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A Heuristic Approach to Correlating ERAM Flight Data from Twenty Centers

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Summary

Among its many other functions, the Federal Aviation Administration's En Route Automation Modernization (ERAM) provides external systems with real-time air traffic data for flights in en-route airspace in the National Airspace System. It replaced the En Route Host computer and backup system used at 20 FAA Air Route Traffic Control Centers (Centers) nationwide. Among the new features of ERAM, its output data stream of flight plan and track data includes a unique identifier for a flight originating in any one of the 20 ERAM Centers. The unique identifier, called the Global Unique Flight Identifier (GUFI), is persistent across all the Centers that track the flight. However, certain factors make it difficult to correlate data using the GUFI. First, the value of the GUFI is only unique within a time window of seven days. Second, the GUFI is attached only to flight-plan related data messages. Finally, track positions reported by ERAM do not reference the GUFI. In order to correlate historical as well as real time flight-plan and position-related ERAM data, an efficient, heuristic approach was developed, and a prototype was developed. The approach showed that the processing speed, through parallel processing, is sufficient to correlate ERAM data in real-time. As described in this paper, when there are multiple track positions reported from multiple Centers within a few seconds, each position is assigned with a weighted score to indicate the quality of the position relative to its last know position. The weighted score can be used to eliminate potentially duplicate track positions. The approach is database-agnostic, and can be implemented in a Big Data system such as an Apache Hadoop system, as well as in traditional database systems.

1 Introduction

There are multiple, disparate FAA systems that act as data sources to provide flight information and surveillance data such as track positions. Each data source has a specific reporting frequency for track positions over its geographic area. Example data sources include the System Wide Information Management's (SWIM) Terminal Data Distribution System (STDDS) for data on or near airport surface, radar data from a Terminal Radar Approach Control (TRACON), surveillance data from En Route Automation Modernization (ERAM) at an Air Route Traffic Control Center (Center), and Airline Situation Display to Industry (ASDI) and Traffic Flow Management Data (TFMData) that cover the National Airspace System (NAS). For each data source, a flight can be uniquely identified, and its track positions be associated, during a time window. Depending on a data source, the identifier has a unique value within a specific time window. The time window varies from a few minutes to a week. In order to get a complete picture of a flight from its departure to its arrival, data from all these disparate data sources must be correlated. Correlating is the process of determining which piece of information applies to which flight. But because the track positions for a flight can be reported from multiple data sources, and each source has its own computations, an aircraft can have multiple, differing track positions reported at the same time, or within a few seconds of each other. This is one of the many challenges in correlating flight data from disparate data sources. In order to provide a single view of all flight data over a long period, those flight data need to be correlated and stored in a Data Warehouse such as NASA's Sherlock [1]. When such a correlating process can be performed within a fraction of a second, it can also be adopted for a real-time system that subscribes to live flight data.

Correlated flight data are currently available from a few commercial vendors. These products, such as ITT Exelis, Passur, and ATAC's Performance Data Analysis and Reporting System (PDARS), all use proprietary algorithms to correlate flight data from multiple data sources.

This document describes one approach to correlating ERAM data from twenty Centers so that all flight information is uniquely identified across time, track positions are properly associated with a flight, and the quality of each track position is assessed. This document also describes a prototype implementing this approach. Additional derived data such as calibrated airspeed, departure fix, and arrival fix, and fix crossing times could be computed on the correlated data. Once the correlated data and derived data are stored in a Data Warehouse, an ATM researcher can readily perform Big Data analyses on them. As a result, a researcher will no longer have to restrict their analyses to one Center or correlate the flight data across the disparate data sources themselves.

The Host Air Traffic Management (ATM) Data Distribution System (HADDS) Application Interface provides external customers such as NASA with ERAM data. It can provide this data in a variety of messages sets sent in several binary stream formats. For a given combination of binary stream format and message type, a set of fields is specified. Evaluations were made on the data from various binary stream formats, namely, CT07, CT08, and NA02. These formats were created by FAA for its Offline Application Registration Service (OARS). For each format, the specifications were entered into a set of worksheets in an Excel workbook file. NA02 was determined to have the most message types and fields. The work described in this document is based on the NA02 format created for NASA by FAA.

2 Objectives

This section describes the process and rules that were implemented to correlate ERAM data from twenty Centers.

1. Each ERAM message is processed, and reformatted from the NA02 binary stream format into an XML format.
2. No ERAM XML message is discarded. It is up to an ATM researcher to determine which ERAM messages are to be analyzed.
3. Each ERAM XML message is assigned a universally unique identifier (UUID) called nasaMsgId. Unlike a simple sequence number or a time-based number, when a UUID is generated from multiple systems, they are distinct and can be consolidated into a single system later on. There are multiple algorithms for generating a UUID [2]; the one used for this effort is described later.
4. If an ERAM XML message contains flight information or track positions, that message is associated with either a new or an existing nasaGufi. nasaGufi is a universally unique identifier that represents a flight. ERAM's GUFI is unique only within a rolling time window of seven days. Relying on ERAM's GUFI is not possible if an historical analysis spans more than seven days.
5. When an ERAM XML message is assigned a nasaGufi, a weighted score, nasaGufiScore, is calculated to determine the accuracy of the assignment. When a new nasaGufi is assigned to an ERAM XML message, this initial nasaGufiScore should be 1. The lowest nasaGufiScore is 0.5.
6. When an ERAM XML message contains a track position for a flight, a weighted score, nasaMsgIdScore, is calculated to determine the quality of the track position when it is compared with the last known reported track position of the same flight. This is valuable information when multiple ERAM Centers report the track position of the same flight at the same time, or within a few seconds. A value between 0 and less than 0.5 indicates a low quality position messages. A value of 0.5 to 1 indicates a high quality. All non-track-position ERAM XML messages have a value of 1.

3 ERAM Messages

In the NA02 binary stream format, 35 message types have been identified in the actual data. Additional message types were described in the OARS NA02 documentation, but they were not reported in the actual data during analysis. See Table 1. The NA02 format specifications has a longer list of message types but not all of them were identified during a detail analysis of the actual ERAM data. Of those 35 message types, 23 (indicated with a grey background in the Table) are related to flight or track position information. The 12 non-flight message types are related to Airspace Utilization, sector assignment, ERAM system health check, and other miscellaneous information.

Table 1. Message types identified in the ERAM HADDS Application Interface NA02 format.

Message Type	Message Class	Description
AH	Flight Data	Flight Amendment Information
AI	Reconstitution	Database Record Transfer Altimeter Status Information (DBRTAI)
BA	Miscellaneous	Beacon Code Reassignment Information
CK0	Communication	Health Check
CL	Flight Data	Cancellation Information
DH	Flight Data	Departure Information
ET	Flight Data	Expected Departure Time Information
FH	Flight Data	Flight Plan Information
FPI	Reconstitution	Database Record Transfer Flight Plan Information (DBRTFPI)
GH	Miscellaneous	General Information
HA	Miscellaneous	Altimeter Setting Information
HF	Track Data	FDB Fourth Line Information
HH	Flight Data	Hold Information
HI	Reconstitution	ERAM Status
HP	Flight Data	Position Update Information
HR	Airspace Utilization	Route Status Information
HS	Communication	ERAM Status
HT	Track Data	Point Out Information
HV	Flight Data	Flight Arrival Information
HX	Flight Data	Converted Route Information
HZ	Track Data	ARTS TZ Information
IH	Flight Data	Aircraft ID Amend Information
LH	Track Data	Interim Altitude Information
NL	Flight Data	Tentative Flight Plan Removal
OH	Track Data	Handoff Status

Message Type	Message Class	Description
PH	Flight Data	Progress Report Information
PT	Track Data	Inbound Point Out Information
RE	Miscellaneous	Beacon Code Restricted Information
RH	Track Data	Drop Track Information
RI	Reconstitution	Database Record Transfer Route Status Information (DBRTRI)
S1	Reconstitution	Database Record Transfer Sector Assignment Information (DBRTSI)
SH	Airspace Utilization	Sector Assignment Status Information
SI	Reconstitution	Database Record Transfer Sector Assignment Information (DBRTSI)
TH	Track Data	Track Information
UB	Miscellaneous	Beacon Code Utilization Information

In order to make ERAM data more accessible, the binary data were formatted into XML for this work. The XML element names closely resemble those of the "Simple Schema" from the System Wide Information Management (SWIM) Flight Data Publication Service (SFDPS) [3]. See **Appendix A: Sample ERAM Messages in XML Format** for each message type. Each ERAM message is identified by a message type (msgType), an originating facility (msgFacility), and a timestamp when the message is received at NASA (msgRcvTimeEpoch). The originating facility is the Center (e.g., ZNY or ZFW).

3.1 Fields Used to Correlate ERAM From Twenty Centers

Among flight related ERAM messages, a specific list of fields is extracted for the correlation process. See Table 2. The list of flight-related ERAM messages is indicated by a grey background. For each message type, M indicates that a field is mandatory for successful correlation; O indicates that a field is optional; M* indicates that a field is mandatory when a Center is ERAM operational; and M+ indicates that a field is derived from another mandatory field.

Table 2. Fields to correlate flight related messages.

msgType	msgFacility	msgRcvTimeEpoch	sourceId_00e	flightId_02a	computerId_02d	sspId_167a	beaconCode_04a	eramGufi_316a	typeOfAircraft_03c	REGIndicator_918d	proposedDepartureTime_2431	departureTime_243n	coordStatus_07d1	coordTime_07d2	flightPlanRoute_10a	departurePoint_26a	destination_27a	groundSpeed_05b	assignedAlt_08a, or reportedAlt_54a	trackPosition_23d	trackVelocity_23e	timeOfTrackData_170a	flightId_02a-2	computerId_02d-2	sspId_167a-2	beaconCode_04a-2	eramGufi_316a-2
AH	M	M	M	M	M	M*	O		M	O			M	M	M	M+	M+										
AI	M	M																									
BA	M	M	M	M	M	M*	M	M*								M	M						M	M	M*	M	M*
CK0	M	M	M																								
CL	M	M	M	M	M	M*										M	M										
DH	M	M	M	M	M	M*			M				M	M		M	M										
ET	M	M	M	M	M	M*																					
FH	M	M	M	M	M	M*	O	M*	M	O			M	M	M	M+	M+										
FPI	M	M		M	M	M*	O	M*	M	O	O	O	M	M	M	M+	M+										
GH	M	M	M																								
HA	M	M	M																								
HF	M	M	M	M	M	M*																					
HH	M	M	M	M	M	M*																					
HI	M	M																									
HP	M	M	M	M	M	M*							M	M													
HR	M	M	M																								
HS	M	M	M																								
HT	M	M	M	M	M	M*																					
HV	M	M	M	M	M	M*										M	M										
HX	M	M	M	M	M	M*																					
HZ	M	M	M	M	M													M	M	M							
IH	M	M	M	M	M	M*										M	M						M	M	M*		
LH	M	M	M	M	M	M*																					
NL	M	M	M	M	M	M*																					
OH	M	M	M	M	M	M*																					
PH	M	M	M	M	M	M*																					
PT	M	M	M	M	M	M*																					
RE	M	M	M	M	M	M*	M	M*								M	M										
RH	M	M	M	M	M	M*																					
RI	M	M																									

msgType	msgFacility	msgRcvTimeEpoch	sourceId_00e	flightId_02a	computerId_02d	sspId_167a	beaconCode_04a	eramGufi_316a	typeOfAircraft_03c	REGIndicator_918d	proposedDepartureTime_2431	departureTime_243n	coordStatus_07d1	coordTime_07d2	flightPlanRoute_10a	departurePoint_26a	destination_27a	groundSpeed_05b	assignedAlt_08a, or reportedAlt_54a	trackPosition_23d	trackVelocity_23e	timeOfTrackData_170a	flightId_02a-2	computerId_02d-2	sspId_167a-2	beaconCode_04a-2	eramGufi_316a-2
S1	M	M																									
SH	M	M	M																								
SI	M	M																									
TH	M	M	M	M	M	M*												M	M	M	M	M					
UB	M	M	M																								

3.2 Available Fields From a Center When ERAM Is Operational

In ERAM, message types that are flight related have two mandatory fields, flightId_02a and computerId_02d. flightId_02a contains usually the callsign of a flight, or the tail number of an aircraft. computerId_02d is a system generated 4-digit number from a Center. computerId_02d is based on the legacy Host Computer System that ERAM replaced. At any given moment in time, a flight can be uniquely identified by computerId_02d from within a Center. When a flight is completed or cancelled within a Center, the value in computerId_02d can be reused for another flight immediately.

