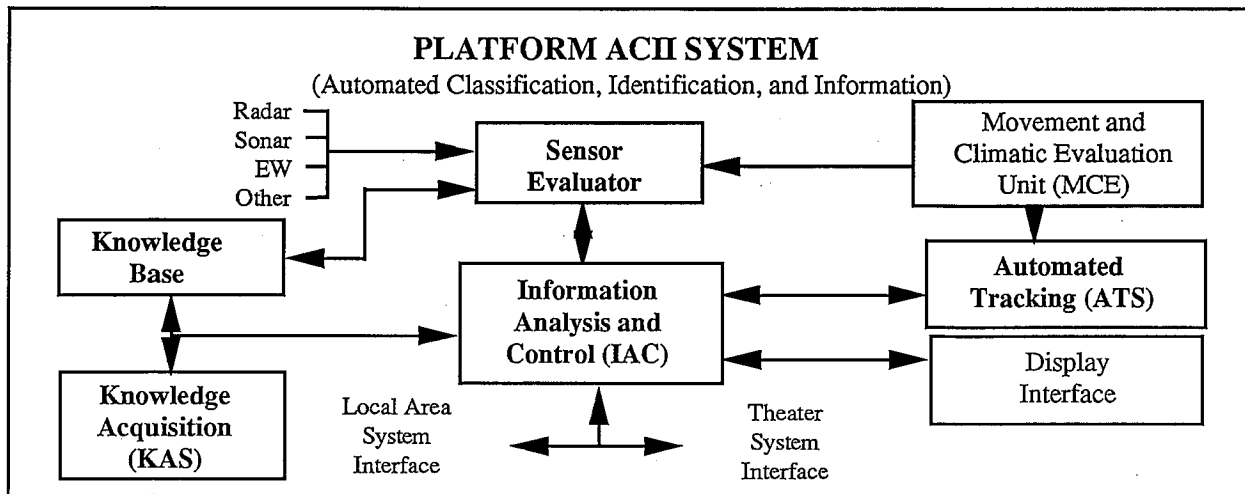


Figure 4. The Platform ACII System block diagram defining interoperability of major components.

V. PLATFORM ACII SYSTEM

The Platform ACII System, Figure 4, is a block diagram of the primary system for ships, submarines, aircraft, and land command and control centers. It is similar to the Theater ACII System. There are several significant differences like the Sensor Evaluator and the interface with the Movement and Climatic Evaluation Unit (MCE). The details of the individual blocks will be presented separately.

Major advantages of the ACII system for the operational platform include speed of evaluation, security of information, automatic report generation, coordinated flow of internal and external information, better decision making, fewer training requirements, reduced manpower in some operational platforms, and knowledge of contacts before internal sensor detection. User-interfaces will be designed to use both presently existing and next generation display, communications, navigation, radar, sonar, weapons, and electronic warfare systems and equipment. Newly developed systems would only require a system interface and modification to the user-interface module. The only additional hardware requirement is a high speed, medium size, TEMPEST approved multi-processor computer for the modules and their interfaces. Bulk encryption units required for the Local Area and Theater communication networks are already in existence. As the hardware will be small, lightweight, and inexpensive, redundant systems could be installed on the larger platforms (like ships and submarines) to prevent loss of the system during hostile operations. For loss of the platform's power source, a secondary power source like batteries and a continuous backup secondary memory system are needed. The individual components are defined next.

V.1 Information Analysis and Control Unit

The Information Analysis and Control unit (IAC) is the Central Control System of the Platform ACII system. It has several functions as shown in Figure 5. The primary function of the IAC is to take a classification (if possible) from the Sensor Evaluator, compare it to contacts in the Automated Tracking unit (Track Coordination Module), determine the identification (Identification Module), and report to the platform's display facilities and the local area and Theater systems (Report Generation Module). Another function is an interface to the platform's display system to handle queries from the platform's information collection center (CIC) such as listing active surface tracks with probable locations inside a hundred mile radius and providing evaluated information based on parameters set by the user. The IAC also interfaces with the Knowledge Acquisition unit to generate new information on contacts like changes in tactics, new sensors, counter-detection activities, etc. The Information Coordination Module controls information flow in the IAC as well as queries of the Knowledge Base. The Mathematical Module is used by all the modules for combinatoric evaluations.

V.2 Sensor Evaluator

The Sensor Evaluator is the primary identification and classification module. It is normally four modules (Radar Evaluator, Electronic Warfare Evaluator, Sonar Evaluator, and Other Signals Evaluator) combined with the Sensor Coordination, Classification, and

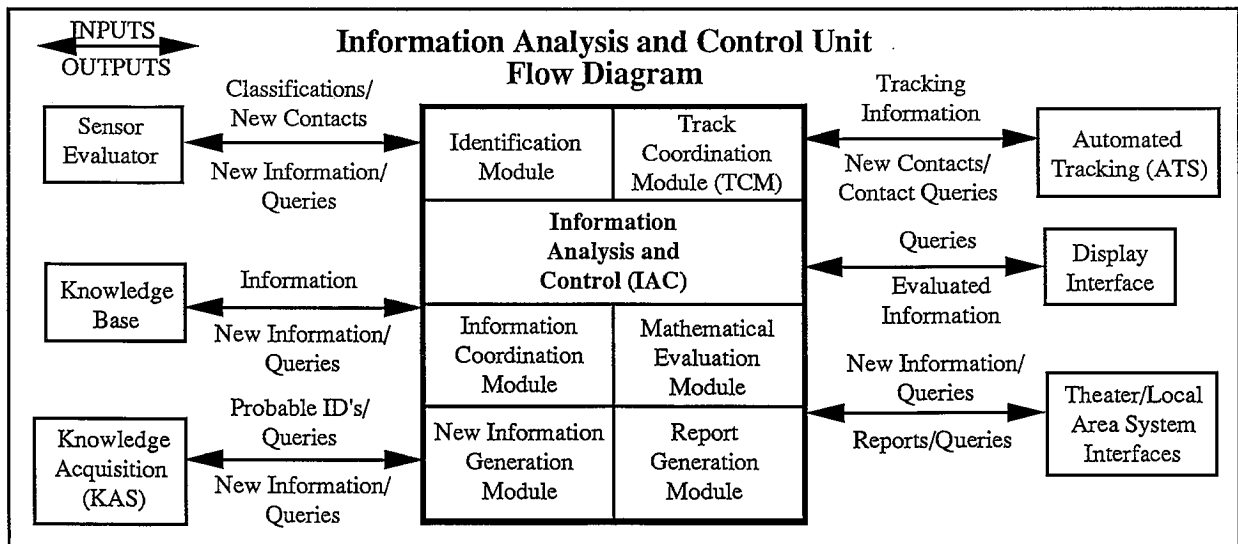


Figure 5. The Information Analysis and Control (IAC) unit flow diagram defining internal module interfaces to other components of the ACII system.

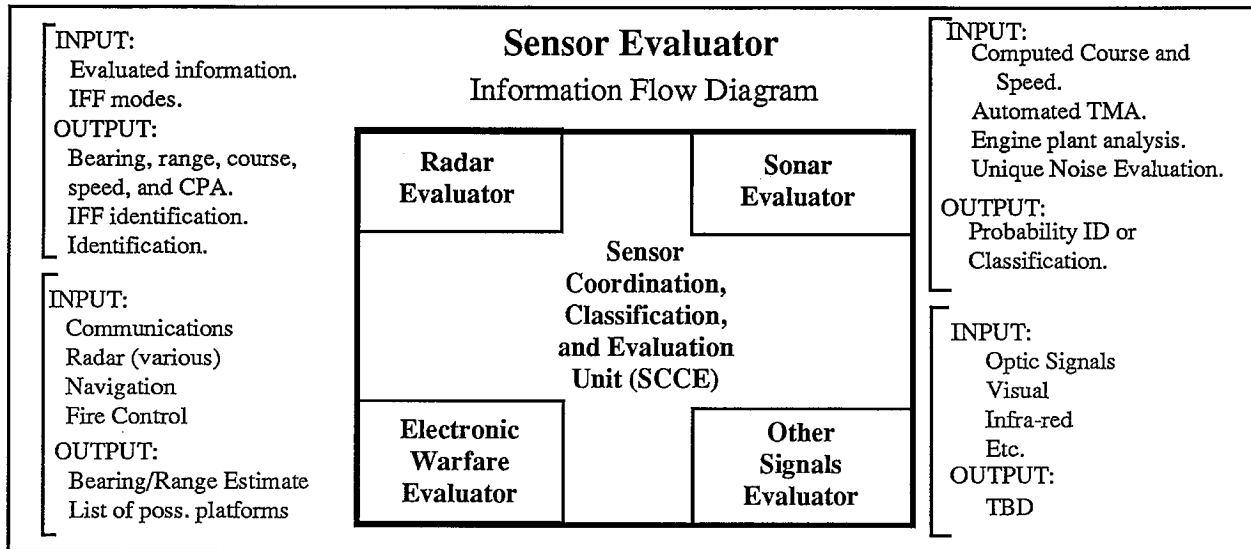


Figure 6. The internal information flows of the sensor modules to the SCCE within the Sensor Evaluator.

Evaluation (SCCE) unit. (See Figure 6.) The purpose of the Sensor Evaluator is to provide classification and/or identification information to the Information Analysis and Control unit (IAC). It uses level one and two data correlation and data fusion techniques. Each module's functions are described separately.

The Radar Evaluator functions similar to existing multiple target tracking radar systems. The individual radar system performs filtering, gating, data association, and probabilistic evaluations as designed. The Radar Evaluator performs multiple radar sensor fusion²⁸ as necessary before sending processed target information to the platform's display consoles throughout the platform and to the SCCE for classification. It provides bearing, range, course and speed of the contact, and the closest point where the contact will pass based on present course and speed (CPA). The Radar Evaluator also provides recommended course and speed changes to increase or decrease the CPA. The standard combatant representations are enhanced to include identification information. Detailed track identification information that includes the track number, type, identification number, assignment, and station is provided as requested using a window operation on the display unit. Other graphical features could be incorporated as necessary.

The Electronic Warfare Evaluator is the most important source of identification and classification information for major land, seaborne, and airborne platforms. Electronic Warfare equipment identifies communications signals and various types of radars (air search, surface search, altimeters, fire control, navigation, and satellite radars). As the equipment is also a computer system, the output of bearing, frequency, emission type, and list of possible platforms for the intercepted signals is used by the SCCE for classification.

The Electronic Warfare Evaluator is a rule based system that generates evaluated information for the SCCE, reducing the complexity of that unit. It is with electronic warfare equipment that the greatest advantage of the multiple platform environment exists. If two widely spaced platforms receive a line of bearing from a contact, a fairly good idea of the target location exists. Three lines of bearing are normally classified as a known location. (If you know a location, you can send out a passive low altitude missile that does not become active until it is almost on the target, preventing counter action to destroy it.)

The Sonar Evaluator is limited to submarines and anti-submarine warfare ships and aircraft. The variety of sonar equipment on the various types of seaborne vessels and aircraft make its generic rule based system a significant challenge. Most sonar systems are automated and generate significant amounts of information. Many of the sonar systems perform classifications themselves which will be interfaced into the Sonar Evaluator. For less sophisticated systems, the Sonar Evaluator's rule based system will perform the classification to standardize input into the SCCE. The Sonar Evaluator will also use Neural Network classifiers³⁶ with the rule based system.

The Other Signals Evaluator refers to direct visual input and other systems like optic and infra-red systems. You could easily refer to this section, other than visual identification and IR, as future developments in sensor technology.

The Sensor Coordination, Classification, and Evaluation unit will collect the above information, perform multiple type sensor fusion and evaluation as required, and provide a classification or likely candidate for classification to the IAC. The SCCE will also coordinate access to the Knowledge Base for classification and identification information, the Knowledge Acquisition unit for classification assistance, and the MCE for climatic information that may be required by the other internal modules.

Solving the *registration*²⁹ problem is one of the primary problems in any multiple sensor environment. The problem is that sensors detect targets using different attributes. The correlation problem is compounded by the fact that sensors are not consistent (e.g., different levels of sensor performance exists on an hourly basis). The ACII system solves this problem with the global position being the registration identification. No two contacts can be at the same location with the same attributes without being the same contact.

The Sensor Evaluator is the most sophisticated module in the platform system. It is also the module most individualized. It must be developed such that as technology changes, the module is adaptable to the new systems and sensors.

V.3 Knowledge Base

The Knowledge Base is another unique system. It is not a standard artificial intelligence list of facts. Primarily, the Knowledge Base contains the rules and guidelines for the operation of the platform including military organization, military doctrine, maneuvering rules, *Rules of Engagement*, contact display rules, communications, weapons, electronics, and whatever expert rules are needed to analyze a particular threat²⁸. The Knowledge Base holds detailed information on all types of platforms. The information includes all necessary information for a platform's area of operations (location). Scenarios, rules, tree constructs, semantic networks, facts, and algorithms to support the other modules are included in this unit²⁸. The following collection of information would be in the Knowledge Base for a contact:

1. Position estimates and track history.
2. Velocity estimates - course and speed, maximum and minimum observed speed, and observed maneuvering behavior.
3. IFF responses.
4. Emitter characteristics.
5. Sound Signature.
6. Intelligence reports.

The Knowledge Base also contains classification information like:

- a. Allegiance (friend, neutral, hostile, unknown).
- b. Identity - basic (e.g., ship, aircraft, missile), class (e.g., fighter, bomber, frigate, carrier), type (e.g., bear, kirov, blackjack, backfire), and name/code (USS Ford, F-889, CG-49).
- c. Base (for aircraft).
- d. Capabilities (e.g., sensors, communications, weapons, maximum speed, endurance).

The Knowledge Base only contains the information necessary for the platform to perform its mission. All of the massive amounts of classified documents that platforms normally retain are no longer necessary. As the retrieval system maintains security, only properly cleared personnel granted access privilege can view information.

The method of access to the Knowledge Base will be an unique system in itself. The system will be or be related to the artificial intelligence support systems, *JOBLIST* and *SOLID*. It forms a network similar to the telephone call system except the nodes are paths to the information. The nodes also define the area of inquiry, type, and priority of the user. (An access by the IAC or SE have higher priority.) Nodes are enabled/disabled based on whether the information relates to the present situation. An example would be

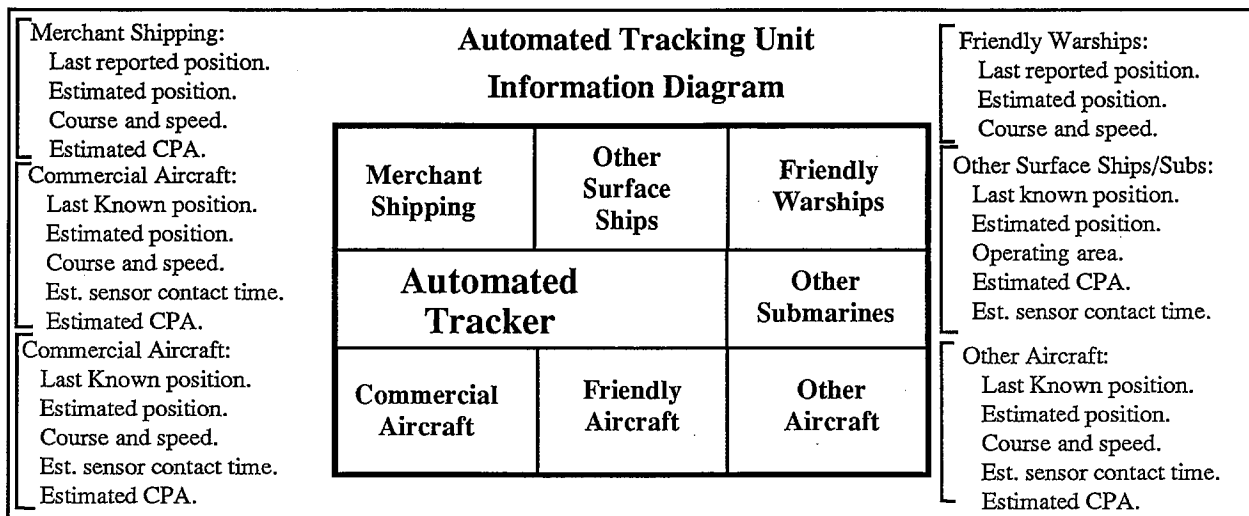


Figure 7. The contact information collected and/or computed for active targets in the Automated Tracker.

when all vessels of a class (like a certain type of submarine) are known to be in port, their path is disabled.

The storage of information is also broken into subunits. Information for rapid access will be stored in a facts list or in specific modules. Rarely used information would be on a secondary storage device.

V.4 Automated Tracking Unit

The Automated Tracking Unit provides the ACII system with prior knowledge about other platforms in an area of operations. The Automated Tracker receives external contact information from the Theater ACII System and locally operating platforms and internal information from the SE. Its function is to continuously compute the location of the contact based on the last known location and course and speed. The ATU's schedule for computing updates is based on the type of platform (i.e., more often for ballistic missiles and less often for surface ships.)

The Automated Tracking Unit is broken into modules as displayed in Figure 7. Each module has a specific type of platform to track. The reason for the different modules is that tracking requirements vary based on type of platform and threat. Commercial aircraft normally have certain profiles (e.g., speed, altitude, *Identification Friend or Foe* (IFF) modes, etc.) to distinguish it from combatant aircraft. Their tracking requirements are minimal as are those for friendly merchant vessels. The requirements for combatant aircraft and warships are significantly increased and require full use of the features

mentioned above. Commercial vessels rarely change course or speed and do not maintain on-station activities. The ATU receives platform movement information from the navigation system called the Movement and Climatic Environmental Unit. The platform's position information is used to determine the range and bearing to a contact for use by the Sensor Evaluator.

