International Civil Aviation Organization
CAR/SAM Regional Planning Implementation Group (GREPECAS)
CNS/ATM Subgroup
Coordination meeting of the ATN ground-ground and ground-air applications project
(Lima, Peru, 19 to 20 May 2010)

Agenda Item 1: Review of the ATN CAR/SAM Planning/Implementation Activities

d) IP routing policy

(Presented by the Coordinator)

SUMMARY	
This working paper presents a set of recommended routing policies for the Caribbean/South America (CAR/SAM) Region Aeronautical Telecommunications Network (ATN) Message Handling system (AMHS) service using the Internet Protocol that is based on MEVA II and REDDIG networks as well as dedicated circuits.	
***ICAO strategic objectives*:**	*A – Safety* *D - Efficiency*

1. Background

1.1 This proposed CAR/SAM AMHS IP Routing Policy (AMHS ground -to-ground version) was presented, reviewed and updated during the last ATN Task Force Meeting held in ICAO NACC Office in Mexico City on 12-13 June 2009. This document presents a set of recommended Routing Policies for the Caribbean/South America (CAR/SAM) Region Aeronautical Telecommunications Network (ATN) Message Handling system (AMHS) service using the Internet Protocol and based on MEVA II and REDDIG networks as well as dedicated circuits.

1.2 This document is meant to describe the Regional routing protocols and policies that are to be used for the use of the ATN AMHS and based on the use of the IPS-based networks for exchanging ATN AMHS messages.

2. Suggested Action

2.1 The IP Routing Policy document must be reviewed and updated accordingly during this meeting.

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APPENDIX

CAR/SAM AMHS IP ROUTING POLICY
(AMHS GROUND-TO-GROUND VERSION)

VERSION 2.00
(THIRD DRAFT)

EXECUTIVE SUMMARY

The CAR/SAM Region has agreed to use IPv4 as the underlying communication infrastructure for AMHS instead of the ATN ICS. In order to route AMHS messages between States and Organizations in the Region, BGP-4 has been selected as the routing protocol. This document presents the definition of routing policies that should be enforced between BGP-4 routers within the Region.

DOCUMENT CONTROL LOG

Edition	Date	Comments	Section/Pages Affected
0.1	23 March 2007	First Draft	All
0.2	28 June 2008	Second Draft	Add Document Control Log
2	13 June 2009	Third Draft	Utilize IPv4 and MEVA/REDDIG dedicated circuits

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1. Introduction

The CAR/SAM Aeronautical Telecommunications Network (ATN) Task Force, and now the ATN Ground-ground and Ground-air Applications Project, is developing its plans for implementing ATN applications throughout the Region. The plans are being described in a set of documents. This document, as a part of the set, describes the network routing protocols and policies that define the Regional network routing.

1.1 Objective

This document is meant to describe the Regional routing protocols and policies that are to be used for the use of the ATN AMHS. This document focuses on the specification of routing protocols and policies based on the use of the IPS-based networks for exchanging ATN AMHS messages.

1.2 Scope

This document is limited to describing the IPS routing protocols and policies to be used between States and Organizations (inter-domain) within the Region.

1.3 References

[1]	ICAO Doc 9705-AN/956	Manual of Technical Provisions for the ATN
[2]	TBD	Proposed Draft of the CAR/SAM Regional AMHS Transition Plan
[3]	RFC 4271	BGP-4 Specification
[4]	RFC 4272	BGP Security Vulnerabilities Analysis
[5]	RFC 4360	BGP Extended Communities Attribute
[6]	RFC 4384	BGP Communities for Data Collection
[7]	RFC 4451	BGP MULTI_EXIT_DISC (MED) Considerations
[8]	RFC 4456	BGP Route Reflection: An Alternative for Full Mesh Internal BGP (IBGP)
[9]	RFC 4486	Sub codes for BGP Cease Notification Message
[10]	RFC 4724	Graceful Restart Mechanism for BGP
[11]	RFC 4760	Multiprotocol Extensions for BGP-4
[12]	RFC 4781	Graceful Restart Mechanism for BGP with MPLS

1.4 Terms Used

Routing Domain	–	A collection of systems that are administered by a single administrative authority that is regulated by a particular set of administrative guidelines. Routing domains are also called autonomous systems.
Intra-domain routing	–	The routing of packets within a single routing domain. Intra-domain routing is based on a level of trust between systems operating within the domain.
Inter-domain routing	–	The routing of packet between routing domains. Inter-domain routing is based on mutual miss-trust in the reception of routing information from other domains.