When ERAM is operational at a Center, all flight related messages from that Center report the field sspId_167a (Site Specific Plan ID). Like computerId_02d, sspId_167a is also a system generated 4-digit number from a Center. The only exception is the HZ (ARTS TZ Information) message. A HZ message reports the track position of a flight from a TRACON source, and this message does not have the field sspId_167a. Only computerId_02d is referenced in a HZ message. And like computerId_02d, when a flight is completed or cancelled within a Center, the value in sspId_167a can also be reused for another flight immediately.

The field eramGufi_316a is a unique flight plan identifier (e.g., KJ84748500). It is reported only in four message types: BA, FH, FPI, and RE, and only when ERAM is operational at a Center. As a flight traverses multiple Centers, the value of eramGufi_316a for the flight is persistent in each of the traversed Centers. However, the value of eramGufi_316a is only unique within a rolling window of seven days across all Centers.

Both computerId_02d and sspId_167a are small, system-generated numbers of four digits. Therefore the numbers from a Center can be short-lived. They can be reused as soon as the flights with which they are associated are completed or cancelled within that Center. For example, sspId_167a with a value of 288 can be assigned to track different flights at the ZNY Center within a period of 24 hours. Track position messages are all associated with either computerId_02d, or computerId_02d and sspId_167a combined, but <u>not</u> eramGufi_316a. Therefore, in order to find the flight plan of a given track position message at a specific moment in time, one needs to find the most recent past flight plan message that has a matching computerId_02d or sspId_167a. As described later in this document, when flight data and track position messages are correlated, unlike with computerId_02d, sspId_167a, or eramGufi_316a, the unique value assigned to a nasaGufi does not have a time limit.

As of October 4th, 2014, the ZNY and ZTL Centers were not ERAM operational. As of March 27th, 2015, all 20 Centers were ERAM operational.

3.3 Flight Data Scenarios

During the development and testing of the flight data correlation approach described in this document, challenging correlation scenarios from the actual ERAM data were analyzed and assembled as test cases. Here are the scenarios:

3.3.1 Multiple Flight Plans Can Be Proposed Prior To Departure Or En Route

Multiple flight plans can be proposed for a single flight prior to departure. Multiple flight plans can also be proposed for a single en-route flight prior to it entering the airspace of a Center. Among the proposed flight plans, at most one will be accepted. Which one this is, is not known until a track position record is associated with the accepted flight plan. Some of the proposed flight plans may get cancelled, or they may expire automatically. A CL message is reported for the former case, but there are no reported messages for the latter case.

3.3.2 Using Same Callsign to Propose a New Flight Plan Upon Arrival

While an aircraft is en route to its destination with a flight plan, FP1, a new flight plan, FP2, can be proposed for the next flight of the aircraft before the completion of the FP1. Both en route and proposed flight plans use the same callsign.

3.3.3 Diverted Flight Has a New Destination in Its Amended Flight Plan

When a flight is diverted to a new destination, an AH message is sent with an updated flight plan. The new arrival airport may be the original departure airport.

3.3.4 Flight Plan of an En Route Flight Is Canceled Before Entering a New Center

When a flight departs from one Center, C1, and enters or passes through another Center, C2, it normally receives a new flight plan before it enters into the airspace of C2, followed by a cancellation of its flight plan in C1. In reality, there are cases in which the cancellation precedes the proposed plan. In order words, the chronological order of these two messages may reverse.

3.3.5 No Messages When Flight Path Over Areas Not Covered by ERAM

When a flight flies from KBOS (Boston) to KSEA (Seattle) via the Canadian airspace, there are no ERAM messages while it is in the Canadian airspace. When the flight flies from the Canadian airspace into ZSE Center, a new eramGufi_316a is assigned. Similar scenarios may also apply to messages from the same Center. For example, in the northern part the ZOB Center, there is an area that is a part of the Canadian airspace. A flight may start in the ZOB Center, go through the CZY Canadian air traffic control center, and enter back into the ZOB Center. When the flights enters back into the ZOB Center, a new eramGufi_316a is assigned. Therefore the original GUFI cannot be used for correlation of the flight.

3.3.6 Flight Path Over Atlantic Ocean

Flight paths in the Atlantic Ocean, especially near Bermuda International Airport (TXKF) have messages sent from ZNY Center. When such a flight has a long gap in track position messages reported over the Atlantic Ocean then becomes tracked again, the newly assigned eramGufi_316a is different from the original. As a result, it is possible to have a flight having two different eramGufi_316a values even though the flight never leaves ZNY Center. Thus the eramGufi_316a cannot be used solely for correlating flight data even within one Center.

3.3.7 Multiple Aircraft From Different Departures Sharing a Callsign

Some airlines schedule connecting flights using the same flight number, or callsign. When an inbound flight arrives late, the outbound connecting flight may get assigned to a different aircraft, using the same callsign as the inbound one. As a result, two flights maybe active within one Center at the same time. While each flight has the same flightId_02a, each flight has a different set of computerId_02d, sspId_167a, eramGufi_316a, departure, and beaconCode_04a.

3.3.8 Multiple Aircraft Sharing a Callsign Split Up While En Route

When two aircraft, AC1 and AC2, are flying in formation (e.g. military aircraft), there may be one flight plan, FP1, for both aircraft. When they no longer share the same flight plan, an IH message is sent to describe the flight plan, FP2, for AC2. FP1 is still valid for AC1.

3.3.9 Multiple Aircraft Merge to Share a Callsign

Multiple aircraft can merge to share a callsign. For example, when a military aircraft joins up with an aerial refueling aircraft.

3.3.10 Callsign Changed After Departure

The callsign of a flight can change after its departure. For example, an incorrect callsign might have been used when a flight plan was proposed, and the callsign was not corrected until after its departure. An IH message is sent to describe the new callsign.

3.3.11 Beacon Code Changed After Departure

One common reason for an en route flight to change its beacon code before entering the airspace of a Center is to avoid conflict with another flight using the same beacon code. A BA message is usually sent to note the new beacon code. This BA message is usually followed by a FH message for the en route flight.

3.3.12 Departure Fix Changed in Proposed Flight Plan When Entering a New Center

When an en route flight files a proposed flight plan before entering the airspace of a Center, the en route flight may not use the original departure fix from its original flight plan as its departure point. Instead, the en route flight may use a Fix Radial Distance (FRD) along its flight path as its departure fix instead. The arrival fix of the proposed flight does not change.

3.3.13 Track Messages May Not Be Received In Chronological Order

In most cases, track positions and the time of those reported positions are sent and received at NASA in chronological order. But sometimes they are not. Perhaps because of a system delay, a track position message just received may reference a position and time earlier than the previous track position message for the same aircraft. This problem is more pronounced when an aircraft is in the vicinity of multiple Center boundaries. Track messages from multiple Centers are reported, but some of the messages may not arrive in the order of the actual time of those track positions.

3.3.14 Multiple Tracks for a Single Flight Reported From Multiple Centers

Because there are overlaps of radar coverage along Center boundaries, multiple track position messages of the same aircraft maybe reported at the same time from two or more Centers near the Center boundaries.

3.3.15 Track Position Messages May Not Be Reported Every 12 Seconds

There are many reasons that track positions may not be updated every 12 seconds or less. One common reason is the limited coverage by ground-based radar. For a coast-to-coast flight over the Canadian airspace, the gap in track position updates can be over four hours.

4 Heuristic Approach to Correlating Flight Data

4.1 General Correlation Process

Because a flight may cross multiple Centers, there may be multiple flight-state-per-Center records associated with one nasaGufi. Flight-state-per-Center is described in Section 4.2. When a flight-related message is reported from a Center, the appropriate flight-state-per-Center needs to be correlated. This is a general two-step process as described in the following:

4.1.1 Finding an Existing nasaGufi

The search method for an existing flight-state-per-Center record is dependent on the category of a flight-related message. As described later in this document, there are three categories of flight-related messages: Route, Track Position, and Generic (see Sections 4.4, 4.5, and 4.6 respectively). The general searching method starts by querying all existing flight-state-per-Center records that have the same flightId_02a from the message. The query imposes a look-back time limit. For example, only flight-state-per-Center records that were last reported within the last five hours from the message's timestamp are queried. Multiple evaluations are made among the fields from the message and the fields in each of the queried flight-state-per-Center records. The evaluations range from simple text matching to a complex if-then-else condition. Each evaluation results in a raw score. A raw score ranges from a positive numeric value for a positive match to a negative value for a mismatch. A simple summation on all the computed raw scores gives the total weighted score on a given flight-state-per-Center record. When all flight-state-per-Center records have their total weighted scores computed, they are ranked. In general, the higher the total weighted score, the higher the likelihood that a match to an existing nasaGufi is found.

When an existing nasaGufi is not found or if the total weighted score is negative, a new nasaGufi is created.

4.1.2 Updating a New Flight-State-Per-Center Record

In the previous step, either an existing nasaGufi is found, or a new nasaGufi is assigned. By using the unique key flightId_02a, msgFacility, computerId_02d, and nasaGufi, the flight-state-per-Center record in the database should be updated accordingly. If the record in the database cannot be updated because it does not exist, a new flight-state-per-Center record is created.

4.2 Structure of Flight-State-Per-Center Record

A flight-related ERAM message is a piece of information that describes the state or an event of the flight at a specific moment in time. The state may contain information such as callsign, tail number, beacon code, flight plan, and track position. Whenever a flight has a change of state or an event, only related information is reported in order to keep the message short and concise for transmission. The complete set of flight information is not reported in a single message.

The first step in correlating the ERAM flight data is to construct the state of each flight for each ERAM Center. This requires processing the messages in the exact chronological order they were received at NASA. Not all fields from the messages are required to correlate a flight. Table 3 shows the list of fields for correlating a flight across multiple Centers. Correlated flight records from multiple Centers are assigned to a unique identifier called nasaGufi. Fields with grey background are related to track position only.

Table 3: Fields for correlating a flight across multiple Centers.

Field Name	Order In Unique Key	Note
flightId_02a	1	Usually callsign or tail number.
msgFacility	2	The Center from which the message is originated
computerId_02d	3	
nasaGufi	4	Value assigned by the flight data correlation process
msgType		An alphanumeric code to represent the message type
msgRcvTimeEpoch		The Epoch time in UTC when the message was received at NASA
sourceId_00e		
sspId_167a		
beaconCode_04a		
eramGufi_316a		
typeOfAircraft_03c		
REGIndicator_918d		
proposedDepartureTime_2431		
departureTime_243n		
coordStatus_07d1		
coordTime_07d2		
flightPlanRoute_10a		
departurePoint_26a		Derived from flightPlanRoute_10a when available
destination_27a		Derived from flightPlanRoute_10a when available
groundSpeed_05b		
assignedAlt_08a, or reportedAlt_54a		assignedAlt_08a from HZ messages; reportedAlt_54a from TH messages
trackPosition_23d		
trackHeading		Derived from trackVelocity_23e which is only available in TH messages
timeOfTrackData_170a		Only available in TH messages

A flight-state-per-Center record is comprised of the fields listed in Table 3. The unique key to a flight-state-per-Center is a combination of four fields, namely, flightId_02a, msgFacility, computerId_02d, and nasaGufi. nasaGufi is a unique identifier for a flight; it is determined by the correlation process, and its uniqueness does not have a time period limit. All flight-state-per-

Center records should be stored in a database in order to allow concurrent access to the information.