In order for the Automated Tracker to function in a global environment, it must track contacts based on global coordinates. By maintaining the system in global coordinates, information in and out of the system does not require computations and synchronization. (The basic tracking scheme is to periodically compute the new latitude and longitude of each contact using a standard mathematical computation³⁸⁻⁴⁰. If other coordinate systems are used, a reference location is required, and the central system would have to synchronize on each operating group's reference.) If location information is defined by range and bearing from the host platform, the Theater ACII System would have to compute the latitude and longitude based on the platform's latitude and longitude at the exact instant the range and bearing were taken. A global coordinate system also eliminates the need to continuously establish a reference location. The progress of a contact is measured by its change in longitude and latitude.

V.5 Movement and Climatic Evaluation Unit

The Movement and Climatic Evaluation unit includes an interface to an automatic navigation system (NAVSAT, SINS, GPS) and a climatic sampling system that collects temperature, temperature gradients, ocean salinity, and other related information for computation, storage, and use by the Sensor Evaluator. For platforms without the capability of obtaining climatic information, it is passed via communications links when needed.

V.6 Display Interface

The display interface will utilize some of the existing automatic information display systems using an interactive user-friendly and system multiple tier interface design³⁷. The user-friendly interface for new and existing display systems will be unique to the type of operational platform. It will exchange information with the system interface providing responses to queries from the user and defined output to the user displays. The system interfaces do not change for new applications and are capable of exchanging internal information with all the rule based systems.

VI. INFORMATION FLOW

The following section provides a description of information flow through the system. It is not detailed, but illustrates how some decisions are made. Specific platforms may have different requirements.

VI.1 Information Analysis and Control Unit

Identification Module - contact information is received from the Sensor Evaluator. If the contact has been identified, the information is reported to the display system and the report generation module for transmission to locally operating platforms and to the theater system. Figure 8 is an example of the decision flow methodology if identification was not completed in the Sensor Evaluator. (Note: The values are created for the example only.) This simulated electronic warfare report has classified the contact as a surface vessel of subgroup 43 based on the detection of electromagnetic emitters 798 and 896. The emitters were detected along bearing 350 degrees. It also reports no radar, sonar, or other confirmation information. The identification module cannot generate a positive identification and generates a query of the Automated Tracking unit. The ATU responds with three contacts of type subgroup 43 near bearing 350 degrees with other information including system identification number, range, and accuracy. Since there are three possible contacts, the identification module generates a query to the Knowledge Base with the sensor report information. The Knowledge Base was able to identify the contact because 4376-34 was the only platform having both emitters. The Knowledge Base simultaneously provided other information on emitters from the identified platform to the Electronic Warfare Evaluator. If the Knowledge Base had not provided an identification match, the Identification Module would have queried the Knowledge Acquisition system for the best probability of identification (worst threat).

Other decision making systems with similar flow diagrams are the Track Coordination Module and the Information Module. Based on previously defined expert rule decisions, the TCM decides when to drop a contact from automated tracking and whether new contacts should be sent to automated tracking or stored in the Knowledge Base for further reference. It also generates a call (head's up) to the Sensor Evaluator that a certain contact should be near the outer range limit of a certain sensor. The Information Module works with the Knowledge Acquisition System when an identification is not made to determine if the contact has changed its profile to prevent identification, is a new vessel type, or is a new tactic employed.

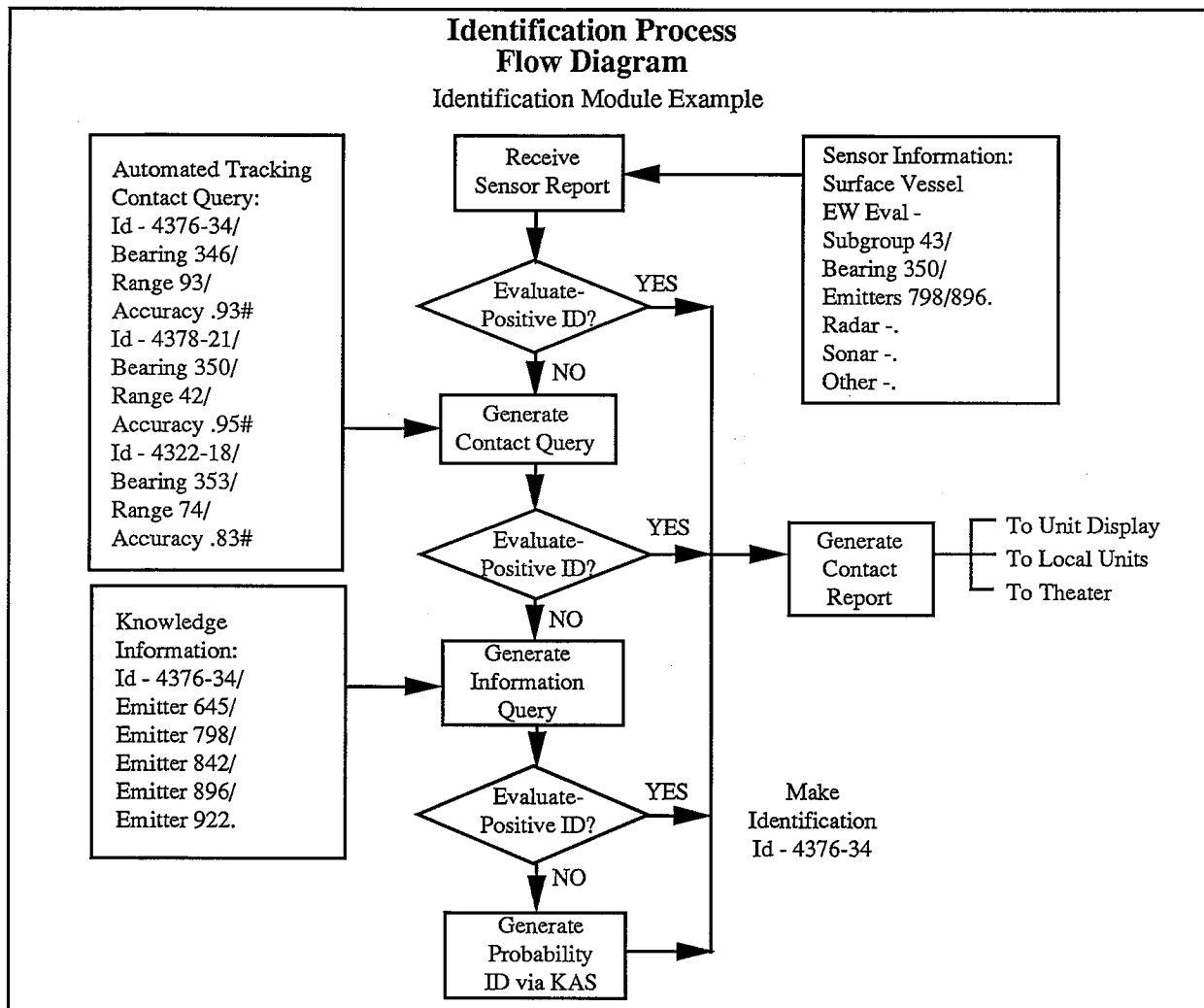


Figure 8. A sample decision flow diagram for identification in the Information Analysis and Control unit.

VI.2 Sensor Evaluator

The Sensor Coordination, Classification, and Evaluation (SCCE) Unit functions similar to Figure 9. The Sonar Evaluator generates a sensor report having classified the vessel as a submarine of subgroup 123. The contact has a five blade screw and unique noise lines of 50 Hertz and 423 Hertz. The probability that the vessel is of subgroup 123 is 76 percent. The vessel has not been identified. The Knowledge Base is queried for further information. Four submarines meet the criteria set forth in the query. The other sensors are checked for contacts with Radar checking along bearing 350 degrees for contacts having the defined course and speed. Electronic Warfare checks for signals from the bearing that matches the four possible submarines. No further classification can be made so the sensor report is submitted to the Information Analysis and Control unit.

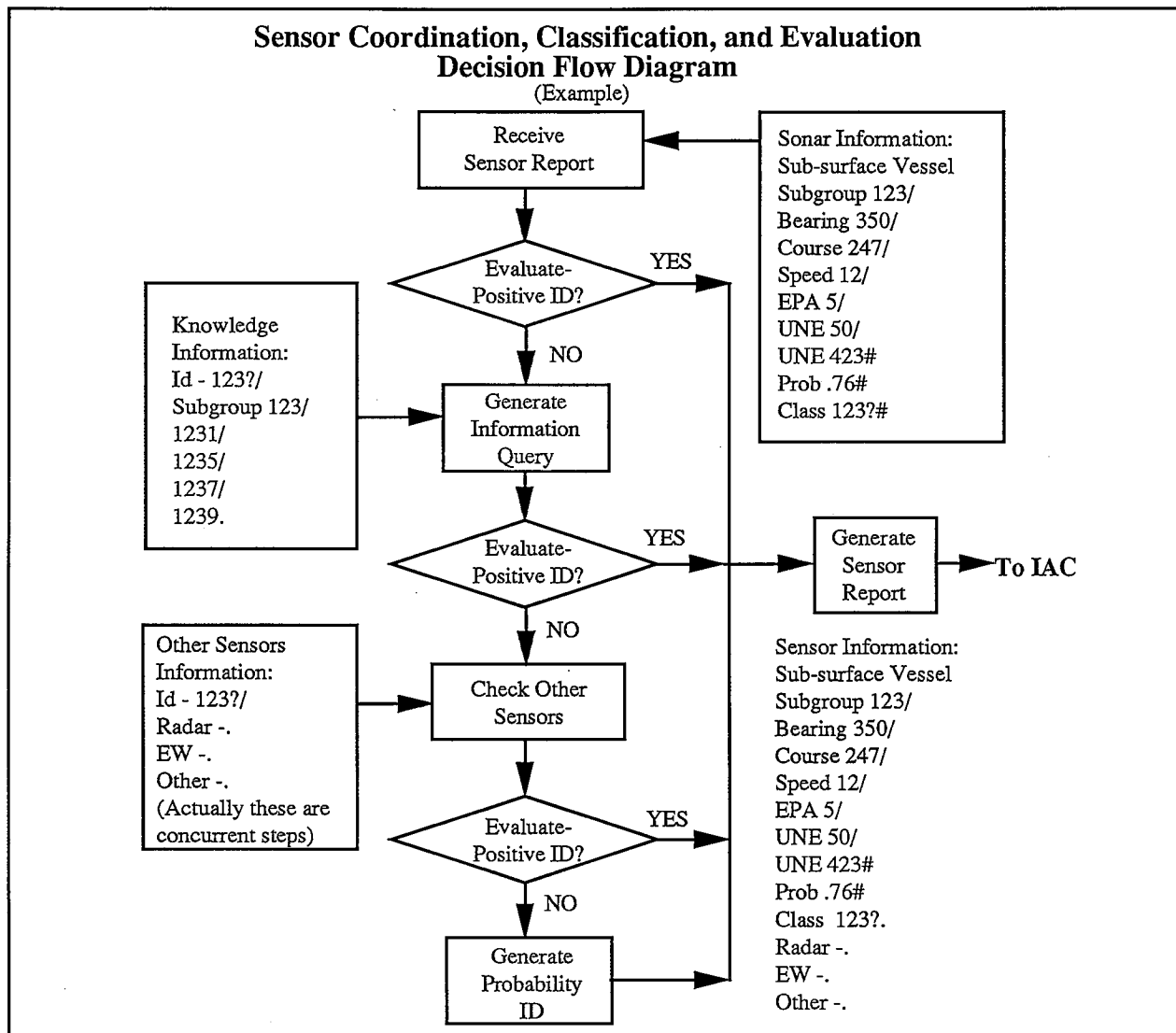


Figure 9. A sample decision flow diagram for identification and/or classification in the Sensor Evaluator.

VI.3 Automated Tracking Unit

The Automated Tracker determines the cell or module of a new contact based on identification or classification. It has a Mathematical Module that polls the contact cells and updates the positions of all the contacts. (Of course, aircraft are polled more often than slower moving contacts. Priorities are also given to certain contacts like high speed, inbound missiles.) The Automated Tracker can also generate the probability that a contact has changed course and could be in an area specified by the IAC.

VI.4 Knowledge Acquisition Unit

This Automatic Adaptive Learning system will generate new information about contacts including new tactics and counter-detection devices. It will also generate a probability matrix on unidentified contacts to generate the best possible candidates based on information and greatest threat. The full function package of the KAU is still in the development phase.

VII. STP DESIGN

This section defines the Software through Pictures (StP) design of the Platform level ACII system. Appendix A is the top level drawing with associated annotations. The drawing consists of three externals, the two reporting systems, and the internal display system. The Platform ACII system is the only process at this level. The Platform ACII system is fully defined at level zero, Appendix B. The six major components of the system as previously defined in Section V are processes with the same externals. The Knowledge Base and Knowledge Acquisition unit are not defined below this level (indicated by the "p" for process specification). The Information Analysis and Control, Sensor Evaluator, Automated Tracker, and Movement and Climatic Evaluation modules are defined to at least one lower level (indicated by the "*"). Level one (Appendix C) is the Information Analysis and Control unit. There are two new modules, the General Information Management and *IAC AUTOLRN* module, that are not in the original description. The GIM is the *JOBLIST/SOLID* module, and the *IAC AUTOLRN* module is the adaptive learning system that controls everything. All the modules except the report generator terminate at this level. The report generator is defined in Appendix D. There are three modules that create reports in the appropriate format for display or communications and a module for coordination. None of these modules is ready to be defined further. The Sensor Evaluator is defined in Appendix E. The modules are as defined in section V.2 and terminate at this level. Appendices F and G define the Automated Tracker and Movement and Climatic Evaluation modules. They are as defined above. Appendix H is the data structure diagrams for the System Drawing, Information Analysis and Control unit, Sensor Evaluator, and Report Generator modules.

VIII. OTHER APPLICATIONS.

The rule based systems developed for the ACII system will have applications in numerous areas other than combat information. The major area would be Weapons Control. A unit like the Sensor Evaluator could be added for Weapons Control. It would have engagement areas defined for independent or group operations. The same communications networks would be available. During group operations, engagements could be conducted by the Warfare Commander even though the Commander is not physically located with the shooting platform. (Of course, the Command by Negation option would still be available to the platform's Commanding Officer.) Incorporation of a weapons unit or set of modules is not part of the initial ACII system development.

VIII.1 Applications for Ships

On ships learning systems could be applied to control a main propulsion system whether it be an Automatic Boiler System, Gas Turbine, or Diesel. They can be applied to engineering auxiliaries like evaporators, fueling systems, and other sensor monitored systems. In damage control, they could be applied to automate sprinkler systems or used to monitor pressurized spaces to detect hull damage. In logistics operations, learning systems could be used to monitor use patterns to detect overuse or misuse of items or as an ordering system based on use patterns rather than limits. In navigation a rule based system could be used to detect collision situations and provide recommended actions, to evaluate Rules of the Road violations, or to evaluate changes to the Rules based on location.

The ACII system is designed to be a building block for the next generation of combatant vessel while interfacing with the present combat environment. The system will reduce present manning requirements on most vessels, primarily enlisted personnel. Future combat vessels, especially ships and submarines, will be manned by warfare specialists, pilots (or ship drivers), and engineers with enlisted personnel being support types only. Ships will have automated engineering and damage control systems. Systems will be distributed so that if one is damaged, another takes its place. The ACII can be the major system for the military of the late 1990's and used well into the twenty-first century.

VIII.2 Non-Combat Uses

Of course, the primary non-combat use would be for air traffic control. The FAA mainly uses radar and radio inputs to provide a picture of the air space. As the amount

of air traffic increases, the need for an intelligent system becomes imperative. The recent disaster when a controller put two aircraft on the same runway, one arriving and one departing, would have been prevented if an automated system had been in use. (The system would have tracked both aircraft plus monitored the decisions. The system would have noted the discrepancy and notified all concerned of the situation and correct actions to take.

Industrial process monitoring such as nuclear power plants, chemical manufacturing plants, and oil and gas facilities could use the system to identify problems and initiate corrective actions early enough to prevent disasters.

Industrial robots will have sophisticated sensors in the future and required extensive sensor fusion. The automated systems would require the robot to perform significantly more tasks with greater efficiency.

Weather forecasting is another example of a data fusion problem. A seismographic evaluation and early warning system would be useful for high earthquake risk areas.

Financial systems are another area where the rapid evaluation of information and the fusion of information could improve decisions. If the government could get early warnings of problems in the economy, decisions could be made early and the number of people being laid off or losing their job would decline.

There are numerous uses for such a system, and it is going to be developed. It may not look like the one described above, but many of the ideas will be in it.

IX. CONCLUSION.

This project provided the opportunity to really learn about the subject of *Command, Control, and Communications*, a subject that is not included in any department's curriculum. There are significant amounts of research being done in this area, although most of the non-communications documentation is from the United Kingdom. The research material found does validate the design of ACII system and address its need. The only area of change from the original design was made to extend the system from a Navy combat system to a national system. Many companies are designing related systems; however, none has designed a complete unclassified system. Part of the problem with a complete system is that individual service and project funding would be cut if a complete system were built. (This of course is not explicitly stated in the research.)

The following problems were encountered during the project. It was difficult to find documentation about Command and Control systems. Much of the documentation was focused on solving a particular problem. The area of communications is the primal example. Hundreds of references were found covering every aspect of telecommunications in the MILCOM yearly conference proceedings. In this project, the primary concern was in military communications, and the MILCOM Proceedings covered every imaginable area of military communications from tactical to packet switched networks. Other documents like ACM Proceeding on Communications, Data Communications magazine, and IEE Proceedings on Networks cover related topics, but they were not as relevant as MILCOM. The mere size of the research in military telecommunications indicates the importance placed on the subject. There is certainly enough information to solve any theater communications problem.

