ADVANCED COMMUNICATIONS PROJECT

Intelligent Gateway Design and Development

Final Report

United States Coast Guard
Research and Development Center
Advanced Communications Technology Project
1082 Shennecossett Rd.
Groton, CT 06340

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LIST OF ABBREVIATIONS AND ACRONYMS

AMSC	American Mobile Satellite Corporation
BPS	Bits Per Second
CAMS	Communications Area Master Station
CAMSLANT	Communications Area Master Station Atlantic
CCS	Communications Control System
CG	Coast Guard
CONUS	Continental United States
DISN	Defense Information System Network
DMS	Defense Message System
DoD	Department of Defense
DSA	Directory System Agent
DTG	Date-Time Group
EIT	Extended Information Type
EOS	Element of Service
FIFO	First In First Out
HF	High Frequency
HFDL	High Frequency Data Link
HFRATT	High Frequency Radio Teletype
IG	Intelligent Gateway
IMDB	IG Message Data Base
INMARSAT	International Maritime Satellite
LDD	Latest Delivery Designation
LMDB	Local Media Data Base
MILSATCOM	Military Satellite Communication
MS	Microsoft
MT	Message Type
MTA	Message Transfer Agent
MTS	Message Transfer System
MUDB	Mobile User Data Base
NAVMACS II	Second generation Naval Modular Automated Communications System
ODBC	Open Data Base Connectivity
PDB	Pending Data Base
PSDN	Public Switched Data Network
PUA	Profiling User Agent
RATT	Radio Teletype
R&D	Research and Development
SATCOM	Satellite Communication
SATRATT	Satellite Radio Teletype
SQL	Structured Query Language
TTD	Time To Deliver (If LDD not present, TTD = precedence time limits + Extended Authorization information, otherwise TTD = LDD)
TTT	Time To Transmit (TTT = precedence queue delay of mode + mode delay + (message length bytes) * 8)/data rate of mode)
UA	User Agent
USCG	United States Coast Guard

1. INTRODUCTION

The Intelligent Gateway (IG) is a Research and Development (R&D) effort to design an algorithm to provide computer-aided routing of ACP-123/X.400 messages by a United States Coast Guard (USCG) Communications Area Master Station (CAMS). The algorithm is designed to be implementation independent; i.e. it is not dependent on a particular programming language, methodology, or hardware platform. The IG development is a proof-of-concept effort and is not intended to be fielded as a stand alone Defense Message System (DMS) component. Instead the USCG is working with the U.S. Navy and DMS product vendors to incorporate IG functionality into future Commercial Off-The-Shelf (COTS) DMS products.

The algorithm is implemented as a rule-based Expert System (ES) that incorporates the message routing expertise of various USCG communications experts; the IG makes the same decision that a Telecommunication Specialist (TC) would make. By design the IG acts as a sub-component of the DMS user agent (UA) or profiler user agent (PUA). Although the IG never actually handles the message, the IG directs the UA/PUA to use the most appropriate communications path (HF radio, military satellite, or commercial satellite service). The IG only acts on messages that are bound for vessels that are underway and that have multiple communications modes. The IG uses the precedence of a message, the size of the message, channel data rates, queuing delays and the cost associated with using a particular communications mode in order to chose the appropriate communications path. In general, the IG chooses the cheapest communications path that will get the message to the reader within the time specified by the writer.

Some additional features to better handle mobile, bandwidth constrained users are included. The IG uses dynamic databases of the equipment status of both the underway unit and the local (CAMS) shore facility in order to determine which communications channels are available. These databases updated via status messages as communications equipment on cutters or at the CAMS becomes available or unavailable. In addition, low precedence messages that cannot be delivered by a low-cost (low bandwidth) channel within the time constraints are sent to a pending database (PDB) to be batched with other messages for the same unit. All messages in the PDB for a single unit are sent in a batch over a high bandwidth (higher cost) channel when a high priority message needs to be sent or when the time limit for delivery is approaching. This lowers the overall cost of sending a message.

1.1 The Defense Message System

DMS represents an effort by DoD to exploit current technology and commercially available products, to replace the manpower intensive and costly AUTODIN/TCC method of message delivery. The fundamental premise of DMS is that all message traffic, both organizational (currently referred to as Record Message Traffic), and personal (e-mail), will be handled in a manner similar to the way personal e-mail is handled. All messaging systems will be transferred to a single system based on the International Telecommunications Union’s (ITU) X.400 Message Transfer System and X.500 Directory System architecture. Figure 1-1[1] shows the basic structure of the message transfer system. Each element shown is a software application, not necessarily running on an independent computer. The User Agent (UA) is an application utilized by an individual to process personal messages. The Profiling User Agent (PUA) is an application used to process organizational messages. Each UA and PUA is “bound to” its assigned Message Transfer Agent (MTA) by including that Agent’s Internet address in the MTA’s address tables. There is only one transfer path between a UA or PUA and its associated MTA.

[1] Figures 1-1 and 1-2 are from “DMS: Prologue to the Government E-Mail Revolution,” used by permission of the author.

DMS messages are encapsulated in several message protocols, as shown in Figure 1-2. The P772 message content revises the 1988 X.400 standard format to include additional information required for military communications. The Message Security Protocol (MSP) layer contains signature and encryption information, and the Message Transfer Envelope completes the DMS message structure.

All messages, both organizational and personal, will consist of these layers. Additionally, the message content format allows for many parts in the body, including graphics and other binary files. One of the effects of all of the DMS related "packaging" is that the size of each message will increase by about three kilobytes.

The DMS background provided here is the minimum necessary for understanding the IG. For those unfamiliar with DMS, the book "DMS: Prologue to the Government E-Mail Revolution," ISBN 0-9647583-4-2, provides a good review.