4.3 When the Callsign of a Flight is Changed

As described in Section 3.3.10, an IH message is reported when there is a callsign change for a single aircraft flight. An IH message may also be used to report an aircraft getting a new callsign while flying in formation with another aircraft (see Section 3.3.8). In the second scenario, the existing and new callsigns are both needed for associating two separate aircraft and their respective flight plans. Callsign is stored in the field flightId_02a, and flightId_02a is also a part of the unique key of each flight-state-per-Center record. In order to handle both scenarios, when a flight has a callsign changed from CS1 to CS2, the solution is to locate the flight-state-per-Center record of the CS1, copy all the state information from the located record to create a new record for CS2. Any subsequent updates of the state (e.g. flight plan) of CS2 would be performed on the newly created record. The flight-state-per-Center record of the CS1 would not be updated once an IH message is processed.

4.4 Weighted Scores to Calculate Route Score

To correlate a flight plan or flight plan amendment message (AH, FH, and FPI), a set of weighted scores is used to evaluate seven conditions of the message with existing flight-state-per-Center records having the same callsign in the database (see Section 4.1.1). The seven conditions are described in Table 4. There is one weighted score from each of the seven conditions. When a condition is met (or not met), a weighted score is assigned for that condition. Combining the weighted scores on each flight-state-per-Center candidate record yields the total combined score of each candidate record.

Scored candidate records are ranked by the following criteria:

1. Total combined score (the higher the better)
2. msgRcvTimeEpoch (the higher the better)
3. sourceId_00e (the higher the better)

The first record returned with a positive total score has the matching nasaGufi. To calculate nasaGufiScore, the total score, and the difference between msgRcvTimeEpoch and the msgRcvTimeEpoch from the matching nasaGufi record is normalized to range between 0.5 and 1. nasaMsgId is system generated by using UUID. nasaMsgIdScore is always 1.

Table 4. Weighted Scores to Calculate Route Score.

Conditions	Weighted Score	Note
1. **Flight Identifier Per Center**		En route flight may cross multiple Centers
msgFacility not match	-1	
msgFacility, and computerId_02d, and sspId_167a (when Center is ERAM operational) match	64	
Otherwise	-15	See scenario described in 3.3.6
2. **Beacon Code**		Key common identifier when crossing multiple Centers when ERAM is not operational
beaconCode_04a match	32	
beaconCode_04a is not known in both state and message	0	
Otherwise	-1	
3. **ERAM GUFI**		Only available when Center is ERAM operational
eramGufi_316a match	16	
eramGufi_316a is not known in both state and message	0	
Otherwise	-1	
4. **Aircraft Type**		
typeOfAircraft_03c match	8	
typeOfAircraft_03c is not known in both state and message	0	
Otherwise	-99	
5. **Aircraft Tail Number**		
REGIndicator_918d match	4	
REGIndicator_918d is not known in both state and message	0	
otherwise	-99	

Conditions	Weighted Score	Note
6. **Departure**		The evaluation of departure requires more than a simple match of the departure from a flight-plan message and the departure from a flight-state-per-Center candidate record. As described in the scenario from Section 3.3.12, the original departure of a flight may not be present in a proposed flight plan when entering into a new Center. The evaluation also needs to work in the scenario when a diverted flight returns to its departure Center from an adjacent Center. This scenario requires the following fields: • proposedDepartureTime_2431 • departureTime_243n • coordStatus_07d1 • coordTime_07d2
departurePoint_26a match	2	
departurePoint_26a is not known in both state and message	0	
eramGufi_316a match, or msgFacility, and computerId_02d match	2	Superseded by matching eramGufi_316a, or msgFacility and computerId_02d
Otherwise	-99	
7. **Arrival**		Need to work with the scenario of a diverted flight
destination_27a match	1	
destination_27a is not known in both state and message	0	
otherwise	-1	

4.5 Weighted Scores to Calculate Track Score

To correlate a track position message (FZ and TH) to a flight, a weighted score is used to evaluate the conditions of the message with existing flight-state-per-Center candidate records having the same callsign in the database (see Section 4.1.1). There are five mutually exclusive conditions as described in Table 5.

Scored candidate records are ranked by the following criteria:

1. Assigned score (the higher the better)
2. msgRcvTimeEpoch (the higher the better)
3. timeOfTrackData_170a (the higher the better)

The first record returned with a positive total score has the matching nasaGufi. To calculate nasaGufiScore, the total score, and the difference between msgRcvTimeEpoch and the msgRcvTimeEpoch from the matching nasaGufi record is normalized to range between 0.5 and 1. nasaMsgId is system generated by using UUID.

Because track positions of an aircraft may be reported by multiple Centers at the same time, or within few seconds, the quality of each reported track position needs to be evaluated. After analyzing actual ERAM data near Center boundaries, it is concluded that it is not reliable to rely on the controlling Center of a flight to determine which track source should be used. Some flights have many track positions reported solely from non-controlling Centers for a few minutes or longer. Therefore, it is better to evaluate track position messages independent of whether they are originated from the controlling Centers.

Evaluating whether a reported track position, P1, follows the flights actual trajectory requires the time, latitude, and longitude of P1, and its last reported position, P0, and the reported bearing from one of the two positions. Bearing is reported in each TH track position message. When the reported bearing does not deviate far from a derived bearing from P0 to P1, the quality of P1, nasaMsgIdScore, is good. nasaMsgIdScore is calculated as follows:

Let position P0 be the last known position of the aircraft at time T0 from the database, and P1 be the position at time T1 from the message. The derived bearing from P0 to P1 is $B1_{derived}$. For a TH message, the bearing at P1, B1, is provided by the message. The rate of bearing difference during the time period from T0 to T1, $\Delta B_{rate,}$ is:

$$\Delta B_{rate} = |B1_{derived} - B1| / |T1 - T0|$$

$B_{rateThreshold}$ is the threshold of the rate of bearing difference. Analysis on the ERAM data showed that when $B_{rateThreshold}$ is 1 degree per second, the transition from one track position to another does not have a seesaw pattern.

nasaMsgIdScore is based on ΔB_{rate}. If $\Delta B_{rate} < B_{rateThreshold}$, nasaMsgIdScore is normalized to range between 0.8 to 0.9 by using the value of ΔB_{rate}. Otherwise, nasaMsgIdScore is normalized to range between 0.141 to 0.49.

Table 5. Weighted Scores to Calculate Track Position Score

Conditions	Weighted Score	Note
1. **Flight Identifier Per Center and Position**		Need to work in the scenario that has track positions reporting from multiple Centers
msgFacility, computerId_02d, and sspId_167a (when Center is ERAM operational) match	5	
msgFacility match, but computerId_02d, and sspId_167a (when Center is ERAM operational) do not match	-99	
msgFacility do not match, and timeOfTrackData_170a match	Variable	Inverse distance (in meter) between trackPosition_23d in state and message Score is normalized to range between 0.5 and 1
msgFacility do not match, and timeOfTrackData_170a do not match	Variable	Inverse of (distance (in meter) between trackPosition_23d in state and message, multiplied by time gap between timeOfTrackData_170a in state and message) Score is normalized to range between 0 and 0.49
Otherwise	-1	

4.6 Weighted Scores to Calculate Generic Score

To correlate any other flight-related message except flight plan and track position, a weighted score is used to evaluate five conditions of the message against existing flight-state-per-Center candidate records having the same callsign in the database (see Section 4.1.1). The five conditions are described in Table 6Table 4. There is one weighted score from each of the five conditions. Combining the weighted scores on each flight-state-per-Center candidate record yields the total combined score of each candidate record.

Scored candidate records are ranked by the following criteria:

1. Total combined score (the higher the better)
2. msgRcvTimeEpoch (the higher the better)
3. sourceId_00e (the higher the better)

The first record returned with a positive total score has the matching nasaGufi. nasaGufiScore is calculated by first adding the total score, and the difference between msgRcvTimeEpoch and the msgRcvTimeEpoch from the matching nasaGufi record. The result is normalized to a range between 0.5 and 1. nasaMsgId is system-generated using the UUID. nasaMsgIdScore is always 1.

Table 6. Weighted Scores to Calculate Generic Score.

Conditions	Weighted Score	Note
1. **Flight Identifier Per Center**		En route flight may cross multiple Centers
msgFacility not match	-1	
msgFacility, and computerId_02d, and sspId_167a (when Center is ERAM operational) match	5	
Otherwise	-99	
2. **Beacon Code**		
beaconCode_04a match	1	
beaconCode_04a is not known in both state and message	0	
Otherwise	-1	
3. **ERAM GUFI**		Only available when Center is ERAM operational
eramGufi_316a match	1	
eramGufi_316a is not known in both state and message	0	
Otherwise	-1	
4. **Departure**		
departurePoint_26a match	1	
departurePoint_26a is not known in both state and message	0	
Otherwise	-99	
5. **Arrival**		
destination_27a match	1	
destination_27a is not known in both state and message	0	
otherwise	-99	

5 Prototype Implementation

A software prototype for correlating ERAM flight data from twenty Centers was implemented. The prototype utilized the Pentaho Data Integration [4] (PDI) application tool and an Oracle database. The Pentaho Data Integration (PDI) application tool was used to read the ERAM XML files created and archived at NASA. An Oracle database was set up to store flight-state-per-Center records, as well as the complete messages with the four added NASA fields. The detailed logic for finding an existing nasaGufi, creating a new nasaGufi, the confidence of the nasaGufi assignment (nasaGufiScore), and evaluating the quality of a track position message (nasaMsgIdScore) were performed by an Oracle package procedure that was written in the Oracle procedure language PL/SQL.

Depending on the message category (Route, Track-Position, or Generic), the appropriate Oracle package procedure is executed, and the appropriate flight-state-per-Center record is updated in the database (see Section 4).

For the prototype, a look-back time limit is set to five hours to query the existing nasaGufi from the existing flight-state-per-Center records in the database (see Section 4.1.1). The five-hour limit is chosen because a normal flight departing from and arriving within the NAS may fly over Canadian airspace for up to about five hours. A longer look-back time limit could be used. Another alternative is to shorten the look-back time limit when flight data from the Canadian airspace is available (e.g., ASDI and TFMData).

5.1 Use of Oracle Database as Data Store

An Oracle relational database was chosen to store and query flight-state-per-Center records. Other in-memory-only databases would likely be better to get faster performance. However, for the proof-of-concept prototype effort, a persistent Oracle relational database allowed for better post-processing analysis. Oracle PL/SQL was also used to implement the flight data correlation process. Oracle PL/SQL provides the procedural language support which SQL does not have. The Oracle database is also currently used as the ATM Sherlock Data Warehouse.

ODS_CFD_LATEST_MSGS is the table that stores flight-state-per-Center records. The purpose of this table is to store the latest state of an associated nasaGufi flight from a Center. In order to maintain an optimal query and update performance on this table, completed flights and old records (e.g., over 24 hours old) can be purged periodically. The order of the columns in the unique key is designed to optimize queries of a given flightId from various Centers. Table 7 shows the table structure of ODS_CFD_LATEST_MSGS.

Table 7. Table structure of ODS_CFD_LATEST_MSGS.

