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To	AGIE/MAGIC Subcommittee	**Date**	October 13, 2011
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Subject **Strawman Circulation**
Strawman for ARINC Project Paper 830: *Aircraft-Ground Information Exchange (AGIE) Using Internet Protocols (IPs)*

Summary Teledyne Controls and Boeing prepared this document as a Strawman input for ARINC Project Paper 830. The document is expected to define a data delivery service between the aircraft and ground-based networks using Internet Protocols (IPs). This includes application-to-application services that are intended to be useful for operations and maintenance, for example, Electronic Flight Bag (EFB) applications and cabin service applications.

Action Please review the Strawman and notify Eric Reichard via email by November 18, 2011, if you have any comments.

Strawman for

ARINC Project Paper 830

Aircraft-Ground Information Exchange (AGIE) Using Internet Protocols (IPs)

Project Paper 830 Proposal

Aircraft-Ground Information Exchange – AGIE

Revision: - Draft 7

Proposed by:

Teledyne Controls and The Boeing Company

22 Sep 2011

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1 Introduction

Aircraft communications is a critical element in the operations and safety of today's commercial airlines. This is becoming even more so as new aircraft being introduced into airlines' fleets, like the A-380 and B-787, involve increasingly more data intensive operations. Similarly, many airlines are incorporating electronic flight bags (EFBs), which typically also have large data requirements, into the operations of their existing legacy aircraft. This increase in the amount of operational data results in a corresponding increased demand on aircraft communications systems and their ability to handle the necessary data exchanges with the various onboard applications.

Today there can be many data communications paths to and from aircraft. These may typically involve many different communications media that could include, for example, VHF, HF, satellite, cellular, and Wi-Fi Gatelink. Some recent implementations in the satellite, cellular, and Wi-Fi GateLink areas potentially have the capability to address the broadband communications requirements needed to help meet the increased data communications demands discussed above. These broadband capabilities are typically IP-based communications technologies. However, separate technology implementations within each of the media as well as between the media themselves currently require each aircraft application to specifically meet the unique interface requirements of each media communications path in order to use it.

It is desirable therefore to have a common aircraft communications interface that all onboard message oriented applications could use to access the appropriate media link to communicate with their ground complements. In addition, because the broadband throughput capability may not always be available along the entire path between the aircraft application and its complement on the ground (e.g., airline server), it is also desirable to allow a common store and forward capability to be implemented at the airport to address such throughput restrictions when they arise. This will help minimize the need for costly communication equipment on the ground that various users might find necessary to deploy to address throughput restrictions impacting their individual applications.

1.1 Purpose

The purpose of ARINC 830 standard is to define a general purpose non-proprietary information exchange framework and protocol for the conduct of Internet Protocol based message traffic conducted between aircraft and airline ground infrastructure.

1.2 Scope

This document defines the AGIE protocol in sufficient detail that any party may develop a functional implementation of the standard.

1.3 Document Overview

This document is structured as follows:

- Section 2 provides a brief overview of the AGIE standard and the considerations driving this standard
- Section 3 describes AGIE from a functional and operational aspect
- Section 4 describes the interface specifications along with message details

- Section 5 defines information security and other relating topics

Attachments/Appendices contain various figures, tables, and related information as necessary.

1.4 Related Documents

The high-level requirements for a messaging service application are addressed in ARINC Report 821, Aircraft Network Server System (NSS) Functional Definition. The ARINC 821 document serves as an umbrella document that identifies and describes the high-level requirements for various network services that are to have their detailed requirements developed in dedicated ARINC standards. Also, besides the high-level requirements, ARINC 821 itself discusses the general prerequisites and design considerations for aircraft network services as well as defines a set of services for management of network elements.

The other network services that have their high-level requirements delineated in ARINC 821 but have their detailed requirements developed in separate, dedicated standards include Avionics Interface Services (ARINC 834); routing services -- the Manager of Air/Ground Interface Connections [MAGIC] (ARINC 839); and messaging services -- Aircraft/Ground Information Exchange [AGIE] (ARINC 830). The latter is the subject of this document.

1.5 Document Precedence

TBD

1.6 Regulatory Approval

TBD

2 AGIE Purpose & Objectives

The aviation industry has spent significant effort defining onboard architectures and communication protocols to support the delivery of large amounts of aircraft information using the Internet Protocol (IP). For example, aircraft and applications have been developed to rely on wireless communication of these data uploads/downloads for efficient operation.

With the advent of this technology to aviation – rather new to this industry – comes the need to assure interoperability between various systems and respective software applications such that every airline, airframer, third-party content provider or Internet datalink service provider may utilize and can rely on the availability of a common non-proprietary information exchange framework. It is also necessary to coordinate and centrally manage uplinked data to manage cost, performance and quality of service and reduce operator's footprint in applications associated server equipment.

Examples of systems that are in need of such an infrastructure include Data Loading Systems, Electronic Flight Bags (EFB), In-Flight Entertainment (IFE), Flight Operations Quality Assurance (FOQA), IP enabled avionics and IP enabled cabin systems.

The intention of the ARINC 830 "Aircraft/Ground Information Exchange (AGIE)" standard thus is to establish a rather simple and well defined and predictable, non-proprietary application level information interchange framework, protocol, functions and interfaces that enables application-to-application information exchange between aircraft applications and airline ground infrastructure in a universal manner using wired, wireless and/or optical technologies.

The AGIE standard defined herein is based on the operational considerations (scenarios) listed in Section 2.1 that in turn yield corresponding high level requirements summarized in Section 2.2.

2.1 Key AGIE Basic Operational Objectives[gw1]

AGIE defines a standard framework that meets several operational objectives associated with the transfer of data between aircraft and ground systems. In particular AGIE defines several types of **messaging services** as described below:

Point-to-Point Small Messages:
exchange of small message data between two end-system applications either of which may be aircraft or ground based (see Section 2.6.1.1)

Point-to-Point Large Data Items:
efficient transfer of large data items between two end system applications either of which may be aircraft or ground based (see Section 2.6.1.2)

Reliable Small Message Multi-cast:
one-to-many distribution of small message of data from a ground based system to multiple – typically aircraft based – systems (see Section 2.6.1.3)

Reliable Large Data Item Multi-cast:
one-to-many dispatch of large data items from a ground based system to multiple – typically aircraft based – end system applications (see Section 2.6.1.4)

Publish and Subscribe:
allows application to selectively retrieve multi-cast messages for certain defined message groups only (see Section 2.6.1.5).

To perform these principal services AGIE defines following principal **management** type functions:

Message Delivery Management:
consistent management of message delivery including administration of delivery date directives, delivery assurance, status enquiry as well tracking, suspending and resumption of transfers (see Section 2.6.2.1)

Message Priority Management:
ability to define prioritization of messaging with respect to other traffic (see Section 2.6.2.2)

Delivery Route Determination:
dynamic determination of transfer path for physically non-stationary end system applications such as EFB applications (see Section 2.6.2.3)

System Administration:
system administration aspect of an AGIE based information exchange infrastructure (see Section 2.6.2.4)

Each of these principal services and management functions is described in more detail in Section 2.6.

2.2 AGIE High Level Requirements

The operational scenarios/objectives as listed in Section 2.1 give rise to a set high level system requirements that govern the definition of the AGIE standard.

To meet the AGIE purpose/objectives an ARINC 830 AGIE standard compliant implementation ***shall***:

1. Implement a universal application to application messaging protocol through which aircraft hosted applications can achieve reliable bi-directional information exchange with applications hosted on ground based systems using IP protocols over IP enabled communication links.
2. Supports application to application data exchange within the same aircraft or between ground-based applications in addition to aircraft/ground messaging.
3. Support messaging data exchange paradigm (as opposed to streaming)
4. Define the data interface specifications as being independent from the data transfer mechanics used for the actual transport of data
5. Supports modern messaging services including "store and forward" as well as the "push and pull", "publish & subscribe", "one-to-one", "one-to-many" messaging, and "urgent delivery" principles for transferring data. Allows the initiation of data transfers without requiring an active communication link between the aircraft and the ground being available at that time.
6. Allow the initiation of data transfers without requiring an active communication link between the applications (such as when there is no aircraft - ground link).
7. Not require for end-system applications to be cognizant of the type and status of aircraft/ground communications link used for aircraft/ground communication
8. Support policies that allow the operator to manage message delivery and routing \
9. Include means for actively managing delivery of messages such as status tracking, retries, notifications etc.as well as transaction accounting

10. Ensure operating system, development system and language independence.
11. Permit exchange of any type of message oriented data, e.g. binary, ASCII, Unicode
12. Permit exchange of messages of unlimited size, subject to the resource constraints of a particular implementation.
13. Provide means to prioritize data transport between applications and between messages within the same application.
14. Include a universal addressing mechanism through which all active members (nodes) of an AGIE data exchange system can be reached
15. Provide that ability for senders of data to specify AGIE nodes at which data can be stored as staging servers.
16. Assure implementation of a secure data path between the AGIE end-system applications for both operator and control data in order to maintain data integrity between the client and the AGIE server as well as between two AGIE servers.
17. Reflect modern information security provisions and associated evolving trends such as authentication, data integrity checking etc.

2.3 Operational Goal

To meet the high level requirements AGIE aims to establish a communication infrastructure within which any end-system application (aircraft or ground-based) can submit data to the AGIE data network for the purpose of having this data being automatically transported and made available for retrieval by the intended recipient end-system (also either aircraft or ground-based) application of this data without any of the end-system applications requiring any knowledge of the actual delivery mechanism.

Operationally this is analogous to a person depositing a letter in a mail box with the expectation that this letter is subsequently delivered by the postal service to a mail box from which the addressee will retrieve this letter at some later time.

While end-system applications need not have knowledge of *how* actual data transport is achieved:

a) The sending application must know in what format data submittal is required and what information it must provide to assure successful data delivery
b) The transport mechanism needs to know how data can be delivered to the intended recipient
c) AGIE needs to maintain delivery status while delivery of data is still pending
d) The receiving application needs to know how to retrieve the data when available

Consequently, the AGIE definition includes two related yet operationally distinctly different types of interfaces:

a) The interface specifications which define how end-system applications submit and retrieve data as well as manage, track and status in-transit messages
b) The operational infrastructure which implements the actual transport of data between end-system applications

Additional goals for the AGIE standards definition include:

- Minimize impact on existing business systems
- Minimize need for new development and unique/proprietary mechanisms
- Integrate end-to-end information security
- Design for long life cycle
- Be programming language, operating system and platform independent

2.4 General Description

Consistent with high level requirements stated in Section 2.1 the AGIE specification defines a client/server based message broker system (illustrated in **Figure** 1) where dedicated AGIE servers manage the data exchange and end system applications implement AGIE clients which associate with AGIE servers for the purpose of submitting data for transfer to and retrieving data from other AGIE clients.

> *Definition: within this document the AGIE server with which an AGIE client is associated will be referred to as its "host" server or "client host server" (see Section 2.5 for a list of AGIE specific terminology).*

AGIE clients submit data for delivery to other AGIE clients to their host AGIE server and the AGIE client for which data is intended in turn obtains data from "its" host AGIE server.

AGIE defines a messaging standard where all data is exchanged as XML documents that may or may include attachments in some form for the purpose of transferring large data items.