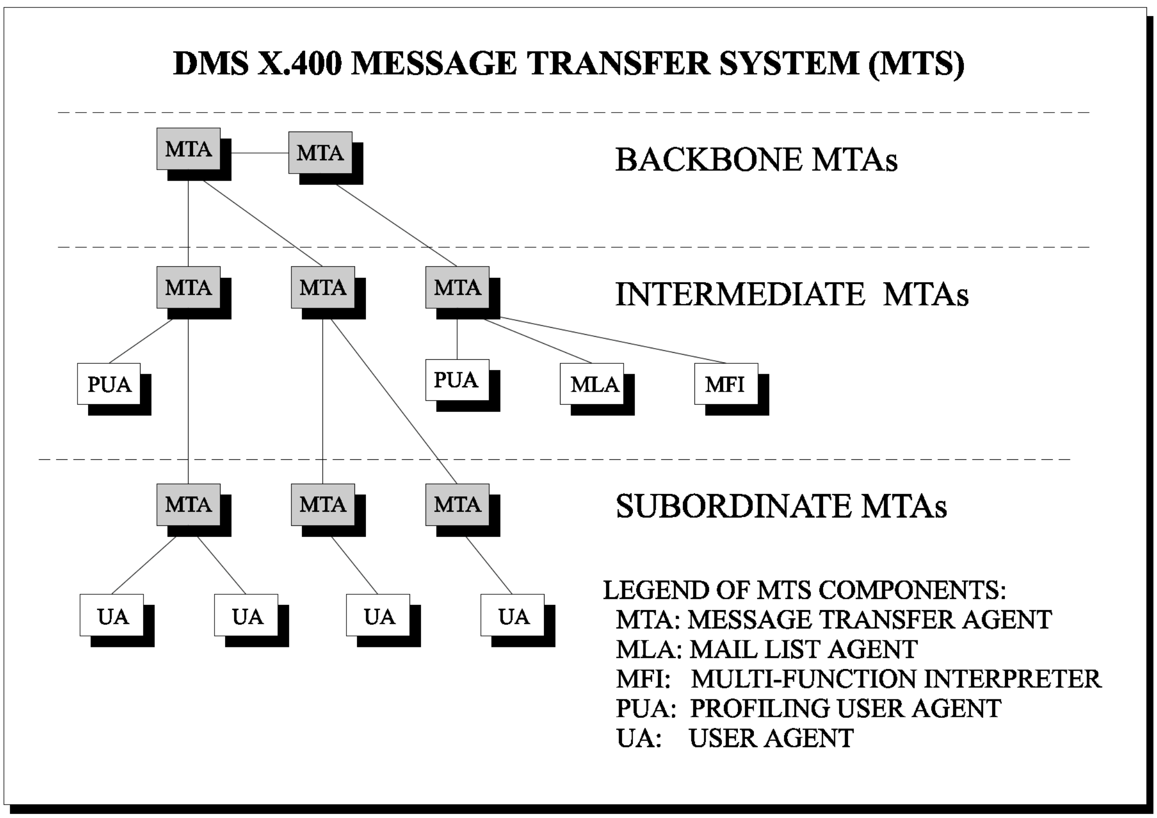

Figure 1-1, DMS X.400 Message Transfer System Components

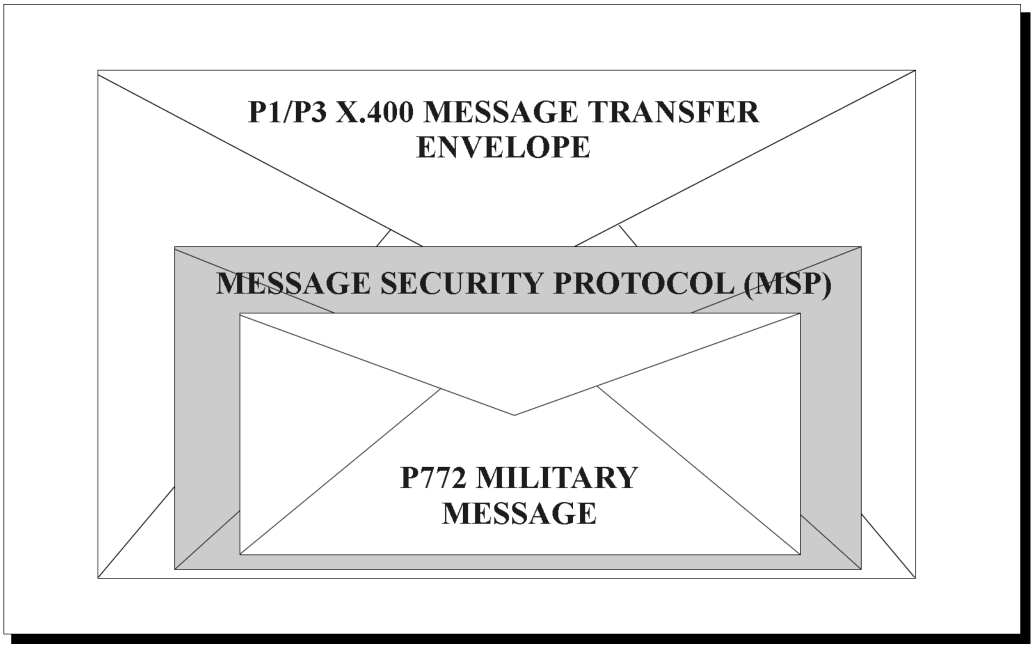

Figure 1-2, DMS Message Envelope Protocols

1.2 Why is an Intelligent Gateway Necessary?

The Coast Guard has communications requirements uncommon to other services. Currently, there are no DMS products that can choose the best path to send messages to underway vessels with multiple modes of communications.

The DMS architecture does not address some of the problems and operational considerations of a mobile independent user; such as, the requirement to make cost-conscious decisions between different methods of wireless transmission to that user, and then to transmit the message via the best method. Since Coast Guard cutters typically operate independently, each cutter relies on onboard means of communications. Coast Guard cutters have multiple modes to communicate with shore facilities, including HF, MILSATCOM, and commercial satellite communications. The problem lies in choosing the best mode. Each mode has drawbacks including cost, bandwidth limitations, timeliness and reliability.

The IG automates the time intensive decision making process by choosing the best communications path. Best is simply defined as the path which gets the message delivered on-time at the least cost. This decision-making process is similar to one a TC would follow in making the routing decisions manually.

Another “feature” of DMS is that messages which cannot be delivered within the Time To Deliver (TTD) are deleted from the system and a non-delivery notice sent to the originator. This situation could happen very frequently with slow, bandwidth limited tactical circuits. In order to ensure that all messages reach underway cutters, a message is considered to be “delivered” when it arrives at the CAMS PUA. The IG then assumes the responsibility for delivering the message to the cutter. Even if the TTD cannot be met, the message is still delivered as soon as bandwidth is available. This IG function would reduce the overhead on the DMS by eliminating numerous non-receipt notifications and the resulting retransmissions.

Since DMS allows for only one transmission path from MTA to PUA, *all* messages bound for an underway cutter would have to be transmitted using a single communications path. None of the currently available communications modes have sufficient bandwidth to ensure that messages will always get to cutters on time. The implementation of DMS with it’s 3 kilobytes of additional overhead on each message will only make this worse. An IG will alleviate the problem by allowing for the use of multiple communications paths. This will increase the total available bandwidth, and will allow on-time delivery of messages.

An extremely important property of the IG is the use of dynamic databases of available communications paths. In its decision process, the IG uses information from databases which describe the communications paths available locally and on each vessel. The IG checks the databases each time it makes a message routing decision. This allows the IG to have great flexibility in routing decisions and to accommodate changes in equipment status.

Another important function of the IG is to filter out personal e-mail. The DMS routes both organizational messages and personal e-mail. Without an IG, the communications system would be forced to (attempt to) deliver all of this personal e-mail in addition to the organization (record message) traffic. One of the features of the IG is that it could filter out the personal e-mail messages before the organizational messages are forwarded to the ship. Personal e-mail messages would be held in a mailbox, either at the CAMS or at the cutter’s home port, for later delivery.

1.3 Basic Assumptions

The IG’s only responsibility is to route messages to underway USCG cutters. The MTAs will automatically route messages destined for shore units to the appropriate shore destination. Shore units, in this sense, include cutters in port which are capable of sending messages via the Defense Information System Network (DISN).

The PUA will parse each ACP-123/X.400 message and present the appropriate parameters to the IG for a routing decision. For this proof-of-concept effort, the IG Message Data Base (IMDB) will be pre-populated with parameter values of hundreds of messages of all types.

The IG only operates on message parameters provided by the PUA and does not directly handle the message. After the IG determines and notifies the PUA of the chosen mode, the PUA must rewrap the ACP-123/X.400 message using an alias identifier that not only identifies the destination, but also the communications mode. The reason for the alias is that the MTA's routing table sends all messages destined for underway units to the CAMS PUA. If an alias was not used, the message would simply loop back to the PUA for routing.

Each mode has four queues: Flash precedence, Immediate precedence, Priority precedence, and Routine precedence. Queues are handled external to the IG. Queue delay values are reported back to the Local Media Data Base (LMDB).

2. ROUTING ALGORITHM DESIGN

The following IG design description is based on the IG Process/Flow Diagram shown in Figure 2-1. The flow diagram is only a framework for depicting a general methodology for determining the best communication mode to route a message. The design description provided below is keyed to major decision points in the diagram. Although specific communications modes are identified in the IG algorithm, it is feasible to insert emerging or alternative communications modes into the design. The IG algorithm is not tied to and does not prohibit any particular communications media.

2.1 Implementation

The algorithm will be implemented as an Expert System (ES) (rule-based), incorporating the message routing expertise of various USCG communications experts. The routing algorithm is designed to be implementation independent. That is, the algorithm is not dependent on a particular programming language, methodology, or hardware platform; therefore, the design may be implemented in any language or on any hardware platform that can meet the requirements of the algorithm.