Column Name	Data Type	Nullable?	Unique Key Column Sequence
MSG_SOURCE	VARCHAR2(30 BYTE)	No	
MSG_FACILITY	VARCHAR2(30 BYTE)	No	2
MSG_TYPE	VARCHAR2(30 BYTE)	No	
MSG_RCV_EPOCH	NUMBER	No	
MSG_RCV_DATE_TIME_UTC	DATE	No	

Column Name	Data Type	Nullable?	Unique Key Column Sequence
SOURCE_DATE_TIME_UTC	DATE	Yes	
SOURCE_SEQ	NUMBER	Yes	
FLIGHT_ID	VARCHAR2(30 BYTE)	No	1
COMPUTER_ID	VARCHAR2(30 BYTE)	No	3
SITE_SPECIFIC_PLAN_ID	NUMBER(38,0)	Yes	
BEACON_CODE	VARCHAR2(30 BYTE)	Yes	
GUFI	VARCHAR2(30 BYTE)	Yes	
AC_TYPE	VARCHAR2(30 BYTE)	Yes	
ICAO_REG_INDICATOR	VARCHAR2(255 BYTE)	Yes	
PPS_DEP_DATE_TIME_UTC	DATE	Yes	
DEP_DATE_TIME_UTC	DATE	Yes	
COORD_STATUS	VARCHAR2(30 BYTE)	Yes	
COORD_DATE_TIME_UTC	DATE	Yes	
FLIGHT_PLAN_ROUTE	VARCHAR2(4000 BYTE)	Yes	
FLIGHT_PLAN_DEP	VARCHAR2(30 BYTE)	Yes	
FLIGHT_PLAN_ARR	VARCHAR2(30 BYTE)	Yes	
GROUND_SPEED_KT	NUMBER(38,0)	Yes	
REPORTED_ALT_FT	NUMBER(38,0)	Yes	
TRACK_LAT_DEG	NUMBER	Yes	
TRACK_LON_DEG	NUMBER	Yes	
TRACK_HEADING_DEG	NUMBER(38,0)	Yes	
TRACK_DATE_TIME_UTC	DATE	Yes	
NASA_GUFI	VARCHAR2(255 BYTE)	No	4

For the prototype, there is a need to analyze the correlated messages. The Oracle relational database was also chosen to store the messages for the prototyping effort. ODS_CFD_MSGS is the table to store all the processed ERAM messages. All messages have two common fields as a result of the correlating process: NASA_MSG_ID and NASA_MSG_ID_SCORE. Not all messages are flight related. Among messages that are flight related, an extra two fields, NASA_GUFI and NASA_GUFI_SCORE, are set.

There are multiple variants and versions of UUID. The prototype selected UUID Version 1 which is based on MAC address and date-time of the computer.

Frequently queried fields from the messages are also explicitly saved as columns in the table. The text of the original message is saved in the column MSG_XML. ERAM messages are reported in the millions per day. In order to get better query performance of a subset of ERAM messages from a given time period, the table that stores processed ERAM messages is configured to store data in a compressed form, and the records are partitioned by the column MSG_RCV_DATE_TIME_UTC on an hourly basis. The unique key on the column NASA_MSG_ID is purposely not enforced because its unique value is generated. Having a unique key on this large table would negatively impact the record insert operation. Table 8 shows the table structure of ODS_CFD_MSGS.

Table 8. Table structure of ODS_CFD_MSGS.

Column Name	Data Type	Nullable?
MSG_RCV_DATE_TIME_UTC	DATE	No
MSG_RCV_EPOCH	NUMBER	No
NASA_MSG_ID	VARCHAR2(255 BYTE)	No
NASA_MSG_ID_SCORE	NUMBER	No
NASA_GUFI	VARCHAR2(255 BYTE)	Yes
NASA_GUFI_SCORE	NUMBER	Yes
MSG_SOURCE	VARCHAR2(30 BYTE)	No
MSG_FACILITY	VARCHAR2(30 BYTE)	No
MSG_TYPE	VARCHAR2(30 BYTE)	No
SOURCE_DATE_TIME_UTC	DATE	Yes
SOURCE_SEQ	NUMBER	Yes
FLIGHT_ID	VARCHAR2(30 BYTE)	Yes
COMPUTER_ID	VARCHAR2(30 BYTE)	Yes
SITE_SPECIFIC_PLAN_ID	NUMBER(38,0)	Yes
BEACON_CODE	VARCHAR2(30 BYTE)	Yes
GUFI	VARCHAR2(30 BYTE)	Yes
AC_TYPE	VARCHAR2(30 BYTE)	Yes
ICAO_REG_INDICATOR	VARCHAR2(255 BYTE)	Yes
PPS_DEP_DATE_TIME_UTC	DATE	Yes
DEP_DATE_TIME_UTC	DATE	Yes
COORD_STATUS	VARCHAR2(30 BYTE)	Yes
COORD_DATE_TIME_UTC	DATE	Yes
FLIGHT_PLAN_ROUTE	VARCHAR2(4000 BYTE)	Yes
FLIGHT_PLAN_DEP	VARCHAR2(30 BYTE)	Yes
FLIGHT_PLAN_ARR	VARCHAR2(30 BYTE)	Yes
GROUND_SPEED_KT	NUMBER(38,0)	Yes
REPORTED_ALT_FT	NUMBER(38,0)	Yes
TRACK_LAT_DEG	NUMBER	Yes
TRACK_LON_DEG	NUMBER	Yes
TRACK_HEADING_DEG	NUMBER(38,0)	Yes
TRACK_DATE_TIME_UTC	DATE	Yes
MSG_XML	CLOB	No

5.2 Handling of Callsign Changes

When a flight has a change of callsign, or when one of the aircraft is leaving from a formation flight, there is an IH message to record the event. In order to ensure that messages that have different but related flightId are processed in chronological order, the table ODS_CFD_IH_MSGS is used to store the handle of a given flightId. The handle always references the original flightId when there is a callsign change event. Whenever a flightId changes its callsign, a record is saved into ODS_CFD_IH_MSGS. Each subsequent callsign change would also result in a new record being saved into the table ODS_CFD_IH_MSGS while maintaining the same handle. Like the table ODS_CFD_LATEST_MSGS, in order to maintain an optimal query and update performance on this table, completed flights and old records (e.g., over 24 hours old) should be purged periodically. The order of the columns in the unique key is designed to optimize queries of a given flightId from various Centers. Table 9 shows the table structure of ODS_CFD_IH_MSGS. The column FLIGHT_ID_HANDLE stores the handle of the flightId from every IH message.

Table 9. Table structure of ODS_CFD_IH_MSGS.

Column Name	Data Type	Nullable?	Unique Key Column Sequence
MSG_SOURCE	VARCHAR2(30 BYTE)	No	4
MSG_FACILITY	VARCHAR2(30 BYTE)	No	2
MSG_RCV_EPOCH	NUMBER	No	3
MSG_RCV_DATE_TIME_UTC	DATE	No	
SOURCE_DATE_TIME_UTC	DATE	No	
SOURCE_SEQ	NUMBER	No	
FLIGHT_ID	VARCHAR2(30 BYTE)	No	1
FLIGHT_ID_HANDLE	VARCHAR2(30 BYTE)	No	

5.3 Parallel Processing of Messages

It was observed that the rate of all ERAM messages reported from twenty Centers peaked around 1,800 messages per second on any given day. In order to process these messages at the peak rate, not only for offline processing but also potentially real-time processing, the prototype was configured to use ten concurrent threads. All flight-related messages are separated into ten groups based on their flightIds. Each flightId was assigned to a flightIdHandle value in case the flightId had a change in callsign earlier (see Section Handling of Callsign Changes). The text value of a flightIdHandle would be hashed to an integer called flightIdHandleCode ranging between 0 and 9. The flightIdHandleCode determined which one of the ten threads to which a message should be assigned and processed. The chronological order of the messages was not altered. All messages were processed in the order they were received at NASA. This is particularly important for evaluating the quality of track position messages. The quality of a track position message, stored as nasaMsgIdScore, is determined by the last known track-position.

Using the ten concurrent threads proved that parallel processing increases the processing speed for correlating messages. 24-hours of ERAM messages were processed in about three hours. When processed messages were stored into the Oracle relational database, the processing speed was about 2,000 messages per second. Because correlated messages may not necessarily need to be stored in a relational database, another test was performed to measure the average speed of correlating messages alone. Without storing the messages into the database, the speed was about 2,800 messages per second. Figure 1 shows the graphical flow of the parallel processing steps in the Pentaho Data Integration application.

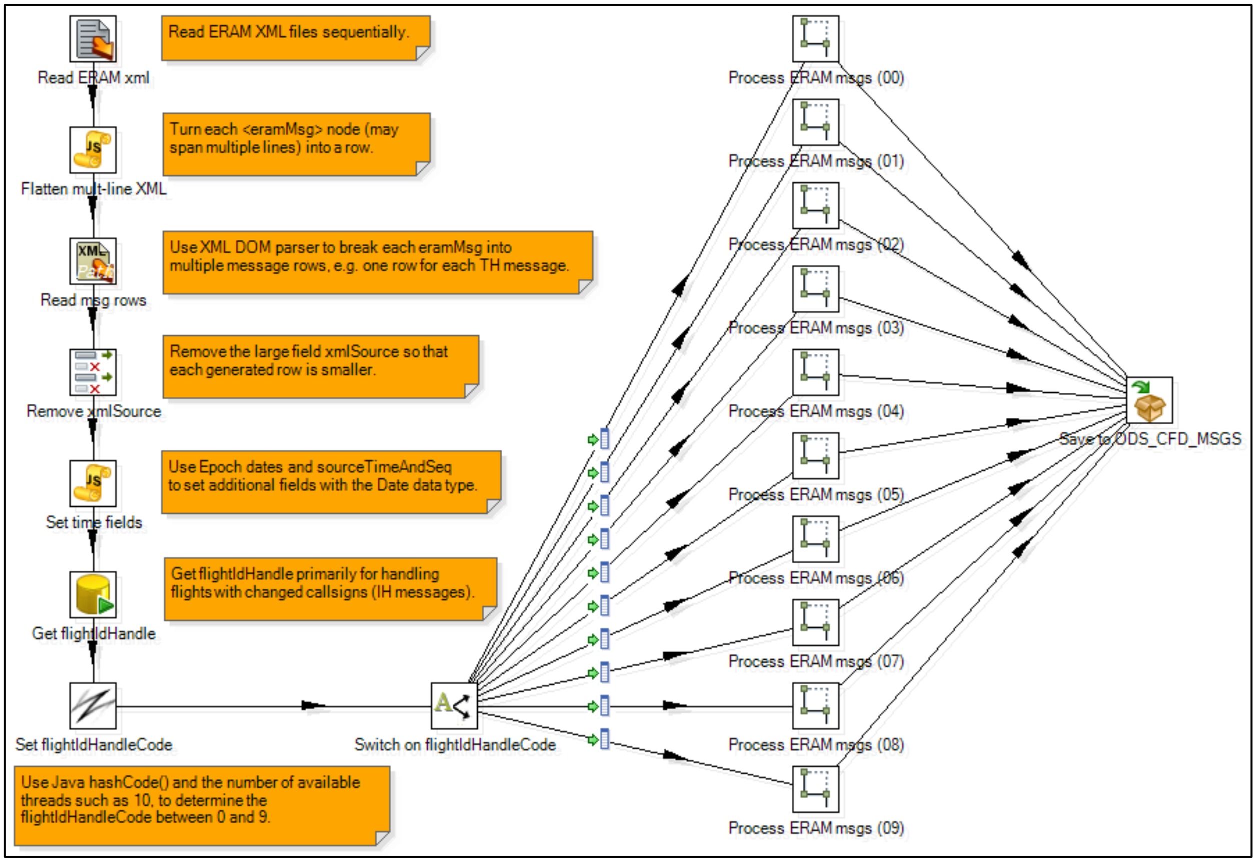

Figure 1. Paralleling processing of ERAM messages by using Pentaho Data Integration.

The correlated messages from the prototype were tested by using the scenarios described in Section 3.3. The test was performed by identifying flights that fall into those scenarios, reporting the correlated messages in chronological order per flight, and visualizing the track positions by using Google Earth.