There was a limitation on research material on applications of Artificial Intelligence to Command and Control. One can only assume the reason is "classification zeal" that exists in the United States, because none of the books on the subject was published here. Of the available research, there seems to be a concentration on logic and rule based systems with symbolic uncertainty schemes for inference engines. The subject most mentioned in connection with artificial intelligence was data fusion. Many of the ideas from the paper in Harris' book²⁸ will become the theoretical basis for the sensor evaluation module in the ACII system.

Security is another problem area in finding research material. Most of the security section is based on personal knowledge of the military security system. Security experiences include serving as security manager for four years, top secret control manager for ten years in the Navy and NATO, inspector and administrator of cryptographic material and equipment for nine years in the Navy and NATO, and inspector and supervisor of SAS top

secret material (relates to special security requirements). A hardware background limited to technician knowledge of military equipment was enough to define the security requirements of the ACII system. The internal security aspects of JOBLIST takes care of internal access, so the lack of research material was not a hinderance.

The CASE tool, Software through Pictures (StP), is an superb product for defining the final system. The tool has the necessary options to perform major correlation of information on the design of software. Although advanced features were not used in the project, they are numerous and available. One problem encountered arose from the limited amount of StP documentation. There should be sufficient copies of the documentation such that a set is available for checkout to students using the tool in a masters level project. The only significant problem with StP came when changes are made at the higher level drawings. When a new level is created, the higher level processes and their associated path information go to the lower level as externals. These externals have annotations and information stored in the data dictionary. This data dictionary information is copied to the new level. If the higher level process or path is changed, the lower level copies for the annotations and descriptive information must also be manually changed. (The problem could be solved if pointers to the external data dictionary entries were passed to the lower levels rather than copies of the information.) Because many of my original entries changed when I moved from the Navy only concept to all government organizations concept, some of the annotations had to be modified in three levels. If there were ten to fifteen levels, a single change can involve major revisions. One minor problem exists with text editing. There is not a line position indicator or an automatic text wrap-around feature. My original printout had hundreds of truncated text errors. The system truncates text longer than seventy-eight characters. StP performs screen wrap-around on path information, but not always at the seventy-eighth character position. Because StP wraps on the screen, the new user thinks the text is fine. Fixing text errors is easy, but it took a lot of hours to go through almost every annotation and process specification. The solution would be for StP to enhance their text editor with a wrap-around feature. The entire text editing part of StP could use an update. Overall, StP is an excellent software development environment.

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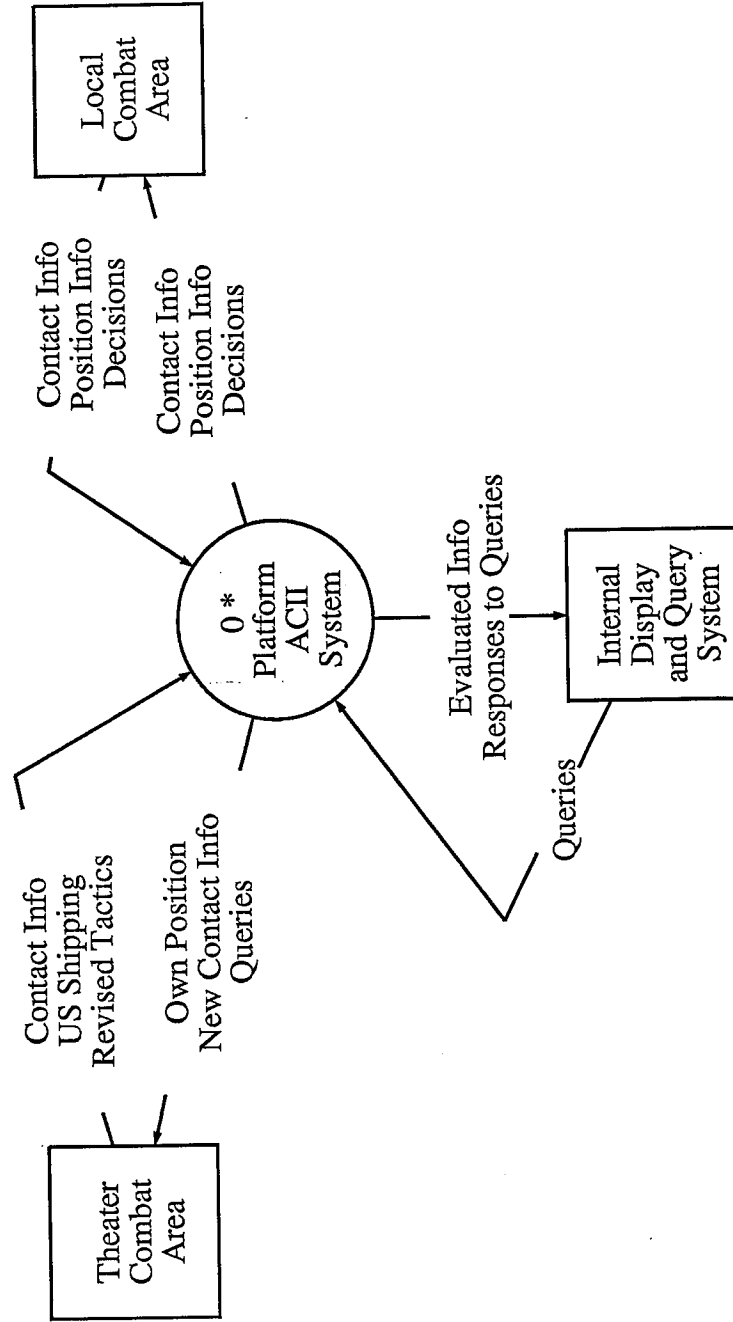
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APPENDIX A - PLATFORM ACII SYSTEM

1. Top Level Drawing



2. Top Level Documentation

Note diag

Author: kbradley

Generated: 16:42:45 30 November 1990

Parent: None

TOP LEVEL DIAGRAM.

This diagram consists of the Automated Combat System process. It is the system defined for a unit (unit being defined as ship, submarine, aircraft, or land command having combat decisions to make. A full description of the system and function is included in the introductory documentation.

Process 0: Platform_ACII_System:

Note process

Author: kbradley

Generated: 7:45:31 25 January 1991

Name: Platform_ACII_System

Automated Classification, Identification, and Information System (ACII) is a system to identify and classify contacts within a specific operating area. The system being defined is for a small unit like a ship, airplane, submarine, or division HQ.

External Internal_Display_and_Query_System:

Note external

Author: kbradley

Generated: 16:57:08 30 November 1990

Name: Internal_Display_and_Query_System

Unit's Combat Control Centers.

This could be the Combat Information Center and Bridge of a ship or similar locations on an aircraft, field headquarters, submarine, etc. The information being collected is for this location. This location is where the Battle decisions are made.

External Local_Combat_Area:

Note external

Author: kbradley

Generated: 16:55:18 30 November 1990

Name: Local_Combat_Area

A Local Combat Area is where units are coordinating activities like a Navy Battle Group, Army Mechanized Division, or Air Force TAC Group.

External Theater_Combat_Area:

Note external

Author: kbradley

Generated: 17:03:16 30 November 1990

Name: Theater_Combat_Area

Theater Combat Center is a theater of operations center like the Unified Commander of the Pacific area (CINCPAC) where all the information flows into, is evaluated, and returned to local operating units and forwarded to all Command Centers (Peace and War Headquarters). See documentation for more information.

Flow: Contact_Info_Position_Info_Decisions:

From: Local_Combat_Area

To: Platform_ACII_System

Note data_flow

Author: kbradley

Generated: 16:32:05 30 November 1990

Name: Contact_Info_Position_Info_Decisions

LOCALAREA-to-UNIT information flow:

1. Coordinated contact information.
2. Local reports.
3. Queries and Responses.
4. Battle Decisions.

BNF: Contact_Info_Position_Info_Decisions ::= [Contact_Info | Position_Info | Decision]

Flow: Contact_Info_Position_Info_Decisions:

From: Platform_ACII_System

To: Local_Combat_Area

Note data_flow

Author: kbradley

Generated: 16:34:06 30 November 1990

Name: Contact_Info_Position_Info_Decisions

UNIT-to-LOCALAREA information flow:

1. Coordinated contact information and reports.

2. Position report.
 3. Queries and Responses.
 4. Battle decisions.
- BNF: Contact_Info_Position_Info_Decision ::=
[Contact_Info | Position_Info | Decision]

Flow: Contact_Info_US_Shipping_Revised_Tactics:

From: Theater_Combat_Area
To: Platform_ACII_System
Note data_flow
Author: kbradley
Generated: 16:20:20 30 November 1990
Name: Contact_Info_US_Shipping_Revised_Tactics
GLOBAL-to-UNIT information flow:
1. Positions of Known Contacts.
2. ID of Known Contacts.
3. Positions of US units.
4. Revised Tactics.
5. Revised general information and updates.
6. Queries and Responses.
BNF: Contact_Info_US_Shipping_Revised_Tactics ::=
[Contact_Info | US_Shipping | Revised_Tactics]

Flow: Evaluated_Info_Responses_to_Queries:

From: Platform_ACII_System
To: Internal_Display_and_Query_System
Note data_flow
Author: kbradley
Generated: 16:47:44 30 November 1990
Name: Evaluated_Info_Responses_to_Queries
SYSTEM-to-INTERNAL information flow:
1. Evaluated information to the display screens or other display devices.
2. Responses to Queries.
3. Information received from other units (LOCAL and GLOBAL).
BNF: Evaluated_Info_Responses_to_Queries ::=
[Evaluated_Info | Responses_to_Queries]

Flow: Own_Position_New_Contact_Info_Queries:

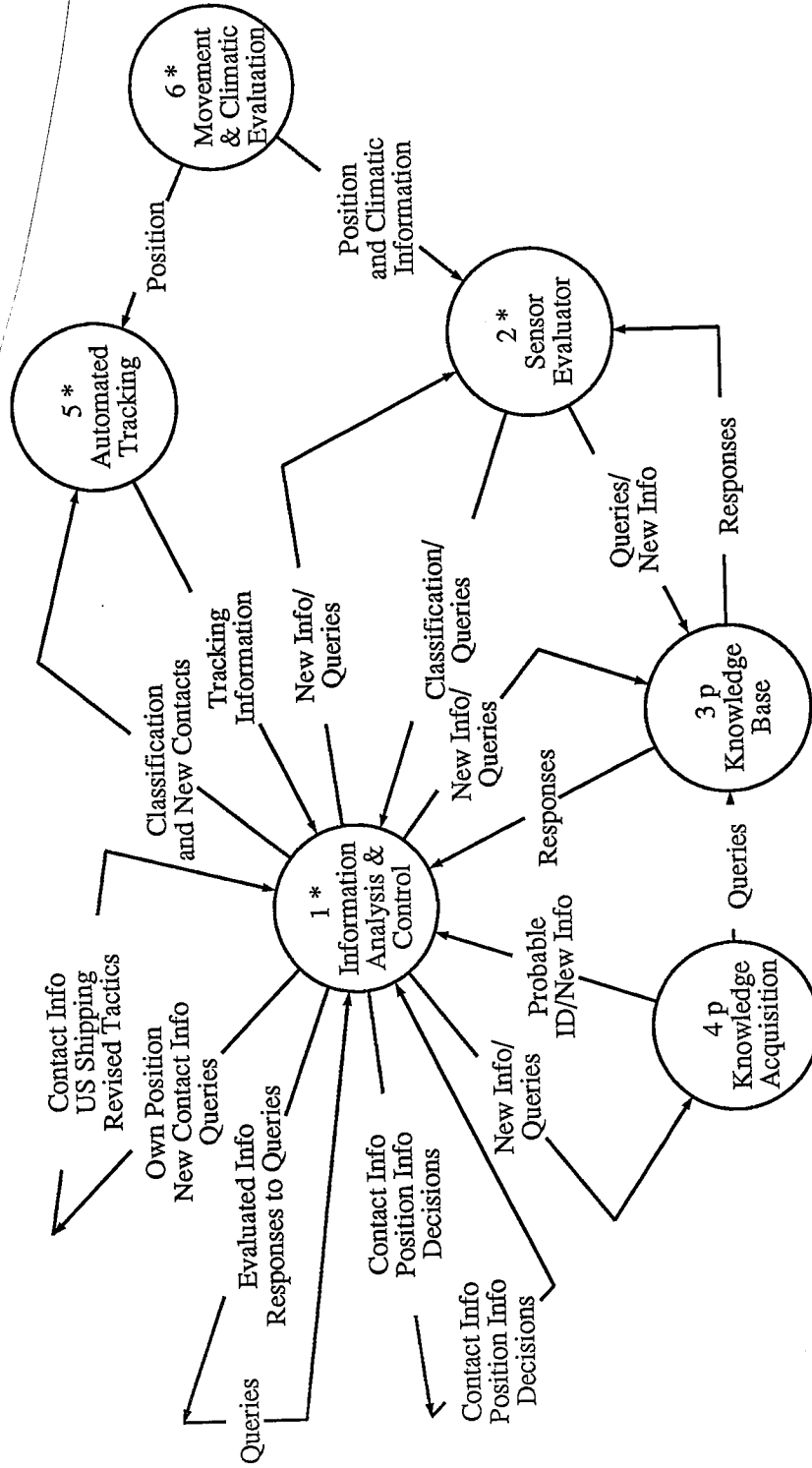
From: Platform_ACII_System
To: Theater_Combat_Area
Note data_flow
Author: kbradley
Generated: 16:24:42 30 November 1990
Name: Own_Position_New_Contact_Info_Queries
SHIP-to-GLOBAL information:
1. Ship's exact position.
2. Positions of contacts.
3. Classifications and reports.
4. Queries and Responses.
BNF: Own_Position_New_Contact_Info_Queries ::=
[Own_Position | New_Contact_Info | Queries]

Flow: Queries:

From: Internal_Display_and_Query_System
To: Platform_ACII_System
Note data_flow
Author: kbradley
Generated: 16:51:28 30 November 1990
Name: Queries
INTERNAL-to-SYSTEM information flow:
1. Queries.
a. Other Friendly units.
b. Non-friendly units.
c. Capabilities.
d. Reports to higher authorities.
e. Battle decisions.
f. Tactical information.
g. Etc.
BNF: Queries ::= Queries

APPENDIX B - PLATFORM ACII SYSTEM DESIGN

1. System Level Drawing



2. System Level Documentation

Note diag

Author: kbradley

Generated: 18:08:11 30 November 1990

Parent: Automated_Combat_System

AUTOMATED COMBAT SYSTEM. The ACS is a program that performs all the tasks required of a combat system on a ship, aircraft, submarine, or local combat system ashore. It will run on a fast workstation networked environment. It provides rapid, secure, fully evaluated information to decision makers to make command by negation decisions. It will coordinate information flow, produce evaluated information, and provide recommendations to combat decisions. It uses advanced expert systems, advanced data retrieval techniques, and reliable, rapid communications.

Process 1: Information_Analysis_&_Control:

Note process

Author: kbradley

Generated: 17:38:09 30 November 1990

Name: Information_Analysis_&_Control

Information Analysis and Control (IAC). The IAC is the brain of the system. It handles all coordination and query activities. It accesses the other knowledge and non-knowledge systems. It generates reports and displays of evaluated information. It also contains an Information Management System related to the SOLID/ JOBLIST system being developed by Dr. P.A.D. de Maine at Auburn University.

Process 2: Sensor_Evaluator:

Note process

Author: kbradley

Generated: 17:51:25 30 November 1990

Name: Sensor_Evaluator

Sensor Evaluator. It is an information gathering, evaluation and classification system. It is an Automatic Deductive System that works with the Knowledge Acquisition System and Knowledge Base to classify contacts. It coordinates information from the radar, electronic warfare, sonar, and weapons areas and provides classification if possible.

Process 3: Knowledge_Base:

Note process

Author: kbradley

Generated: 17:52:00 30 November 1990

Name: Knowledge_Base

Knowledge Base. The knowledge base will contain detailed information on all types of units. It is classified as a process because it has intelligence. It is not a standard list of facts or programs but a dynamic system. It works with the Knowledge Acquisition System and the Sensor Evaluator to classify contacts and retrieve associated information.

Note ProcessSpec

Process 3: Knowledge_Base

Pspec generated

28 April 1991 at 14:05:45 by kbradley@lab3

This process has 5 data flows:

Responses, New_Info/_Queries, Queries, Responses,
Queries/_New_Info

input data flows New_Info/_Queries, Queries, Queries/_New_Info

output data flows Responses, Responses

description

KNOWLEDGE BASE. The Knowledge Base is a collection of facts, tactical information, decisions trees, etc. that can handle queries internally and externally, create new facts using the Knowledge Acquisition System and Sensor Evaluator, and respond to the changing environment.

Information includes:

1. Position estimates and track history.
2. Velocity estimates - course/speed, max/min observed speed, etc.
3. IFF responses.
4. Emitter characteristics.
5. Sound Signature.
6. Intelligence reports.

Classification information:

- a. allegiance (friend, neutral, hostile, unknown).
- b. identity - basic / class / type.
- c. base or homeport.
- d. capabilities.

end pspec

Process 4: Knowledge_Acquisition:

Note process

Author: kbradley

Generated: 17:52:50 30 November 1990

Name: Knowledge_Acquisition

Knowledge Acquisition unit. This Automatic Adaptive Learning System will generate new information about contacts like new tactics and counter-detection. Its primary purpose is to classify contacts by using information generated from external sources and internal sensors to classify. It will generate either a classification or the greatest threat based on the available data.