Autonomous System	–	Another term used within the Internet community for Routing Domain

1.5 Acronyms

ATN	–	Aeronautical Telecommunications Network
AMHS	–	ATN Message Handling System
CLNP	–	OSI Connectionless Network Protocol
IDRP	–	OSI Inter-Domain Routing Protocol
ICS	–	ATN Internet Communication Service
ES	–	End System
IS	–	Intermediate System
NSAP	–	Network Service Access Point
BIS	–	Border Intermediate System
BBIS	–	Backbone Border Intermediate System
BG	–	Border Gateway
BGP	–	Border Gateway Protocol
RFC	–	Internet Engineering Task Force Request For Comment
IPS	–	Internet Protocol System
PDU	–	Protocol Data Unit
MPLS	–	Multiprotocol Labeling System

1.6 Overview of IPS Specification Issues

The following subsections present issues that affect the completion of the routing policy document and/or in operating the IPS-based AMHS network.

1.6.1 BGP-4 Specification

The BGP-4 RFC [3] presents the overall definition of the protocol and its operation. However as in any complex protocol specification, there are options and methods of operation that require users of the protocol to make a more detailed selection. Since BGP-4 is designed to use IPv4, a separate specification [11] is also needed to specify BGP-4 over IPv6. At the present time, there is no BGP-4 specification for the Region. This makes the development of policy difficult.

Examples of issues to be decided are:

- disposition of routing tables (last paragraph of the overview section),
- value and calculation of the HOLD timer,
- use of AS-PATH parameter, and
- aggregation requirements.

The set of documents describing BGP-4 includes several that define optional/extended parameters (see [5] and [6]). The use of optional parameters needs to be carefully defined.

The set of documents describing BGP-4 includes several that define optional/extended mechanisms (see [7], [8], [10] and [12]). The use of optional mechanisms needs to be carefully defined.

The current approach is based on MEVA and REDDIG network with dedicated circuits.

1.6.2 **Use of TCP**

BGP-4 uses TCP connections for the exchange of information. As a part of the use of BGP-4, a specification of TCP parameters and timers for use in the region is needed.

This can be achieved during the test procedure between associated States.

1.6.3 **Use of TCP MD5**

For the authentication of BGP-4 peers, the TCP MD5 options are mandatory. However, this requires the generation, distribution, and management of the certificates. Both the technical and administrative aspects of the use of MD5 need to be defined.

1.6.4 **Autonomous System Number Assignment**

In order to operate as a BGP-4 router, each router must be assigned a unique AS number. At the present time, these numbers are assigned by IANA.

The region has already proposed and in the process to finalize IPv4 addressing scheme. This is a closed and private network that is based on MEVA and REDDIG. Therefore, coordination with IANA is not necessary.

1.6.5 **IPv6 Address Architecture**

A central feature missing between the use of the ATN ICS and the IPS is the definition of a comprehensive IPv6 addressing architecture. In the case of the ATN ICS, the NSAP is divided into a hierarchy. The hierarchy is based on the "owner" of each part of the address space and maps to the hierarchical nature of routing domains. The use of the NSAP address hierarchy by IDRP enables a considerable reduction in routing information dissemination.

An IPv6 address structure is needed that enables the efficient aggregation of routes based on a global or regional basis.

IPV6 is not considered in the immediate future per the regional planning. IPv4 addressing schemes has been proposed and in the process to be adopted by the region.

1.6.6 **Security**

The developers of BGP-4 understand that there are security issues relating to route dissemination (see [3]). The selection of options and/or procedures has not been decided.

The region needs to review the security requirement such as authentication or verifying network (establishing Virtual Private Network or using dedicated circuits/channels).

2. **Background**

The ATN AMHS as defined in Sub-Volume 3 of [1] is based upon the use of the ATN ICS and utilizes the OSI transport protocol, CLNP, and IDRP for the exchange of messages across the network. There has been considerable debate on the use of the IPS as a replacement for the ATN ICS protocols and this Region has agreed to use the IPS within the Region and with States in other Regions that support these protocols.

One of the problems when discussing the routing architecture for the ATN is that it uses the terminology from the OSI Reference Model where the terminology from the IPS is somewhat different. This section describes and contrasts the two terminologies while explaining the routing architecture for the Region.

2.1 Routing Domain Fundamentals

2.1.1 Domains

Using the terminology of the ICAO/ATN, the ATN consists of a set of End Systems (ESs) and a set of Intermediate Systems (ISs). End systems are typically the computers that contain the applications and are not involved with routing packets to other systems. Intermediate systems are typically routers.

The ESs and ISs are organized into *Routing Domains*. Routing Domains are used to define sets of systems (that typically operate together) into clusters. These clusters have two major properties:

- they are controlled by a single organization, and
- a significant amount of the traffic is internal to the cluster.