Figure 2 shows a three-dimensional image of track positions for a flight at a level altitude of 32,000 feet. Each track position and extruded vertical line in red is a position reported by a different Center. When positions are reported within a few seconds of each other, the trajectory has a seesaw pattern. When the nasaMsgIdScore >= 0.5 filter is applied to the track positions, those that don't align with the reported bearings are eliminated. The resulting trajectory, in blue, better reflects the actual position history of the flight.

Figure 2. Duplicate track positions reported from multiple Centers.

As described in Section 3.3.6, when a flight flew over the Atlantic Ocean, two different GUFIs are used to identify a single flight. As show in Figure 3, the prototype correctly identifies that the two GUFIs are actually of the same flight. Tracks were reported from the Bermuda airport at the lower right hand corner. No tracks were reported after it flew out of the range of the ground based radar station. Tracks were not reported until the flight was closer to shore.

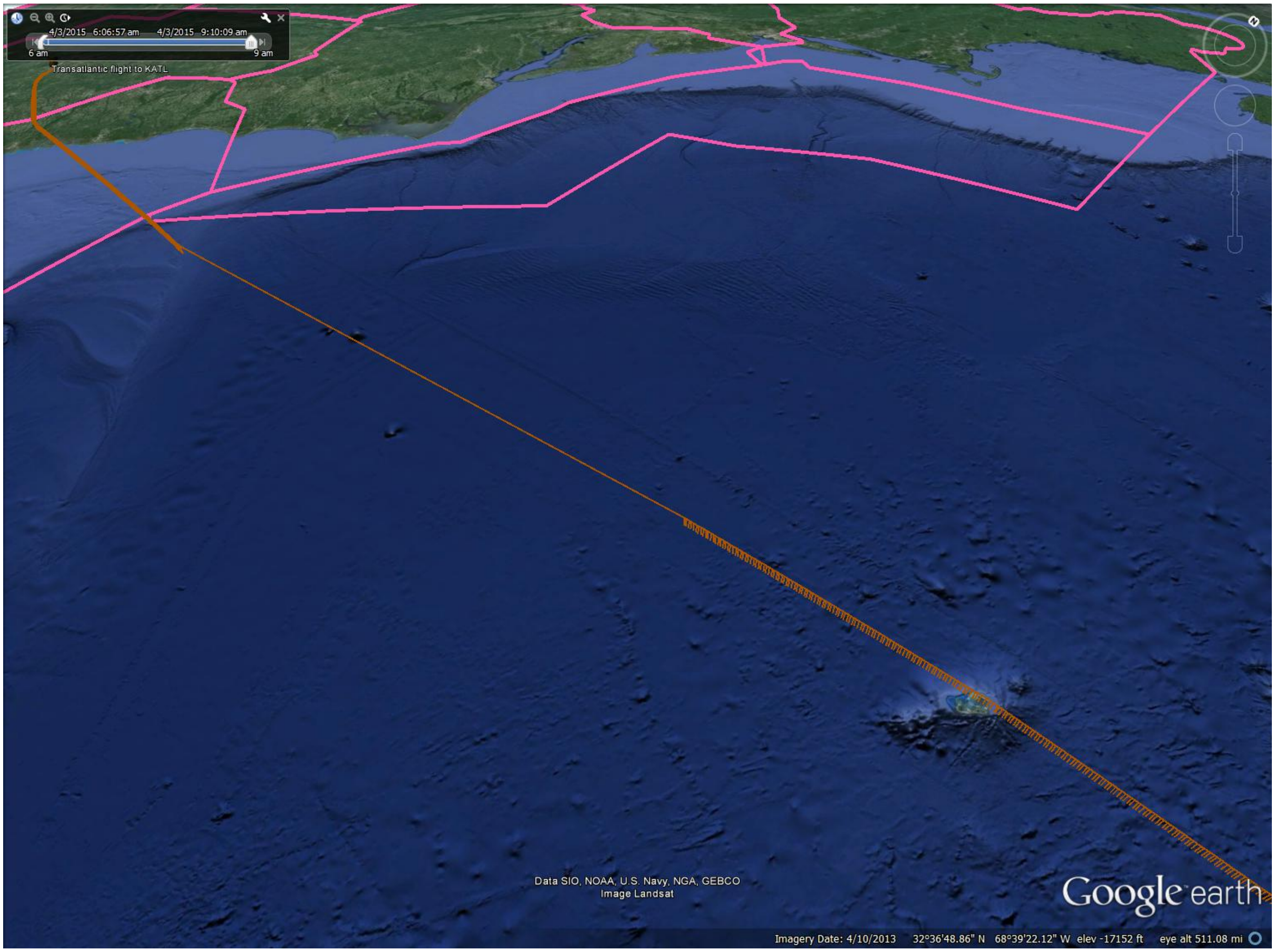

Figure 3. Multiple GUFIs to track the same flight within the Center ZNY.

6 Conclusions

An efficient heuristic approach for correlating flight data from 20 ERAM Centers was developed, and a prototype was completed and tested. The approach was intended to resolve challenging scenarios such as a flight receiving multiple reports from different Centers within a few seconds, or the callsign of a flight changing while en route. All ERAM messages were processed, flight data were correlated, and all data were stored in a database. Each ERAM message and each flight are assigned with unique identifiers created by the application. Unlike the identifiers assigned by ERAM, the two unique identifiers assigned by the application, nasaMsgId for each message, and nasaGufi for each flight, do not have any time window constraint. This allows a much more efficient and correct analysis of all historical flight data in a data warehouse. For a flight-related message, the confidence in the assigned nasaGufi is expressed as a weighted score value, nasaGufiScore. For a flight position message, the quality of the track position is also expressed as a weighted score value, nasaMsgIdScore. Users of the correlated flight messages can apply a filter on nasaMsgIdScore of 0.5 or higher to select only non-conflicting track positions. The processing speed for correlating ERAM messages exceeds the receiving rate of messages. The prototype demonstrated that the approach is viable not only for offline processing but also real-time processing.

7 References

[1] M. Eshow, M. Lui and S. Ranjan, "Architecture and Capabilities of a Data Warehouse for ATM Research," in *33rd Digital Avionics Systems Conference*, Colorado Springs, CO, October 5-9, 2014.

[2] *Refer to http://en.wikipedia.org/wiki/Universally_unique_identifier.*

[3] John A. Volpe National Transportation Systems Center (Volpe Center) Air Traffic Management Systems Division, "SWIM Flight Data Publication Service Reference Manual," 55 Broadway Cambridge, MA 02142, December 16, 2004.

[4] *Refer to http://community.pentaho.com/projects/data-integration/.*

Appendix A: Sample ERAM Messages in XML Format

The following sample ERAM messages from each message type are sourced from the binary stream NA02 format. In order to make the ERAM messages be more accessible without using a custom reader, the messages are reformatted in XML. In this custom ERAM XML format, the element names closely resemble those of the “Simple Schema” from SFDPS.

AH (Flight Amendment Information)


```
<eramMsg facility="ZAB" msg_type="AH" rcv_time="1429567582.999346">
<sourceId_00e>2151217630</sourceId_00e>
<flightId_02a>FFT250</flightId_02a>
<computerId_02d>817</computerId_02d>
<sspId_167a>6</sspId_167a>
<numberOfAircraft_03a/>
<typeOfAircraft_03c>A319</typeOfAircraft_03c>
<airborneEquip_03e>L</airborneEquip_03e>
<beaconCode_04a>3446</beaconCode_04a>
<externalBeaconCode_04b/>
<trueAirSpeed_05a>442</trueAirSpeed_05a>
<coordFix_06a>LAA202073</coordFix_06a>
<coordStatus_07d1>E</coordStatus_07d1>
<coordTime_07d2>2211</coordTime_07d2>
<assignedAlt_08a>390</assignedAlt_08a>
<requestedAlt_09/>
<flightPlanRoute_10a>KDEN.SPAZZ3.TBE.J17.PNH..MQP.DRLLR4.KIAH/2332</flightPlanRoute_10a>
<FPA_143a0/>
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<FPA_143a2/>
<FPA_143a3/>
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<ADRNonFld10_142d/>
<AARNonFld10_142f/>
<remarks_11c/>
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<EETIndicator_918b/>
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<SELIndicator_918e>ARCP</SELIndicator_918e>
<OPRIndicator_918f/>
<STSIndicator_918g/>
<TYPIndicator_918h/>
<PERIndicator_918i/>
<COMIndicator_918j/>
<DATIndicator_918k/>
<NAVIndicator_918l/>
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<TALTIndicator_918u/>
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<RNVEnroute_925b>0100</RNVEnroute_925b>
<RNVOceanic_925c/>
<RNVDeparture_925d>0100</RNVDeparture_925d>
<RNVSpare1_925e/>
<RNVSpare2_925f/>
<RNPArrival_925g/>
<RNPEnroute_925h/>
<RNPOceanic_925i/>
<RNPDeparture_925j/>
<RNPSpare1_925k/>
<RNPSpare2_925l/>
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<ICAO2ndAdaptedField18_999b/>
<ICAO3rdAdaptedField18_999c/>
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<ICAO6thAdaptedField18_999f/>
<ICAO7thAdaptedField18_999g/>
<ICAO8thAdaptedField18_999h/>
<ICAO9thAdaptedField18_999i/>
<ICAO10thAdaptedField18_999j/>
<ICAO11thAdaptedField18_999k/>
<ICAO12thAdaptedField18_999l/>
<ICAO13thAdaptedField18_999m/>
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```
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<ICAO25thAdaptedField18_999y/>
<localIntendedRoute_10b/>
<ATCIntendedRoute_10c/>
<flightPlanRouteRevisionNumber_148a/>
</eramMsg>
```


AI (Database Record Transfer Altimeter Status Information)


```
<eramMsg facility="ZAB" msg_type="AI" rcv_time="1429567580.720730">
<observedTime_35a/>
<stationId_13_3>0E0</stationId_13_3>
<altimeterData_34a>995</altimeterData_34a>
</eramMsg>
```


BA (Beacon Code Reassignment Information)


```
<eramMsg facility="ZBW" msg_type="BA" rcv_time="1429567636.184530">
<sourceId_00e>2152158372</sourceId_00e>
<flightIdInUse_02a>OPT410</flightIdInUse_02a>
<computerIdInUse_02d>620</computerIdInUse_02d>
<eramGufiInUse_316a>KB55866200</eramGufiInUse_316a>
<sspIdInUse_167a>450</sspIdInUse_167a>
<beaconCodeInUse_04a>1884</beaconCodeInUse_04a>
<departurePointInUse_26a>KAUG</departurePointInUse_26a>
<destinationInUse_27a>KTEB</destinationInUse_27a>
<flightId_02a>EJA962</flightId_02a>
<computerId_02d>438</computerId_02d>
<eramGufi_316a>KR59306201</eramGufi_316a>
<sspId_167a>473</sspId_167a>
<beaconCode_04a>1866</beaconCode_04a>
<departurePoint_26a>KMIA</departurePoint_26a>
<destination_27a>KBED</destination_27a>
</eramMsg>
```


CK0 (Health Check)


```
<eramMsg facility="ZAB" msg_type="CK0" rcv_time="1429567579.806474">
<sourceId_00e>2151182720</sourceId_00e>
</eramMsg>
```


CL (Cancellation Information)


```
<eramMsg facility="ZAB" msg_type="CL" rcv_time="1429567599.842162">
<sourceId_00e>2151357674</sourceId_00e>
```

```
<flightId_02a>N622TR</flightId_02a>
<computerId_02d>251</computerId_02d>
<sspId_167a>559</sspId_167a>
<departurePoint_26a>CCR</departurePoint_26a>
<destination_27a>SDL</destination_27a>
</eramMsg>
```