AGIE further defines a flexible AGIE addressing scheme which operates similar to the email addressing convention although there are some distinct differences in order to account for the esoteric requirements for data transport in aerospace and aviation applications.

Figure 1 provides a conceptual overview of the intended AGIE system architecture.

The architecture consists of two primary groups of components: aircraft based and ground based nodes. Typically all actual transfer between the ground and aircraft occurs between two AGIE servers. However, the AGIE standard does allow direct association of an aircraft client with a ground based AGIE server.

The AGIE standard addresses the management and protocol of message exchange between AGIE clients only and does not address ***how*** data is exchanged between AGIE servers. However, it does define high level policies and functions that allow AGIE to perform the data exchanges in a manner desired by the operator in AGIE coordination message formats. Any available TCP/IP supported communication link technology may be employed to transfer data between two AGIE servers (such as an aircraft AGIE server and a ground based server). As such this exchange may occur via ARINC 839 "MAGIC" compliant transport mechanisms on the aircraft side but AGIE does not specifically require this and any available means may be used. AGIE as defined in this document is an application (Layer 7) set of interfaces and functions and does not attempt to define any new network or lower layer functionality or new requirements.

Depending on the type of aircraft/ground communication link, for a particular system, the connection may not be available at all time, e.g. if communication links are used which are only available while an

aircraft is on the ground then during flight no communication is available over that link. The AGIE standard provides for this situation by supporting dynamic associations.

An important aspect of AGIE is that a client need *not* be aware (though it may be) of

1. The type of aircraft/ground communication link that may be used
2. If the destination client is reachable
3. If an aircraft/ground communication is active at the time a data transfer is initiated

An AGIE client can be any software application hosted either on an aircraft or ground-based system or connected via the operator's ground network. While typically data exchange occurs between aircraft based and ground-based applications, AGIE does not stipulate this as a requirement. An aircraft resident AGIE client may also exchange messages with other aircraft resident AGIE clients and likewise ground-based AGIE clients can exchange messages with other ground-based AGIE clients.

As far as data traffic is concerned AGIE is a symmetric system, i.e. the same data exchange mechanics apply ground to aircraft and aircraft to ground data transfers.

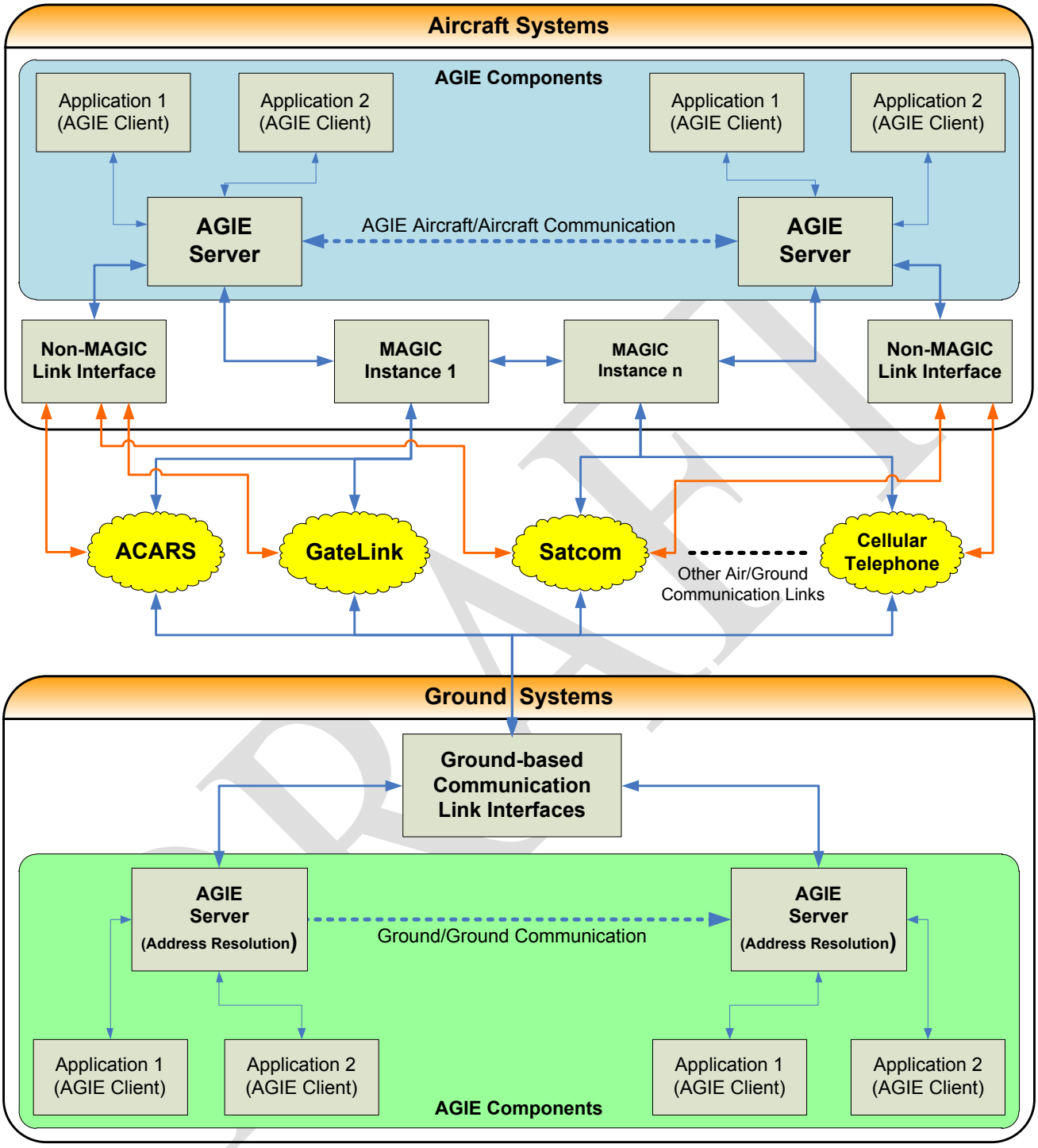


Figure 1 – Conceptual AGIE System Overview

2.5 AGIE Terminology

The following terms are used throughout this document and are defined as follows:

AGIE General Definitions

AGIE:	Industry standard defined through the ARINC 830 document and specifies a message broker network type framework having as its primary purpose the management of secure and reliable delivery of messages between aircraft and/or ground based software applications.
AGIE Standard:	The ARINC 830 standards document itself
AGIE System:	Implementation of the AGIE standard which consists of the collection of AGIE nodes, and associated databases and configuration
AGIE Network:	Static set of all AGIE servers and their instantaneous connectivity this is the internal core of an AGIE implementation (server-to-server)
AGIE Central Network:	Main component of AGIE Network that contains the Primary Server (on the ground)
AGIE Sub-Network:	A defined subset of one or more connected of AGIE servers and their connections. Usually airplane sub-network, may be disconnected from AGIE Central Network, should function autonomously with associated clients, contains a local AGIE DNS
Disconnected Sub-Network:	AGIE sub-network that does not have a connection to the Central Network (primary server)

AGIE Components

Application:	Aircraft or ground hosted software program that performs a specific function.
(AGIE) Server:	Software that implements AGIE server defined functions, i.e. manages the delivery of messages as well as connections between servers
(AGIE) Client:	Software application that is not tied to a specific hardware that implements AGIE client protocol and interfaces with the AGIE system for the purpose of exchanging information with other clients/applications within the system. A client establishes a functional connection with an AGIE server to enable message exchange with other clients
(AGIE) Node:	AGIE server or AGIE client
Association:	Functional network connection between a client and a server
Connection:	Functional network link between two AGIE servers
Fixed Client:	A client that may be associated with only a predetermined AGIE server
Mobile Client:	A client that can dynamically associate and dis-associate with any AGIE server in its accessibility list
Associated Client:	A client currently associated with an AGIE server
Primary Server:	AGIE server that holds central knowledge of the static and instantaneous AGIE

	system configuration including association between clients and servers
Secondary Server:	Backup server to the Primary server (for system redundancy)
Originating Server:	Host of message originating client
Destination Server:	Host of the message receiving client
Proxy Server:	Temporary storage server for messages that is defined by the message type or message group and may be used for staging messages temporarily at admin determined server locations *(NEW CONCEPT)*
Host Server:	Server associated with a client, for fixed client is assigned, for mobile client is dynamic from list
Dynamic Server:	AGIE server that supports dynamic associations to primary server, typically airplane server

AGIE Messaging flow methods

Store and Forward:	Indirect method of data delivery, where data **is** temporarily stored on a network node (server) by the sender and from which the receiver either picks up the method actively (pull) or receives the data passively through the server action (push)
Pull:	Transfer of a message to the receiver is initiated by the receiving application itself
Push:	Transfer of a message to the receiver is initiated by the server
Publish-Subscribe:	A means for applications to selectively receive information based on operator defined messages groups. An application's client generates and submits "publishes" a message into the AGIE system and stores it on the proxy server. The proxy server notifies a list of clients that "subscribe" to the message group of the message availability. The "subscribed" host server then notifies the application that new data belonging to those groups is available for retrieval. The application's client may then "pull~~s~~" the respective data.

2.6 Key Operations

Section 2.1 introduces the key (messaging) services and associated management function defined by AGIE. These are described in more detail in the subsequent sections and all are subject to the following considerations, requirements and/or constraints:

1. The operation of AGIE is not contingent on the type of link that may be available for aircraft-ground communication at any given time
2. Due to the fact that the availability of aircraft-ground communication links cannot be guaranteed at any given time the AGIE standard definition:
   - Includes a "Store and Forward" as well as "push and pull" type of information transfer paradigm

- Does not stipulate for information to be exchanged in real-time but instead stipulates for all AGIE implementations to use best effort with the aim to minimize latency to the best extent possible, to maximize communication links efficiency and reduce costs.

3. Although AGIE is primarily intended to define a protocol for information exchange between aircraft and ground based system, the scope of the AGIE standard also includes information exchange between applications with AGIE clients residing on the same aircraft and between ground based systems
4. Initially AGIE is envisioned to be employed primarily by the Aircraft Information System (AIS) and the Passenger Information and Entertainment System (PIES); not envisioned to be used in the POD domain but may be used by within the Aircraft Control Domain (ACD).

2.6.1 AGIE Principal Services

2.6.1.1 Message Service Type 1: Point-to-Point Small Messages

Description

This is the first fundamental AGIE data exchange service addressing the need to exchange information between end-system applications (clients) that is sufficiently small to be encapsulated in a single message document.

Message Path

The message originator can be any application that implements an AGIE client and may send a message:

a) An aircraft application sending a message to:
   a. A ground-based application or application on another aircraft
   b. An application on the same aircraft

b) A ground based application sending a message to:
   a. An aircraft based application or
   b. Another ground-based application.

Message Timing

Message may be sent at any time and with near-real time message delivery not guaranteed.

Acknowledgement

Return request may be included in original message in which case the message originator expects[gw2] explicit notification of delivery or failure.

2.6.1.2 Message Service Type 2: Point-to-Point Large Data Items

Description

This is the second fundamental AGIE data exchange service addressing the need to transfer data between end-system applications too large in size to be included as part of a single message. Large data items are attached to a standard message document as one or more attachments.