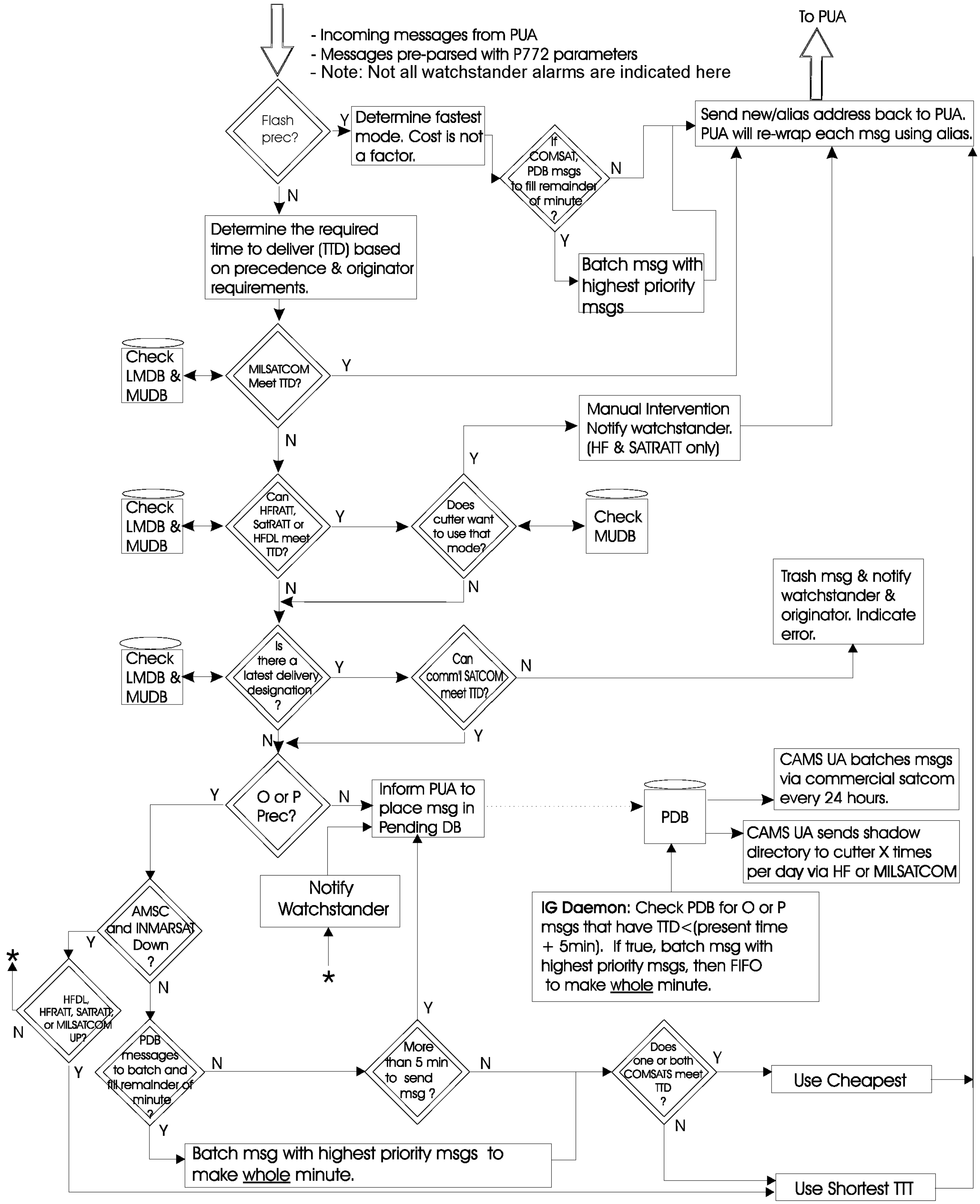

Figure 2-1 Intelligent Gateway Routing Algorithm Flow Chart

2.2 Design Assumptions

- The delivery time requirements imposed by ACP-123 which are shown in Section 3.3, are requirements that must be met by the CG.
- In DMS terms, the PUA and/or MTA are not smart enough to choose the communication mode that meets the delivery time requirements at the lowest cost.
- Each cutter will have an MTA (or similar application process) onboard that accepts messages from an HF, military or commercial satcom service.
- The IG is not responsible for fanning out message distribution/mail lists. MTAs will handle that function. For messages destined for shore units, the MTAs will automatically route those messages to the next MTA. That is, those messages will not be routed through the IG.
- Because the status of the communications equipment may be different for each vessel, a MUDB entry must be created for each cutter and not only for each class of vessel.
- The PUA will parse each ACP-123(X.400) message and present the appropriate parameters to the IG making the routing decisions.
- The IG is not required to know the channel error rates, channel data rates, and other related communications parameters.
- The PUA at CAMS must have access to each public key material in order to check the P42 header to ensure data integrity, digital signatures, and non-repudiation.
- The IG will not be involved with initialization, maintenance, and tear down of communications channels and circuitry; these are functions of the Communications Control System (CCS).
- The IG acts as a sub-process to the PUA. Incoming messages not bound to underway cutters are routed by MTAs within the Message Transfer System (MTS). There is no need for the IG or PUA to get involved.
- Each communication mode MTA-hosted router that is used to transmit messages to underway units has its own unique IP address. In essence, the IG informs the PUA/UA which address (communication mode) to use.
- Because the Navy will be DMS compliant, cutters can shift their communications guard to Navy facilities or other DoD facilities while in port. Routers within DISN will be updated in real time to re-route messages to cutters whenever they plug into a different DISN location; e.g., when at ports other than their home port.
- Personal e-mail messages will not be sent to personnel underway because of prohibitive costs associated with wireless transmission of the potentially high volume of personal messages. Individual messages will be sent to a special individual mailbox at the CAMS or at the cutter's home port. How the cutter receives its individual mail is a matter of policy. Either the individual mail would be transferred to the cutter once in port or the cutter may be allowed to dial-up and download the individual e-mail, possibly at direct cost to the cutter.
- Messages to underway cutters will be routed to the CAMS PUA, whereby the message is considered "delivered." It is understood at this point that the CAMS/IG will attempt to meet the TTD requirement (imposed either by the originator or indirectly by the precedence of the message).

- If the message cannot be transmitted to meet the originator-specified latest delivery time/designation (LDD), the message will be discarded. It is assumed that if the originator specifies an LDD, the message is considered to have no value after the LDD. Both the originator and the watchstander will be notified.
- If the message cannot be delivered to meet the TTD implied by the precedence of the message, the message will still be delivered as soon as possible. This is contrary to "normal" DMS procedures. Low precedence traffic will be placed in the PDB, whereas higher precedence traffic will be delivered as soon as possible.
- After the IG notifies the PUA of the chosen communications mode, the PUA must rewrap the ACP-123/X.400 message using an alias identifier that identifies both the destination and the communications mode. The reason for the alias is that the MTA's routing table sends all messages destined for an underway cutter to the CAMS PUA. If an alias was not used, the message would simply loop back to the PUA for routing. The IG passes the new destination address (alias) containing the selected media back to the PUA, which passes the message on to an MTA assigned to the chosen communication mode.
- NAVMACS II will be the MTA onboard WMECs and WHECs for Military Satellite Communication (MILSATCOM) and HF media.
- When a cutter arrives in port without a connection into DISN, a remote dial-in capability, either to a DISN MTA or directly to the CAMS Public Switched Data Network (PSDN) MTA, is available. Otherwise, a cutter must retain its communications guard while in that port. This may be an inexpensive opportunity for a cutter to dial-in to download all backlogged traffic and/or individual e-mail.
- There is no inherent reason to route a classified message any differently than an unclassified message after DMS is fully implemented. The Directory Services will not allow a classified message to get routed to an unclassified destination.
- A cutter about to get underway should issue a *redirection of incoming messages* EOS command to deliver all messages to CAMS. In this sense, messages sent to an underway cutter will be delivered to CAMS. CAMS will then forward messages to the underway cutter according to the delivery time requirements.
- Communications guards, as they are now known, will no longer exist. When cutters need to change their communications routing, for example from one CAMS to another, they will issue a *redirection of incoming message* EOS command. The MTA will then redirect the message to the new destination User Agent (UA).
- Cutters will send formatted messages to CAMS to update the MUDB.
- *Requested delivery method* EOS will not be used by the IG. The reason is that if the originator chooses a communications mode that is not active, then the message will not be delivered according to ACP-123.
- The maximum message length that the IG will allow is 10 Mbytes.
- Routine messages may not meet the delivery time requirements because of satellite service fees. For example, a routine message that cannot be delivered on time by one of the no-cost methods will be put into the PDB, where it will either be batched (1) with a priority or higher message or (2) with all the messages that are downloaded to the underway cutter once a day.

- Although the MILSATCOM and HF systems are quite expensive to operate and maintain, once the fixed system costs are paid, there is no direct cost per message. The IG calculates the use of these systems as no cost.

2.3 Message Routing Algorithm

The Intelligent Gateway routes messages according to the top-down algorithm in Figure 2-1. The general flow of the decision-making process is described in the paragraphs below.

2.3.1 Cost Exempt (Flash Traffic) Routing

For Flash messages, the IG determines the fastest delivery mode and sends the message via that mode. Cost is not a factor.

First the IG checks the status of each possible delivery mode in both the MUDB and the LMDB to determine if mode is active at both the CAMS and the destination (unit underway). If the MUDB lists the mode as active, the underway unit for which the message is destined is equipped with the delivery mode hardware, and the hardware is functioning.

If the mode is active at both ends, the Time To Transmit (TTT) is computed. There are three components of the TTT. The first component is the precedence queue delay for a particular communications mode. There is a queue delay value for each precedence; Flash (F), Immediate (O), Priority (P) and Routine (R). The first component of the TTT in this case is the F-queue delay. The next component, called the mode delay, is the total time to get the message to the transmission facility, including the time to establish a communications circuit. The last component is the time for the actual hardware to transmit the data that is characterized by the actual data rate. Specifically,

TTT = precedence queue delay of mode + mode delay
+ (message length in bytes * 8)/data rate of mode

The F-queue delay of mode and mode delay parameter values are located in the LMDB. The message length value is located in the IMDB and the data rate of mode value is found in the MUDB.

Once the TTT for all active modes has been computed, the IG selects the mode with the shortest TTT and notifies the PUA of the new destination address (alias address). If the selected mode is a SATCOM mode, then the Pending Data Base is checked for priority and routine messages to batch with the Flash message to fill out the whole minute (commercial satellite billing is made by the minute). For the proof of concept effort, the new destination address is simulated by incrementing a queue count for the selected mode and writing the mode name into the IMDB. It is presumed that the PUA will rewrap the message with the alias address and forward the message to the appropriate MTA.

2.3.2 MILSATCOM Preferred Routing

If the precedence is not Flash, MILSATCOM is always the most desirable mode, since it can be used at “no additional cost” to the Coast Guard and does not require manual intervention. MILSATCOM’s TTT must be less than or equal to the Time To Deliver (TTD) requirement of the message, where

TTD = precedence time limits + Extended Authorization Information.[2]

See paragraph 3.3.7 for precedence time limits. The Extended Authorization Information is a message parameter.

Once the TTD has been determined, both the MUDB and LMDB are checked for availability and status of the MILSATCOM mode. If the MILSATCOM mode is available and will accept both the Message Type (MT) and Precedence of the message as limited by the MILSATCOM Precedence Allowed and MILSATCOM MT Allowed fields of the LMDB, the IG notifies the PUA of the new destination address. Both the Message Type and Precedence are message parameters.