DH (Departure Information)

```
<eramMsg facility="ZAU" msg_type="DH" rcv_time="1429567616.443814">
<sourceId_00e>2151558942</sourceId_00e>
<flightId_02a>ENY3262</flightId_02a>
<computerId_02d>132</computerId_02d>
<sspId_167a>318</sspId_167a>
<numberOfAircraft_03a/>
<typeOfAircraft_03c>E135</typeOfAircraft_03c>
<airborneEquip_03e>L</airborneEquip_03e>
<departurePoint_26a>KORD</departurePoint_26a>
<coordStatus_07d1>D</coordStatus_07d1>
<coordTime_07d2>2152</coordTime_07d2>
<destination_27a>KGRB</destination_27a>
<ETA_28a/>
</eramMsg>
```

ET (Expected Departure Time Information)

```
<eramMsg facility="ZMA" msg_type="ET" rcv_time="1429567760.074021">
<sourceId_00e>2154190882</sourceId_00e>
<flightId_02a>DAL1512</flightId_02a>
<computerId_02d>722</computerId_02d>
<sspId_167a>416</sspId_167a>
<EDCT_92a>6</EDCT_92a>
<cancellationIndicator_92b/>
</eramMsg>
```

FH (Flight Plan Information)

```
<eramMsg facility="ZAB" msg_type="FH" rcv_time="1429567586.140405">
<sourceId_00e>2151257641</sourceId_00e>
<flightId_02a>N441AB</flightId_02a>
<computerId_02d>624</computerId_02d>
<sspId_167a>237</sspId_167a>
<numberOfAircraft_03a/>
<typeOfAircraft_03c>C441</typeOfAircraft_03c>
<airborneEquip_03e>L</airborneEquip_03e>
<beaconCode_04a/>
<externalBeaconCode_04b/>
<trueAirSpeed_05a>280</trueAirSpeed_05a>
<coordFix_06a>CIM034042</coordFix_06a>
<coordStatus_07d1>E</coordStatus_07d1>
<coordTime_07d2>2228</coordTime_07d2>
<assignedAlt_08a>290</assignedAlt_08a>
```

<requestedAlt_09/>
<flightPlanRoute_10a>KGJT./.JNC096030..F05</flightPlanRoute_10a>
<FPA_143a0/>
<FPA_143a1/>
<FPA_143a2/>
<FPA_143a3/>
<FAV_143b0/>
<FAV_143b1/>
<FAV_143b2/>
<FAV_143b3/>
<ADARId_141a/>
<ADRId_141b/>
<AARId_141c/>
<ADARNonFld10_142b/>
<ADRNonFld10_142d/>
<AARNonFld10_142f/>
<remarks_11c/>
<flightRules_908a>I</flightRules_908a>
<typeOfFlight_908b>N</typeOfFlight_908b>
<wakeTurbulenceCat_909c>L</wakeTurbulenceCat_909c>
<comNavApproachEquip_910a/>
<survEquip_910b/>
<comNavApproachEquipICAO2012_910c>DGVW</comNavApproachEquipICAO2012_910c>
<survEquipICAO2012_910d>C</survEquipICAO2012_910d>
<altAero_916c/>
<EETIndicator_918b/>
<RIFIndicator_918c/>
<REGIndicator_918d/>
<SELIndicator_918e/>
<OPRIndicator_918f/>
<STSIndicator_918g/>
<TYPIndicator_918h/>
<PERIndicator_918i/>
<COMIndicator_918j/>
<DATIndicator_918k/>
<NAVIndicator_918l/>
<DEPIndicator_918m/>
<DESTIndicator_918n/>
<ALTNIndicator_918o/>
<RALTIndicator_918p/>
<CODEIndicator_918q/>
<RACEIndicator_918r/>
<SURIndicator_918s/>
<DLEIndicator_918t/>
<TALTIndicator_918u/>
<DOFIndicator_918v/>
<ORGNIndicator_918w/>
<PBNIndicator_918x/>
<RNVArrival_925a/>

```
&lt;RNVEnroute_925b/&gt;
&lt;RNVOceanic_925c/&gt;
&lt;RNVDeparture_925d/&gt;
&lt;RNVSpare1_925e/&gt;
&lt;RNVSpare2_925f/&gt;
&lt;RNPArrival_925g/&gt;
&lt;RNPEnroute_925h/&gt;
&lt;RNPOceanic_925i/&gt;
&lt;RNPDeparture_925j/&gt;
&lt;RNPSpare1_925k/&gt;
&lt;RNPSpare2_925l/&gt;
&lt;ICAO1stAdaptedField18_999a/&gt;
&lt;ICAO2ndAdaptedField18_999b/&gt;
&lt;ICAO3rdAdaptedField18_999c/&gt;
&lt;ICAO4thAdaptedField18_999d/&gt;
&lt;ICAO5thAdaptedField18_999e/&gt;
&lt;ICAO6thAdaptedField18_999f/&gt;
&lt;ICAO7thAdaptedField18_999g/&gt;
&lt;ICAO8thAdaptedField18_999h/&gt;
&lt;ICAO9thAdaptedField18_999i/&gt;
&lt;ICAO10thAdaptedField18_999j/&gt;
&lt;ICAO11thAdaptedField18_999k/&gt;
&lt;ICAO12thAdaptedField18_999l/&gt;
&lt;ICAO13thAdaptedField18_999m/&gt;
&lt;ICAO14thAdaptedField18_999n/&gt;
&lt;ICAO15thAdaptedField18_999o/&gt;
&lt;ICAO16thAdaptedField18_999p/&gt;
&lt;ICAO17thAdaptedField18_999q/&gt;
&lt;ICAO18thAdaptedField18_999r/&gt;
&lt;ICAO19thAdaptedField18_999s/&gt;
&lt;ICAO20thAdaptedField18_999t/&gt;
&lt;ICAO21stAdaptedField18_999u/&gt;
&lt;ICAO22ndAdaptedField18_999v/&gt;
&lt;ICAO23rdAdaptedField18_999w/&gt;
&lt;ICAO24thAdaptedField18_999x/&gt;
&lt;ICAO25thAdaptedField18_999y/&gt;
&lt;localIntendedRoute_10b/&gt;
&lt;eramGufi_316a&gt;KD76327200&lt;/eramGufi_316a&gt;
&lt;ATCIntendedRoute_10c/&gt;
&lt;flightPlanRouteRevisionNumber_148a/&gt;
&lt;/eramMsg&gt;
```

FPI (Database Record Transfer Flight Plan Information)

```
&lt;eramMsg facility="ZAB" msg_type="FPI" rcv_time="1429567580.936686"&gt;
&lt;computerId_02d&gt;1&lt;/computerId_02d&gt;
&lt;flightId_02a&gt;N5262&lt;/flightId_02a&gt;
&lt;sspId_167a&gt;52&lt;/sspId_167a&gt;
&lt;eramGufi_316a&gt;KA78389200&lt;/eramGufi_316a&gt;
&lt;numberOfAircraft_03a/&gt;
```

<typeOfAircraft_03c>CL30</typeOfAircraft_03c>
<airborneEquip_03e>L</airborneEquip_03e>
<beaconCode_04a/>
<trueAirSpeed_05a>458</trueAirSpeed_05a>
<coordFix_06a>KELP</coordFix_06a>
<coordStatus_07d1>P</coordStatus_07d1>
<coordTime_07d2>2345</coordTime_07d2>
<departureTime_243n/>
<proposedDepartureTime_2431>2345</proposedDepartureTime_2431>
<estDepartureClearanceTime_2432/>
<arrivalTime_28b/>
<assignedAlt_08/>
<requestedAlt_09a>410</requestedAlt_09a>
<flightPlanRoute_10a>
KELP..SUMMY..CME..TXO.J74.IRW.J98.SGF..DELMA.DELMA2.KCPS/0204
</flightPlanRoute_10a>
<localIntendedRoute_10b>
KELP.LATVE2.CME..TXO.J74.IRW.J98.SGF..DELMA.DELMA2.KCPS/0204
</localIntendedRoute_10b>
<ETA_28a/>
<remarks_11c/>
<holdDataFix_21a/>
<holdDataTime_21d/>
<progressReportFix_18a/>
<progressReportTime_18d/>
<interimAlt_76b/>
<AARNonFld10_142f/>
<ADRFld10_142c>.LATVE2.CME</ADRFld10_142c>
<ADARNonFld10_142b/>
<AARId_141c/>
<ADRId_141b>LATVE</ADRId_141b>
<ADARId_141a/>
<FPA_143a0/>
<FPA_143a1/>
<FPA_143a2/>
<FPA_143a3/>
<FAV_143b0/>
<FAV_143b1/>
<FAV_143b2/>
<FAV_143b3/>
<flightRules_908a>I</flightRules_908a>
<typeOfFlight_908b>G</typeOfFlight_908b>
<wakeTurbulenceCat_909c>M</wakeTurbulenceCat_909c>
<comNavApproachEquip_910a/>
<survEquip_910b/>
<altAero_916c>KSTL</altAero_916c>
<comNavApproachEquipICAO2012_910c>SBDE3FGHRWXYZ</comNavApproachEquipICAO2012_910c>
<survEquipICAO2012_910d>SB1</survEquipICAO2012_910d>
<NAVIndicator_918l>SBAS</NAVIndicator_918l>

<CODEIndicator_918q>A6A1D6</CODEIndicator_918q>
<SURIndicator_918s>260B</SURIndicator_918s>
<PBNIndicator_918x>A1B2D2</PBNIndicator_918x>
<elementGroupCount_224h>8</elementGroupCount_224h>
<fixTime_68c>KELP/2345</fixTime_68c>
<fixTime_68c>LATVE/2349</fixTime_68c>
<fixTime_68c>AKASE/2351</fixTime_68c>
<fixTime_68c>BLRNG/2355</fixTime_68c>
<fixTime_68c>RIICK/2358</fixTime_68c>
<fixTime_68c>CME/0003</fixTime_68c>
<fixTime_68c>TXO/0016</fixTime_68c>
<fixTime_68c>IRW/0045</fixTime_68c>
<timeRouteValues_2461>0</timeRouteValues_2461>
</eramMsg>

GH (General Information)

<eramMsg facility="ZDV" msg_type="GH" rcv_time="1428036373.727371">
<sourceId_00e>0431134837</sourceId_00e>
<remarks_11c>|E1 ZDV CFAD & CRAD CERTS STARTED.......+</remarks_11c>
</eramMsg>

HA (Altimeter Setting Information)

<eramMsg facility="ZAU" msg_type="HA" rcv_time="1429567648.803693">
<sourceId_00e>2152289076</sourceId_00e>
<observedTime_35a/>
<stationId_13_3>SBN</stationId_13_3>
<altimeterData_34a>954</altimeterData_34a>
</eramMsg>

HF (FDB Fourth Line Information)

<eramMsg facility="ZAB" msg_type="HF" rcv_time="1429567584.487572">
<sourceId_00e>2151237636</sourceId_00e>
<elementGroupCount_224h>1</elementGroupCount_224h>
<flightId_02a>AAL636</flightId_02a>
<computerId_02d>944</computerId_02d>
<sspId_167a>198</sspId_167a>
<FDB4thLineHeading_155a/>
<FDB4thLineSpeed_155b>M80</FDB4thLineSpeed_155b>
<FDB4thLineText_155c/>
</eramMsg>

HH (Hold Information)

<eramMsg facility="ZMA" msg_type="HH" rcv_time="1429567778.756257">
<sourceId_00e>2154370958</sourceId_00e>
<flightId_02a>N873QS</flightId_02a>
<computerId_02d>866</computerId_02d>
<sspId_167a>226</sspId_167a>
<holdDataFix_21a>HOLID</holdDataFix_21a>
<holdDataTime_21d>2230</holdDataTime_21d>

```
</eramMsg>
```