Message Path

The message originator can be any application that implements an AGIE client and may send a message:

a) An application of an aircraft installed system sending a message to:
    a. A ground-based application or
    b. An application hosted by a system on the same aircraft
b) A ground-system based application sending a message to:
    a. An aircraft based application or
    b. Another ground-based system

Message Timing

Message may be sent at any time and with near-real time message delivery not expected and the file may be broken into smaller fragments for efficient transmission.

Acknowledgement

Return request may be included in original message in which case the message originator expects explicit notification of delivery.

2.6.1.3 Message Service Type 3: Reliable Small Message Multi-cast

Description

This is the third fundamental AGIE data exchange paradigm addressing the need for - typically ground-based - application to multi-cast information sufficiently small in size to be encapsulated in a single message document to multiple – typically aircraft based – applications although the recipients may also be other ground based applications.

Message Path

The message originator is typically a ground-based application though airplane clients may also use the service and the recipient may be any combination of aircraft or ground based applications

Message Timing

Message may be sent at any time and with near-real time message delivery not guaranteed.

Acknowledgement

This multi-cast type of delivery does not support explicit message acknowledgement. But allows the sender to obtain a list of successful deliveries

2.6.1.4 Message Service Type 4: Reliable Large Data Item Multi-cast

Description

This is the fourth fundamental AGIE data exchange service addressing the need for an application - typically on the ground - to transfer large data items that cannot be encapsulated into a single message document to multiple – typically aircraft based – applications in a multi-cast type manner although the

recipients may also be ground based applications. The large data items represent attachments to the main message document.

Message Path

The message originator is typically a ground-based application though that's' not required and the recipient may be any combination of aircraft or ground based applications

Message Timing

Message may be sent at any time and with near-real time message delivery not expected.

Acknowledgement

This multi-cast type of delivery does not support explicit message acknowledgement but allows the sender to obtain a list of successful deliveries.

2.6.1.5 Message Service Type 5: Publish and Subscribe

Description

This is the fifth fundamental AGIE data exchange service addressing the need for an application to inform "its" host server that it wishes to be notified of the availability of messages belonging to certain message groups, i.e. "subscribes" to specific message groups. The server in turn "publishes" a list of messages available for subscription upon request from clients. Upon notification the client may then "pull" the respective messages from the server. In a Publish/Subscribe situation the server never "pushes" data to a client.

Message Path

The originators of messages being distributed on a Publish/Subscribe basis are typically ground-based applications and the recipients may be any combination of aircraft or ground based applications. For publish/subscribe to be engaged the predefined message header attribute "MsgGroup" must be non-blank (see Section 4). Moreover, a proxy server must be designated for the one-to-many spread (or the Primary server will be used as a default.)[WS3]

Message Timing

Message may be sent at any time and with near-real time message delivery not expected.

Acknowledgement

There is no specific acknowledgement of message delivery for publish/subscribe type message distribution. However, the server does notify a client that a message belonging to a subscribed message group is available for retrieval. As part of standard message delivery status tracking (see Section 4.2) the originator may obtain a list of successful deliveries.

2.6.2 AGIE Principal Management Functions

2.6.2.1 Management Function 1: Message Delivery Management

The AGIE data delivery framework includes a well-defined method of managing data flow that includes status tracking and enquiry, event notification such as non-delivery, delivery timing management.

2.6.2.2 Management Function 2: Message Priority Management

This function addresses the need to support some type of prioritization between messages based on message class, message type and message service used. At a minimum a sender must be able to specify that a message is of higher priority that most "normal" traffic and that AGIE provides a mechanism to accommodate that need.

The objective is for an AGIE system to maintain high priority as well as normal message queues where messages tagged as being of high priority are serviced ahead of normal message traffic.

The priority request needs to be part of the message document standard set of meta data.

2.6.2.3 Management Function 3: Delivery Route Determination

One of the main challenges of an AGIE based data exchange system is to accommodate the need to dynamically determine how AGIE clients can be reached at any given time. Not only do aircraft with on-board AGIE servers move but certain equipment may be removed from one aircraft and installed on a different aircraft while having to maintain the same identity. Moreover, this equipment and applications may even need to interact with the infrastructure through ground-based AGIE servers. A typical example of are removable Electronic Flight Bag (EFB) applications that are ported from aircraft to ground networks, e.g. hotels, and again to another aircraft.

The AGIE standard must address this need and thus defined as a separate AGIE objective.

2.6.2.4 Management Function 4: System Administration

A final although – perhaps self-explanatory – function is to provide a centralized and common/interoperable System Configuration Management framework. This is an essential aspect of the system definition and is therefore identified as one of the key AGIE management functions.

2.7 High Level Functional/Interface Description

All AGIE data are transported as XML documents sent by AGIE Clients as messages to the host AGIE server. It is that server's responsibility to coordinate the transfer of the respective message to the AGIE Server through which the destination client receives that message.

Two fundamental types of data transport interfaces exist as part of the AGIE standard:

a) The exchange of data between an AGIE client and an AGIE server

b) The exchange of data between two AGIE servers

The actual transport of AGIE XML message documents is accomplished through the Advanced Message Queuing Protocol (AMQP) for both the client/server and server/server data transport interfaces. The details of this protocol binding are described in further in Section 3.4.

For aircraft/ground information exchanges AGIE messages need to pass through some type of aircraft/ground communication link. This communication link may or may not be managed by an ARINC 839 "MAGIC" system and may take on any form which in turn may or may not use proprietary technology.

Consequently, key to AGIE is the ability address all nodes in a consistent manner. To enable this AGIE adopts a mechanism which is very similar to conventional email addressing and is defined further in Section 3.5.The main challenge of addressing is to achieve a reliable mechanism which allows easy identification on how a destination server can be reached.

2.8 Policy and Quality of Service Considerations

AGIE is an application level protocol and defines a common format and basic hand shake type protocol to permit applications implemented by various vendors and installed on various systems to exchange information with each other using each other's services. As such performance and quality of service related requirements do not significantly drive the AGIE standards definition. Those detailed requirements belong to the transport layer aspects of communication such as the ARINC 839 MAGIC standard.

This section requires more substance…

2.9 Certification and Partitioning Considerations

TBD[gw4]…

2.10 Assumptions/Constraints

TBD[gw5]…

3 AGIE Functional Specification

This section defines the operation of an AGIE system on a functional level without defining details such as message structures and addresses the following areas:

1. Principles of operation
2. System topology
3. Connection management
4. Addressing
5. Data delivery and status management
6. System configuration management

The content of this section extends the brief system description provided in Section 2.4 and needs to viewed in context with the conceptual system architecture illustrated in **Figure** 1.

3.1 AGIE principles of operation

The AGIE standard primary objective is to define a protocol for exchange of data between end systems/applications. To do so end system software applications implement AGIE client interfaces through which applications associate as client with an AGIE server. Typically Aircraft based applications clients associate themselves with an aircraft resident server while non-aircraft based applications associate themselves with a ground-based server (of which there may be one or more in a particular system). The AGIE definition does not, however, preclude clients to associate themselves directly with ground-based servers while respective communication links are active. On the other hand, ground based clients cannot associate themselves with an aircraft based AGIE server[gw6].

In addition servers associate with other servers by connecting over active communication links which can be established or lost at any given time.

The association process includes the establishment of an active connection in both of those two cases.

> ***Note**: The association process does not constitute a network type authentication. AGIE makes the assumption (and requirement) that this type of authentication from an information security point of view is performed at a lower level. The association process thus constitutes a connection establishment only and is further addressed in Section 3.2.1* though there may be security considerations inherent in this process as well.

Some AGIE clients are only associated with a designated/fixed server and only need to associate and (re)associate occasionally, e.g. in the event of aircraft power up sequence. An example of a "fixed" client is an airborne data loader, which is permanently installed in the aircraft that also hosts an aircraft AGIE server.

Other clients may not be permanently attached to the same server. An example of this is a Class I EFB. Class I EFB's are typically removed from the cockpit by the flight crew after a flight and thus disassociated from the system. Later, the EFB associates again as a client for another flight, which may be a different aircraft in turn using a different server than before. It is also possible that a flight crew member associates the EFB with a ground based client, while on the ground from within a flight

operations facility or perhaps a hotel room. Nonetheless, all clients associated with an AGIE server *must* to be addressable by other AGIE nodes.

The following key requirements must be met to achieve this type of flexibility with AGIE:

a) An AGIE system is a closed, it consists of statically pre-defined nodes

b) AGIE uses an addressing mechanism which supports dynamic association of mobile clients with servers and fixed servers with dynamically linked servers

c) AGIE clients cannot be associated with aircraft tails alone but require association with some other entity such as specific application on specific aircraft or even flight crew member's client~~s~~.

These requirements are discussed in more detail in the following sections.

3.2 AGIE Topology

AGIE defines a message broker system where dedicated AGIE servers manage the data exchange and end system applications associate as AGIE clients with the "host" AGIE server for the purpose of submitting data for transfer to and retrieve data from other AGIE clients.

This requires a flexible way for AGIE nodes to address each other and the respective addressing mechanics are defined in Section 3.5.

To allow flexible addressing of AGIE nodes, especially AGIE clients, an AGIE system MUST be a closed system in the following sense:

1. The comprehensive set of all clients and servers that make up the full system is known at all times to the Primary server (or servers if partitioned).
2. The network topology between all AGIE servers is (essentially) static, i.e. all nodes are pre-defined, fixed connectivity is known, any limits on dynamic associations and connections are bounded.

In this closed system the association between all servers is static in the sense that all server identifiers are known, fixed connections are known and dynamic connections are bounded by admin. On the other hand the association between clients and servers can be dynamic such that any known client can associate with any server and this association can change at any time (within admin defined accessibility limits). To assure full addressing capability is maintained the "new" server MUST make all new associations available to all other servers in the system. This is further described in Section 3.5.2.

All clients MUST be uniquely identifiable within the system independent of associations with servers. In the event more than one instantiation of an identical application associates with a server it is necessary that each application instantiation is provided with its own unique identification. Typical scenarios of this are again EFBs or credit card authorization devices[gw7].

It will, of course, be necessary to amend the static system configuration from time to time. Such a change requires a controlled effort managed by authorized system administrators (one rationale behind system administration being a key AGIE management function) and MUST be visible globally across the system. AGIE defines special configuration notification messages[gw8] for this purpose, see Section 4.

Part of the definition of a static system also includes a definition of which end-system applications are "allowed" to exchange data with which other end system applications. This is accomplished by

providing each such end system application with a list of "known" clients (per admin visibility/accessibility rules).

An AGIE system needs to provide a central means for management of global system configuration and has this information available to all system nodes. To prevent the rollout of this information from becoming too complex, and costly the AGIE standard states that this information is centrally managed on one or more ground-based servers which take the role of a Primary knowledge store (which also supports AGIE Domain Name Server – DNS type functions). All AGIE servers can enquire about the association between accessible client and servers and other AGIE databases from Primary (AGIE DNS) at any time. In the event redundant DNS are used, it is a requirement that those be kept synchronized. One of the servers is always the primary and all others are secondary. All AGIE servers must know how to reach an AGIE DNS. These AGIE DNS also provide the translation from AGIE node identifiers to actual IP addresses, ports and provides path quality parameters.