The MILSATCOM Precedence Allowed and MILSATCOM MT Allowed fields of the LMDB permit the Navy to limit the type and precedence of messages that are transmitted using MILSATCOM. The Navy implements such restrictions by issuing a Minimize message, whereby the CAMS watchstanders must update those fields in the LMDB.

2.3.3 RATT and HFDL Routing

If MILSATCOM cannot meet the TTD, the following modes are checked to determine if they can meet TTD: High Frequency Radio Teletype (HFRATT), Satellite Radio Teletype (SATRATT), and High Frequency Data Link (HFDL)[3]. These modes are preferred to commercial satellites since they have no direct service fees, however, since manual intervention is required by the cutter's crew for HFRATT or SATRATT, the cutter may choose not to use either method.

First, the IG checks the HFDL_RATT Option field in the MUDB to determine the mode for which the destination cutter is equipped. Implied in this check is that if any one of the three modes is specified (HFDL, HFRATT, or SATRATT), the cutter is equipped for that mode, the cutter's equipment for that mode is operable, and the cutter wishes to use that mode. If "None" is specified, either the cutter is not equipped for any of the three modes, does not wish to use the mode for which it is equipped, or the equipment is inoperable.

If any one of the HFDL_RATT Options in the MUDB is specified, the equipment status field in the LMDB is checked for the status of the corresponding CAMS equipment. If the selected mode is HFDL and the HFDL mode is active at both ends, and the TTD can be met (TTT <= TTD), the PUA is notified of the new destination address. If the selected mode is one of the RATT modes, the RATT mode is active at both ends, and the TTD can be met (TTT <= TTD), the CAMS watchstander is notified.[4]

2.3.4 Commercial Satellite Routing

If MILSATCOM, HFDL, HFRATT, or SATRATT modes cannot meet the TTD for any reason, the message is checked for an originator-specified Latest Delivery Designation (LDD). If the originator has specified a time for the LDD, then TTD = LDD, and a determination is made if a commercial satellite communication (SATCOM) mode (AMSC, or INMARSAT) can meet the TTD.

The appropriate status field (AMSC or INMARSAT) in the MUDB and the equipment status field in the LMDB are checked for availability and status of the SATCOM equipment. If one or

[2] Extended Authorization Information is an ACP-123/X.400 term meaning the date-time-group of the message.

[3] USCG Cutters have either HFRATT AND SATRATT modes, or just HFDL mode; HFDL and the RATT modes are mutually exclusive.

[4] Manual intervention is required for RATT communications.

both modes are active at both ends, the TTT is computed. The mode with the shortest TTT (TTT <= TTD) is chosen as the delivery mode. If neither of the modes can meet the TTD (TTT > TTD) or the equipment is inoperable, the message is discarded and the originator and watchstander are notified. The decision to discard the message based solely on the originator's request to deliver the message by a specific time; the message is considered to have no value after the designated time. Messages are only discarded if the LDD has expired. If at least one of the modes can meet the TTD, then the message is further processed as described below.

2.3.5 Immediate and Priority Messages

Immediate and Priority messages that could not be delivered on time by MILSATCOM, HFDL, HFRATT, or SATRATT are sent via the cheapest commercial SATCOM method that will meet the TTD. If both AMSC and INMARSAT are down, the message is sent by the method with the shortest TTT. If there is no operational means of transmitting the message, the watchstander is notified, and the message is placed in the PDB.

If either of the commercial SATCOM modes are active, the IG checks the PDB for other messages to batch with the Immediate or Priority message to fill out a whole minute. If there are messages to batch, TTTs are computed for the active SATCOM modes. If one or both COMSATs meet the TTD, then the IG selects the lowest cost mode to transmit the messages. If neither SATCOM mode meets the TTD, then the IG selects the mode with the shortest TTT.

If no message exists in the PDB and the TTD for the Immediate or Priority message is more than five minutes, the PUA is directed to place the message in the PDB. If the TTD for the message is less than five minutes, the IG selects the mode that meets the TTD with the lowest cost. If neither COMSAT meets the TTD, then the IG selects the mode with the shortest TTT. The IG notifies the PUA of the new destination address (alias address) as a final step.

2.3.6 Routine Messages

Routine messages that could not be sent to the cutter within the TTD using MILSATCOM or HFDL or RATT modes are placed in the PDB where they wait to be batched with Priority, Immediate, or Flash messages. Routine messages that are not batched with other messages will be sent to the cutter once every 24 hours via commercial SATCOM.

2.4 Strengths and Weaknesses

2.4.1 Strengths

- The IG routing algorithm enables automated processing of a currently labor-intensive activity. If the Intelligent Gateway is fully implemented, messages could be routed to underway cutters with less delay and at a lower cost per message.
- The IG does not act upon the message itself, but rather upon the parameters associated with each message. The IG routing algorithm requires only the parameters necessary to make the routing decision, leaving all other functions to existing agents (e.g., PUA, MTA). This enables the IG to be implemented as a process (or sub-process) with a defined and minimal interface to existing agents.
- The IG routing algorithm is extensible, and can be modified to accommodate additional communications modes, routing parameters, as well as new CG requirements.

- The IG routing algorithm was designed to meet the CG's unique message routing requirements. The IG routing algorithm encapsulates the expertise of CG message routing expert and communications facility operators. This expertise is automated in a repeatable, predictable process that is less prone to human errors.

2.4.2 Weaknesses

- The numerous assumptions made in Section 2.2 were made to decrease the complexity of the problem and to simplify development of the proof-of-concept IG. Accordingly, the algorithm cannot account for all possible situations.
- HF and MILSATCOM queue delays are entered manually into the MUDB. Currently, automating this process is not possible without a substantial engineering effort. The "network manager" CAMS watchstander will be required to update each queue delay periodically.
- HF queue delays do not accurately depict how long it will take to send a message to a cutter[5].
- Estimates for the HF and MILSATCOM queue delays are not validated. CAMS does not have any statistics on the queue delays for either HF or MILSATCOM.
- One inconsistency within the IG algorithm occurs with the delivery of Routine messages. For example, if a Routine message cannot be delivered via MILSATCOM, HFDL, or Radio Teletype (RATT), the algorithm instructs the PUA to place the message in the PDB. Since the only option left is to use a commercial satellite communications mode, the Routine messages are placed in the PDB to avoid the delivery service charge. This occurs even if those messages could be delivered prior to TTD expiration. The idea behind this approach is to attempt to batch Routine messages with Priority or Immediate messages for economy.
- Since the PUA must decrypt each message bound for an underway cutter, there may be a substantial delay at the PUA as it retrieves the public key material from the Directory System Agent (DSA). If the public key material of 250 cutters can be cached locally, this may not be an issue.
- The IG will *attempt* to deliver each message before the TTD expires, but will *ensure* delivery of messages with no LDD attached[6]. In order to avoid massive non-delivery notifications to message originators, each message must be considered as delivered upon reaching the PUA. At that point, the IG will attempt to deliver the message before the TTD expires, with no guarantee of doing so.

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[5] The reason for the inaccuracy lies in the fact that the HF queue has messages for several cutters. If CAMS does not have communications with a cutter (for a variety of propagation reasons), messages bound for that cutter will simply sit in the queue until CAMS re-establishes communications.

[6] The question is whether or not the Defense Message System (DMS) will allow this. If not then one possible solution would be to send the message originator a non-delivery notification with the comment "CAMS will

- The IG does not currently have the capability to transmit all the messages in the PDB to a particular destination on command, as would be the case, when a cutter enters port and desires to clear its backlog. This capability could also be used by the CAMS to transmit the backlog at a certain time each day.

continue to attempt delivery of the message, but due to circuit load was unable to deliver the message by the TTD." The originator may accept this fact or resend the message at a higher priority.

3. IG DATABASE DESIGN

The designs of the databases required by the IG routing algorithm are described in the following sections. The databases required by the routing algorithm, and their design and implementation are largely dependent on the final design and implementation of the routing algorithm and the type of software used for the implementation of the routing algorithm. Four databases are required for the implementation of the IG routing algorithm: Mobile User Data Base (MUDB), Local Media Data Base (LMDB), IG Message Data Base (IMDB), and Pending Data Base (PDB).

3.1 Mobile User Database

The MUDB contains ship communications equipment status and performance data for each USCG cutter that receives routed messages from the IG. The MUDB contains one record for each cutter. The MUDB for the proof-of-concept software contains records for six cutters. The MUDB fields are described below. Table 1 gives further information about the fields and their contents.

1. <u>AMSC Data Rate</u>: Data rate for the AMSC mode from the transmission site to the cutter—fixed at 4800 bps. The respective cutter is responsible for maintaining the accuracy of this field in the MUDB.

2. <u>AMSC Status</u>: Operational status of the AMSC equipment onboard the respective cutter. A value of TRUE for this field implies that the cutter is equipped for the AMSC mode and that the equipment is operational. A value of FALSE implies that either the cutter is not equipped or the equipment is not operational. The default value will depend on the class of the cutter.