HI (ERAM Status)


```
<eramMsg facility="ZAB" msg_type="HI" rcv_time="1429567580.934553">
<statusChangeIndicator_140a>ON2</statusChangeIndicator_140a>
<statusIndicator_140b>PSN</statusIndicator_140b>
<statusChangeIndicator_140c>SSN</statusChangeIndicator_140c>
<shutdownStartTime_32a/>
<shutdownTerminateTime_33a/>
<statusChangeIndicator_140d>DON</statusChangeIndicator_140d>
<statusIndicator_140e>ON</statusIndicator_140e>
<systemTypeIdentification_168a>ERAM</systemTypeIdentification_168a>
<cmsVersionNumber_169a>D211</cmsVersionNumber_169a>
</eramMsg>
```


HP (Position Update Information)


```
<eramMsg facility="ZAB" msg_type="HP" rcv_time="1429567588.469579">
<sourceId_00e>2151277656</sourceId_00e>
<flightId_02a>ASH5751</flightId_02a>
<computerId_02d>464</computerId_02d>
<sspId_167a>127</sspId_167a>
<coordFix_06a>BLH089039</coordFix_06a>
<coordStatus_07d1>E</coordStatus_07d1>
<coordTime_07d2>2149</coordTime_07d2>
</eramMsg>
```


HR (Route Status Information)


```
<eramMsg facility="ZKC" msg_type="HR" rcv_time="1429568310.876490">
<sourceId_00e>2203300640</sourceId_00e>
<elementGroupCount_224h>1</elementGroupCount_224h>
<routeStatusElements_135a>SF003</routeStatusElements_135a>
<actionIndicator_36a>ON</actionIndicator_36a>
</eramMsg>
```


HS (ERAM Status)


```
<eramMsg facility="ZTL" msg_type="HS" rcv_time="1429570765.877018">
<sourceId_00e>2244258827</sourceId_00e>
<statusChangeIndicator_140a>ON2</statusChangeIndicator_140a>
<statusIndicator_140b>PSN</statusIndicator_140b>
<statusChangeIndicator_140c>SSN</statusChangeIndicator_140c>
<statusChangeIndicator_140d>DON</statusChangeIndicator_140d>
<shutdownStartTime_32a/>
<shutdownTerminateTime_33a/>
<statusIndicator_140e>ON</statusIndicator_140e>
<systemTypeIdentification_168a>ERAM</systemTypeIdentification_168a>
<cmsVersionNumber_169a>D220</cmsVersionNumber_169a>
</eramMsg>
```

HT (Point Out Information)


```
<eramMsg facility="ZAU" msg_type="HT" rcv_time="1429567621.419576">
<sourceId_00e>2152008973</sourceId_00e>
<flightId_02a>DAL1897</flightId_02a>
<computerId_02d>859</computerId_02d>
<sspId_167a>450</sspId_167a>
<sourceSectorRouting_134b>62</sourceSectorRouting_134b>
<elementGroupCount_224h>1</elementGroupCount_224h>
<targetSector_16g>27</targetSector_16g>
</eramMsg>
```


HV (Flight Arrival Information)


```
<eramMsg facility="ZAB" msg_type="HV" rcv_time="1429567599.837874">
<sourceId_00e>2151357673</sourceId_00e>
<flightId_02a>N622TR</flightId_02a>
<computerId_02d>251</computerId_02d>
<sspId_167a>559</sspId_167a>
<departurePoint_26a>CCR</departurePoint_26a>
<destination_27a>SDL</destination_27a>
<arrivalTime_28b>A2151</arrivalTime_28b>
</eramMsg>
```


HX (Converted Route Information)


```
<eramMsg facility="ZAB" msg_type="HX" rcv_time="1429567583.060284">
<sourceId_00e>2151217631</sourceId_00e>
<flightId_02a>FFT250</flightId_02a>
<computerId_02d>817</computerId_02d>
<sspId_167a>6</sspId_167a>
<elementGroupCount_224h>4</elementGroupCount_224h>
<fixTime_68c>TBE/2210</fixTime_68c>
<fixTime_68c>KENTO/2215</fixTime_68c>
<fixTime_68c>PNH/2229</fixTime_68c>
<fixTime_68c>MQP/2257</fixTime_68c>
</eramMsg>
```


HZ (ARTS TZ Information)


```
<eramMsg facility="ZAB" msg_type="HZ" rcv_time="1429726468.701880">
<sourceId_00e>1759263253</sourceId_00e>
<addresseeARTS_00d>A</addresseeARTS_00d>
<addresserARTS_00a>LLL</addresserARTS_00a>
<elementGroupCount_224h>1</elementGroupCount_224h>
<hzTrack>
<flightId_02a>N247MD</flightId_02a>
<computerId_02d>225</computerId_02d>
<groundSpeed_05b>191</groundSpeed_05b>
<assignedAlt_08a>062</assignedAlt_08a>
<trackPosition_23d>334905N/1124712W</trackPosition_23d>
</hzTrack>
</eramMsg>
```

IH (Aircraft ID Amend Information)


```
<eramMsg facility="ZNY" msg_type="IH" rcv_time="1429567862.838519">
<sourceId_00e>2156025731</sourceId_00e>
<flightId_02a>ZZYCWA5</flightId_02a>
<computerId_02d>504</computerId_02d>
<sspId_167a>299</sspId_167a>
<newFlightId_02aN>ZNYCWA5</newFlightId_02aN>
<newComputerId_02dN>504</newComputerId_02dN>
<newSspId_167aN>299</newSspId_167aN>
<departurePoint_26a>FQM</departurePoint_26a>
<destination_27a>MIP</destination_27a>
</eramMsg>
```


LH (Interim Altitude Information)


```
<eramMsg facility="ZAB" msg_type="LH" rcv_time="1429567583.083282">
<sourceId_00e>2151227634</sourceId_00e>
<interimAlt_76a>D</interimAlt_76a>
<flightId_02a>AAL535</flightId_02a>
<computerId_02d>783</computerId_02d>
<sspId_167a>294</sspId_167a>
</eramMsg>
```


NL (Tentative Flight Plan Removal)


```
<eramMsg facility="ZJX" msg_type="NL" rcv_time="1429567767.558814">
<sourceId_00e>2154269113</sourceId_00e>
<flightId_02a>N3278Z</flightId_02a>
<computerId_02d>506</computerId_02d>
<sspId_167a>602</sspId_167a>
<mergedFPStatus_339a>S</mergedFPStatus_339a>
<mergedFPComputerId_341a/>
<mergedFPSspId_342a/>
</eramMsg>
```


OH (Handoff Status)


```
<eramMsg facility="ZAB" msg_type="OH" rcv_time="1429567582.127478">
<sourceId_00e>2151207626</sourceId_00e>
<flightId_02a>N803GJ</flightId_02a>
<computerId_02d>229</computerId_02d>
<sspId_167a>696</sspId_167a>
<controllingFacility_138a>ZAB</controllingFacility_138a>
<controllingSector_138b>67</controllingSector_138b>
<receivingFacility_139a>ZLA</receivingFacility_139a>
<receivingSector_139b>36</receivingSector_139b>
<acceptingFacility_334a>ZLA</acceptingFacility_334a>
<acceptingSector_335a>36</acceptingSector_335a>
<handoffEventIndicator_336a>A</handoffEventIndicator_336a>
</eramMsg>
```

PH (Progress Report Information)


```
<eramMsg facility="ZME" msg_type="PH" rcv_time="1429570601.479217">
<sourceId_00e>2241404432</sourceId_00e>
<flightId_02a>N3696C</flightId_02a>
<computerId_02d>611</computerId_02d>
<sspId_167a>135</sspId_167a>
<progressReportFix_18a>KMDQ</progressReportFix_18a>
<progressReportTime_18d>2241</progressReportTime_18d>
</eramMsg>
```


PT (Inbound Point Out Information)


```
<eramMsg facility="ZID" msg_type="PT" rcv_time="1429567779.616497">
<sourceId_00e>2154388363</sourceId_00e>
<flightId_02a>AAL70</flightId_02a>
<computerId_02d>746</computerId_02d>
<sspId_167a>369</sspId_167a>
<controllingFacility_138a>ZME</controllingFacility_138a>
<controllingSector_138b>63</controllingSector_138b>
<receivingFacility_139a>ZID</receivingFacility_139a>
<receivingSector_139b>81</receivingSector_139b>
</eramMsg>
```


RE (Beacon Code Restricted Information)


```
<eramMsg facility="ZTL" msg_type="RE" rcv_time="1429568540.623683">
<sourceId_00e>2207197179</sourceId_00e>
<flightId_02a>DAL1772</flightId_02a>
<computerId_02d>693</computerId_02d>
<eramGufi_316a>KA69599200</eramGufi_316a>
<sspId_167a>379</sspId_167a>
<beaconCode_04a>3720</beaconCode_04a>
<departurePoint_26a>KPHX</departurePoint_26a>
<destination_27a>KATL</destination_27a>
<restrictedBeaconCode_04aR>2119</restrictedBeaconCode_04aR>
</eramMsg>
```


RH (Drop Track Information)


```
<eramMsg facility="ZAB" msg_type="RH" rcv_time="1429567593.103749">
<sourceId_00e>2151327671</sourceId_00e>
<flightId_02a>RANCH52</flightId_02a>
<computerId_02d>306</computerId_02d>
<sspId_167a>604</sspId_167a>
</eramMsg>
```