3.2.1 AGIE network topology options

Depending on operational needs an actual AGIE system implementation may result in different types of architectures including but not necessarily limited to:

- "Basic" AGIE network comprising a central AGIE server on the ground as well as per aircraft (this configuration is considered the baseline architecture)
- "Minimal" AGIE network comprising a ground based AGIE system only
- "Federated" AGIE network comprising multiple ground and aircraft AGIE servers
- "Partitioned" AGIE network AGIE network partitioned for ACD, ASI, PIES *(NEW CONCEPT)*

Only the "Basic" and "Partitioned" network options are explained further in this section and additional architecture options are discussed in Appendix, Section 6.2.

3.2.1.1 "Basic" (or baseline) AGIE network

The "Basic" AGIE network is illustrated in Figure 2 and closely resembles **Figure** 1.

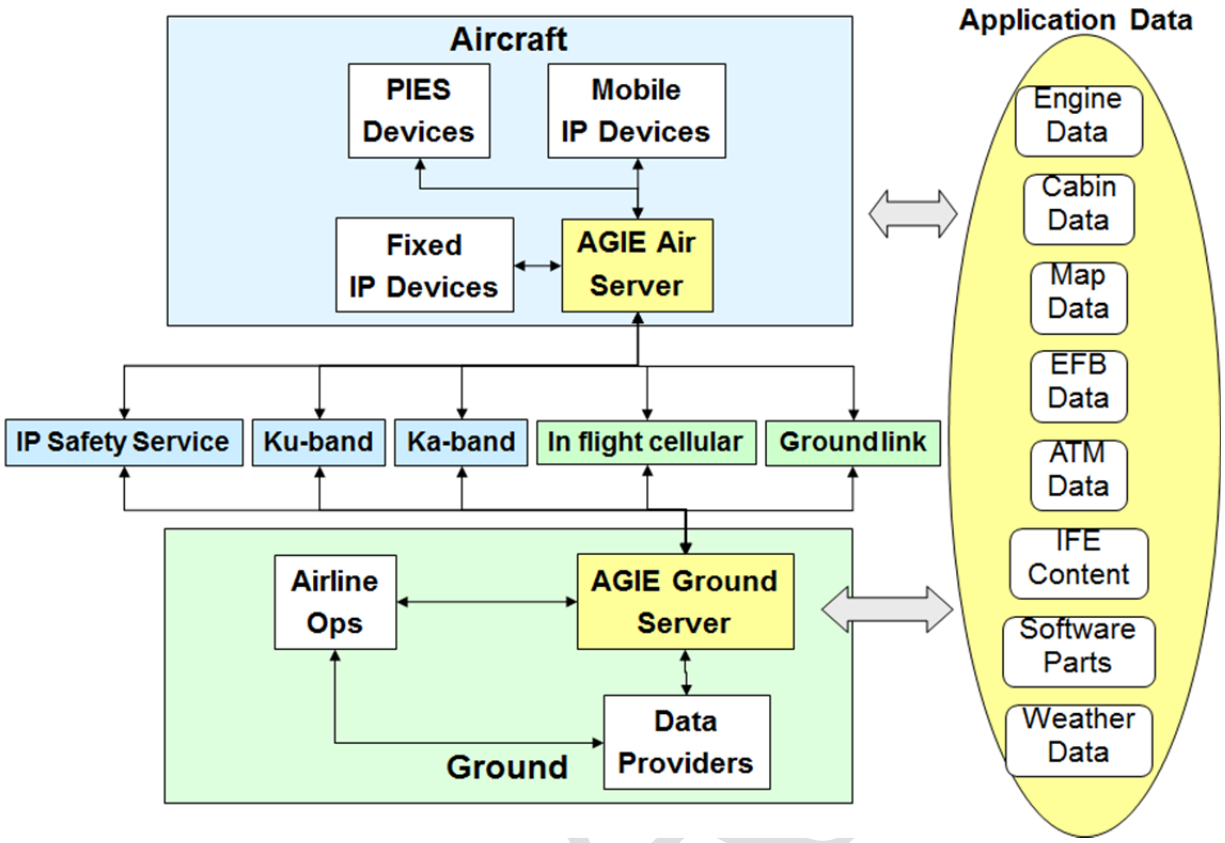


Figure 2 – Basic AGIE System Architecture

The "Basic" AGIE network topology (architecture) is characterized through the usage of a:

- Single, centralized ground server and a
- Single, centralized server on each airplane

This topology has the following **benefits/advantages**:

- Central ground management
- Secure air-to-ground
- Simple to understand
- All advanced AGIE messaging features
- No limits on functional capability for AIS or PIES

This topology has the following **disadvantages**:

- May not support higher critical applications
- Single air AGIE supports multiple domains
- No ground staging
- Global backhaul

- Single application enclave
- Single client point of access

3.2.1.2 "Partitioned" AGIE network

The "Partitioned" AGIE network topology (architecture) allows segregation of data traffic based on the aircraft domains (e.g. ACD, AIS or PIES) as illustrated in Figure 3.

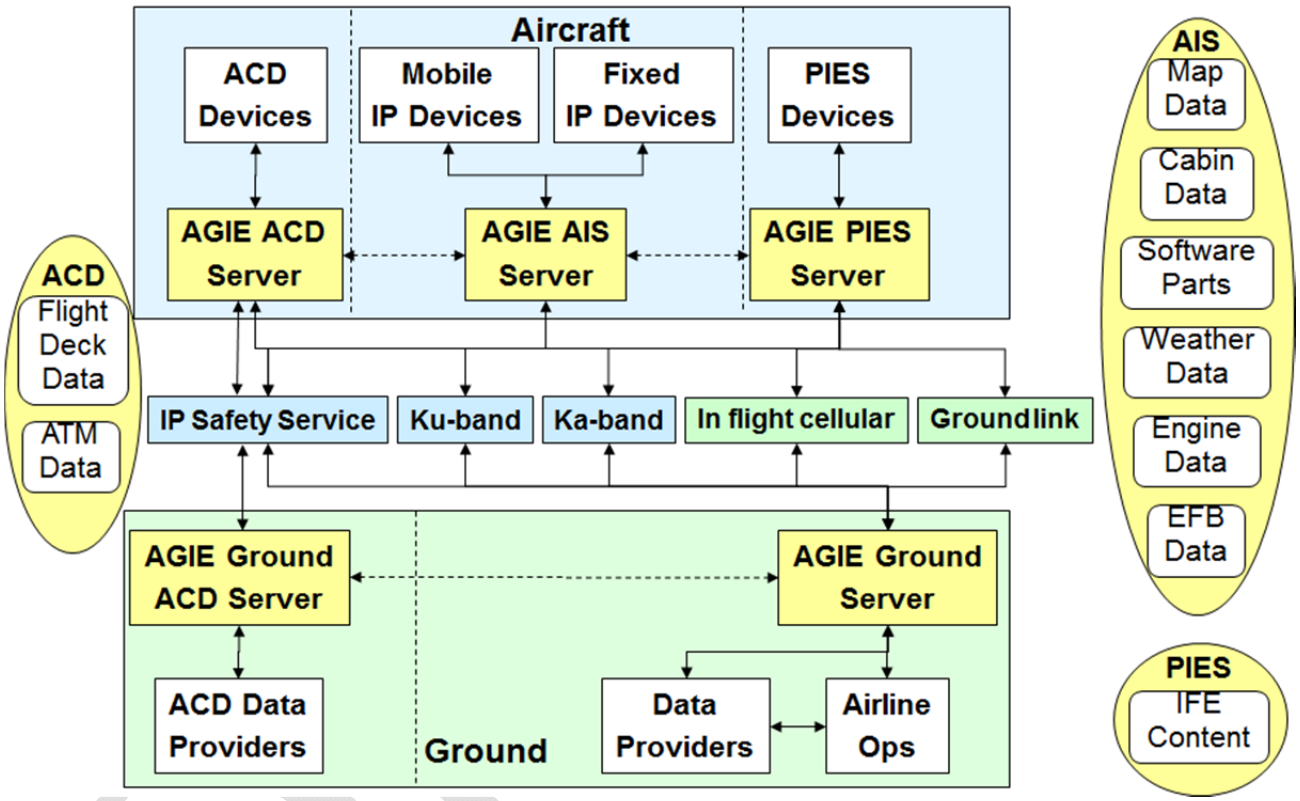


Figure 3 – Partitioned AGIE System Architecture

The "Partitioned" AGIE network topology (architecture) is characterized through the usage of dedicated AGIE client and server systems for each domain that function independent from each other. In essence the "Partitioned" AGIE topology comprises several "parallel" AGIE installations. Nonetheless these "parallel" systems (can) share aircraft/ground communication link resources.

Advantages

- Allows isolation of data traffic between domains and thus allows for high level of data security.

Disadvantages

- Higher operational overhead compared to the "Basic" topology.

Further details tbd[gw9]

3.3 Connection management

Within the framework of AGIE two types of communication connections exist:

1. Connections between an AGIE client and an AGIE server
2. Connections between two AGIE servers

The initiation of connection establishment is subject to the following rules/conventions:

1. A client always initiates a connection with a server, i.e. this connection is never initiated by the server and is referred to as a **client-server** association.
2. An aircraft based server always initiates a connection with a ground-based server, i.e. a ground-based server cannot initiate a connection with an aircraft based server and it is referred to as a **server-server** connection.
3. The precedence of connection establishment between two aircraft based servers or two ground based servers is generally not defined and may be mutual, i.e. either could initiate the connection but may be subject to precedence in "Partitioned" AGIE implementations.
4. An AGIE client can establish a direct connection with another AGIE client but a ground based (only) client can never associate with an airplane based server.

As AGIE is an application level (Layer 7) protocol AGIE connections should be viewed as logical links rather than physical communication links. For that reason one AGIE entity is said to be "associated" with another AGIE entity on an application level and this state indicates to each party that the ability to exchange information has been established. The actual physical link occurs outside the AGIE framework at a lower layer and is managed by the underlying protocol employed for actual transport of AGIE messages, described further in Section 3.4 "Protocol Binding".

The "association" process involves the exchange of specific coordination messages between two AGIE nodes (defined further in Section 4.2.2). Within AGIE the exchange of such messages is the only mechanisms through which AGIE entities "know" that the connection between the two is in fact operational though path requests and status messages may be used.

AGIE relies on the underlying transport protocol to provide connection heartbeat information based on IP's inherent capabilities. An AGIE implementation – irrespective of whether a server or client implementation – may therefore utilize the provisions of the underlying transport protocol to enquire about the status of a connection to another visible AGIE client (or node if enquirer is an AGIE server).

The creation of an AGIE connection, i.e. association, is automatic and does not include any human action or any external trigger by an application. However, in the event an application detects that the connection has been interrupted the party which normally initiates the connection MUST re-initiate the connection.

AGIE does not define a specific "dis-association" process. Once a connection is established it remains active until interrupted in some "abrupt" fashion, e.g. through loss of power to an LRU or aircraft/ground link interruption. There is no requirement to first terminate the connection from an application level. Nonetheless, at their discretion the application developer may implement a

specific/active "dis-association" process (message), e.g. to increase system efficiency. AGIE, however, does not specify a specific behavior for such a process.