Note ProcessSpec

Process 4: Knowledge_Acquisition

Pspec generated

28 April 1991 at 14:05:46 by kbradley@lab3

This process has 3 data flows:

Queries, Probable_ID/New_Info, New_Info/_Queries	
input data flows	New_Info/_Queries
output data flows	Queries, Probable_ID/New_Info
description	

KNOWLEDGE ACQUISITION. This is an expert system designed to evaluate the tactical environment and generate new information. Among the things it will do is classifications of contacts and recognition of new tactics by the opposition.
end pspec

Process 5: Automated_Tracking:

Note process

Author: kbradley

Generated: 17:44:09 30 November 1990

Name: Automated_Tracking

Automated Tracking Unit provides the IAC with tracking or location information on all contacts within a specified area of operations. The Automated Tracker also provides a probable location of units whose recent updating information is past a certain time frame. (It has not been located by sensors in certain period of time.)

Process 6: Movement_&_Climatic_Evaluation:

Note process

Author: kbradley
Generated: 17:49:44 30 November 1990
Name: Movement_&_Climatic_Evaluation
Movement and Climatic Evaluation Unit - It provides position information to the Automatic Tracking System and to the Sensor Evaluator. It also provides ocean information to the sonar subsystem of the SE.
BNF: Position ::= Latitude Longitude
ClimaticInfo ::= Temp {Gradient} {Salinity} {Other}

Flow: Classification/_Queries:

From: Sensor_Evaluator
To: Information_Analysis_&_Control
Note data_flow
Author: kbradley
Generated: 18:07:12 30 November 1990
Name: Classification/_Queries
CLASSIFICATIONS. They are provided to the Information Analysis and Control unit as they are determined. The non-fully classified contacts are also reported with all the available information.
QUERIES. Queries are made to the IAC for information to improve a classification. Also information is requested to correlate contacts.
BNF: Classification/_Queries ::=
[Classification | Queries]

Flow: Classification_and_New_Contacts:

From: Information_Analysis_&_Control
To: Automated_Tracking
Note data_flow
Author: kbradley
Generated: 18:06:20 30 November 1990
Name: Classification_and_New_Contacts
CLASSIFICATIONS. Identifies the new contacts with any known classification like Merchant vessel, Boeing 747 commercial, etc. to determine type of tracking and frequency.
NEW CONTACTS. Identifies new contacts with the criteria for tracking including the classification if known. There are standard criteria for unknown contacts based on speed and Closest Point of Approach.
BNF: Classification_and_New_Contacts ::=

[Classification | New Contacts]

Flow: Contact_Info_Position_Info_Decisions:

From: Offpage.0
To: Information_Analysis_&_Control
Note data_flow
Author: kbradley
Generated: 16:32:05 30 November 1990
Name: Contact_Info_Position_Info_Decisions
LOCALAREA-to-UNIT information flow:
1. Coordinated contact information.
2. Local reports.
3. Queries and Responses.
4. Battle Decisions.
BNF: Contact_Info_Position_Info_Decisions ::= [
Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_Position_Info_Decisions:

From: Information_Analysis_&_Control
To: Offpage.0
Note data_flow
Author: kbradley
Generated: 16:34:06 30 November 1990
Name: Contact_Info_Position_Info_Decisions
UNIT-to-LOCALAREA information flow:
1. Coordinated contact information and reports.
2. Position report.
3. Queries and Responses.
4. Battle decisions.
BNF: Contact_Info_Position_Info_Decisions ::= [
Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_US_Shipping_Revised_Tactics:

From: Offpage.0
To: Information_Analysis_&_Control
Note data_flow
Author: kbradley

Generated: 16:20:20 30 November 1990

Name: Contact_Info_US_Shipping_Revised_Tactics

GLOBAL-to-UNIT information flow:

1. Positions of Known Contacts.
2. ID of Known Contacts.
3. Positions of US units.
4. Revised Tactics.
5. Revised general information and updates.
6. Queries and Responses.

BNF: Contact_Info_US_Shipping_Revised_Tactics ::= [Contact_Info | US_Shipping | Revised_Tactics]

Flow: Evaluated_Info_Responses_to_Queries:

From: Information_Analysis_&_Control

To: Offpage.0

Note data_flow

Author: kbradley

Generated: 16:47:44 30 November 1990

Name: Evaluated_Info_Responses_to_Queries

SYSTEM-to-INTERNAL information flow:

1. Evaluated information to the display screens or other display devices.
2. Responses to Queries.
3. Information received from other units (LOCAL and GLOBAL).

BNF: Evaluated_Info_Responses_to_Queries ::= [Evaluated_Info | Responses_to_Queries]

Flow: New_Info/_Queries:

From: Information_Analysis_&_Control

To: Sensor_Evaluator

Note data_flow

Author: kbradley

Generated: 18:06:54 30 November 1990

Name: New_Info/_Queries

New information is provided the Sensor Evaluator to improve its classification capability. Queries are made to the SE for the system to change a search criteria.

BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: New_Info/_Queries:

From: Information_Analysis_&_Control
To: Knowledge_Base

Note data_flow

Author: kbradley

Generated: 18:07:51 30 November 1990

Name: New_Info/_Queries

NEW INFO. It provides updated information on contacts from the Sensor Evaluation, updates from the Local and Global systems, new information not previously held, changes to procedures and tactics, etc.

QUERIES. It queries for information on every subject in the Knowledge and Databases. This is the major query section of the system. All retrievals of information are directed to or through the IAC.

BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: New_Info/_Queries:

From: Information_Analysis_&_Control

To: Knowledge_Acquisition

Note data_flow

Author: kbradley

Generated: 18:09:11 30 November 1990

Name: New_Info/_Queries

NEW INFO. If the Information Analysis and Control unit wants something evaluated, it sends the new information and awaits the reply.

QUERIES. The IAC also requests status information on evaluations.

BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: Own_Position_New_Contact_Info_Queries:

From: Information_Analysis_&_Control

To: Offpage.0

Note data_flow

Author: kbradley

Generated: 16:24:42 30 November 1990

Name: Own_Position_New_Contact_Info_Queries

SHIP-to-GLOBAL information:

1. Ship's exact position.
2. Positions of contacts.
3. Classifications and reports.
4. Queries and Responses.

BNF: Own_Position_New_Contact_Info_Queries ::=
[Own_Position | New_Contact_Info | Queries]

Flow: Position:

From: Movement_&_Climatic_Evaluation
To: Automated_Tracking
Note data_flow
Author: kbradley
Generated: 18:10:45 30 November 1990
Name: Position

The Unit's position is updated periodically based on the type of sensor used. The ATU also dead reckons between updates. The position of surface and airborne units is not as critical as SATNAV updates position very accurately. Submarine updated information is very critical as they rely on internal navigation systems.

BNF: Position ::= Position

Flow: Position_and_Climatic_Information:

From: Movement_&_Climatic_Evaluation
To: Sensor_Evaluator
Note data_flow
Author: kbradley
Generated: 18:10:30 30 November 1990
Name: Position_and_Climatic_Information

Position information is provided the Sensor Evaluator for use with sensors and evaluations. Climatic Information is also provided for Sonar evaluations (For ocean layer calculations, etc.)

BNF: Position_and_Climatic_Information ::=
[Position | Climatic_Information]

Flow: Probable_ID/New_Info:

From: Knowledge_Acquisition
To: Information_Analysis_&_Control
Note data_flow
Author: kbradley
Generated: 18:08:55 30 November 1990
Name: Probable_ID/New_Info

The best available classification information or other information developed by the

situation. The new information could be new tactics, new unit sensor combinations on a certain unit type, new unit types, etc.

BNF: Probable_ID/New_Info ::= [Probable_ID | New_Info]

Flow: Queries:

From: Offpage.0
To: Information_Analysis_&_Control
Note data_flow
Author: kbradley
Generated: 16:51:28 30 November 1990
Name: Queries

INTERNAL-to-SYSTEM information flow:

1. Queries.
 - a. Other Friendly units.
 - b. Non-friendly units.
 - c. Capabilities.
 - d. Reports to higher authorities.
 - e. Battle decisions.
 - f. Tactical information.
 - g. Etc.

BNF: Queries ::= Queries

Flow: Queries:

From: Knowledge_Acquisition
To: Knowledge_Base
Note data_flow
Author: kbradley
Generated: 18:09:28 30 November 1990
Name: Queries

The Knowledge Base is Queried for classification information via the Direct Address Data Retrieval system. The response to this query is actually returned to the IAC as a new classification.

BNF: Queries ::= Queries

Flow: Queries/_New_Info:

From: Sensor_Evaluator
To: Knowledge_Base

Note data_flow

Author: kbradley

Generated: 18:09:47 30 November 1990

Name: Queries/_New_Info

QUERIES. The SE requests information used for various classifications like table conversions. It is simpler for the SE to access the evaluation tables directly, eliminating the need for a separate database for the SE.

NEW INFO. The SE can change and update its tables.

BNF: Queries/_New_Info ::= [Queries | New_Info]

Flow: Responses:

From: Knowledge_Base

To: Information_Analysis_&_Control

Note data_flow

Author: kbradley

Generated: 18:08:38 30 November 1990

Name: Responses

This is the major link to the Knowledge Base. The IAC is the Query handling system. All queries are coordinated through the information management system located in the IAC. The responses are returned via the information management system.

BNF: Responses ::= Responses

Flow: Responses:

From: Knowledge_Base

To: Sensor_Evaluator

Note data_flow

Author: kbradley

Generated: 18:10:00 30 November 1990

Name: Responses

The Knowledge Base responds to requests from the SE on various topics via the IAC. This arrow is drawn because the information is from the KB to SE. The information management systems which coordinates information just happens to be in the IAC.

BNF: Responses ::= Responses

Flow: Tracking_Information:

From: Automated_Tracking
To: Information_Analysis_&_Control

Note data_flow

Author: kbradley

Generated: 18:06:37 30 November 1990

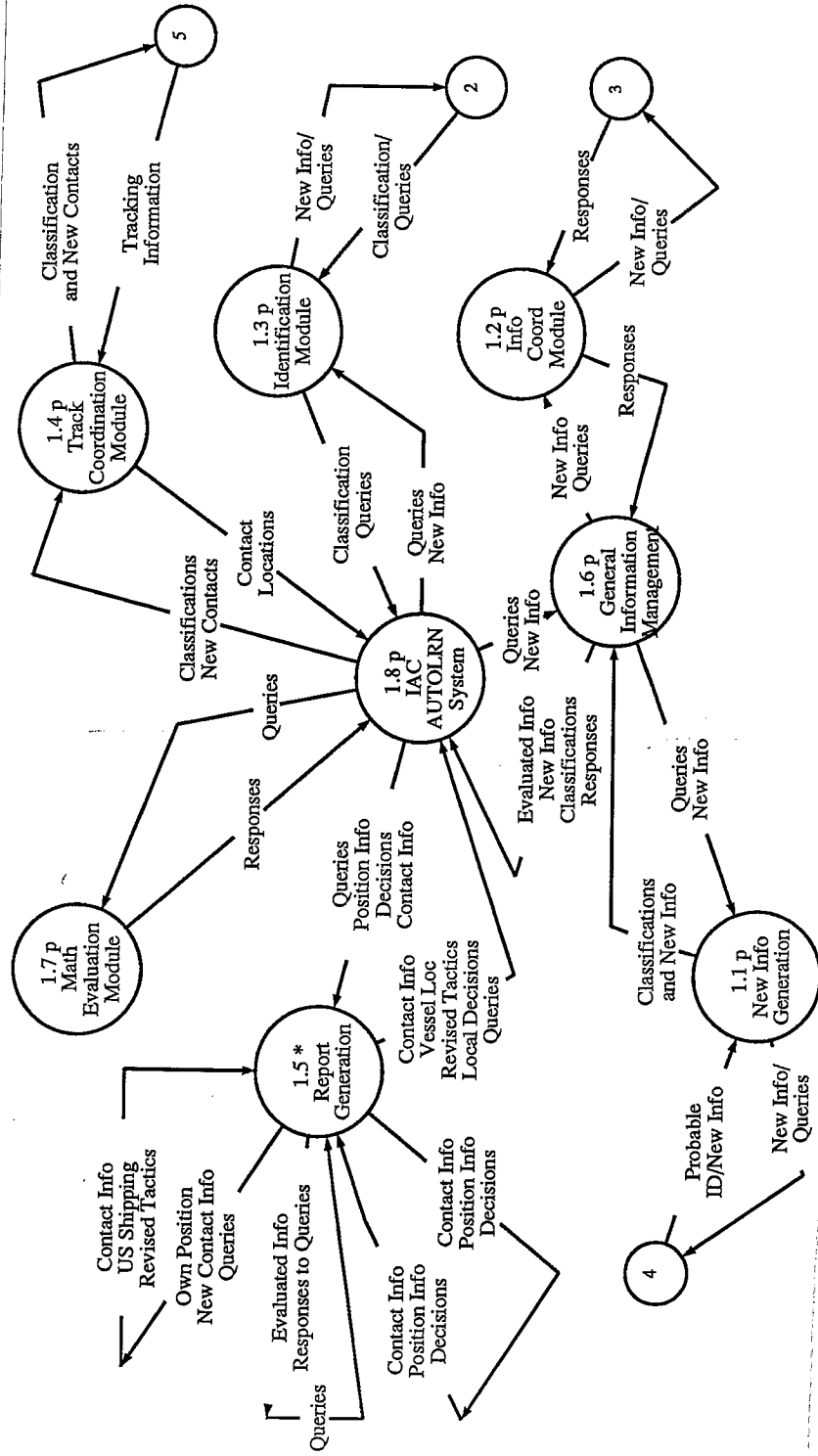
Name: Tracking_Information

Tracking information is retrieved by the Information Analysis and Control Unit as needed.

BNF: Tracking_Information ::= Tracking_Information

APPENDIX C - INFORMATION ANALYSIS AND CONTROL UNIT

1. IAC Module Level Drawing



2. IAC Module Documentation

Note diag

Author: kbradley

Generated: 18:56:29 7 December 1990

Parent: Information_Analysis_&_Control

As described above in the previous level.

BNF: Tracking_Information ::= Tracking_Information

Process 1.1: New_Info_Generation:

Note process

Author: kbradley

Generated: 18:03:32 5 December 1990

Name: New_Info_Generation

Note ProcessSpec

Process 1.1: New_Info_Generation

Pspec generated

26 April 1991 at 13:53:10 by kbradley@gauss

This process has 4 data flows:

Probable_ID/New_Info, New_Info/_Queries, Queries_New_Info,
Classifications_and_New_Info

input data flows

Probable_ID/New_Info, Queries_New_Info

output data flows

New_Info/_Queries, Classifications_and_New_Info

description

NEW INFORMATION GENERATION. This module is for communications and coordination between the Knowledge Acquisition System and the IAC. As new classifications are made, they are retrieved via GIM but coordinated by this module. New information like a new tactic employed by a unit and its probability of success is passed to the IAC for reporting and updating of knowledge.

end pspec

Process 1.2: Info_Coord_Module:

Note process

Author: kbradley

Generated: 18:03:47 5 December 1990

Name: Info_Coord_Module

Note ProcessSpec

Process 1.2: Info_Coord_Module

Pspec generated

26 April 1991 at 13:53:11 by kbradley@gauss

This process has 4 data flows:

Responses, New_Info/_Queries, New_Info_Queries, Responses
input data flows

Responses, New_Info_Queries
output data flows

New_Info/_Queries, Responses
description

INFORMATION COORDINATION MODULE. This module is for coordination between the IAC's General Information Management system and the Knowledge Base. Its function is to assist the other modules in identifying information, especially the information generated by the DADR system. It is an optional module and may be replaced by the GIM system depending on its specification.
end pspec

Process 1.3: Identification_Module:

Note process

Author: kbradley

Generated: 18:04:17 5 December 1990

Name: Identification_Module

Note ProcessSpec

Process 1.3: Identification_Module

Pspec generated

26 April 1991 at 13:53:11 by kbradley@gauss

This process has 4 data flows:

New_Info/_Queries, Classification/_Queries, Classification_Queries,
Queries_New_Info

input data flows

Classification/_Queries, Queries_New_Info
output data flows

New_Info/_Queries, Classification_Queries
description

IDENTIFICATION. This module is for coordination between the Sensor

Evaluator and the IAC. It is also an interface through the IAC AUTOLRN to the Knowledge Base and the Knowledge Acquisition Unit. Its primary function is to assist classification efforts of the IAC and Sensor Evaluator. It passes new information received externally to the SE and classifications and new contact information to the system for reporting.

end pspec

Process 1.4: Track_Coordination_Module:

Note process

Author: kbradley

Generated: 18:04:30 5 December 1990

Name: Track_Coordination_Module

Note ProcessSpec

Process 1.4: Track_Coordination_Module

Pspec generated

26 April 1991 at 13:53:12 by kbradley@gauss

This process has 4 data flows:

Tracking_Information, Classification_and_New_Contacts,
Contact_Locations, Classifications_New_Contacts

input data flows

Tracking_Information, Classifications_New_Contacts

output data flows

Classification_and_New_Contacts, Contact_Locations

description

TRACK COORDINATION. This module coordinates activities between the IAC and the Automated Tracker. The Track Coordinator sends new contacts to the Automated Tracker, determines when to start or stop a tracking session, and updates the Automated Tracker as new information is received. It also coordinates access to the Math Module for certain calculations required by the ATS.

end pspec

Process 1.5: Report_Generation:

Note process

Author: kbradley

Generated: 18:02:55 5 December 1990

Name: Report_Generation

Report Generation Module. Creates reports for internal display, transmittal to the global area coordination center, and transmittal to other units operating locally.