3. <u>HF Data Rate</u>: Data rate for the HFDL and HFRATT modes. The data rate range is 75-2400 bps, with the default rate set at 75 bps. The respective cutter is responsible for maintaining the accuracy of this field in the MUDB.

4. <u>HFDL/RATT Option</u>: Identifies the mode for which the cutter is equipped. USCG cutters have either HFRATT andSATRATT modes, or only the HFDL mode. In other words, the HFDL and RATT modes are mutually exclusive. Implied in the value of this field is that if any one of the three modes is specified (HFDL, HFRATT, or SATRATT), the cutter is equipped for that mode, the cutter's equipment for that mode is operable, and the cutter wishes to use that mode. If “None” is specified, either the cutter is not equipped for any of the three modes, does not wish to use the mode for which it is equipped, or the equipment is inoperable. The default value is “None.”

5. <u>Hull Number</u>: Hull number of the respective cutter. The value is fixed for each cutter.

6. <u>INMARSAT Data Rate</u>: Data rate for the INMARSAT modes from the transmission site to the cutter. The data rate range is 9600-64000 bps, with the default rate set at 9600 bps. The respective cutter is responsible for maintaining the accuracy of this field in the MUDB.

7. <u>INMARSAT Status</u>: Operational status of the INMARSAT equipment onboard the respective cutter. A value of TRUE for this field implies that the cutter is equipped for the INMARSAT mode and that the equipment is operational. A value of FALSE implies that either the cutter is not equipped or the equipment is not operational.

8. MILSATCOM Data Rate: Data rate for the MILSATCOM mode from the transmission site to the cutter. The data rate range is 75-9600 bps, with the default rate set at 2400 bps. The respective cutter is responsible for maintaining the accuracy of this field in the MUDB.

9. MILSATCOM Status: Operational status of the MILSATCOM equipment onboard the respective cutter. A value of TRUE for this field implies that the cutter is equipped for the MILSATCOM mode and that the equipment is operational. A value of FALSE implies that either the cutter is not equipped or the equipment is not operational. The default value will depend on the cutter class.

10. O R Name: Name of entity (person, cutter, or command) that last updated the MDUB.

11. SATRATT Data Rate: Data rate for the High Frequency Satellite Radio Teletype (SATRATT) mode from the transmission site to the cutter. Fixed at 300 bps.

12. Ship Name: Name of the respective USCG cutter. See Table 1 for a list of valid ship names for the R&D effort. Ship Name is a key field for the MUDB, and is fixed for each cutter.

13. Time To Inport: Estimated time for respective cutter to enter port. The respective cutter is responsible for maintaining the accuracy of this field in the MUDB. Currently this field is not used during the routing decision. Future refinement of the algorithm may use this field to influence the routing decision.

Table 1 Mobile User Data Base (MUDB)

Field	Type	Limit/Range	Managed/By	Default Value
AMSC Data Rate	Numeric	4800 bps	Fixed	4800 bps
AMSC Status	Boolean	TRUE/FALSE	Cutter	FALSE
HF Data Rate	Numeric	75-2400 bps	Cutter	75 bps
HFDL/RATT Option	String	HFDL HFRATT SATRATT None	Cutter	None
Hull Number	Numeric		Fixed	Undetermined
INMARSAT Data Rate	Numeric	9600-64000 bps	Cutter	9600 bps
INMARSAT Status	Boolean	TRUE/FALSE	Cutter	FALSE
MILSATCOM Data Rate	Numeric	75-9600 bps	Cutter	2400 bps
MILSATCOM Status	Boolean	TRUE/FALSE	Cutter	FALSE
O R Name	String	N/A	MUDB	Undetermined
SATRATT Data Rate	Numeric	300 bps	Fixed	300 bps
Ship Name	String	Ship Names	Fixed	Undetermined
Time To Inport	Numeric	0-	Cutter	Undetermined

Note: This database shall contain one record for each ship.

3.2 Local Media Database

The LMDB contains CAMS equipment status and performance data for each mode type (AMSC, HFDL, HFRATT, INMARSAT, MILSATCOM, and SATRATT). The LMDB contains one record for each mode type. The LMDB fields are described below, with Table 2 giving further descriptions of the field contents.

1. Cost: Cost for transmitting a particular message by a particular mode. See Default Value column in Table 2 for the cost per mode. Note that no direct costs are associated with the HF and MILSATCOM modes.

2. F Queue Delay: Queue delay for respective communication mode for messages with Flash precedence. The queue delay is the time, in seconds, required for the last message in the queue to reach the front of the queue, i.e., ready to be transmitted.

3. Media Name: Name of the respective communications mode. See Table 2 for list of communication modes. Media Name is a key field for the LMDB.

4. MILSATCOM Message Type Allowed: ACP-123/X.400 message types allowed to be transmitted by the MILSATCOM mode. Default is All. This field is managed by CAMS, based on feedback from NCTAMS.

5. MILSATCOM Precedence Allowed: ACP-123/X.400 message precedence allowed to be transmitted by the MILSATCOM mode. Precedences allowed include specified value and all precedences of higher value. Flash precedence is highest value. Routine precedence is lowest value. Default value is Routine. This field is managed by CAMS, based on feedback from NCTAMS.

6. Mode Delay: Total time to get the message to the transmission facility including the time to establish a communications circuit.

7. O Queue Delay: Queue delay for respective communication mode for messages with an Immediate precedence. The queue delay is the time, in seconds, required for the last message in the queue to reach the front of the queue, i.e., ready to be transmitted.

8. P Queue Delay: Queue delay for respective communication mode for messages with a Priority precedence. The queue delay is the time, in seconds, required for the last message in the queue to reach the front of the queue, i.e., ready to be transmitted.

9. R Queue Delay: Queue delay for respective communication mode for messages with a Routine precedence. The queue delay is the time, in seconds, required for the last message in the queue to reach the front of the queue, i.e., ready to be transmitted.

10. Equip Status: Operational status of respective communication mode equipment at the CAMS. TRUE value indicates the equipment is operational. FALSE value indicates the equipment is not operational.

Table 2 Local media Data Base (LMDB)

Field	Type	Limit/Range	Managed/By	Default Value
Cost	Numeric	Fixed. Same as default.	Fixed	HFDL=$0/Kbyte HFRATT=$0/Kbyte SATRATT=$0/Kbyte AMSC=$1.49/min INMARSAT= $4.95/min MILSATCOM=$0 /min
F Queue Delay	Numeric	0- 360,000 sec.	CAMS	0 seconds
Media Name (KEY)	String	AMSC, HFDL, HFRATT, INMARSAT, MILSATCOM, SATRATT	Fixed	N/A
MILSATCOM Message Type Allowed	String	Operational, Operational and Administrative, All, N/A	CAMS	All
MILSATCOM Precedence Allowed	String	Flash, Immediate, Priority, Routine, N/A	CAMS	Routine
Mode Delay	Numeric	0- 36,000 sec.	Unknown	0 seconds
O Queue Delay	Numeric	0- 360,000 sec.	Unknown	0 seconds
P Queue Delay	Numeric	0- 360,000 sec.	Unknown	0 seconds
R Queue Delay	Numeric	0- 360,000 sec.	Unknown	0 seconds
Equip Status	Boolean	TRUE/FALSE	CAMS	FALSE

Note: This database shall contain one record that includes the above fields for each media type (AMSC, HFDL, HFRATT, INMARSAT, MILSATCOM, SATRATT). For INMARSAT, the Cost field will not be fixed, but will depend on the transmission rate.

3.3 IG Message Database

The IMDB contains parameters parsed from the message by the PUA and that are to be used by the routing algorithm. The IMDB contains one record for each message to be routed by the IG. The IMDB fields are described below and in Table 3.

1. Extended Authorization Information: The date and time when the message was released as a Date-Time Group (DTG). Depending upon national requirements, the DTG may indicate either the date and time when the message was officially released by the releasing officer or the date and time when the message was submitted to the communications facility for transmission.

2. Latest Delivery Designation (LDD): Latest time, specified by the originator, by which the message is to be delivered. If the message cannot be delivered by the time specified, the message is canceled and a non-delivery report returned.

3. Message Length: Length of message in bytes. The length of the message is provided by a message length field in the respective message.

4. From: Originator of the message.
5. Subject: A standardized code used by the originator to indicate the subject of the respective message.
6. Recipient: Designated recipients who have the responsibility to act on the delivered message (action addressees). The recipient shall be a USCG cutter (vice an individual) in the context of the IG.
7. Precedence: Value that reflects the originator's determination of the relative message importance. This determines the required speed of service and its associated message handling by the recipient(s). ACP-123/X.400 precedences and their handling requirements are:

Precedence	Originator-to-Recipient Time to Delivery
Flash	10 minutes
Immediate	20 minutes
Priority	45 minutes
Routine	No more than 8 hours, or start of next business day.