A connection is considered interrupted when the communication is interrupted within the lower level data transport protocol.

3.4 Protocol Binding

The binding of the AGIE XML message documents to a data transport protocol is achieved through the use of the Advanced Message Queuing Protocol (AMQP) for both:

- Client to Server Communication
- Server to Server Communication.

Details regarding the nature of this protocol binding are defined in the subsequent sections.

3.4.1 Client/Server Protocol Binding

Here we need a run down on how AMQP should be used for client/server communication.

3.4.2 Server/Server Protocol Binding

Here we need a run down on how AMQP should be used for server/server communication.

3.5 AGIE Addressing

Addressing is a key element of the AGIE standard and MUST in accommodate the requirement to that the association between AGIE clients and AGIE server may be dynamic. EFB are particular good examples of AGIE clients that can regularly change association with AGIE servers. For example, the same EFB may be associated with an AGIE server on one aircraft, followed by a association with a ground based AGIE server while the pilot resides in a hotel and subsequently be associated with an aircraft based AGIE server for the next flight.

It is therefore necessary for an AGIE system to centrally maintain a database containing the following information for the entire AGIE system:

1. List of all defined AGIE clients
2. List of all defined AGIE servers
3. List of current associations between clients and servers
4. List of current connections between servers.

To assure that all AGIE nodes can access this central database it needs to be a ground based system. To do so at least one ground based AGIE server MUST be configured to perform AGIE DNS services and host all central databases in addition to standard AGIE server functions.

All aircraft/ground and ground/ground data exchange are automatically[gw10] routed through this central server for subsequent message routing based on the destination address.

It is, however, not practical for client to client data exchange within the *same* aircraft (or other sub-network) to require the routing messages through a central ground based server. Therefore, an aircraft based AGIE server (or other admin defined sub-network local DNS server) may also take the role of a DNS for a sub-network but with limited scope managing information for that particular aircraft (sub-network) only. Should a message be received whose destination is also an AGIE entity on the same aircraft (sub-network) then this message can be routed within the aircraft (sub-network) accordingly without requiring aircraft/ground communication.

To permit adequate DNS type service an AGIE server is identified via the following minimum set of attributes and maintained as an[gw11] XML document:

- SERVER_ID – specifies the formal server identifier/name given by the system integrator
- IP_ADDRESS – fixed IP address of the server
- SERVER_INSTALL – an indicator if server is aircraft or ground based may take one of the following two values: AIRCRAFT or GROUND
- SERVER_LOCATION – defines the physical location of the server and takes the following type of values:
  - Aircraft identifier (tail number or similar text defined by the operator) if aircraft based, e.g. D-AGIE, F-AGIE or N1234A
  - Geographic location if ground based, e.g. Chicago, Paris or Frankfurt
  - Other domain specific information, such as ACD, AIS, PIES

  Note: the aircraft identifier is required for aircraft servers but may be omitted for ground based servers.
- AGIE_DNS – indicates if the server performs the role of an AGIE DNS server with values as YES or NO
- CLIENT_LIST – list of formal client identifiers currently associated with this server (a server may have zero or more clients associated at any time) and a list of fixed clients attached (may or may not be associated) to the server.

It is paramount that this information be kept up to date to the best extent possible. Any time an AGIE server experiences a change in client/server association, or if defined by operator and implementation when information is requested, this server is required to send a coordination message to the other AGIE node providing the necessary updated information. This applies to the central ground based DNS as well as any aircraft based DNS AGIE nodes that perform this type of function.

3.5.1 The AGIE Address

AGIE defines two different types of addresses:

1. AGIE Client Addresses
2. AGIE Server Addresses

The identifiers contains within the address be composed of any characters that are permissible for use with conventional email and internet addresses.

3.5.1.1 AGIE Client Address

A standard AGIE *client* address follows the same general convention as standard email addresses and takes the general form:

<client_identifier>@agie.<airline_domain>

The "agie" token immediately to the *right* of the "@" symbol is required and serves as an indicator that the address represents an AGIE address rather than a conventional email address.

The token <airline_domain> is the nominal internet domain that an airline is associated with, e.g. "united.com", "airfrance.com" or "lufthansa.com" etc.

Examples of a full AGIE client address are[gw12]:

efb.fo@agie.lufthansa.com	(First Officer EFB AGIE address)
adl@agie.united.com	(Airborne Data Loader AGIE address)
flight_ops@agie.airfrance.com	(Ground based flight operations AGIE address)

For messages to be sent within the same domain (airline) it is not necessary for a sending client to specify the full address as the domain is assumed. An AGIE server automatically expands the address to the full definition. Only in the event a message needs to be sent to a different domain the right hand side of the address is necessary.

An AGIE client identifier may be a node, may be a particular application instant or even be a physical person. AGIE intentionally does not make any restrictions on how client identifiers are defined and this is left to the discretion of the system implementer.

Moreover, the AGIE standard does not stipulate how <client_identifiers> are constructed and this is also up to the implementer to define a suitable naming convention.

3.5.1.2 AGIE Server Address

The addressing of a specific server rather than an AGIE client is required for the exchange of coordination messages between AGIE servers. To differentiate a client address from a server address a standard AGIE *server* address takes the general form:

<server_identifier>.agie.<airline_domain>

Note the absence of the "@" symbol, which signifies that this address is a server address and not a client address.

The "agie" token is again required to identify the address as an AGIE address and the <airline_domain> is the same as for AGIE client addresses.

The <server_identifier> is the formal name of any AGIE server node as defined by the attributes defined for each server. Unlike AGIE clients AGIE servers MUST always use the full address to assure that are addresses are interpreted correctly.

3.5.2 Address Resolution

The following types of principal address resolution scenarios must be supported by AGIE:

1. A client sends a message to another client associated with the same server
2. A client sends a message to another client associated with a different server on the same aircraft (or sub-network)
3. An aircraft based client sends a message off the aircraft (either to another aircraft or a ground based client)
4. A ground based client sends a message to an aircraft based client
5. A ground based client sends a message to another ground based client associated with the same server
6. A ground based client sends a message to another ground based client associated with a different server

Address resolution is the process of determining how to "find" the destination server. Actual routing is then performed using standard IP routing between the given source and destination serves. This may be normal least cost destination routing or directed source-destination routing..

3.5.2.1 Address resolution sequence[gw13]

The following steps define the standard sequence of resolving AGIE addresses for messages originating from an aircraft or from a ground based node:

1. A client sends a message intended for another client to its server (i.e. the server it is associated with) – this step does not apply if the message originates from a server itself
2. The sending server checks if the receiver client is also associated with that server (which may in this case also be the DNS node) – if so the message is routed directly to the destination client
3. If the receiving client is not associated with the sending client's server also then the message is routed to the applicable DNS node:
    1. If the sender resides on an aircraft then the message is routed to the respective aircraft DNS node which then determines if the receiver is on the same aircraft – if so the message is routed accordingly directly to the destination client without requiring ground communication
    2. If the sender resides on an aircraft and DNS determines that the destination client is not on the aircraft the message is routed to the ground based DNS for further routing
    3. If the sender is a ground based client the message is routed to the ground DNS for further routing.

In the event an address cannot be resolved the sending server is provided with a non-deliverable notification.

The need and use of a DNS type service by certain AGIE servers as already described at the beginning of Section 3.5 as required to perform full address resolution.

To assure that AGIE DNS data is always up to date it is necessary for any AGIE server (aircraft or ground based) to "report" any change in client/server association to the central DNS node by sending the

respective CONFIGURATION COORDINATION message (see Section 4.2). If the change occurs within an aircraft (or detached sub-network) the aircraft based AGIE DNS as well as the central ground DNS node are informed. If the change occurs on the ground on the central ground based DNS needs to be informed. This may be accomplished by sending a complete client list to this server or only a change to that list or responding to a client or server association/connection/path request. The AGIE DNS will update its internal records accordingly. Such changes in association would only occur on a regular basis for portable devices but not for stationary devices.

If at any time it is determined that the address path was incorrect but the destination address was resolvable anyway the sender as well as the DNS are notified accordingly. Likewise the original "incorrect" address is replaced by the "correct" address.

3.6 AGIE data delivery management

AGIE supports a "store and forward" protocol. All end-system related "payload" type data are sent strictly from one AGIE *client* to another AGIE *client* with no exception. Internally AGIE may send some data to specific staging servers (defined as proxy servers) for efficient delivery to follow. To initiate a transfer of data to a destination client the originator client sends an XML document as a message to the server it is currently associated with using the protocol the client is associated with. This server locally stores the information until it is able to transfer this message to the either the destination server to which the recipient AGIE client is associated or attached, or to the designated proxy server; otherwise, i.e. whenever a an acceptable connection is established.

Within the AGIE standard definition only two logical servers exist:

a) the ORIGINATOR server from which a message originates after being submitted by a client

b) the DESTINATION server which "keeps" the message until it can be delivered to the destination client (proxy server may become destination for some message types and message groups, or when designated and the client association/attachment is not known.

While actual data paths may require multiple physical "server hops", depending on the underlying network topology, only the ORIGINATOR and the DESTINATION server are of relevance for an AGIE data transfer. The ORIGINATOR and DESTINATION server may in fact be the same AGIE server.

Data transfer between those two "end" servers is managed via standard TCP/IP protocol[gw14] in conjunction with any other aircraft/ground link infrastructure such as MAGIC.

For fixed, accessible end servers, the destination server locally stores the information until it is able to deliver the data to the final destination. For mobile non-accessible servers, the originator server stores the information. For clients with designated proxy servers the data is stored on the proxy server.

AGIE defines two principal classes of messages, described in detail in Section 3.6.2.2:

1. STANDARD messages used to transfer end-system application related data between AGIE clients
2. COORDINATION messages used to communicate any internal system management related information such as notifications, status enquires, connection coordination etc.

"Payload" data are communicated via STANDARD messages. For small data items the data can be encapsulated as part of the AGIE XML document body while for large volume transfers such data can be transferred as attachments to AGIE messages.

Each message is assigned a unique identifier which is a combination of the sender identifier plus an integer number which is unique to the server from which the message originates at the time the message is sent. Such integer may be re-used provided at the time of sending this number is unique.

The delivery of data may take two forms depending on the message type, class and message service used.:

1. The server notifies the client of the data and the client subsequently requests the data to be transferred to the client – this is the normal delivery mode for STANDARD messages and for one-to-many message services
2. The server can also "push" the data directly to a client when a connection is established without prior explicit notification if supported by the chosen protocol – this the normal delivery mode for COORDINATION messages and is also used for URGENT STANDARD messages for delivery of urgent messages or data which may need to be processed in near real-time;

   ***Note**: this mode should be used sparingly for STANDARD messages depending on the underlying AGIE implementation of priorities, queues, threads and resource scheduling.*

In addition, the client may poll a server for availability of data. When a client has received indication that data are available for this data the client asked the data to be transferred via a dedicated AGIE message.

AGIE also defines the capability to multi-cast and publish messages to multiple clients. Although operationally this is primarily intended for ground-based applications to broadcast to aircraft clients the standard does not impose this restriction explicitly. The delivery mechanism for multi-cast messages is similar to all other STANDARD messages and requires a one-to-one to the proxy then the one-to-many from proxy to the destination.