Process 1.6: General_Information_Management:

Note process

Author: kbradley

Generated: 17:46:33 7 December 1990

Name: General_Information_Management

General Information Management System. This is a system related to or actually the SOLID/JOBLIST system being developed by P.A.D. de Maine. It will handle all queries of the Knowledge Base and the Knowledge Acquisition System. It will also coordinate the retrieval of classifications as they are mapped into the system using the DADR system.

Note ProcessSpec

Process 1.6: General_Information_Management

Pspecc generated

26 April 1991 at 13:53:12 by kbradley@gauss

This process has 6 data flows:

Queries_New_Info,

Evaluated_Info_New_Info_Classifications_Responses, Queries_New_Info,

Classifications_and_New_Info, New_Info_Queries, Responses

input data flows

Queries_New_Info, Classifications_and_New_Info, Responses

output data flows

Evaluated_Info_New_Info_Classifications_Responses,

Queries_New_Info, New_Info_Queries

description

GENERAL INFORMATION MANAGEMENT. This module is the query handling part of the system. The GIM will be the JOBLIST/SOLID or related system that is being developed by P.A.D. de Maine at Auburn University. It will handle all queries of the Knowledge Base and Knowledge Acquisition system or other memory search requirement of the system. It also handles responses to classifications developed by the DADR system that maps its address into a JOBLIST address.

end pspecc

Process 1.7: Math_Evaluation_Module:

Note process

Author: kbradley

Generated: 18:50:18 7 December 1990

Name: Math_Evaluation_Module

MATHEMATICAL MODULE.

This is a mathematical module for use by the various systems for things like matrix manipulation, probability calculation, etc. The system is for any system needing its services that does not have it in its own system. As several systems are related, their mathematical requirements are the same, therefore, it is more economical to have a module perform the operations for them.

Note ProcessSpec

Process 1.7: Math_Evaluation_Module

Pspec generated

26 April 1991 at 13:53:13 by kbradley@gauss

This process has 2 data flows:

Responses, Queries

input data flows Queries

output data flows Responses

description

MATH EVALUATION. This module is for use by several of the systems to do matrix manipulation, probability calculations, etc. The module is for any system needing its services. Having one module to perform mathematical operations is more economical. The data flow diagram indicates flow to the IAC AUTOLRN module only, but that is only temporary until all system requirements are defined.
end pspec

Process 1.8: IAC_AUTOLRN_System:

Note process

Author: kbradley

Generated: 17:54:31 7 December 1990

Name: IAC_AUTOLRN_System

IAC Automatic Learning System. This is the brain of the Automated Combat System. It processes all queries from external systems. It makes decisions as to what information is to be reported, what contacts to actively track, when to classify a contact, and how to synergize the systems.

Note ProcessSpec

Process 1.8: IAC_AUTOLRN_System

Pspec generated

26 April 1991 at 13:53:14 by kbradley@gauss

This process has 10 data flows:

Responses, Queries,

Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries,

Contact_Locations, Classifications_New_Contacts,

Queries_Position_Info_Decisions_Contact_Info, Queries_New_Info,

Evaluated_Info_New_Info_Classifications_Responses,

Classification_Queries, Queries_New_Info

input data flows

Responses,

Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries,

Contact_Locations,

Evaluated_Info_New_Info_Classifications_Responses,

Classification_Queries

output data flows

Queries, Classifications_New_Contacts,

Queries_Position_Info_Decisions_Contact_Info, Queries_New_Info,

Queries_New_Info

description

IAC AUTOLRN. This module is the brain of the system. It is the most sophisticated expert system in the ACS. It processes all the requirements, queries, classifications, reporting, etc. of the ACS. It makes tracking decisions, tactical decisions, etc. based on "Command by Negation" options. It also creates the synergism of the system as it is the center of activities.

end pspec

Flow: Classification/_Queries:

From: Offpage.1

To: Identification_Module

Note data_flow

Author: kbradley

Generated: 18:07:12 30 November 1990

Name: Classification/_Queries

BNF: Classification/_Queries ::= [Classification | Queries]

Flow: Classification_Queries:

From: Identification_Module
To: IAC_AUTOLRN_System
Note data_flow
Author: kbradley
Generated: 19:18:26 7 December 1990
Name: Classification_Queries

CLASSIFICATIONS. These are classifications that the Sensor Evaluator has made. This is not the actual data flow as the DADR systems maps the classification into a GIM address and it is returned via that method. This data flow is for representation of where the information was generated.

NEW CONTACTS. This information is sent to the IAC AUTOLRN system for further evaluation in conjunction with the Knowledge Acquisition System.

BNF: Classification_Queries ::= [Classification | Queries]

Flow: Classification_and_New_Contacts:

From: Track_Coordination_Module
To: Offpage.1
Note data_flow
Author: kbradley
Generated: 18:06:20 30 November 1990
Name: Classification_and_New_Contacts

CLASSIFICATIONS. Identifies the new contacts with any known classification like Merchant vessel, Boeing 747 commercial, etc. to determine type of tracking and frequency.

NEW CONTACTS. Identifies new contacts with the criteria for tracking including the classification if known. There are standard criteria for unknown contacts based on speed and Closest Point of Approach.

BNF: Classification_and_New_Contacts ::= [Classifications | New_Contacts]

Flow: Classifications_New_Contacts:

From: IAC_AUTOLRN_System
To: Track_Coordination_Module
Note data_flow
Author: kbradley
Generated: 19:09:27 7 December 1990
Name: Classifications_New_Contacts

CLASSIFICATIONS. These are new classifications of contacts in the tracking system from internal or external classification systems.

NEW CONTACTS. These are new contacts to be injected into the tracking system. The new contacts may be from internal sensor systems, from external systems providing contact information they have, or from contacts held in the Knowledge Base because they were out of the designated tracking range.

BNF: Classifications_New_Contacts ::= [Classifications | New_Contacts]

Flow: Classifications_and_New_Info:

From: New_Info_Generation

To: General_Information_Management

Note data_flow

Author: kbradley

Generated: 18:38:08 7 December 1990

Name: Classifications_and_New_Info

CLASSIFICATIONS. The Knowledge Acquisitions System, in conjunction with the Sensor Evaluator, generates classifications of contacts. The classifications are actually sent using the DADR to the Knowledge Base for entrance into the system. This data flow is representational in nature.

NEW INFORMATION. Includes new tactics employed by other units and an evaluation of their success, new sensors detected on units not previously having them, new sensor detections, etc.

BNF: Classifications_and_New_Information ::= [Classifications | New_Information]

Flow: Contact_Info_Position_Info_Decisions:

From: Offpage.1

To: Report_Generation

Note data_flow

Author: kbradley

Generated: 16:32:05 30 November 1990

Name: Contact_Info_Position_Info_Decisions

LOCALAREA-to-UNIT information flow:

1. Coordinated contact information.
2. Local reports.
3. Queries and Responses.
4. Battle Decisions.

BNF: Contact_Info_Position_Info_Decisions ::= [Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_Position_Info_Decisions:

From: Report_Generation
To: Offpage.1
Note data_flow
Author: kbradley
Generated: 16:34:06 30 November 1990
Name: Contact_Info_Position_Info_Decisions
UNIT-to-LOCALAREA information flow:
1. Coordinated contact information and reports.
2. Position report.
3. Queries and Responses.
4. Battle decisions.
BNF: Contact_Info_Position_Info_Decisions ::=
[Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_US_Shipping_Revised_Tactics:

From: Offpage.1
To: Report_Generation
Note data_flow
Author: kbradley
Generated: 16:20:20 30 November 1990
Name: Contact_Info_US_Shipping_Revised_Tactics
GLOBAL-to-UNIT information flow:
1. Positions of Known Contacts.
2. ID of Known Contacts.
3. Positions of US units.
4. Revised Tactics.
5. Revised general information and updates.
6. Queries and Responses
BNF: Contact_Info_US_Shipping_Revised_Tactics ::=
[Contact_Info | US_Shipping | Revised_Tactics]

Flow: Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries:

From: Report_Generation
To: IAC_AUTOLRN_System
Note data_flow
Author: kbradley

Generated: 18:57:33 7 December 1990

Name: Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries

These are external queries of the system from the unit itself requesting information like contacts within a certain range, from local units trying to coordinate classifications, or from the global area control unit trying to get information.

CONTACT INFORMATION. These contacts are developed by external sources including Local and Global sources. It could be contacts within the operating area or contacts like aircraft with the potential to move into the operating area.

VESSEL LOCATIONS. These are positions of friendly units operating in the area. It differs from the above because these are reported by the units based on navigation and not sensor detection and reporting.

REVISED TACTICS. The revised tactics for non-US units from the KAS from other units. This information is routed to the Knowledge Base for reference by the Unit's KAS.

LOCAL DECISIONS. These decisions are made by locally operating units to let others know what they are doing. The decisions include maneuvering and combat decisions. Combat decisions are important to prevent several unit from attacking the same contact.

QUERIES. Includes accesses to data, decisions, tactics, etc.

BNF: Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries ::= [Contact_Info|Vessel_Loc|Revised_Tactics|Local_Decisions|Queries]

Flow: Contact_Locations:

From: Track_Coordination_Module

To: IAC_AUTOLRN_System

Note data_flow

Author: kbradley

Generated: 19:15:36 7 December 1990

Name: Contact_Locations

Contact locations are continuously submitted to the IAC system for internal display and external reporting.

BNF: Contact_Locations ::= Contact_Locations

Flow: Evaluated_Info_New_Info_Classifications_Responses:

From: General_Information_Management

To: IAC_AUTOLRN_System

Note data_flow

Author: kbradley

Generated: 18:47:07 7 December 1990

Name: Evaluated_Info_New_Info_Classifications_Responses

EVALUATED INFORMATION. This is information either from the Knowledge Base or Knowledge Acquisition system. It has been evaluated for future use or storage. It is ready for report generation.

NEW INFORMATION. New information is generated by the Knowledge Acquisition expert system and includes such things as new tactics, new classifications, and new equipment (emitters).

RESPONSES. Responses to queries, usually to the Knowledge Base.

CLASSIFICATIONS. Classifications are made by the KAS, mapped to the GIM address, and returned from the Knowledge Base via the GIM.

BNF: Evaluate_Info_New_Info_Classifications_Responses::=

[Evaluated_Info | New_Info | Classifications | Responses]

Flow: Evaluated_Info_Responses_to_Queries:

From: Report_Generation

To: Offpage.1

Note data_flow

Author: kbradley

Generated: 16:47:44 30 November 1990

Name: Evaluated_Info_Responses_to_Queries

SYSTEM-to-INTERNAL information flow:

1. Evaluated information to the display screens or other display devices.
2. Responses to Queries.
3. Information received from other units (LOCAL and GLOBAL).

BNF: Evaluated_Info_Responses_to_Queries ::=

[Evaluated_Info | Responses_to_Queries]

Flow: New_Info/_Queries:

From: New_Info_Generation

To: Offpage.1

Note data_flow

Author: kbradley

Generated: 18:09:11 30 November 1990

Name: New_Info/_Queries

BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: New_Info/_Queries:

From: Info_Coord_Module
To: Offpage.1
Note data_flow
Author: kbradley
Generated: 18:07:51 30 November 1990
Name: New_Info/_Queries
BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: New_Info/_Queries:

From: Identification_Module
To: Offpage.1
Note data_flow
Author: kbradley
Generated: 18:06:54 30 November 1990
Name: New_Info/_Queries
NEW INFO. Includes new contact information from external sources, tracking "heads-up" on contacts that should be appearing on the sensors, etc.
QUERIES. Includes request for information as to whether a contact has appeared, amplify information previously sent, status of sensor equipment, etc.
BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: New_Info_Queries:

From: General_Information_Management
To: Info_Coord_Module
Note data_flow
Author: kbradley
Generated: 18:04:59 7 December 1990
Name: New_Info_Queries
Queries of the Knowledge Base from the IAC AUTOLRN system. These queries are usually responses to externally generated requests.
BNF: New_Info_Queries ::= [New_Info | Queries]

Flow: Own_Position_New_Contact_Info_Queries:

From: Report_Generation
To: Offpage.1
Note data_flow
Author: kbradley

Generated: 16:24:42 30 November 1990

Name: Own_Position_New_Contact_Info_Queries

SHIP-to-GLOBAL information:

1. Ship's exact position.
2. Positions of contacts.
3. Classifications and reports.
4. Queries and Responses.

BNF: Own_Position_New_Contact_Info_Queries ::=

[Own_Position | New_Contact_Info | Queries]

Flow: Probable_ID/New_Info:

From: Offpage.1

To: New_Info_Generation

Note data_flow

Author: kbradley

Generated: 18:08:55 30 November 1990

Name: Probable_ID/New_Info

BNF: Probable_ID/New_Info ::= [Probable_ID | New_Info]

Flow: Queries:

From: Offpage.1

To: Report_Generation

Note data_flow

Author: kbradley

Generated: 16:51:28 30 November 1990

Name: Queries

INTERNAL-to-SYSTEM information flow:

1. Queries.
 - a. Other Friendly units.
 - b. Non-friendly units.
 - c. Capabilities.
 - d. Reports to higher authorities.
 - e. Battle decisions.
 - f. Tactical information.
 - g. Etc.

BNF: Queries ::= Queries

Flow: Queries:

From: IAC_AUTOLRN_System
To: Math_Evaluation_Module
Note data_flow
Author: kbradley
Generated: 19:04:06 7 December 1990
Name: Queries

This is a request to provide a mathematical service. As the actual units needing the service is not known at this time, the connection is made to the IAC control center. As direct flows are generated, the new data lines will be added.
BNF: Queries ::= Queries

Flow: Queries_New_Info:

From: General_Information_Management
To: New_Info_Generation
Note data_flow
Author: kbradley
Generated: 18:42:09 7 December 1990
Name: Queries_New_Info

These are requests for new information to be generated based on the present situation. It is the unit requesting correspondence of contacts, best tactics, development of new tactics, etc. It also includes new information received from external sources.
BNF: Queries_New_Info ::= [Queries | New_Info]

Flow: Queries_New_Info:

From: IAC_AUTOLRN_System
To: General_Information_Management
Note data_flow
Author: kbradley
Generated: 18:44:34 7 December 1990
Name: Queries_New_Info

These are request for known information to be routed to the Knowledge Base or a request for new information about contacts, tactics, etc. to the Knowledge Acquisition System. All requests for information must go through the General Information Management System.
BNF: Queries_New_Info ::= [Queries | New_Info]

Flow: Queries_New_Info:

From: IAC_AUTOLRN_System

To: Identification_Module

Note data_flow

Author: kbradley

Generated: 19:22:53 7 December 1990

Name: Queries_New_Info

This query is based on requests to see if a contact reported externally can be found on the unit sensors by varying the search criteria to look in a new area to confirm another units report. It also includes new information received from external sources and the Automated Tracking system.

BNF: Queries_New_Info ::= [Queries | New_Info]

Flow: Queries_Position_Info_Decisions_Contact_Info:

From: IAC_AUTOLRN_System

To: Report_Generation

Note data_flow

Author: kbradley

Generated: 19:00:29 7 December 1990

Name: Queries_Position_Info_Decisions_Contact_Info

This is evaluated information being sent to unit display or for external unit reporting. It is also responses to queries. As all the information has at some time been evaluated, it is called evaluated rather than just responses.

QUERIES. This request is submitted to the addressed reporting unit including Global, Local, or Unit Display.

POSITION INFORMATION. This is the Unit's navigational position.

DECISIONS. These are outgoing decisions to allow locally operating units to know the maneuvers and combat decisions of this unit.

CONTACT INFORMATION. These are contacts from the Sensor Evaluator and/or classifications from the SE and KAS.

BNF: Queries_Position_Info_Decisions_Contact_Info ::=

[Queries | Position_Info | Decisions | Contact_Info]

Flow: Responses:

From: Offpage.1

To: Info_Coord_Module

Note data_flow

Author: kbradley

Generated: 18:08:38 30 November 1990

Name: Responses

Responses to queries of the database for return to the system via the Information Module.

BNF: Responses ::= Responses

Flow: Responses:

From: Info_Coord_Module

To: General_Information_Management

Note data_flow

Author: kbradley

Generated: 18:02:38 7 December 1990

Name: Responses

Responses to Queries of the Knowledge Base. It is also the return path of DADR (Knowledge Acquisition System) classifications.

BNF: Responses ::= Responses

Flow: Responses:

From: Math_Evaluation_Module

To: IAC_AUTOLRN_System

Note data_flow

Author: kbradley

Generated: 19:06:23 7 December 1990

Name: Responses

These are responses to the mathematical services. This will be evaluated information.