The single most important characteristic is that they are controlled by a single organization. This characteristic is manifested in technical terms by mutual trust between all routers in a routing domain. Routing protocols are based on the fact that the information exchanged between *intra-domain* (within a domain) routers can be trusted. No special reliability or trust is required to accept information about advertised routes.

The second characteristic, most traffic is internal to a routing domain, is more an artifact of proper network engineering. In the ATN, routing domains are established through the NSAP addressing conventions established for the ATN in Doc 9705, Sub-Volume 5. All systems with NSAP addresses defined with the same address prefix are by definition in the same routing domain. Within the IPS, routing domains may be established by IPv6 address conventions. The definition of the IPv6 address architecture for the CAR/SAM Region may have significant impacts on the definition of the appropriate routing domain structure.

2.1.2 Intra-Domain Routing

Intra-domain routing is the routing of PDUs from the source to destination where both are in the same domain. Intra-domain routing implies one or more ISs capable of routing PDUs across the domain. Examples of intra-domain routing would be CLNP-capable routers exchanging PDUs between two Local Area Networks.

2.1.3 Inter-Domain Routing

The central definition of routing in the ATN is concerned with inter-domain routing. This is a particularly difficult problem since by the very nature of inter-domain routing; the information received cannot be fully trusted.

Inter-domain routing is based upon the mutual distrust of the received routing information. First, reliability mechanisms must be build-in to ensure the reliable transfer of the information. Second, the received information must be filtered to ensure that it meets the suitability constraints of the received system (in other words, it can be believed.)

After receiving routing information, the inter-domain router must build routing tables based upon its internal policy about routing its data.

2.1.4 Types of Routing Domains

There are two basic types of routing domains: end routing domains, and transit routing domains. An end routing domain routes PDUs to and from end-systems within its routing domain. Figure 1 shows an end routing domain.

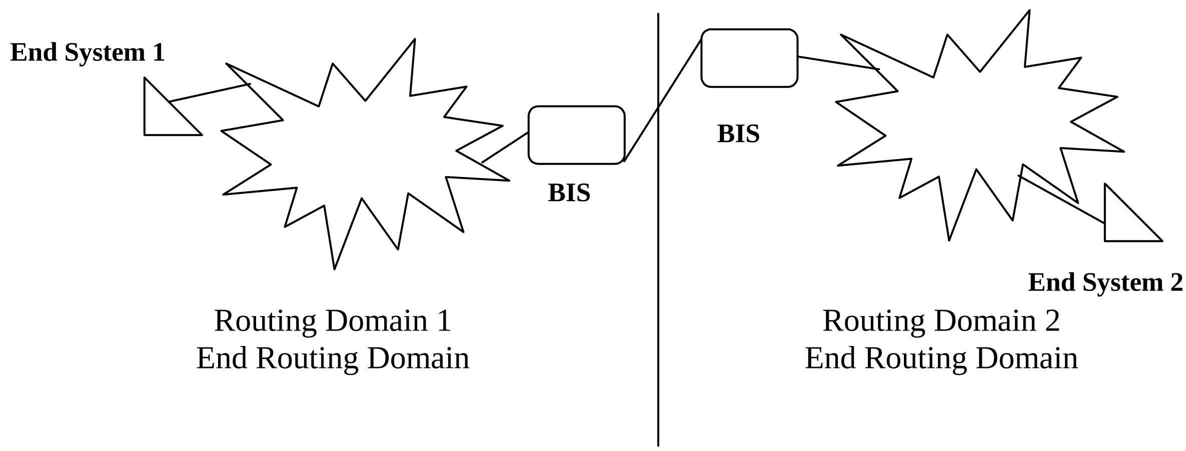


Figure 1 – End Routing Domains

A transit routing domain routes PDUs between two or more routing domains, and may as an option also act as an end routing domain. An example of a transit domain is where a set of backbone routers is configured in their own routing domain with all of the end systems in end routing domains attached to the backbone. Figure 2 shows Routing Domain 2 as a transit routing domain.