8. Message Type: Provided by the originator of the message. Distinguishes messages that relate to a specific exercise, operation, drill, or project. Used to determined if MILSATCOM will accept messages of a particular type.
9. Military Message Identifier: Conveys a unique message identifier in {First three letters of originator YYYYMMDDHHMMSS Serial Number} format (for example, DAL 19960129135659 001).
10. Extended Information Type (EIT): The Extended Information Type (EIT) field shall be IA5 and G3-Fax. These fields shall be used for reference only, not as routing parameters.

Table 3 IG Message (IMDB)

Field	Type	Limit/Range	Default Value
Extended Authorization Info	Time		Undetermined
Latest Delivery Designation	Time		Undetermined
Message Length	Numeric	0- 10,240,000 Bytes	Undetermined
From	String	N/A	Undetermined
Subject	String	N/A	Undetermined
Recipient	String	Ship Names	Undetermined
Precedence	String	Flash, Immediate, Priority, Routine	Undetermined
Message Type	String	Administrative, Drill, Exercise, Individual, Operational, Project	Undetermined
Military Message Identifier (KEY)	String	Unique Value	Undetermined
EIT	String	IA5, G3-FAX	Undetermined

3.4 Pending Database

The PDB is a repository for Routine messages, and for Immediate and Priority messages that have more than five minutes before required delivery. Messages in the PDB wait to be batched with other messages to fill out a whole minute for SATCOM (AMSC or INMARSAT) delivery. Filling out whole minutes with messages waiting in the database takes advantage of the otherwise unused transmit time that results from charging in one-minute increments. Messages are removed from the PDB by various criteria. The Routine messages are selected for batching based on precedence, then message length, since this optimizes the available transmit time.

The PDB contains the same data as the IMDB with the addition of the Time to Deliver parameter described below. The PDB contains one record for each message that it contains. See Table 4 for a description of the PDB fields and their contents.

> Time To Deliver: Unique to the PDB. The time required by a particular communications mode to deliver a particular message. If a Latest Delivery Designation is available, then TTD = LDD, else TTD = precedence time limits + Extended Authorization information.

The PDB is checked once every minute. If an Immediate or Priority message is found with a TTD < (present time + five minutes), the message is entered into the rules processing once again and will routed by the IG. The message will not end up in the pending database again because the TTD will be less than five minutes.

Every twenty-fours hours, the IG batches all messages remaining in the PDB and delivers them via one of the commercial SATCOM modes (AMSC or INMARSAT). In addition, several times per day, the IG sends, via HF or MILSATCOM, a shadow directory of the PDB to each cutter that has messages in the PDB.[7]

Table 4 Pending database (PDB)

Field	Type	Limit/Range	Default Value
Extended Authorization Info	Time		Undetermined
Latest Delivery Designation	Time		Undetermined
Message Length	Numeric	0- 10,240,000 Bytes	Undetermined
From	String	N/A	Undetermined
Subject	String	N/A	Undetermined
Recipient	String	Ship Names	Undetermined
Precedence	String	Flash, Immediate, Priority, Routine	Undetermined
Message Type	String	Administrative, Drill, Exercise, Individual, Operational, Project	Undetermined
Military Message Identifier (KEY)	String	Unique Value	Undetermined
EIT	String	IA5, G3-FAX	Undetermined
Time To Deliver	Time		Undetermined

[7] The number of times per day that the shadow directory will be sent to the cutter is to be determined. It is assumed that the PUA will be responsible for determining the best delivery mode (HF or MILSATCOM).

4. IG DEMONSTRATION

4.1 Implementation

To implement the routing algorithm, it was necessary to identify software for the operating system, database, and expert system. All packages considered were off-the-shelf (PC-based) products meeting the following criteria: ease of use, ease of interfacing, features required for implementing the routing algorithm, contractor familiarity, and USCG requirements.

The proof-of-concept algorithm was implemented on a Pentium 120 PC. While it can be run on lesser platforms, the time required to run through a message routing scenario may become prohibitively long. A screen shot of the demonstration software is included as Figure 4-1.

4.1.1 Gateway Algorithm

The following products were chosen for implementation of the routing algorithm based on research conducted of various software packages. These products were chosen because of their suitability for the project, and because they interface very well with each other using Open Data Base Connectivity (ODBC):

- Operating System - Windows NT
- Database - Microsoft Access
- Expert System - Level5 Object Professional

Windows NT

Windows NT was chosen for the project because it provides the capabilities required, and is the operating system for the Coast Guard SWIII.

MS Access

MS Access is a very flexible database development package that will interface exceptionally well to Level5 Object because they both provide object representation. Communication between Access and Level5 Object is via ODBC using the Structured Query Language (SQL).

Level5 Object Professional

Level5 Object (L5O) is a Windows-based Expert System development environment that is specifically designed to implement complex logic problems. L5O captures and codifies valuable expertise in the form of objects, rules, and triggers. The contractor has used L5O for the past five years for the implementation of various Expert Systems and considers L5O an excellent product for the implementation of the routing algorithm. Other systems considered were Goldworks III, CLIPS, and KAPPA PC.

The algorithm as implemented is not exactly as shown in the flowchart of Figure 2.1. The software as it exists treats Priority messages the same as Routine, whereas Priority messages, according to the flowchart should be treated the same as Immediate.

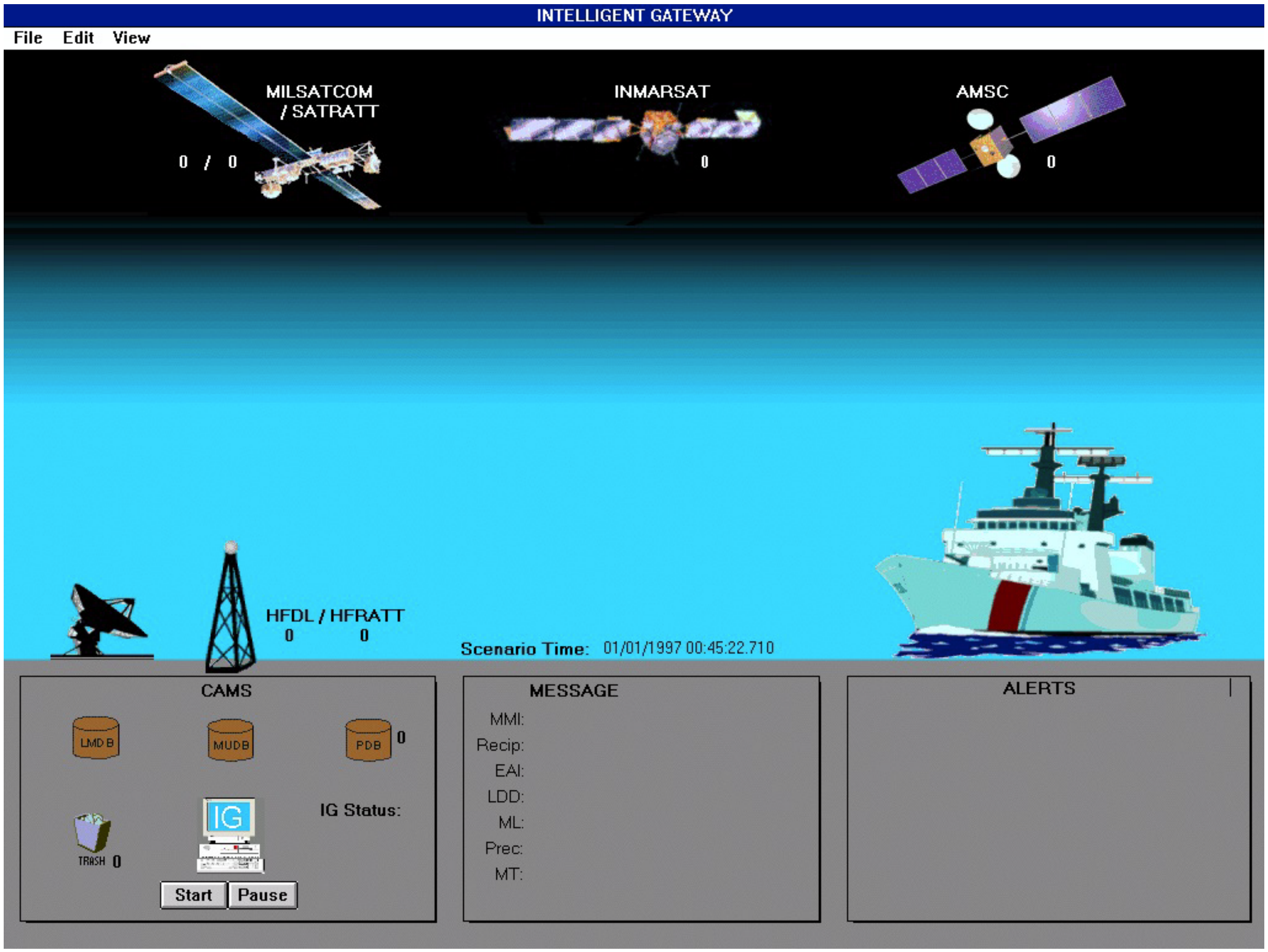

Figure 4-1, Screen Shot of the IG Proof-of-Concept Demonstration software

4.1.2 Databases

The four databases are implemented in different ways. The IMDB and PDB are implemented in Microsoft Access and database values are accessed via Structured Query Language (SQL) calls from LEVEL5. The MUDB and LMDB are implemented as instances of LEVEL5 objects. For example, a LEVEL5 object is created with attributes representing the parameters of the various MUDB fields. When a message updates the MUDB, an instance of the MUDB object is updated with attribute values corresponding to parameters in the message.