BNF: Responses ::= Responses

Flow: Tracking_Information:

From: Offpage.1

To: Track_Coordination_Module

Note data_flow

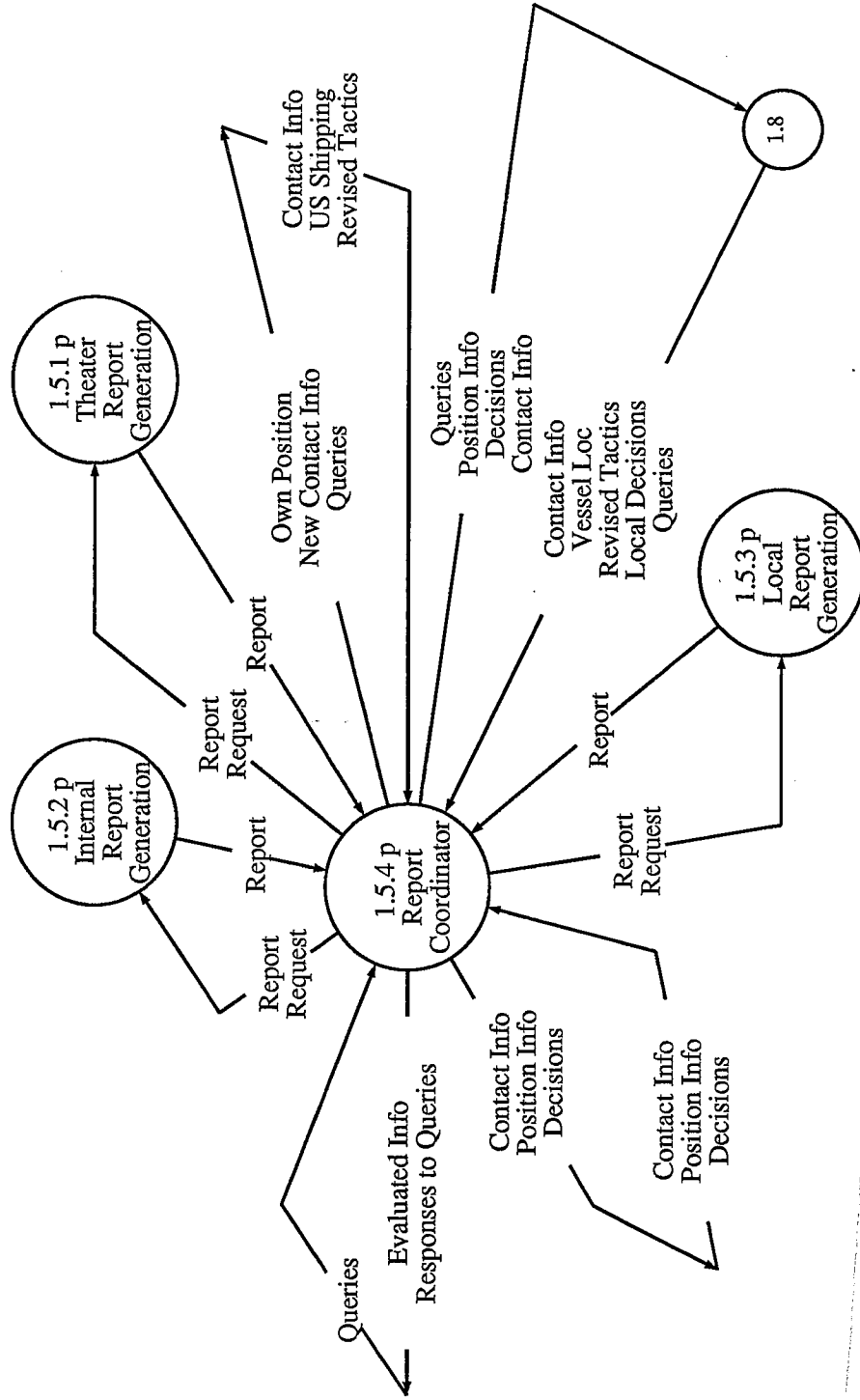
Author: kbradley

Generated: 18:06:37 30 November 1990

Name: Tracking_Information

APPENDIX D - REPORT GENERATOR

1. Report Generator Submodule Level Drawing



2. Report Generator Submodule Documentation

Note diag

Author: kbradley

Generated: 8:44:09 8 December 1990

Parent: Report_Generation

This is the reporting system employed by the system. It is flexible enough for any unit to operate in an integrated combat environment without converting to a common system. The conversions occur in this part of the system. It also permits Units to set their own internal reporting requirements to meet the needs of the combat condition or alert status.

Process 1.5.1: Theater_Report_Generation:

Note ProcessSpec

Process 1.5.1: Theater_Report_Generation

Pspec generated

26 April 1991 at 16:24:19 by kbradley@gauss

This process has 2 data flows:

Report, Report_Request

input data flows Report_Request

output data flows Report

description

GLOBAL REPORT GENERATION. This module is used to convert queries and information into a reporting form that is usable to the receiver. If the information is from the Global Area System, it is converted for use in the ACS. If the information is internal, it is converted to formats required by the Global System (i.e., Position Report, Contact Reports, OPNAV Serious Incident, etc.).

end pspec

Process 1.5.2: Internal_Report_Generation:

Note ProcessSpec

Process 1.5.2: Internal_Report_Generation

Pspec generated

26 April 1991 at 16:24:19 by kbradley@gauss

This process has 2 data flows:

Report, Report_Request

input data flows Report_Request

output data flows Report

description

INTERNAL REPORT GENERATION. This module creates a format for the system information to be displayed on the Unit's Display System. This module allows the Unit to define its own display within certain constraints. It also handles queries from the system and converts it to a format the system can rapidly use.

end pspec

Process 1.5.3: Local_Report_Generation:

Note ProcessSpec

Process 1.5.3: Local_Report_Generation

Pspec generated

26 April 1991 at 16:24:20 by kbradley@gauss

This process has 2 data flows:

Report, Report_Request

input data flows Report_Request

output data flows Report

description

LOCAL REPORT GENERATION. This module converts internal system information into a format for transmission within the local environment and local environmental information into a format for internal use. The module allows users of different services and nations to use their own system.

end pspec

Process 1.5.4: Report_Coordinator:

Note ProcessSpec

Process 1.5.4: Report_Coordinator

Pspec generated

26 April 1991 at 16:24:20 by kbradley@gauss

This process has 14 data flows:

Own_Position_New_Contact_Info_Queries,

Contact_Info_US_Shipping_Revised_Tactics,

Contact_Info_Position_Info_Decisions,

Contact_Info_Position_Info_Decisions,

Evaluated_Info_Responses_to_Queries, Queries,

Queries_Position_Info_Decisions_Contact_Info,

Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries,

Report, Report_Request, Report, Report_Request, Report,

Report_Request

input data flows

Contact_Info_US_Shipping_Revised_Tactics,
Contact_Info_Position_Info_Decisions, Queries,
Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries,
Report, Report, Report

output data flows

Own_Position_New_Contact_Info_Queries,
Contact_Info_Position_Info_Decisions,
Evaluated_Info_Responses_to_Queries,
Queries_Position_Info_Decisions_Contact_Info, Report_Request,
Report_Request, Report_Request

description

REPORT COORDINATOR. This module is the brain of the reporting system. It handles internal report conversions, passes outgoing information to communications facility, and incoming information to the IAC AUTOLRN module. It is an expert system with the ability to recognize formats and pass them to the appropriate converting process.

end pspec

Flow: Contact_Info_Position_Info_Decisions:

From: Offpage.1.5
To: Report_Coordinator
Note data_flow
Author: kbradley
Generated: 16:32:05 30 November 1990
Name: Contact_Info_Position_Info_Decisions
LOCALAREA-to-UNIT information flow:
1. Coordinated contact information.
2. Local reports.
3. Queries and Responses.
4. Battle Decisions.
BNF: Contact_Info_Position_Info_Decisions ::=
[Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_Position_Info_Decisions:

From: Report_Coordinator
To: Offpage.1.5
Note data_flow

Author: kbradley
Generated: 16:34:06 30 November 1990
Name: Contact_Info_Position_Info_Decisions
UNIT-to-LOCALAREA information flow:
1. Coordinated contact information and reports.
2. Position report.
3. Queries and Responses.
4. Battle decisions.
BNF: Contact_Info_Position_Info_Decisions ::=
[Contact_Info | Position_Info | Decisions]

Flow: Contact_Info_US_Shipping_Revised_Tactics:

From: Offpage.1.5
To: Report_Coordinator
Note data_flow
Author: kbradley
Generated: 16:20:20 30 November 1990
Name: Contact_Info_US_Shipping_Revised_Tactics
GLOBAL-to-UNIT information flow:
1. Positions of Known Contacts.
2. ID of Known Contacts.
3. Positions of US units.
4. Revised Tactics.
5. Revised general information and updates.
6. Queries and Responses
BNF: Contact_Info_US_Shipping_Revised_Tactics ::=
[Contact_Info | US_Shipping | Revised_Tactics]

Flow: Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries:

From: Offpage.1.5
To: Report_Coordinator
Note data_flow
Author: kbradley
Generated: 19:00:29 7 December 1990
Name: Contact_Info_Vessel_Loc_Revised_Tactics_Local_Decisions_Queries
This is evaluated information being sent to unit display or for external unit reporting. It is also responses to queries. As all the information has at some time been evaluated, it is called evaluated rather than just responses.

BNF: Same as previous level.

Flow: Evaluated_Info_Responses_to_Queries:

From: Report_Coordinator

To: Offpage.1.5

Note data_flow

Author: kbradley

Generated: 16:47:44 30 November 1990

Name: Evaluated_Info_Responses_to_Queries

SYSTEM-to-INTERNAL information flow:

1. Evaluated information to the display screens or other display devices.
2. Responses to Queries.
3. Information received from other units (LOCAL and GLOBAL).

BNF: Evaluated_Info_Responses_to_Queries ::=

[Evaluated_Info | Responses_to_Queries]

Flow: Own_Position_New_Contact_Info_Queries:

From: Report_Coordinator

To: Offpage.1.5

Note data_flow

Author: kbradley

Generated: 16:24:42 30 November 1990

Name: Own_Position_New_Contact_Info_Queries

SHIP-to-GLOBAL information:

1. Ship's exact position.
2. Positions of contacts.
3. Classifications and reports.
4. Queries and Responses.

BNF: Own_Position_New_Contact_Info_Queries ::=

[Own_Position | New_Contact_Info | Queries]

Flow: Queries:

From: Offpage.1.5

To: Report_Coordinator

Note data_flow

Author: kbradley

Generated: 16:51:28 30 November 1990

Name: Queries

INTERNAL-to-SYSTEM information flow:

1. Queries.
 - a. Other Friendly units.
 - b. Non-friendly units.
 - c. Capabilities.
 - d. Reports to higher authorities.
 - e. Battle decisions.
 - f. Tactical information.
 - g. Etc.

BNF: Queries ::= Queries

Flow: Queries_Position_Info_Decisions_Contact_Info:

From: Report_Coordinator

To: Offpage.1.5

Note data_flow

Author: kbradley

Generated: 18:57:33 7 December 1990

Name: Queries_Position_Info_Decisions_Contact_Info

These are external queries of the system from the unit itself requesting information like contacts within a certain range, from local units trying to coordinate classifications, or from the global area control unit trying to get information.

BNF: Queries_Position_Info_Decisions_Contact_Info ::=

[Queries | Position_Info | Decisions | Contact_Info]

Flow: Report:

From: Internal_Report_Generation

To: Report_Coordinator

Note data_flow

Author: kbradley

Generated: 8:20:49 8 December 1990

Name: Report

Internal Report. Coordinates all reports to the Unit Display System. It determines the type and format of the display based on preset values set from the Unit.

BNF: Report ::= Report

Flow: Report:

From: Local_Report_Generation
To: Report_Coordinator
Note data_flow
Author: kbradley
Generated: 8:37:42 8 December 1990
Name: Report

This report generator creates a report for submitting information to other Units operating in the local area. It also converts local information to system usable format. This permits Units from different services and nations to operate locally without switching to a common reporting system.

BNF: Report ::= Report

Flow: Report:

From: Theater_Report_Generation
To: Report_Coordinator
Note data_flow
Author: kbradley
Generated: 8:30:38 8 December 1990
Name: Report

The Global System reporting system has established reporting formats. This report is information from the system converted to that format or information from the Global System format converted to system usable format.

BNF: Report ::= Report

Flow: Report_Request:

From: Report_Coordinator
To: Internal_Report_Generation
Note data_flow
Author: kbradley
Generated: 8:23:27 8 December 1990
Name: Report_Request

The system generates information that needs to be put into the appropriate format for display.

BNF: Report_Request ::= Report_Request

Flow: Report_Request:

From: Report_Coordinator

To: Local_Report_Generation
Note data_flow
Name: Report_Request
BNF: Report_Request ::= Report_Request

Flow: Report_Request:

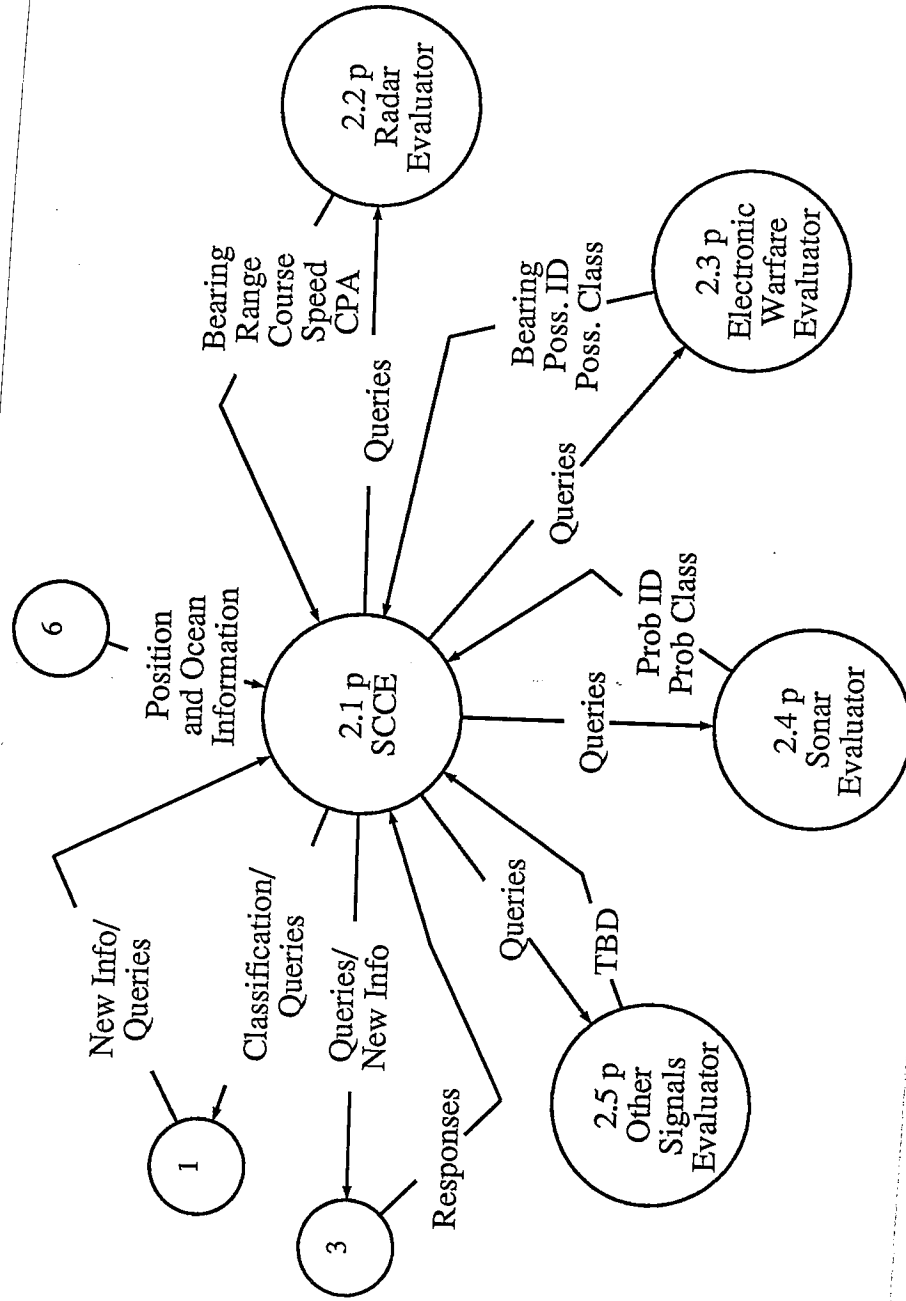
From: Report_Coordinator
To: Theater_Report_Generation
Note data_flow
Author: kbradley
Generated: 8:35:13 8 December 1990
Name: Report_Request

The reporting information is sent to the Global Report Generator to create the external report or to convert the report to system usable format.

BNF: Report_Request ::= Report_Request

APPENDIX E - SENSOR EVALUATOR

1. Sensor Evaluator Module Level Drawing



2. Sensor Evaluator Module Documentation

Note diag

Parent: Sensor_Evaluator

Process 2.1: SCCE:

Note process

Author: kbradley

Generated: 15:20:40 25 April 1991

Name: SCCE

SENSOR COORDINATION, CLASSIFICATION, AND EVALUATION: The SCCE takes the information from the sensor units and attempts to classify and/or identify the target. It will also perform collation of the target, attempting to ensure the target has not been previously classified or identified by another sensor.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing|Range|Course|Speed|ID|Class|Threat|
{TargetInfo}

Note ProcessSpec

Process 2.1: SCCE

Pspec generated

26 April 1991 at 13:54:48 by kbradley@gauss

This process has 13 data flows:

Position_and_Ocean_Information, New_Info/_Queries,
Classification/_Queries, Responses, Queries/_New_Info

input data flows

Position_and_Ocean_Information, New_Info/_Queries,
Responses, Bearing_Range_Course_Speed_CPA,
Bearing_Poss._ID_Poss._Class, Prob_ID_Prob_Class, TBD

output data flows

Classification/_Queries, Queries/_New_Info, Queries,
Queries, Queries, Queries

description

SENSOR COORDINATION, CLASSIFICATION, AND EVALUATION. The SCCE performs sensor data fusion on the information generated in the individual sensor modules. It also attempts further classification and identification. The SCCE uses its Intelligence System, data collation, and Knowledge Base retrieval techniques to perform its evaluation. It passes its information to the IAC.

end pspec

Process 2.2: Radar_Evaluator:

Note process

Author: kbradley

Generated: 17:30:42 9 April 1991

Name: Radar_Evaluator

RADAR EVALUATOR. The Radar Evaluator receives information from the individual radars (i.e., surface search, air search, or fire control) partially evaluated and performs IFF identification, computes the CPA and outputs the information along with the bearing, range, course, and speed.