The exchange of data via AGIE is completely symmetrical, i.e. the same services apply for aircraft to ground as wells as for ground to aircraft messaging.

AGIE does not define how data are locally stored at any server location as part of the "store and forward" operation but provides operationally selectable options at originator, destination and proxy servers.

3.6.1 Data transfer prioritization

Within the framework of AGIE only two levels of fixed data priority are defined and they are "NORMAL[gw15]" and "URGENT". The vast majority of traffic is expected to be managed as NORMAL traffic.

As a rule all data are strictly queued and actioned on a First-In First-Out (FIFO) basis irrespective of their origin and/or destinations. Priorities are applied to server functions and communication paths/ports. With respect to NORMAL vs URGENT messages the following general rules apply:

1. URGENT messages take precedence over NORMAL messages
2. Newly appearing URGENT message generally are placed ahead of the queue
3. URGENT messages are queued in FIFO order with respect to each other

4. URGENT can suspend the processing of a NORMAL message provided the URGENT message is of less than some maximum parameter defined size; otherwise transfer of message in progress continues until completion and the new URGENT message will become the next one to be serviced.

   ***Note**: this could in principle lead to a situation where no NORMAL messages are ever processed and hence the use of URGENT message should be used sparingly, therefore it is expected that AGIE implementations service queues and ports with independent computing threads with a type of priority-fair-weighted queuing mechanism in a manner that appears to have independent queues for each input-output port (per connection).It is not acceptable for a low priority message or a very large message to block server functions and/or transmission of higher priority messages or COORDINATION messages.*

The AGIE standard does not stipulate how many queues a particular server (or client) may maintain, e.g. it may be possible that a server maintains a separate queue for each client that is associated with that server. Likewise, there may be separate queues to manage more than one connection to other AGIE servers. However, it is assumed that any single event (client message or COORDINATION message transfer or server processing function will not block other higher priority functions. Also, it is assumed that efforts will me made to ensure the multiple, high cost, low-bandwidth communication links are efficiently utilized within administrator settings.

The prioritization rules however apply to each such queue individually.

The use of "URGENT" traffic should be restricted to cases where near real-time transaction processing is desired and/or required or in the event important information is to be delivered to clients. Moreover, "URGENT" messages are recommended to only be used for small data items.

The AGIE definition provides for a system administrator to define maximum data sizes to apply to URGENT data. Should such a maximum data size be defined for a system, then, in the event that the size of a particular data transaction exceeds this value, such transfers are actioned as "normal" only regardless as to whether this transaction is designated as "urgent" or "normal" and a message sent to the originating client of this action. Moreover, if a maximum "urgent" data size is defined then this maximum applies globally to the entire system. Also provided is the ability to declare a maximum size for each path dependent on connection limitations and capabilities.

Data transactions designated as "urgent" are always "pushed" by the server to any associated client. In the event the destination client of an "urgent" message is not associated to the server, which holds this message, then this server needs to deliver this message as soon as this client associates with that server, provided the latest delivery date has not yet expired. The administrator will always have the option to choose this parameter sufficiently large to allow most data sizes to be treated as "URGENT" should this be necessary.

"NORMAL" is the default priority attribute value for all transactions.

A message field is provided to allow the implementation to support more fidelity in prioritization. This is a free text capability and is not further defined in this document. Any additional level of prioritization is either managed on an end-system application level or within lower level transport layer, such as QoS or any prioritization rules implemented by MAGIC (ARINC 839 standard) or ground side IP network or by the ISP/DSP. A priority interface is provided between AGIE and the underlying IP network to map AGIE message priorities to IP network priority mechanisms.

3.6.2 Delivery status management

All AGIE servers *must* track the status of a message they originate until successful delivery or a non-delivery status or timeout is determined.

A sending client can enquire about the status of a message at any time while this message is in transit. This is done through special ENQUIRY messages (see Section 4.1).

AGIE must also ensure a history of all transactions is maintained. The retention period thereof is likely to be largely defined based on regulatory and/or operational considerations and are in any case configuration defined and managed by associated network or systems management functions. It is expected that aircraft side transaction history and/or event logging is minimized and all air-to-ground transactions are logged on the ground side. Also when possible aircraft logged events are transferred to ground services for logging.

AGIE does not define actual such retention time values, or require AGIE functions to log events, but does define as a requirement that transaction logs are created and retention periods are definable and defines different parameters and interfaces for each of:

- Aircraft based clients
- Aircraft based servers
- Ground based servers
- Ground based clients

3.6.2.1 Delivery Date/Time Parameters

To manage delivery and associated notifications the AGIE standard defines the following message delivery related date/time parameters which are passed as part of AGIE messages and serves various purposes:

1. Origin Date/Time
2. Delivery Date/Time
3. Creation Date/Time
4. Effectivity Date/Time
5. Expiry Date/Time
6. Latest Delivery Date/Time
7. Resubmission Date/Time

The first two parameters server informational purpose only and may be used for purposes such as transaction logging etc. Parameters 3-5 are mainly of interest to the applications that consume the information, while the last two attributes factor into the delivery mechanism of data itself. Table 1 summarizes these attributes including their intended purpose/use.

Table 1 – AGIE Date/Time Attributes

Date/Time Attribute	Attribute Description/Definition	Used By/For
Origin Date/Time	Date/time stamp set at the moment a message is sent by the message originator.	**By**: Any message consumer **For**: Maintain internal reference of receipt and for possible receipt confirmation
Delivery Date/Time	Date/time stamp set at the moment a message has been successfully received by the intended recipient of a message. This attribute is not part of the original message and is only used for receipt notification as well as event logging purposes.	**By**: Any message consumer **For**: Maintain internal reference of receipt and for possible receipt confirmation
Creation Date/Time	Date/time at which sent data was generated (which may not be the same as "Origin_Date/Time). This attribute is generally more of relevance to attachments rather than directly encapsulated payload data.	**By**: Destination application **For**: Informational purpose
Effectivity Date/Time	Informs consumer of message of the date/time at which the payload information of a message becomes of relevance to the receiver application(s).	**By**: Destination application **For**: Establish start of data validity period
Expiry Date/Time	Defines date/time at which the payload information of a message is no longer of relevance to the receiver application(s). This attribute may be used to determine if further attempts to deliver this message may be stopped.	**By**: • Destination application • AGIE servers • Message originator **For**: • Determine if stopping delivery attempts • Provide notification to message originator • Generate alert to system operator
Latest Delivery Date/Time	Defines date/time at which a message needs to reach the intended destination at the latest. Inability to deliver data by this date/time results in alerts being generated to the system operators. This is a compulsory message attribute.	**By**: • AGIE servers • Message originator **For**: • Provide notification to message originator • Generate alert to system operator

Date/Time Attribute	Attribute Description/Definition	Used By/For
Resubmission Date/Time	Defines an intermediate date/time value which may be used to inform the originator of a message of the inability to delivery some time prior to the **Latest Delivery Date/Time** date/time so that the originator may resubmit this message at its discretion. This is an optional message attribute.	**By**: • AGIE servers • Message originator **For**: • Server provides notification to message originator • Originator may resubmit message/data upon notification

3.6.2.2 Inability to deliver

In the event a delivery path cannot be determined, a client does not accept data which is pushed by the server or alternatively the client does not retrieve data from the server by the time the **Latest Delivery Date/Time**, **Expiry Date/Time** or **Resubmission Date/Time** has expired (see Section 3.6.2.1), the server sends a non-delivery notification to the originator of the message. If delivery cannot be made by either **Latest Delivery Date/Time** or **Expiry Date/Time** some type of alert needs to be presented to a system operator representative or to the originating application (e.g. system administrator) on the ground of the inability to deliver or partial delivery for large messages.

3.7 AGIE system configuration management

Aircraft are identified by unique identifiers, with which an air operator registers its fleet. This is typically the aircraft registration but it is also possible to use other means of identification provided all aircraft within the fleet can be uniquely identified within the fleet.

AGIE only works within this closed system. Any communication to external systems must occur via one of the AGIE clients and this would typically apply primarily to ground based systems.

Also, in the event of a configuration update being received the AGIE server from admin, the server will push the new configuration to all the clients which are connected at that time.

At any time a client reconnects with a server the server provides, as part of the acknowledgement of the connection, the meta data of the latest configuration.

Likewise, whenever an aircraft resident server must reconcile with a ground based server that it does in fact have the latest configuration parameters at hand. Any server will keep two copies of the system configuration: the most recent one and the one preceding it.

There is a static server configuration definition file and a static client definition file. Both files are read-only XML files which can only be amended by an authorized system administrator.

On the other hand an AGIE client can connect and disconnect itself from the network at any time. However, all possible AGIE clients must be known to the Primary server if connected or the local DNS server if part of a disconnected sub-network.. The dynamic aspect is to associate any known clients with a known server which can change dynamically.

The AGIE servers must dynamically exchange information regarding which client is associated which server at any given time. The purpose of this is to allow clients to be moved dynamically such as Class I EFBs. A possible scenario is a flight crew member connects to a ground-based AGIE server in a hotel room then removes the EFB from the network and reconnects after he/she has entered the cockpit and reconnected to another server on the aircraft.

4 AGIE Messaging

4.1 AGIE message definitions

All AGIE data transactions involve the exchange of special AGIE XML documents as messages and messages can be exchanged between two clients, two servers or between a client and a server. However, true "payload" type messages occur between clients only and messaging between servers is used for system management purposes only.

AGIE defines two primary message *classes*:

a) **STANDARD** messages which are used for exchange of end-system specific information between two AGIE clients only

b) **COORDINATION** messages which represent all other non end-user "payload" related data communication and are categorized as one of the following (further described in Section 4.1.1.1:

- NOTIFICATION messages
- ENQUIRY messages
- CONNECTION (management) messages

Both the STANDARD and COORDINATION messages have each standard sets of attributes as described in Section 4.1.1. Some of those attributes are shared between the two message classes.

Each message requires a specific and unique **MsgID**. The value is auto-assigned by the AGIE node (client or server) from which the message originates. The respective convention for establishing the value this identifier is defined in Section 4.1.1.2.

STANDARD messages do not require any additional message type classification other than the message priority, message server, and message group. COORDINATION class messages, however, require further type classification is defined to permit establishment of specific COORDINATION message purposes, see Section 4.1.1.2.

The AGIE standard does not define specific methods for data exchange. Instead, all AGIE messaging strictly consists of one node (server or client) sending an (XML) AGIE document to another AGIE node with the XML documents themselves containing all necessary information that may need to be conveyed to another AGIE node.

The use and inter relationship of and between COORDINATION messages is described in Section 4.2.

4.1.1 AGIE message attributes

The pre-defined set of attributes for STANDARD messages is defined in Section 4.1.1.1 and the pre-defined set of attributes for all COORDINATION messages is defined in Section 4.1.1.2.

The set of attributes are intended to be sufficiently comprehensive as part of the AGIE XML message document itself to permit complete management of the messages across an entire AGIE system.

Some attributes are compulsory for all messages, while some are required for certain types of messages only, others are optional (like Operational Priority Value). Attributes that have default values assigned are interpreted consistent with those return values if the attribute is not part of the message itself.