4.2 Scenario Design

The proof-of-concept IG program was tested with a scenario consisting of 120 messages. The messages were from several different originators to the following six ships:

- Dallas
- Dauntless
- Juniper
- Mohawk
- Mustang
- Polar Star

Table 5 is an extract from the 182 message database used for the simulation. The messages were of varying precedence, length, and message type. In order to realistically depict the manner in which messages would arrive, all messages were given a scenario time to indicate the order of arrival at the IG, not necessarily in the data/time order given by the Military Message Identifier.

4.3 Testing

To test the accuracy of the algorithm, the message database was processed using the IG software. The MUDBs for the various cutters were changed periodically during the scenario to simulate changes in the cutter’s communications equipment status.

The simulation program logged all decisions made by the routing algorithm. The decisions made during the processing of message number TST 19970101003232379, an excerpt of that log, are included as Appendix A. The reliability of the decisions made by the algorithm can be verified by careful examination of the contents of the log.

Table 5, Extract from the IG Message Database

Military_Message_Identifier	Recipient	Extended_ Authorization_Info	Scenario_Time	Latest_Delivery _Designation	Message_ Length	From	Subject	Precedence	Message_Ty
TST 19970101002029 341	Mohawk	970101002029	970101005229	9701010220	22000	MLCPAC	Routine to Mohawk	Routine	Project
TST 19970101002038 419	Mustang	970101002038	970101005838	9701010120	30000	MLCPAC	Priority to Mustang	Priority	Operational
TST 19970101002146 334	Dauntless	970101002146	970101005646		13000	LANTAREA	Priority to Dauntless	Priority	Administrative
TST 19970101002212 360	Polar Star	970101002212	970101005212		60000	PACAREA	Routine to Polar Star	Routine	Operational
TST 19970101002226 339	Dauntless	970101002226	970101005826		30000	HQ	Priority to Dauntless	Priority	Operational
TST 19970101002229 359	Mohawk	970101002229	970101005829		30000	MLCPAC	Priority to Mohawk	Priority	Operational
TST 19970101002246 322	Dauntless	970101002246	970101005246		6000	PACAREA	Priority to Dauntless	Priority	Administrative
TST 19970101002255 382	Juniper	970101002255	970101005255		6000	LANTAREA	Priority to Juniper	Priority	Administrative
TST 19970101002915 398	Juniper	970101002915	970101005815		60000	USCGR&D	Routine to Juniper	Routine	Operational
TST 19970101003203 309	Dallas	970101003203	970101005503		60000	LANTAREA	Priority to Dallas	Priority	Operational
TST 19970101003218 412	Mustang	970101003218	970101005618		16000	HQ	Priority to Mustang	Priority	Operational
TST 19970101003232 379	Polar Star	970101003232	970101005832	9701010102	30000	MLCLANT	Immediate to Polar Star	Immediate	Operational
TST 19970101003235 399	Juniper	970101003235	970101005835	9701010117	30000	HQ	Priority to Juniper	Priority	Operational
TST 19970101003258 402	Mustang	970101003258	970101005258		6000	PACAREA	Priority to Mustang	Priority	Administrative
TST 19970101003349 342	Mohawk	970101003349	970101005249		6000	PACAREA	Priority to Mohawk	Priority	Administrative
TST 19970101003349 354	Mohawk	970101003349	970101005649		13	PACAREA	Priority to Mohawk	Priority	Administrative
TST 19970101003446 337	Dauntless	970101003446	970101005746	9701010124	7000	MLCLANT	Priority to Dauntless	Priority	Exercise
TST 19970101003512 369	Polar Star	970101003512	970101005512	9701010120	60000	HQ	Priority to Polar Star	Priority	Operational
TST 19970101003515 389	Juniper	970101003515	970101005515		60000	MLCPAC	Priority to Juniper	Priority	Operational
TST 19970101003523 313	Dallas	970101003523	970101005623	9701010135	40000	USCGR&D	Priority to Dallas	Priority	Operational
TST 19970101003712 366	Polar Star	970101003712	970101005412		100000	PACAREA	Immediate to Polar Star	Immediate	Exercise
TST 19970101003823 310	Dallas	970101003823	970101005523		11000	PACAREA	Priority to Dallas	Immediate	Operational
TST 19970101003926 336	Dauntless	970101003926	970101005726		6000	PACAREA	Immediate to Dauntless	Immediate	Project
TST 19970101003929 344	Mohawk	970101003929	970101005329		22000	USCGR&D	Immediate to Mohawk	Immediate	Operational
TST 19970101004009 352	Mohawk	970101004009	970101005609		16000	LANTAREA	Priority to Mohawk	Priority	Operational
TST 19970101004043 302	Dallas	970101004043	970101005243		6000	PACAREA	Priority to Dallas	Priority	Administrative
TST 19970101004043 305	Dallas	970101004043	970101005343	9701010120	7000	MLCLANT	Immediate to Dallas	Immediate	Operational
TST 19970101004043 317	Dallas	970101004043	970101005743	9701010110	7000	MLCLANT	Priority to Dallas	Priority	Exercise
TST 19970101004155 397	Juniper	970101004155	970101005755	9701010126	7000	MLCLANT	Priority to Juniper	Priority	Exercise
TST 19970101004158 405	Mustang	970101004158	970101005358	9701010101	7000	USCGR&D	Immediate to Mustang	Immediate	Operational
TST 19970101004206 329	Dauntless	970101004206	970101005506		60000	MLCLANT	Priority to Dauntless	Priority	Operational

4.4 Results

The IG was thoroughly tested on the message scenario described in section 4.2. The gateway routed messages as expected, and delivered all of the higher precedence (Immediate and Flash) messages on time.

The scenario was run again with both the AMSC and INMARSAT options disabled. The result was that 18% of the high precedence messages could not be delivered on time. Changing the software to treat the Priority messages the same as Immediate as shown in the IG flowchart in Figure 2.1 would most likely result in a much higher percentage of messages not delivered on time. This would be the effect if DMS were implemented with only the currently available communications modes.

5. IG FUTURE

5.1 Proof-of-Concept Software

The IG proof-of-concept software can be used to determine the effects of different equipment configurations and message volumes, such as the effect/cost of allowing personal e-mail to be routed to ships along with organizational messages. It has enough flexibility to add messages of various types and lengths. The software can also be used to estimate the effect of implementing DMS without using commercial SATCOM for message delivery.

5.2 Operational Implementation

This was a proof-of-concept effort, and leaves many implementation questions remaining unanswered. The IG could be implemented as part of the PUA, possibly as a sub-process to the Profiler Process, shown in Figure 5-1. Since the Profiler Process provides a means for searching definable locations for information, profiles could be customized to search those fields required by the IG, and the required information could then be passed to the IG sub-process. However, actual implementation will be up to the manufacturers of off-the-shelf DMS products.

The IG algorithm has been demonstrated to Navy SPAWAR, Xerox (a DMS compliant vendor) and numerous non-DMS compliant vendors. Each vendor has shown interest in the possibility of incorporating IG-like features into their products. The information contained in this report will be made available to interested DMS vendors to encourage the incorporation of the IG functionality in the next generation of DMS products. The Coast Guard DMS implementation staff should also continue to liaison with the DMS Tactical Working Group members to help ensure such services are included in future DMS products.