BNF: Target ::= TargetInfo

TargetInfo ::= Course | Bearing | Speed | Range | CPA

Note ProcessSpec

Process 2.2: Radar_Evaluator

Pspec generated

26 April 1991 at 13:54:49 by kbradley@gauss

This process has 2 data flows:

Queries, Bearing_Range_Course_Speed_CPA

input data flows Queries

output data flows Bearing_Range_Course_Speed_CPA

description

RADAR EVALUATOR. The Radar Evaluator takes the inputted Range, Bearing, Course, and Speed from the individual radar and computes its CPA. It also uses the IFF to attempt an ID. It also correlates expected Targets. end pspec

Process 2.3: Electronic_Warfare_Evaluator:

Note process

Author: kbradley

Generated: 15:42:29 25 April 1991

Name: Electronic_Warfare_Evaluator

ELECTRONIC WARFARE EVALUATOR. Performs classification and/or identification on ELINT signals.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing {PRR} {PW} {FREQ} {OTHER}

Note ProcessSpec

Process 2.3: Electronic_Warfare_Evaluator

Pspec generated

26 April 1991 at 13:54:50 by kbradley@gauss

This process has 2 data flows:

Queries, Bearing_Poss._ID_Poss._Class

input data flows Queries

output data flows Bearing_Poss._ID_Poss._Class

description

ELECTRONIC WARFARE EVALUATOR. The EW evaluator uses its knowledge to attempt to classify and/or identify an ELINT capture. As there are several unique systems, this unit will often perform an identification.

end pspec

Process 2.4: Sonar_Evaluator:

Note process

Author: kbradley

Generated: 15:49:16 25 April 1991

Name: Sonar_Evaluator

SONAR EVALUATOR. The Sonar Evaluator attempts to classify and/or identify contacts receive via passive or active sonar. The SE also evaluates information received from sonarbuoys.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing | Range | ID | Class

Note ProcessSpec

Process 2.4: Sonar_Evaluator

Pspec generated

26 April 1991 at 13:54:50 by kbradley@gauss

This process has 2 data flows:

Prob_ID_Prob_Class, Queries

input data flows Queries

output data flows Prob_ID_Prob_Class

description

SONAR EVALUATOR. The Sensor Evaluator will perform evaluations on targets receive to determine the classification and/or identification. The SE uses a rule based learning system to perform its classification procedures. The SE uses information like bearing, range, unique noise, engine plant information, propeller noise and type, etc. for its classification and identification attempts.

end pspec

Process 2.5: Other_Signals_Evaluator:

Note process

Author: kbradley

Generated: 16:04:32 25 April 1991

Name: Other_Signals_Evaluator

OTHER SIGNALS EVALUATOR. The evaluator is for future systems that are being deployed, like IR, RPV data, Vision,

BNF: Target ::= TargetInfo

TargetInfo ::= TBD

Note ProcessSpec

Process 2.5: Other_Signals_Evaluator

Pspec generated

26 April 1991 at 13:54:51 by kbradley@gauss

This process has 2 data flows:

Queries, TBD

input data flows Queries

output data flows TBD

description

OTHER SIGNALS EVALUATOR. This system is to indicate that there are new sensors being developed like infra-red sensors.

end pspec

Flow: Bearing_Poss._ID_Poss._Class:

From: Electronic_Warfare_Evaluator

To: SCCE

Note data_flow

Author: kbradley

Generated: 16:26:40 25 April 1991

Name: Bearing_Poss._ID_Poss._Class

Bearing / Possible ID. The output of the EW Evaluator is a bearing with a possible identification based on the evaluation of the contact.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing {Class} {ID}

Flow: Bearing_Range_Course_Speed_CPA:

From: Radar_Evaluator

To: SCCE
Note data_flow
Author: kbradley
Generated: 16:32:48 25 April 1991
Name: Bearing_Range_Course_Speed_CPA
Bearing/Range/Course/Speed/CPA. The output of the Radar Evaluator has all the standard information that exists in the present system.
BNF: Target ::= TargetInfo
TargetInfo ::= Bearing Range Course Speed CPA {Other}

Flow: Classification/_Queries:

From: SCCE
To: Offpage.2
Note data_flow
Author: kbradley
Generated: 18:07:12 30 November 1990
Name: Classification/_Queries
CLASSIFICATIONS. They are provided to the Information Analysis and Control unit as they are determined. The non-fully classified contacts are also reported with all the available information.
QUERIES. Queries are made to the IAC for information to improve a classification. Also information is requested to correlate contacts.
BNF: Classification/_Queries ::= [Classification | Queries]

Flow: New_Info/_Queries:

From: Offpage.2
To: SCCE
Note data_flow
Author: kbradley
Generated: 18:06:54 30 November 1990
Name: New_Info/_Queries
New information is provided the Sensor Evaluator to improve its classification capability. Queries are made to the SE for the system to change a search criteria.
BNF: New_Info/_Queries ::= [New_Info | Queries]

Flow: Position_and_Ocean_Information:

From: Offpage.2

To: SCCE
Note data_flow
Author: kbradley
Generated: 18:10:30 30 November 1990
Name: Position_and_Ocean_Information
Position information is provided the Sensor Evaluator for use with sensors and evaluations. Ocean Information is also provided for Sonar evaluations (For ocean layer calculations, etc.)
BNF: Position_and_Ocean_Information ::= [Position | Ocean_Information]

Flow: Prob_ID_Prob_Class:

From: Sonar_Evaluator
To: SCCE
Note data_flow
Author: kbradley
Generated: 16:20:52 25 April 1991
Name: Prob_ID_Prob_Class
Probable ID / Probable Class. The Sensor information with the best probability of identification and classification.
BNF: Target ::= TargetInfo
TargetInfo ::= Bearing {Range} {Class} {ID} {Prob}

Flow: Queries:

From: SCCE
To: Radar_Evaluator
Note data_flow
Author: kbradley
Generated: 16:30:42 25 April 1991
Name: Queries
Queries from the SCCE to determine is a contact can be correlated. BNF:
BNF: Target ::= TargetInfo
TargetInfo ::= Bearing {Range} {Course} {Speed} {Class}

Flow: Queries:

From: SCCE
To: Electronic_Warfare_Evaluator

Note data_flow

Author: kbradley

Generated: 16:23:38 25 April 1991

Name: Queries

Queries from the SCCE attempting to classify/ID a target.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing {Course} {Speed} {Range} {Class}

Flow: Queries:

From: SCCE

To: Sonar_Evaluator

Note data_flow

Author: kbradley

Generated: 16:18:12 25 April 1991

Name: Queries

Queries from the SCCE attempting to classify/identify a target.

BNF: Target ::= TargetInfo

TargetInfo ::= Bearing {Range} {Course} {Speed}

Flow: Queries:

From: SCCE

To: Other_Signals_Evaluator

Note data_flow

Author: kbradley

Generated: 16:16:53 25 April 1991

Name: Queries

Queries from the SCCE attempting to classify/identify a target. No BNF.

Flow: Queries/_New_Info:

From: SCCE

To: Offpage.2

Note data_flow

Author: kbradley

Generated: 18:09:47 30 November 1990

Name: Queries/_New_Info

QUERIES. The SE requests information used for various classifications like table conversions. It is simpler for the SE to access the evaluation tables directly,

eliminating the need for a separate database for the SE.
NEW INFO. The SE can change and update its tables.
BNF: Queries/_New_Info ::= [Queries | New_Info]

Flow: Responses:

From: Offpage.2
To: SCCE
Note data_flow
Author: kbradley
Generated: 18:10:00 30 November 1990
Name: Responses

The Knowledge Base responds to requests from the SE on various topics via the IAC. This arrow is drawn because the information is from the KB to SE. The information management systems which coordinates information just happens to be in the IAC.

BNF: Responses ::= Responses

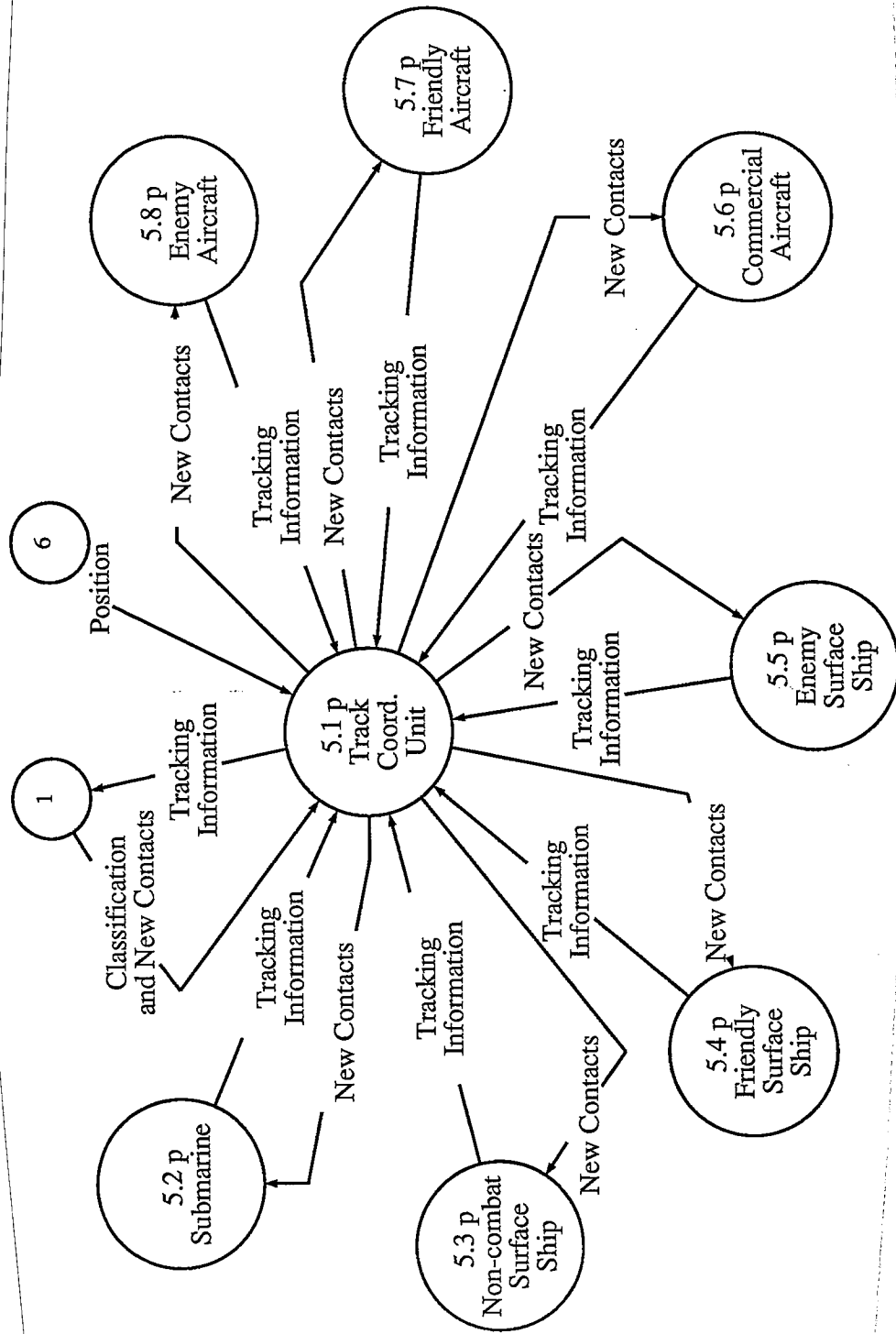
Flow: TBD:

From: Other_Signals_Evaluator
To: SCCE
Note data_flow
Author: kbradley
Generated: 16:15:42 25 April 1991
Name: TBD

TBD. As the sensor types are not defined, neither is the type of output.
No BNF available.

APPENDIX F - AUTOMATIC TRACKING UNIT

1. Automatic Tracking Unit Module Level Drawing



2. Automatic Tracking Unit Module Documentation

Note diag

Author: kbradley

Generated: 9:11:51 20 March 1991

Parent: Automated_Tracking

Process 5.1: Track_Coord._Unit:

Note process

Author: kbradley

Generated: 10:09:21 7 April 1991

Name: Track_Coord._Unit

TRACK COORDINATION UNIT. This is the Heart of the ATU. It is the connection to the system, handles all queries, assigns new contacts to their module, coordinates the clocking for updating modules, and performs all global coordinate calculations.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Time Location Control

Note ProcessSpec

Process 5.1: Track_Coord._Unit

Pspec generated

26 April 1991 at 13:56:09 by kbradley@gauss

This process has 17 data flows:

Tracking_Information, Classification_and_New_Contacts,
Position, Tracking_Information, New_Contacts, Tracking_Information,
Tracking_Information, New_Contacts, Tracking_Information,
New_Contacts, Tracking_Information, New_Contacts,
Tracking_Information, New_Contacts, Tracking_Information,
New_Contacts, New_Contacts

input data flows

Classification_and_New_Contacts, Position,
Tracking_Information, Tracking_Information, Tracking_Information,
Tracking_Information, Tracking_Information, Tracking_Information,
Tracking_Information

output data flows

Tracking_Information, New_Contacts, New_Contacts,
New_Contacts, New_Contacts, New_Contacts, New_Contacts,
New_Contacts

description

TRACK COORDINATION MODULE.

This is the heart of the ATU. Based on the situation, it determines when to update the various tracks. It has the capability to adjust the clocking of the modules at the battle situation changes. It is the interface to the IAC, and is the focal point for all targets moving in and out of the system.

end pspec

Process 5.2: Submarine:

Note process

Author: kbradley

Generated: 16:45:07 25 April 1991

Name: Submarine

SUBMARINE TRACKING MODULE.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.2: Submarine

Pspec generated

26 April 1991 at 13:56:13 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts

input data flows

New_Contacts

output data flows

Tracking_Information

description

SUBMARINE TRACKING MODULE.

This module is for tracking submarines. It also does not require a rapid update as submarines travel slowly and the closing speed is slow also.

end pspec

Process 5.3: Non-combat_Surface_Ship:

Note process

Author: kbradley

Generated: 16:53:24 25 April 1991

Name: Non-combat_Surface_Ship

NON-COMBATANT SURFACE SHIP.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.3: Non-combat_Surface_Ship

Pspec generated

26 April 1991 at 13:56:10 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts

input data flows

New_Contacts

output data flows

Tracking_Information

description

MERCHANT SHIP TRACKING MODULE.

This module tracks slow moving vessels and does not require updates very often.

Often this is just used to determine if a new contact could be a merchant.

end pspec

Process 5.4: Friendly_Surface_Ship:

Note process

Author: kbradley

Generated: 17:09:51 25 April 1991

Name: Friendly_Surface_Ship

FRIENDLY SURFACE SHIP.

Tracks the locally operating ships and well as ships from friendly nations.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.4: Friendly_Surface_Ship

Pspec generated

26 April 1991 at 13:56:11 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts

input data flows

New_Contacts

output data flows

Tracking_Information
description
FRIENDLY COMBAT SHIP TRACKING MODULE.
Tracks friendly shipping including ships operating in the Battle Group or Convoy.
It also tracks ships from friendly nations. This does NOT require a fast update
as the platforms are slow and the closing speed is slow.
end pspec

Process 5.5: Enemy_Surface_Ship:

Note process
Author: kbradley
Generated: 17:57:57 25 April 1991
Name: Enemy_Surface_Ship
ENEMY SURFACE SHIP. This is also a high priority update item because of its
capability to launch seaskimming missiles. It is tracked to ensure the system knows
when the contact is in sensor range and within its launch range.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Note ProcessSpec
Process 5.5: Enemy_Surface_Ship
Pspec generated
26 April 1991 at 13:56:11 by kbradley@gauss
This process has 2 data flows:
Tracking_Information, New_Contacts
input data flows
New_Contacts
output data flows
Tracking_Information
description
ENEMY COMBAT SURFACE SHIP TRACKING MODULE.
Although the closing speed on this platform is slow, its importance is based on its
capability to launch surface-to-surface missiles. The update priority is second only
to the Enemy Aircraft module. The modules keeps track of when the contact
should appear on the platform's sensor and when it is within its launch range.
end pspec

Process 5.6: Commercial_Aircraft:

Note process

Author: kbradley

Generated: 17:53:56 25 April 1991

Name: Commercial_Aircraft

COMMERCIAL AIRCRAFT. Although the closing speed on contact can also be significant, the priority is low as it is a known object.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.6: Commercial_Aircraft

Pspec generated

26 April 1991 at 13:56:12 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts

input data flows

New_Contacts

output data flows

Tracking_Information

description

COMMERCIAL AIRCRAFT TRACKING MODULE.

This module also has a rapid closing speed and a low priority. The commercial aircraft is a known item and its location is used to assist in the classification and identification process.

end pspec

Process 5.7: Friendly_Aircraft:

Note process

Author: kbradley

Generated: 17:48:07 25 April 1991

Name: Friendly_Aircraft

FRIENDLY AIRCRAFT.

This module tracks friendly aircraft, but only from the aspect of ensuring the IAC knows when friendly contacts are expected to assist in the classification and identification function.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.7: Friendly_Aircraft

Pspec generated

26 April 1991 at 13:56:12 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts
input data flows

New_Contacts
output data flows

Tracking_Information
description

FRIENDLY COMBAT AIRCRAFT TRACKING MODULE.