***Note** that for all text based message fields all leading or trailing white spaces of the content are ignored when interpreted. This allows any AGIE client or server implementation to trim such content accordingly.*

Default values are assigned automatically if not explicitly provided by the sender of a message.

4.1.1.1 STANDARD Message Attributes

For STANDARD messages the **MsgClass** value is always **STANDARD** and its purpose is to convey end-system/application data between AGIE clients. Table 2 defines all attributes of a STANDARD messages that are contained within the XML message document.

Table 2 – AGIE STANDARD Message Attributes

Message Attribute	Attribute Description/Definition	Value Profile
MsgID	Unique message identifier assigned by originator of the message – this id is unique from the orignators point of view	Auto assigned as defined in Section 4.1.1.2 Compulsory: Yes Default value: *none*
MsgClass	Defines if this is a "payload" or a coordination type message	For STANDARD message this value is always **STANDARD** Compulsory: Yes
MsgPriority~~Type~~	Specifies the priority of the message	Can take one of the following values: • **NORMAL** (default) • **URGENT** (for high priority delivery)
MsgGroup	**Specifies grouping of messages for the purpose of supporting Publish & Subscribe, i.e. Publish & subscribe registration is based on this value.**	**Free Text Field up to 64 bytes in length and can take any value.** **Compulsory: No** **Default value: *empty string – if blank then message is not subject to publish-subscribe service***
Description	Optional text field intended to provide a short subject line similar to an email subject line. This field may be used to provide a brief description for attachments or instructions relating to encryption of the associated data	Free Text Field up to 256 bytes in length Compulsory: No – but its use is encouraged Default value: *empty string*

Message Attribute	Attribute Description/Definition	Value Profile
DestinationClientAddress	Compulsory attribute defining the AGIE address(s) of the final destination of the message For multiple addresses this is an array of addresses all of which are separated from each other using the ";" (semicolon) symbol.	AGIE Client Address as defined in Section 3.5.1.1 Compulsory: Yes Default Value: *none*
SourceClientAddress	Compulsory attribute defining the AGIE address of sender of message	AGIE Client Address as defined in Section 3.5.1.1 Compulsory: Yes Default Value: *none*
NextServerAddress **StagingServerAddress??**	Address of the next server a message is to be routed to.	AGIE **Server** Address as defined in Section 3.5.1.2 Compulsory: No – when sent by clients Yes – when being forwarded from one server to another server Default Value: *none*
LastServerAddress	Address of the most recent server that is holding this message.	AGIE **Server** Address as defined in Section 3.5.1.2 Compulsory: No – when sent by clients Yes – when being forwarded from one server to another server Default Value: *none*
Origin_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: Yes Default Value: *none*
Delivery_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: Yes Default Value: *none*
Creation_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: No Default Value: *none*

Message Attribute	Attribute Description/Definition	Value Profile
Effectivity_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: No Default Value: *none*
Expiry_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: No Default Value: *none*
LatestDelivery_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: Yes Default Value: *none*
Resubmission_DateTime	As per Table 1	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: No Default Value: *none*
ReturnReceipt	Specifies if the receiver needs to send a special message to an originator acknowledging the receipt of the message. The return receipt is a NOTIFICATION message (see Section 4.1.1.2.1	Can take one of the following values: • **NO** • **YES** Compulsory: No Default value: **NO** (assumed if field is not present)
MsgContent	This attribute contains the message payload if not provided though an attachment. This is a compulsory attribute but may be of zero length. How the data is encoded is defined through the **ContentType** attribute. Additional data can be provided through **Attachments** (see below).	Free Field Text of arbitrary length but recommended to not exceed 2048 bytes. Compulsory: Yes Default Value: *empty string*
ContentType	Describes how the information in **MsgContent** is encoded.	Can take the following values: **ASCII** **UNICODE** **BINARY** Compulsory: Yes if not ASCII Default: ASCII

Message Attribute	Attribute Description/Definition	Value Profile
Attachments	Array of values describing the size (in bytes) of the attached files as well as the respective path (URL) through which the files can be retrieved. This attribute is not mandatory and if omitted attachments are presumed to not be present.	Array of two values, the first defines the size of the attachment and the second the path/url through which the attached data can be accessed. If omitted no attachments are expected Compulsory: No Default Value: <**0**, ""> i.e. zero and blank string[gw16]

At this point a good example of a full AGIE message needs to be provided - tbd

4.1.1.2 COORDINATION message attributes

This section describes the various **types** of messages defined within the AGIE standard that serve the purpose of coordinating communication between AGIE nodes. Table 3 lists the pre-defined attributes of a COORDINATION message XML document.

Table 3 – AGIE COORDINATION Message Attributes

Message Attribute	Attribute Description/Definition	Value Profile
MsgID	Unique message identifier assigned by originator of the message – this id is unique from the orignators point of view	Auto assigned as defined in Section 4.1.1.2 Compulsory: Yes Default value: *None*
MsgClass	Defines if this is a "payload" or a coordination type message	For COORDINATION messages can take one of the following values: • **NOTIFICATION** • **ENQUIRY** • **CONNECTION** Compulsory: Yes Default value: *None*
MsgType	Future specifies the nature of a particular message	Possible values depend on **MsgClass** value – see Sections 4.1.1.2.1 through 4.1.1.2.3

Message Attribute	Attribute Description/Definition	Value Profile
Description	Optional text field that may contain relevant information regarding a particular message type.	Free Text Field up to 256 bytes in length *(length limit required?)* Compulsory: No – but encouraged Default value: *empty string*
MsgReference	**MsgID** reference required by many **COORDINATION** type messages to which the latter applies	Same format as **MsgID** Compulsory: required for most COORDINATION messages Default value: *none*
DestinationAddress	Compulsory attribute defining the AGIE address of the final destination of the message which could be client or a server This may be an array of addresses all of which are separated from each other using the ";" (semicolon) symbol.	Format as defined in Section 3.5.1.1 or Section 3.5.1.2 Compulsory: Yes Default Value: *none*
SourceAddress	Compulsory attribute defining the AGIE address of original sender of a message which could be client or a server	Format as defined in Section 3.5.1.1 or Section 3.5.1.2 Compulsory: Yes Default Value: *none*
NextServerAddress	Address of the next server a message is to be routed to.	AGIE **Server** Address as defined in Section 3.5.1.2 Compulsory: No – when sent by clients Yes – when being forwarded from one server to another server Default Value: *none*
LastServerAddress	Address of the most recent server that is holding this message.	AGIE **Server** Address as defined in Section 3.5.1.2 Compulsory: No – when sent by clients Yes – when being forwarded from one server to another server Default Value: *none*

Message Attribute	Attribute Description/Definition	Value Profile
Msg_DateTime	Date/Time stamp at which the message was created.	Single field using the following format: <YYYYMMDD-hh:mm:ss> Compulsory: Yes Default Value: *none* – auto assigned
MsgContent	This is attribute is used for some COORDINATION message to convey relevant information and its format depends on the purpose – see Section 4.1.1.2.1 through 4.1.1.2.3	Free Field Text of arbitrary length but recommended to not exceed 2048 bytes. Compulsory: Yes Default Value: *empty string*[gw17]

The different types of COORDINATION messages are described further below.

4.1.1.2.1 NOTIFICATION message attributes

The purpose of this message is to provide an *unsolicited* notification of some type from one AGIE node to another, which can be server to client or server to server (typically). NOTIFICATION messages do *not* generate a response from the recipient.

For NOTIFICATION message the **MsgClass** value is "**NOTIFICATION**".

Table 4 – Predefined NOTIFICATION message values

MsgType	Purpose	MsgReference	MsgContent
DATA_AVAILABLE	A server notifies a client that data are available for retrieval for that client	*Not used*	Array of **MsgReference** values that is available for retrieval by a client Compulsory: Yes Default Value: *none*
FETCH_DATA	Client instructs the server to send one or more messages listed in the MsgContent field of the DATA_AVAILABLE message that precedes this message. Server then sends the actual STANDARD messages	*Not used*	Array of **MsgReference** values that is available for retrieval by a client Compulsory: Yes Default Value: *none*
ACKNOWLEDGE	General purpose message to acknowledge the receipt of any other message irrespective of the type of message or which sender	**MsgID** of message being acknowledged	*Not used*

MsgType	Purpose	MsgReference	MsgContent
CONFIG_UPDATE	Notifies recipient that of any change in system configuration	*Not used*	Includes relevant information about system configuration changes such as adding or removing AGIE addresses – further described in Section NN. *(not entirely clear if this is required)*
MSG_RECALL	Instructs AGIE servers to no longer attempt delivery of an already sent message. This essentially cancels a message	**MsgID** of message being recalled	*Not used*
MSG_RESUBMIT	Send by a server after expiry of **Resubmission_DateTime**	**MsgID** of message to be resubmitted	*Not used*
ALERT	Notifies a node of a certain event or that an expected event has not taken place within a predefined period of time	**MsgID** of message being referenced	Possible values are: ▪ **NON_DELIVERY –** inability to deliver a message by requested time ▪ **LATE_DELIVERY –** inability to deliver a message in time ▪ **INCORRECT_ADDRESS** – addressee not found ▪ **LINK_DOWN** – sent if aircraft/ground link has not been available for a specified period of time; used for server to clients if messages are pending for delivery between aircraft and ground (either direction) *Others?*

4.1.1.2.2 ENQUIRY message attributes

The purpose of ENQUIRY messages is for one AGIE node to enquire about a particular piece of information. Unlike NOTIFICATION messages ENQUIRY messages require a response by the recipient such that the **MsgType** value always come in pairs as described in Table 5.

(so far only three types of enquiry are identified but there may be more)

Table 5 – Predefined ENQUIRY message values

MsgType	Purpose	MsgReference	MsgContent
DELIVERY_CHECK	Sent by any node to enquire about delivery status of a particular message	**MsgID** of message being referenced	*Not used*
DELIVERY_STATUS	Response to a **DELIVERY_CHECK** enquiry	**MsgID** of preceding **ADDRESS_ CHECK** message	Possible values are one of: ▪ **DELIVERED –** if at final destination ▪ **IN_TRANSIT –** if not yet at final destination ▪ **FAILED –** if delivery was not feasible ▪ **RECALLED –** if a message was recalled by the sender Plus the following: **AGIE address** of node that currently holds the message and **Date/Time** at which the message had arrived at that node
LINK_CHECK	Check on availability of aircraft/ground data link. Can be initiated from a ground AGIE member or an aircraft based AGIE member	*Not used*	*Not used*
LINK_STATUS	Response to a **LINK_STATUS** enquiry	**MsgID** of preceding **ADDRESS_ CHECK** message	Possible values are: ▪ **LINK_OK –** if a link is currently operational or ▪ **LINK_DOWN –** if no link is currently operational
ADDRESS_CHECK	Used to check if a destination address can be reached without requiring aircraft/ground data link, i.e.	*Not used*	Address of AGIE member (client or server) to be checked for ability to accessed
ADDRESS_STATUS	Response to ADDRESS_CHECK	**MsgID** of preceding **ADDRESS_ CHECK** message	Return value can be one of: ▪ **ON_AIRCRAFT <aircraft identifier>** indicating the address represents a member that entity on that aircraft ▪ **ON_GROUND** indicating the address represents a ground based member at this time ▪ **NOT_FOUND** indicating that address could not be resolved by the server directly
GET_PUBLISHED	Client requests from server a list of all MsgGroups that may be subscribed to from this server	*Not used*	*Not used*
ALL_PUBLISHED	Send list of published MsgGroups by a server to a client	*Not used*	Return value is list of Published MsgGroups

MsgType	Purpose	MsgReference	MsgContent
SUBSCRIBE	Client instructs host server to inform client of any message belonging to the list of MsgGroups	*Not used*	List of MsgGroup identifers to which a clients which to subscribe
SUBSCRIBE_ALL	Client subscribes to all data items available through client.	*Not used*	*Not used*

4.1.1.2.3 CONNECTION message attributes

The purpose of CONNECTION messages is to coordinate a AGIE level communication link between two AGIE nodes. Table 6 defines the predefined attribute values for CONNECTION messages.