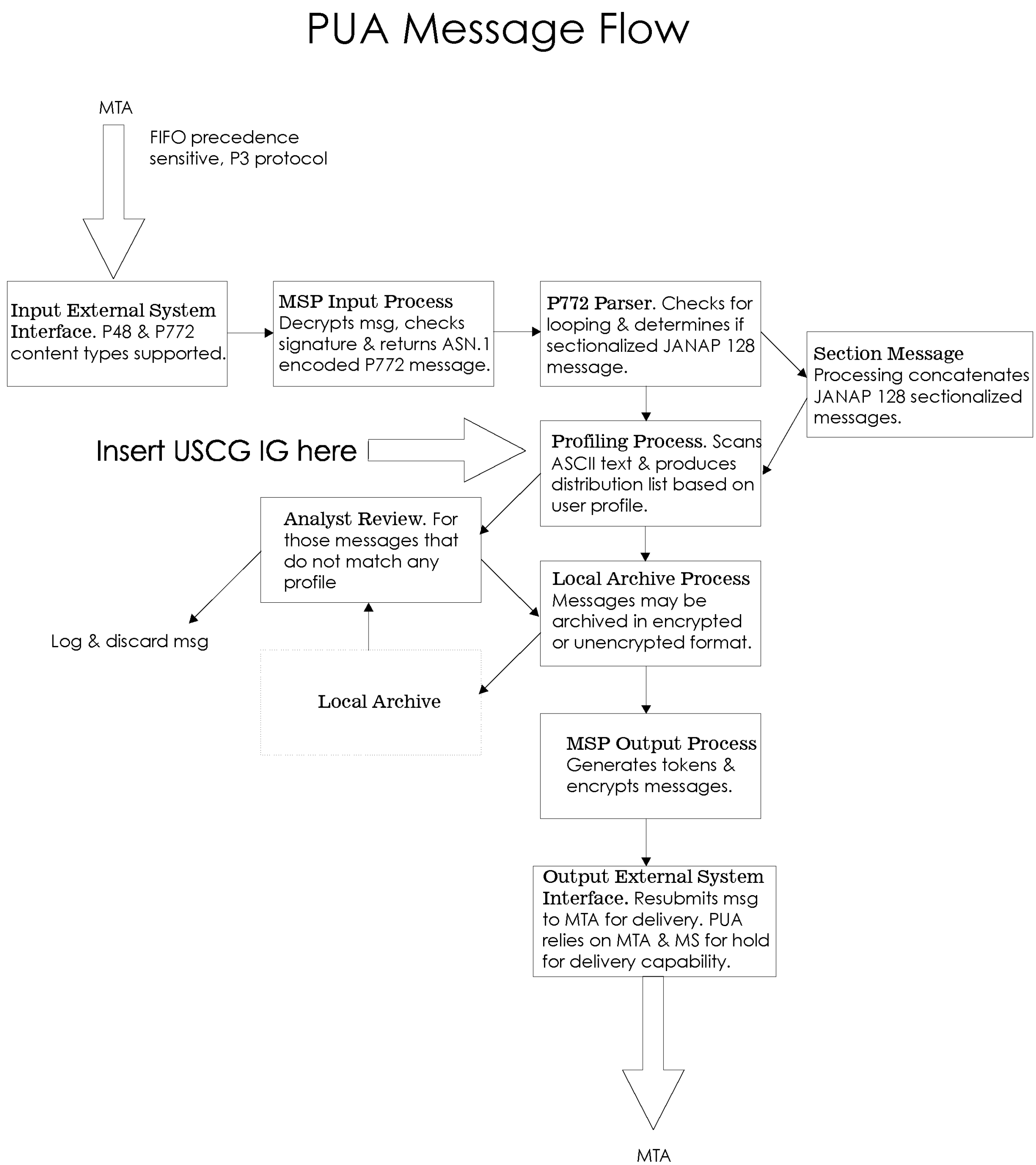

Figure 5-1 PUA Message Flow

Appendix A

IG log file excerpt for Immediate Message TST 19970101003232 379

```
**************************************************************************
IG Transaction Time is 01/01/1997 00:59:27.310
IG Military Message Identifier is TST 19970101003232 379
The current MUDB entry is Polar Star
AMSC Time To Transmit When Needed called. It is:70
INMARSAT Time To Transmit When Needed called. It is: 40 seconds.
HFDL Time To Transmit When Needed called. It is: 585 seconds.
Fastest_Delivery_Method When Needed called. It is: INMARSAT1
Rule FLASH_MILSATCOM failed.
Rule Immediate Priority or Routine executed. !!
MILSATCOM Time To Transmit When Needed called. It is: 285 seconds.
Time To Deliver When Needed called. It is: 0 00:03:32.200
Rule FREE_ MILSATCOM1 failed.
Rule FREE_ MILSATCOM4 failed.
Rule FREE_ MILSATCOM2 failed.
Rule FREE_ MILSATCOM3 failed.
Rule FREE_ MILSATCOM5 failed.
Rule FREE_ MILSATCOM6 failed.
Rule FREE_ MILSATCOM7 failed.
Rule FREE_ MILSATCOM8 failed.
Rule FREE_ MILSATCOM9 failed.
HFRATT Time To Transmit When Needed called. It is: 600 seconds.
SATRATT Time To Transmit When Needed called. It is: 6980 seconds.
Rule HFDL_HFRATT_MILSATCOM_AND_SATRATT_TTT Is Greater Than TTD executed. !!
Rule O_MILSATCOM_NOTHING_MEETS_TTD failed.
Rule HFDL_Is_Up fired. !!
Rule FLASH_HF failed.
Rule OPR_HFDL failed.
Rule O_HFDL_NOTHING_MEETS_TTD failed.
Rule FLASH_SATRATT failed.
Rule SATRATT failed.
Rule O_SATRATT_NOTHING_MEETS_TTD failed.
Rule HFRATT failed.
Rule FLASH_HFRATT failed.
Rule O_HFRATT_NOTHING_MEETS_TTD failed.
Rule INMARSAT_Is_Up fired. !!
Rule FLASH_INMARSAT failed.
Rule No_LDD_Or_INMARSAT_Meets_LDD fired. !!
AMSC Cost To Transmit When Needed called. It is:1.49
INMARSAT Cost To Transmit When Needed called. It is:4.95
The Cheapest_Delivery_Method OF Program Variables is: AMSC1
Entering INMARSAT Message Length To Batch When Needed Method.
Seconds to batch is :40
Total Message Length to batch is :60000
Exiting INMARSAT Message Length To Batch When Needed Method.
Entering Batch Messages When Needed.
Military_Message_Identifier of Batch_PR is : TST 19970101005232 373
Batch Messages is TRUE.
Batch Messages When Needed called.
Rule O_INMARSAT_BATCH_NOT_TTD failed.
Entering INMARSAT Message Length To Batch When Needed Method.
Seconds to batch is :40
```

```
Total Message Length to batch is :60000
Exiting INMARSAT Message Length To Batch When Needed Method.
Entering Batch Messages When Needed.
Military_Message_Identifier of Batch_PR is : TST 19970101005232 373
Batch Messages is TRUE.
Batch Messages When Needed called.
Rule O_INMARSAT_BATCH_TTD failed.
Entering Batch Messages When Needed.
Military_Message_Identifier of Batch_PR is : TST 19970101005232 373
Batch Messages is TRUE.
Batch Messages When Needed called.
Rule O_INMARSAT_NOBATCH_UNDER5MIN_NOT_TTD failed.
Entering Batch Messages When Needed.
Military_Message_Identifier of Batch_PR is : TST 19970101005232 373
Batch Messages is TRUE.
Batch Messages When Needed called.
Rule O_INMARSAT_NOBATCH_UNDER5MIN_TTD failed.
Rule AMSC_Is_Up1 fired. !!
Rule FLASH_AMSC failed.
Rule No_LDD_Or_AMSC_Meets_LDD fired. !!
Entering AMSC Message Length To Batch When Needed Method.
Seconds to batch is :10
The AMSC Message Length to batch is :6000 bytes.
Exiting the AMSC Message Length To Batch When Needed Method.
Entering Batch Messages When Needed.
Military_Message_Identifier of Batch_PR is : TST 19970101005232 373
Batch Messages is TRUE.
Batch Messages When Needed called.
Rule O_AMSC_BATCH_TTD executed. !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

The following IG_Message was sent out via AMSC:

 MESSAGE PARAMETERS------------------------------------------------------
 IG Transaction Time: 01/01/1997 00:59:27.310
 MMI: TST 19970101003232 379
 Scenario Time: 01/01/1997 00:58:32.000
 Precedence: Immediate
 Extended Auth Info: 970101003232
 Extended Auth Info_T: 01/01/1997 00:32:32.000
 Originator: MLCLANT
 Recipient: Polar Star
 Subject: Immediate to Polar Star
 Latest Delivery Designation_S: 9701010102
 Latest Delivery Designation_T: 01/01/1997 01:02:00.000
 Message Type: Operational
 Message Length: 30000
 EIT: IA5
 Time To Deliver_T:
 Time To Deliver_S:
 Time To Deliver_I: 0 00:03:32.200
 ------------------------------------------------------------------------

25 messages have been sent to AMSC.
The total message length to batch is: 6000
Running total is : 0
The following Batch_PR_Message was sent via AMSC with an Immediate message.
```

```
 BATCH MESSAGE PARAMETERS------------------------------------------------
 IG Transaction Time:
 MMI: TST 19970101005232 373
 Precedence: Priority
 Extended Auth Info: 970101005232
 Originator: MLCLANT
 Recipient: Polar Star
 Subject: Priority to Polar Star
 Latest Delivery Designation_S:
 Latest Delivery Designation_T:
 Message Type: Operational
 Message Length: 40
 EIT: IA5
 Time To Deliver_S: 01/01/1997 01:37:32.930
 Time To Deliver_I:
 ------------------------------------------------------------------------


Entering  the RESET When Changed method.
Exiting the RESET When Changed method.
This is the TTT Seconds STring value: 46
It took 2.91 seconds to process this message
The average message processing and the last message processing times are:  363.893.62
The scenario counter and message count values are: 179 : 182
The average time to process a message for this scenario was : 367.51
```

Appendix B

IG Proof Of Concept Software Users Manual