This module tracks known aircraft to assist in the identification and classification process. Although the closing speeds are significant, the updating function is not a high priority compared to the enemy aircraft.

end pspec

Process 5.8: Enemy_Aircraft:

Note process

Author: kbradley

Generated: 17:37:05 25 April 1991

Name: Enemy_Aircraft

ENEMY AIRCRAFT. This is the most important module in the Automatic Tracker. This module takes over control of the ATU when combat is occurring to support the battle. The enemy aircraft have significant greater closing speed than the other targets. In addition to airplanes, this module also tracks missiles.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Note ProcessSpec

Process 5.8: Enemy_Aircraft

Pspec generated

26 April 1991 at 13:56:13 by kbradley@gauss

This process has 2 data flows:

Tracking_Information, New_Contacts
input data flows

New_Contacts
output data flows

Tracking_Information
description

ENEMY COMBAT AIRCRAFT AND MISSILE TRACKING MODULE.

This module is the heart of the ATU. It tracks all the fast moving targets including airplanes and missiles. The closing speeds of all the contacts in this module is significantly faster than any other possible hostile contact. Therefore, this module can take control of the update function in a battle situation.

end pspec

Flow: Classification_and_New_Contacts:

From: Offpage.5
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 18:06:20 30 November 1990
Name: Classification_and_New_Contacts
CLASSIFICATIONS. Identifies the new contacts with any known classification like Merchant vessel, Boeing 747 commercial, etc. to determine type of tracking and frequency.
NEW CONTACTS. Identifies new contacts with the criteria for tracking including the classification if known. There are standard criteria for unknown contacts based on speed and Closest Point of Approach.
BNF: Classification_and_New_Contacts ::= [Classification | New Contacts]

Flow: New_Contacts:

From: Track_Coord._Unit
To: Non-combat_Surface_Ship
Note data_flow
Author: kbradley
Generated: 9:12:19 20 March 1991
Name: New_Contacts
NEW CONTACT: New contact information and termination of tracking information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Time Location

Flow: New_Contacts:

From: Track_Coord._Unit

To: Friendly_Surface_Ship
Note data_flow
Author: kbradley
Generated: 9:13:50 20 March 1991
Name: New_Contacts
NEW CONTACTS: Inputs new contacts to track and termination of tracking information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: New_Contacts:

From: Track_Coord_Unit
To: Enemy_Surface_Ship
Note data_flow
Author: kbradley
Generated: 9:14:23 20 March 1991
Name: New_Contacts
NEW CONTACTS: Inputs new contacts and provides termination information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Time Location

Flow: New_Contacts:

From: Track_Coord_Unit
To: Commercial_Aircraft
Note data_flow
Author: kbradley
Generated: 9:15:29 20 March 1991
Name: New_Contacts
NEW CONTACTS: Inputs the new contact information and track termination information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Time Location

Flow: New_Contacts:

From: Track_Coord_Unit
To: Friendly_Aircraft
Note data_flow

Author: kbradley
Generated: 9:16:00 20 March 1991
Name: New_Contacts
NEW CONTACTS: Inputs the new contact information and track termination information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: New_Contacts:

From: Track_Coord._Unit
To: Enemy_Aircraft
Note data_flow
Author: kbradley
Generated: 9:16:47 20 March 1991
Name: New_Contacts
NEW CONTACTS: Inputs new contact information and track termination information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Time Location

Flow: New_Contacts:

From: Track_Coord._Unit
To: Submarine
Note data_flow
Author: kbradley
Generated: 9:09:40 20 March 1991
Name: New_Contacts
NEW CONTACTS: New contact report of contact not presently held by any sensor. (Actually, pointer to location in memory).
BNF: Target ::= TargetInfo
TargetInfo ::= Location Time Course Speed

Flow: Position:

From: Offpage.5
To: Track_Coord._Unit
Note data_flow
Author: kbradley

Generated: 18:10:45 30 November 1990

Name: Position

The Unit's position is updated periodically based on the type of sensor used. The ATU also dead reckons between updates. The position of surface and airborne units is not as critical as SATNAV updates position very accurately. Submarine updated information is very critical as they rely on internal navigation systems.

BNF: Position ::= Position

Flow: Tracking_Information:

From: Track_Coord._Unit

To: Offpage.5

Note data_flow

Author: kbradley

Generated: 18:06:37 30 November 1990

Name: Tracking_Information

Tracking information is retrieved by the Information Analysis and Control Unit as needed.

BNF: Tracking_Information ::= Tracking_Information

Flow: Tracking_Information:

From: Non-combat_Surface_Ship

To: Track_Coord._Unit

Note data_flow

Author: kbradley

Generated: 9:12:47 20 March 1991

Name: Tracking_Information

TRACK INFORMATION: Provides latest position information.

BNF: Target ::= TargetInfo

TargetInfo ::= Course Speed Location

Flow: Tracking_Information:

From: Friendly_Surface_Ship

To: Track_Coord._Unit

Note data_flow

Author: kbradley

Generated: 9:13:28 20 March 1991

Name: Tracking_Information

TRACKING INFORMATION: Provides the latest position information for contacts.

BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: Tracking_Information:

From: Enemy_Surface_Ship
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 9:14:06 20 March 1991
Name: Tracking_Information
TRACKING INFORMATION: Provides the latest position on contacts being tracked.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: Tracking_Information:

From: Commercial_Aircraft
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 9:14:44 20 March 1991
Name: Tracking_Information
TRACKING INFORMATION: Provides the latest position information.
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: Tracking_Information:

From: Friendly_Aircraft
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 9:15:43 20 March 1991
Name: Tracking_Information
TRACKING INFORMATION: Provides the latest position information on the requested contact.

BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

Flow: Tracking_Information:

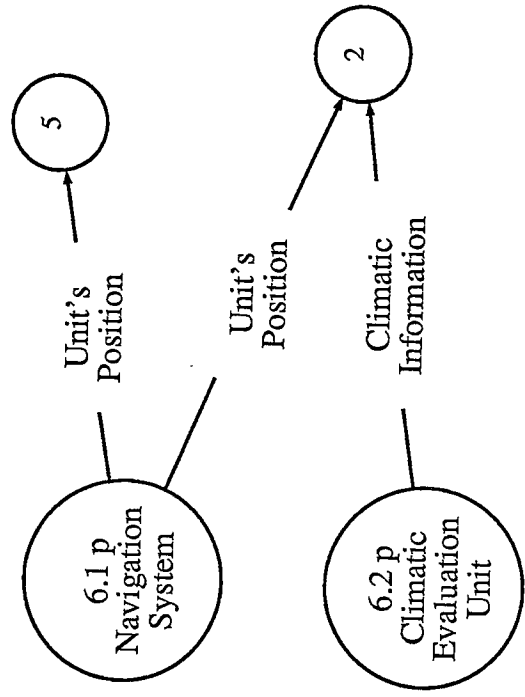
From: Enemy_Aircraft
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 9:44:05 20 March 1991
Name: Tracking_Information
TRACKING INFORMATION: Provides the latest position on the contact.

Flow: Tracking_Information:

From: Submarine
To: Track_Coord._Unit
Note data_flow
Author: kbradley
Generated: 9:04:02 20 March 1991
Name: Tracking_Information
TRACKING INFORMATION: Provides the latest computed position of the requested contact. (Provides pointer to the location in memory).
BNF: Target ::= TargetInfo
TargetInfo ::= Course Speed Location

APPENDIX G - MOVEMENT AND CLIMATIC EVALUATION UNIT

1. Movement and Climatic Evaluation Unit Module Level Drawing



2. Movement and Climatic Evaluation Unit Module Documentation

Note diag

Parent: Movement_&_Ocean_Evaluation

Process 6.1: Navigation_System:

Note process

Author: kbradley

Generated: 8:38:11 16 January 1991

Name: Navigation_System

NAVIGATION SYSTEM. The Navigation System computes the Unit's position and passes it to the Sensor Evaluator and the Automated Tracker for their use.

BNF: Position ::= Latitude Longitude

Note ProcessSpec

Process 6.1: Navigation_System

Pspec generated

28 April 1991 at 14:09:35 by kbradley@lab3

This process has 2 data flows:

Unit's_Position, Unit's_Position

input data flows

output data flows

Unit's_Position, Unit's_Position

description

NAVIGATION SYSTEM. Each unit has its own navigation system. This is a system interface to the platform Navigation system.

end pspec

Process 6.2: Climatic_Evaluation_Unit:

Note process

Author: kbradley

Generated: 8:39:03 16 January 1991

Name: Climatic_Evaluation_Unit

CLIMATIC EVALUATION. The Climatic Evaluation Unit is responsible for collecting ocean conditions for Sonar evaluation. It is very important in Sonar operations to know the ocean conditions so that the layer depths are known.

BNF: ClimaticInfo ::= Temp {Gradient} {Salinity} {Other}

Note ProcessSpec
Process 6.2: Climatic_Evaluation_Unit
Pspec generated
28 April 1991 at 14:09:36 by kbradley@lab3

This process has 1 data flows:

Climatic_Information
input data flows
output data flows
Climatic_Information
description

OCEAN EVALUATION UNIT. This is a system interface to the existing system for evaluation of the environment. It may involve something as minor as direct input of climatic conditions or as sophisticated as a ocean probes to determine all ocean conditions.

end pspec

Flow: Climatic_Information:

From: Climatic_Evaluation_Unit

To: Offpage.6

Note data_flow

Author: kbradley

Generated: 8:46:47 16 January 1991

Name: Climatic_Information

OCEAN INFORMATION.

Ocean Information is provided for Sonar evaluations (For ocean layer calculations, etc.).

BNF: Ocean_Information ::= [Ocean_Information]

Flow: Unit's_Position:

From: Navigation_System

To: Offpage.6

Note data_flow

Author: kbradley

Generated: 18:10:30 30 November 1990

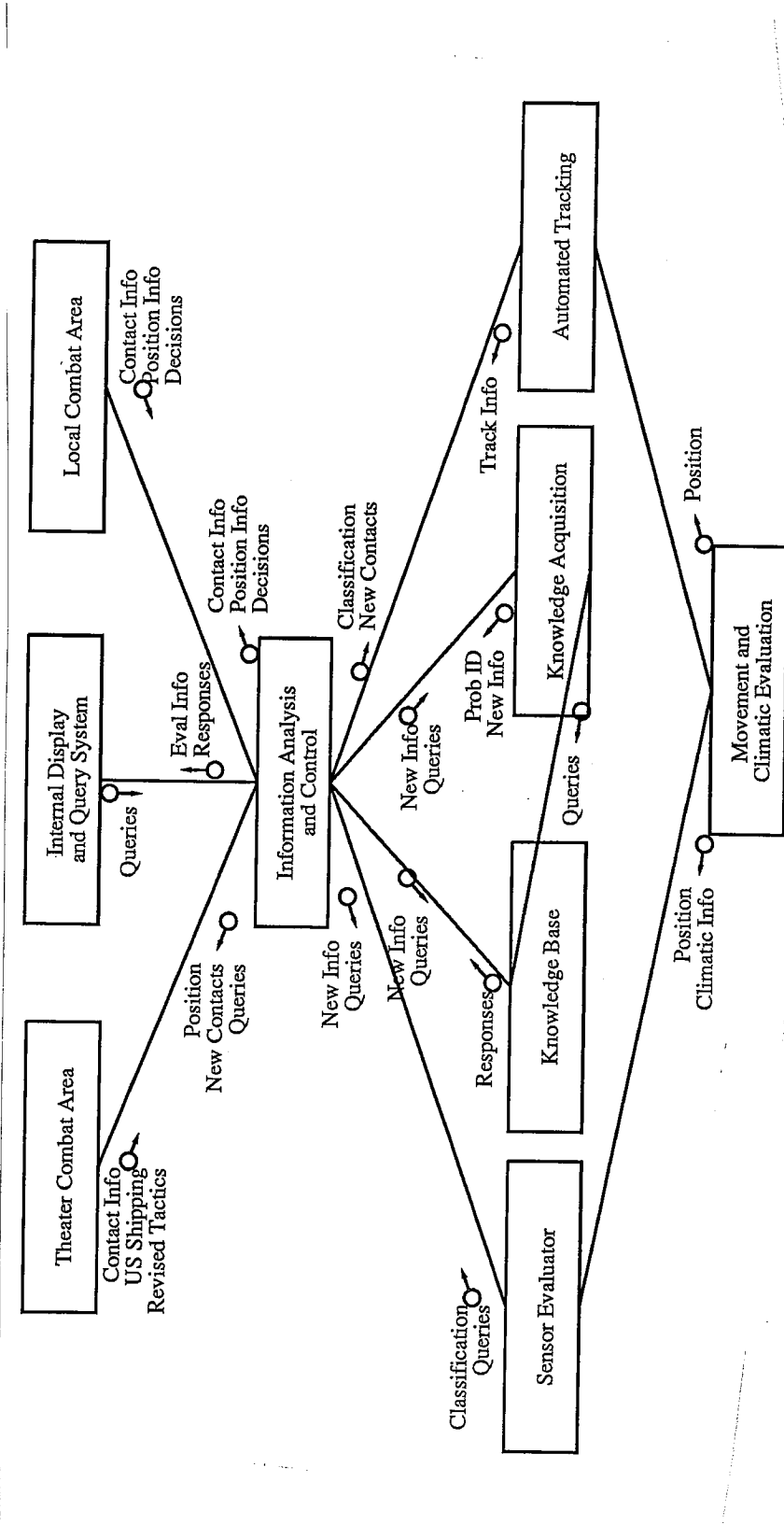
Name: Unit's_Position

The Unit's position is updated periodically based on the type of sensor used. The ATU also dead reckons between updates. The position of surface and airborne units is not as critical as SATNAV updates position very accurately. Submarine updated information is very critical as they rely on internal navigation systems.

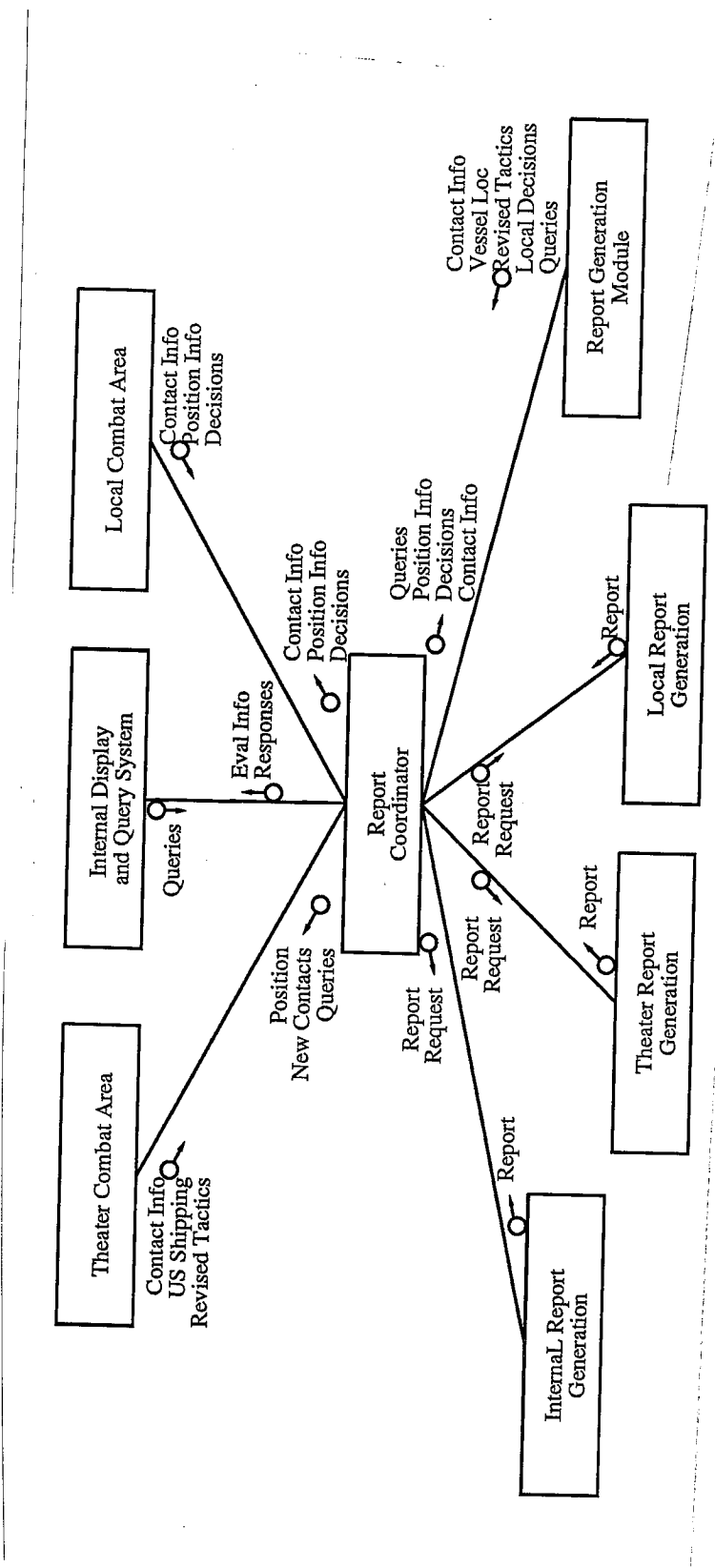
BNF: Position ::= Latitude Longitude

APPENDIX H - STRUCTURE CHART DIAGRAMS

1. System Level Structure Chart



3. Sensor Evaluator Structure Chart



4. Report Generator Structure Chart (Lowest Level)