Table 6 – Predefined CONNECTION message values

Message_Class	Purpose	MsgReference	MsgContent Values
CONNECTION_ REQUEST	For a client or a server to request establishment of an AGIE link	Not used	*Not used*
CONNECTION_ RESPONSE	Response to CONNECTION_REQUEST	MsgID of **CONNECTION_ REQUEST** message that is responded to	Can take one of the following values: ▪ **GRANTED –** response from server to requestor to "allow" connection ▪ **STANDBY –** response from server to notify requestor that a request cannot be serviced immediately ▪ **UNABLE –** response from server to notify requestor of the inability to grant the request, e.g. due to lack of authentication

4.1.2 Message Identifier

All AGIE messages are encapsulated as XML documents. To assure complete uniqueness the message identifier is as follows essentially a combination of date/time and *sender* full AGIE address e.g.:

"<Random Seq Num>-YYYYMMDD:<AGIE identifier>"

For example a typical message identifier *could* be:

"12345678-20100312:fo.efb"

The random sequence number is assigned by the sending component and SHOULD be sufficiently large to minimize the possibility of duplication.

4.2 AGIE message management

This section further defines when and how certain message classes and types are used.

4.2.1 STANDARD message management

(This section is meant to address various scenarios that may be encountered while a STANDARD messages is in "transit")

Standard messages serve the purpose of conveying some type of end-system (application) information to another application, where both the sender and recipient are AGIE clients. The payload content of STANDARD messages is of no relevance to any of the AGIE nodes (that also includes the AGIE clients) and is only of interest to the sending and receiving applications themselves.

Any client can send a STANDARD message at any time to any other AGIE client within its visibility anywhere in the system. However, the actual process of delivery of such STANDARD messages can be influenced by a number of factors such as:

- Location of both clients, i.e. on/off aircraft, different aircraft etc
- Link availability for aircraft/ground data exchange
- Type of protocol being employed for data transport
- Message service being employed
- Availability of destination client, destination server, whether destination client is fixed or mobile, and if a proxy host has been defined.

4.2.1.1 STANDARD message exchange scenarios

~~1.~~ STANDARD message exchange by definition involves the transfer of "payload" messages between AGIE clients only (conceptually illustrated in Figure 4) and may involve messages being sent from:

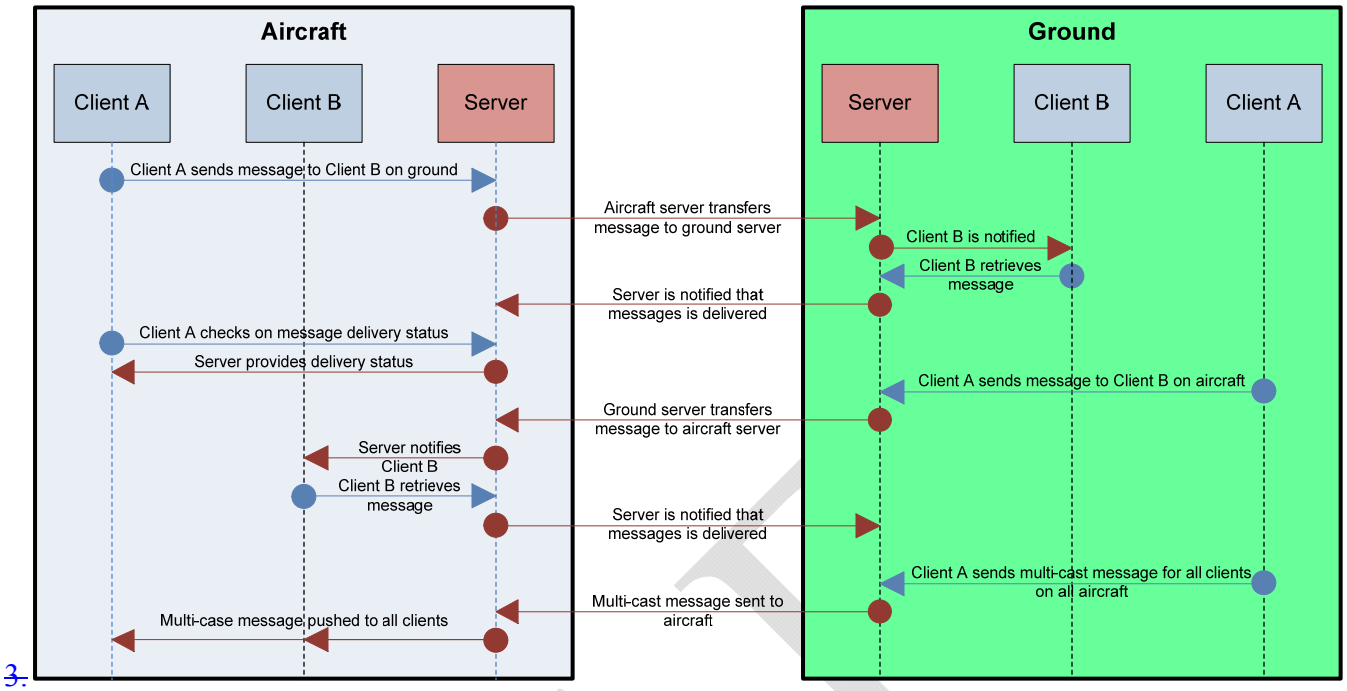
~~2.~~**1.** An aircraft application to a ground application

~~3.~~**2.** A ground application to another ground application

~~4.~~**3.** A ground application to one or more aircraft applications

~~5.~~**4.** One application on an aircraft to a different application on the same aircraft

~~2.~~



3.

Figure 4 – Basic payload message exchange sequences

4.2.2 COORDINATION message management

4.2.2.1 NOTIFICATION message management

Notifying another AGIE node of something

4.2.2.2 ENQUIRY message management

Checking on various status entities

4.2.2.3 CONNECTION message management

This function involves the establishment of operational network connections between AGIE nodes as conceptually illustrated in Figure 5, which in particular shows connection establishment between

- Aircraft client to aircraft server
- Ground client to ground server
- Aircraft server to ground server
- Aircraft client to ground server

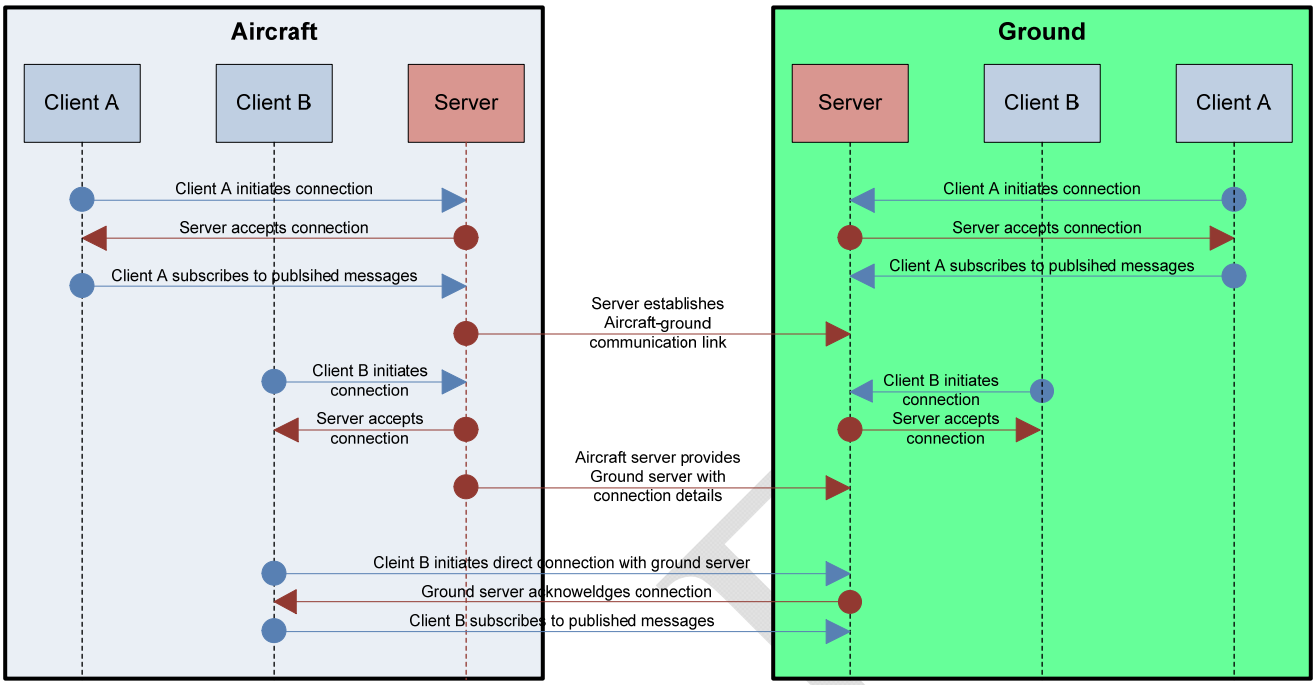


Figure 5 – Connection establishment message sequence

4.2.3 Connection Authentication

Use of keys etc – tbd…

4.3 Message Attachments

Any STANDARD message may include an attachment but only one attachment per message. Attachments use the MIME standard.

5 AGIE Information Security

The AGIE standard does not stipulate any particular Information Security[gw18] related requirements. Instead, AGIE makes the assumption that any AGIE entity is being properly authenticated at a lower network level.

Moreover, AGIE intentionally does not impose any data encryption type of requirements to assure flexibility. This type of information security measure is implemented by the aircraft/ground link technologies themselves and/or by the end-system applications.

AGIE's role is to assure data are transported to the intended destinations, free from unintentional snooping, securely and delivered accurately and in a timely manner using a certifiable mechanism.

However, if an AGIE node is not properly authenticated at a lower communication protocol layer and therefore is not able to deliver messages for that reason then the respective delivery status MUST reflect this fact, i.e. use a predefined non-delivery reason.

6 Appendices

6.1 AGIE Transport Protocol Definition

6.1.1 Details on AMQP Protocol Binding

tbd…

6.2 AGIE System Architectures

Examples of AGIE architectures are discussed in Section 3.2 which discusses the "Basic" as well as the "Partitioned" networks in more details. Two additional examples are provided here as well, i.e. Minimal AGIE and Federated AGIE.

Tbd..