RI (Database Record Transfer Route Status Information)


```
<eramMsg facility="ZAB" msg_type="RI" rcv_time="1429567579.846798">
<routeStatusElements_135a>ABLVG</routeStatusElements_135a>
<actionIndicator_36a>OFF</actionIndicator_36a>
<seqNoOfLastRouteStatusMsg_251c>33557789</seqNoOfLastRouteStatusMsg_251c>
<timeLastRouteStatusMsgRcvd_251d>1429185578</timeLastRouteStatusMsgRcvd_251d>
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</eramMsg>
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S1 (Database Record Transfer Sector Assignment Information)


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<eramMsg facility="ZAB" msg_type="S1" rcv_time="1429567580.720234">
<elementGroupCount_224h>48</elementGroupCount_224h>
<sector_29a>10</sector_29a>
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<FAV_29d>1001</FAV_29d>
<sector_29a>15</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>1562</FAV_29d>
<FAV_29d>1564</FAV_29d>
<sector_29a>16</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>0216</FAV_29d>
<FAV_29d>1601</FAV_29d>
<FAV_29d>1602</FAV_29d>
<sector_29a>17</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>0217</FAV_29d>
<FAV_29d>1701</FAV_29d>
<FAV_29d>1702</FAV_29d>
<FAV_29d>6801</FAV_29d>
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<elementGroupCount_224h/>
<FAV_29d>1901</FAV_29d>
<FAV_29d>1902</FAV_29d>
<FAV_29d>1903</FAV_29d>
<FAV_29d>8901</FAV_29d>
<FAV_29d>8902</FAV_29d>
<FAV_29d>8903</FAV_29d>
<sector_29a>20</sector_29a>
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<sector_29a>21</sector_29a>
<elementGroupCount_224h/>
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<sector_29a>37</sector_29a>
<elementGroupCount_224h/>
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<sector_29a>38</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>3801</FAV_29d>
<FAV_29d>3901</FAV_29d>
<FAV_29d>5038</FAV_29d>
<FAV_29d>5039</FAV_29d>
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<elementGroupCount_224h/>
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<sector_29a>41</sector_29a>
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<sector_29a>42</sector_29a>
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<FAV_29d>4244</FAV_29d>
<FAV_29d>4943</FAV_29d>
<sector_29a>43</sector_29a>
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<FAV_29d>3701</FAV_29d>
<FAV_29d>4301</FAV_29d>
<FAV_29d>4302</FAV_29d>
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<FAV_29d>4501</FAV_29d>
<sector_29a>46</sector_29a>
<elementGroupCount_224h/>
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<FAV_29d>4642</FAV_29d>
<sector_29a>47</sector_29a>
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<FAV_29d>5868</FAV_29d>
<FAV_29d>5893</FAV_29d>
<sector_29a>63</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2001</FAV_29d>
<FAV_29d>2002</FAV_29d>
<FAV_29d>2003</FAV_29d>
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<sector_29a>68</sector_29a>
<elementGroupCount_224h/>

<noFAV_29c>-</noFAV_29c>
<sector_29a>70</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>7001</FAV_29d>
<sector_29a>71</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>7101</FAV_29d>
<FAV_29d>7102</FAV_29d>
<FAV_29d>7201</FAV_29d>
<FAV_29d>7271</FAV_29d>
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<sector_29a>79</sector_29a>
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<sector_29a>80</sector_29a>
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<FAV_29d>8004</FAV_29d>
<sector_29a>81</sector_29a>
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<sector_29a>82</sector_29a>
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<FAV_29d>8501</FAV_29d>
<sector_29a>86</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>8601</FAV_29d>
<sector_29a>87</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2160</FAV_29d>
<FAV_29d>2161</FAV_29d>
<FAV_29d>2301</FAV_29d>
<FAV_29d>2302</FAV_29d>
<FAV_29d>2382</FAV_29d>
<FAV_29d>8701</FAV_29d>
<sector_29a>89</sector_29a>

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<sector_29a>90</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>4739</FAV_29d>
<FAV_29d>4740</FAV_29d>
<FAV_29d>9016</FAV_29d>
<sector_29a>91</sector_29a>
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<sector_29a>92</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9201</FAV_29d>
<sector_29a>93</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9301</FAV_29d>
<sector_29a>94</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>0294</FAV_29d>
<FAV_29d>7994</FAV_29d>
<FAV_29d>9401</FAV_29d>
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<FAV_29d>9501</FAV_29d>
<FAV_29d>9601</FAV_29d>
<sector_29a>96</sector_29a>
<elementGroupCount_224h/>
<noFAV_29c>-</noFAV_29c>
<sector_29a>97</sector_29a>
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<FAV_29d>9801</FAV_29d>
<sector_29a>98</sector_29a>
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<noFAV_29c>-</noFAV_29c>
<sector_29a>99</sector_29a>
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<noFAV_29c>-</noFAV_29c>
<seqNoOfLastSectorAssignmentStatusMsg_250c>34500422</seqNoOfLastSectorAssignmentStatusMsg_250c>
<timeLastSectorAssignmentStatusMsgRcvd_250d>1429565608</timeLastSectorAssignmentStatusMsgRcvd_250
d>
<elementGroupCount_224h/>
</eramMsg>
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SH (Sector Assignment Status Information)


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<eramMsg facility="ZFW" msg_type="SH" rcv_time="1429567782.084823">
<sourceId_00e>2154415466</sourceId_00e>
<elementGroupCount_224h>56</elementGroupCount_224h>
<sector_29a>14</sector_29a>
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<noFAV_29c>-</noFAV_29c>
<sector_29a>16</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2201</FAV_29d>
<FAV_29d>2220</FAV_29d>
<FAV_29d>2243</FAV_29d>
<FAV_29d>2251</FAV_29d>
<FAV_29d>2298</FAV_29d>
<sector_29a>17</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>18</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>19</sector_29a>
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<sector_29a>1b</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2701</FAV_29d>
<sector_29a>1c</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2501</FAV_29d>
<FAV_29d>2801</FAV_29d>
<sector_29a>1d</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2901</FAV_29d>
<sector_29a>1e</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>3001</FAV_29d>
<sector_29a>20</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>3201</FAV_29d>
<FAV_29d>4400</FAV_29d>
<sector_29a>21</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>22</sector_29a>
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<FAV_29d>0097</FAV_29d>
<FAV_29d>3401</FAV_29d>
<FAV_29d>3402</FAV_29d>
<FAV_29d>0051</FAV_29d>
<FAV_29d>3403</FAV_29d>
<FAV_29d>3404</FAV_29d>
<FAV_29d>3501</FAV_29d>
<FAV_29d>3502</FAV_29d>
<sector_29a>23</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>25</sector_29a>
<elementGroupCount_224h/>

<FAV_29d>3701</FAV_29d>
<sector_29a>26</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>3801</FAV_29d>
<FAV_29d>2601</FAV_29d>
<FAV_29d>5001</FAV_29d>
<sector_29a>27</sector_29a>
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<sector_29a>28</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>29</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>2a</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>4101</FAV_29d>
<FAV_29d>4201</FAV_29d>
<sector_29a>2b</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>2c</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>2e</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>4601</FAV_29d>
<sector_29a>2f</sector_29a>
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<FAV_29d>2301</FAV_29d>
<FAV_29d>4701</FAV_29d>
<sector_29a>30</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>4801</FAV_29d>
<FAV_29d>5101</FAV_29d>
<sector_29a>31</sector_29a>
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<FAV_29d>4901</FAV_29d>
<FAV_29d>4301</FAV_29d>
<sector_29a>32</sector_29a>
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<sector_29a>34</sector_29a>
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<sector_29a>35</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>5301</FAV_29d>
<FAV_29d>5398</FAV_29d>
<FAV_29d>5399</FAV_29d>
<sector_29a>37</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>5501</FAV_29d>

<sector_29a>39</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>3d</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2402</FAV_29d>
<FAV_29d>6101</FAV_29d>
<sector_29a>3e</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>6201</FAV_29d>
<sector_29a>3f</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>6301</FAV_29d>
<FAV_29d>4001</FAV_29d>
<sector_29a>40</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>6401</FAV_29d>
<FAV_29d>6402</FAV_29d>
<FAV_29d>6403</FAV_29d>
<FAV_29d>6404</FAV_29d>
<sector_29a>41</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>6501</FAV_29d>
<sector_29a>42</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>6600</FAV_29d>
<FAV_29d>6601</FAV_29d>
<FAV_29d>6602</FAV_29d>
<FAV_29d>6603</FAV_29d>
<FAV_29d>6604</FAV_29d>
<FAV_29d>6605</FAV_29d>
<FAV_29d>6606</FAV_29d>
<sector_29a>45</sector_29a>
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<sector_29a>47</sector_29a>
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<sector_29a>4a</sector_29a>
<noFAV_29c>-</noFAV_29c>
<sector_29a>4b</sector_29a>
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<FAV_29d>7501</FAV_29d>
<sector_29a>4d</sector_29a>
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<FAV_29d>7701</FAV_29d>
<sector_29a>50</sector_29a>
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<sector_29a>51</sector_29a>
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<sector_29a>52</sector_29a>
<elementGroupCount_224h/>

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<FAV_29d>2401</FAV_29d>
<FAV_29d>8201</FAV_29d>
<sector_29a>53</sector_29a>
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<sector_29a>56</sector_29a>
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<FAV_29d>8601</FAV_29d>
<sector_29a>58</sector_29a>
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<FAV_29d>8800</FAV_29d>
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<elementGroupCount_224h/>
<FAV_29d>8901</FAV_29d>
<sector_29a>5a</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>2001</FAV_29d>
<FAV_29d>9001</FAV_29d>
<FAV_29d>2002</FAV_29d>
<sector_29a>5d</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9301</FAV_29d>
<FAV_29d>9302</FAV_29d>
<sector_29a>5e</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9401</FAV_29d>
<sector_29a>60</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9601</FAV_29d>
<FAV_29d>9602</FAV_29d>
<FAV_29d>9699</FAV_29d>
<sector_29a>61</sector_29a>
<elementGroupCount_224h/>
<FAV_29d>9701</FAV_29d>
<FAV_29d>9702</FAV_29d>
<sector_29a>63</sector_29a>
<noFAV_29c>-</noFAV_29c>
<elementGroupCount_224h/>
</eramMsg>
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SI (Database Record Transfer Sector Assignment Information)


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<eramMsg facility="ZAB" msg_type="SI" rcv_time="1429567580.618051">
<sector_29a>10</sector_29a>
<elementGroupCount_224h>1</elementGroupCount_224h>
<FAV_29d>1001</FAV_29d>
<seqNoOfLastSectorAssignmentStatusMsg_250c>34500422</seqNoOfLastSectorAssignmentStatusMsg_250c>
<timeLastSectorAssignmentStatusMsgRcvd_250d>1429565608</timeLastSectorAssignmentStatusMsgRcvd_250
d>
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```
</eramMsg>
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TH (Track Information)


```
<eramMsg facility="ZAB" msg_type="TH" rcv_time="1429726476.851562">
<sourceId_00e>1759353287</sourceId_00e>
<elementGroupCount_224h>25</elementGroupCount_224h>
<thTrack>
<flightId_02a>N8577M</flightId_02a>
<computerId_02d>558</computerId_02d>
<sspId_167a>480</sspId_167a>
<groundSpeed_05b>118</groundSpeed_05b>
<assignedAlt_08g>VFR</assignedAlt_08g>
<reportedAlt_54a>96</reportedAlt_54a>
<reportedAlt_54b>2f</reportedAlt_54b>
<reportedAlt_54c/>
<controllingFacility_138a>ZLA</controllingFacility_138a>
<controllingSector_138b>08</controllingSector_138b>
<receivingFacility_139a>ZAB</receivingFacility_139a>
<receivingSector_139b>43</receivingSector_139b>
<trackPosition_23d>350613N/1134816W</trackPosition_23d>
<trackVelocity_23e>+62/-100</trackVelocity_23e>
<coastIndicator_153a/>
<timeOfTrackData_170a>1429725562</timeOfTrackData_170a>
<targetPosition_171a>350615N/1134813W</targetPosition_171a>
<targetAlt_172a>096</targetAlt_172a>
<targetAltInvalid_172b/>
<timeOfTargetData_173a>1429725562</timeOfTargetData_173a>
</thTrack>
<thTrack>
<flightId_02a>N700CZ</flightId_02a>
<computerId_02d>96</computerId_02d>
<sspId_167a>229</sspId_167a>
<groundSpeed_05b>252</groundSpeed_05b>
<assignedAlt_08a>250</assignedAlt_08a>
<reportedAlt_54a>250</reportedAlt_54a>
<reportedAlt_54b>43</reportedAlt_54b>
<reportedAlt_54c/>
<controllingFacility_138a>ZLA</controllingFacility_138a>
<controllingSector_138b>35</controllingSector_138b>
<receivingFacility_139a/>
<receivingSector_139b/>
<trackPosition_23d>361150N/1130736W</trackPosition_23d>
<trackVelocity_23e>+85/-238</trackVelocity_23e>
<coastIndicator_153a/>
<timeOfTrackData_170a>1429725566</timeOfTrackData_170a>
<targetPosition_171a>361148N/1130734W</targetPosition_171a>
<targetAlt_172a>250</targetAlt_172a>
<targetAltInvalid_172b/>
<timeOfTargetData_173a>1429725566</timeOfTargetData_173a>
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&lt;/thTrack&gt;
...
&lt;/eramMsg&gt;
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UB (Beacon Code Utilization Information)

```
&lt;eramMsg facility="ZFW" msg_type="UB" rcv_time="1429567759.877769"&gt;
&lt;sourceId_00e&gt;2154185347&lt;/sourceId_00e&gt;
&lt;internalPrimarySecondaryAdaptedCodes_47a&gt;0049/0252&lt;/internalPrimarySecondaryAdaptedCodes_47a&gt;
&lt;internalTertiaryAdaptedCodes_47b&gt;0000/0000&lt;/internalTertiaryAdaptedCodes_47b&gt;
&lt;externalPrimarySecondaryAdaptedCodes_47c&gt;0138/0378&lt;/externalPrimarySecondaryAdaptedCodes_47c&gt;
&lt;externalTertiaryAdaptedCodes_47d&gt;0027/0151&lt;/externalTertiaryAdaptedCodes_47d&gt;
&lt;codeReassignments_47e&gt;0028&lt;/codeReassignments_47e&gt;
&lt;/eramMsg&gt;O
```