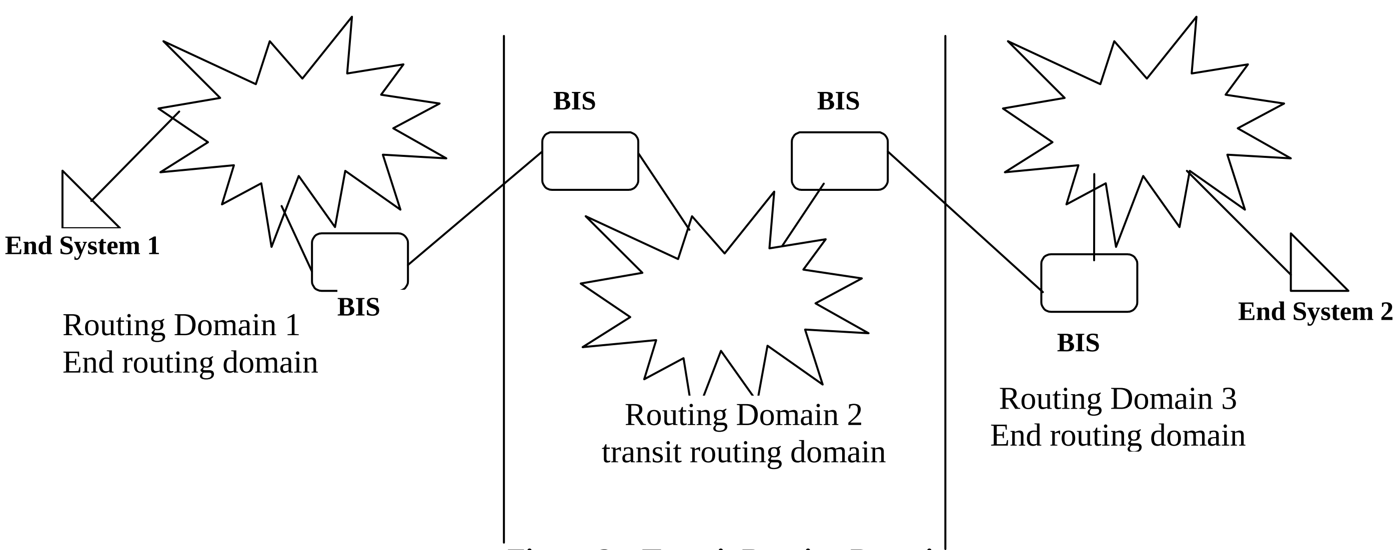


Figure 2 – Transit Routing Domains

2.1.5 Routing Domain Definition Requirements

For each routing domain that is accessible in the Region, there must be at least one inter-domain router. (In ATN terms, there must be at least one Boundary Intermediate System (BIS) for each routing domain supporting AMHS.)

2.1.6 IPS Autonomous Systems and Routing

As mentioned earlier, the terminology between ATN/OSI and the IPS is somewhat different. In the context of the IPS documentation, the term Autonomous System (AS) is introduced to define a network or set of networks that managed by a single organization. The use of AS is needed since there is not the same concept as “routing domain” in the IPS architecture.

The addressing scheme for IPv6 (and IPv4) does not include the concept of routing domains. Rather any defined address prefix length can be used for routing without regards to “domains”. The AS terminology is a way to describe routing domains through the use of network(s) management. For the purposes of describing routing using IPS, an AS can be considered equivalent to an ATN/OSI routing domain.

2.2 Router Fundamentals

All routers and routing protocols discussed within this document are ICAO Doc. 9705 Boundary Intermediate Systems (BISs). Using the IPS terminology, all routers discussed within this document are “Border Gateway (BG)” routers that communicate between Autonomous Systems.

2.2.1 BIS and Border Gateway Systems

There are two primary types of BISs (or BGs) employed within the Region:

- Backbone BISs/BGs (BBISs/BGs), and
- End BISs/BGs (EBISs/EBGs)

2.2.1.1 Backbone BIS/BG

A BBIS/BBG is a router that primarily routes PDUs between routing domains or ASs. These routers are typically higher performance routers that aid in the efficient flow of data between domains/ASs. BBIS/BBG may have End-Systems connected to them, but they are often limited to router-to-router connections.

Within the context of the CAR/SAM Region, BBISs/BGs can be further subdivided into Regional BBIS/BGs and Inter-Regional BBISs/BGs. Regional BBISs/BGs are backbone routers that only connect to routers within the Region. Inter-regional Backbone BBIS/BGs are those backbone routers that also connect to BBISs in other Regions.

Note 1*: A single, high-performance router may act as both a Regional BBIS and an Inter-Regional BBIS based upon meeting the requirements for performance and reliability.*

Note 2*: For completeness of the routing architecture, it must be mentioned that the router out-side of the Region to which Inter-Regional Backbone BISs attach are, in fact, Inter-Regional Backbone BISs in the other Region.*

Note 3*: The interconnection of backbone BISs typically require higher capacity communication lines based on the consolidation of traffic through those backbone routers. Even thought the architecture takes into account existing AFTN infrastructure facilities, the need to upgrade the communication facilities as traffic throughout the backbone increases may be necessary.*

Note 4*: It is possible for some States to provide transit routing from its routing domain to the routing domains of other States using BISs that are not backbone routers. For the purposes of this routing architecture, it is not possible to distinguish between these transit routing domain routers and BBISs.*

Note 5*: Due to the restrictions of the ICAO SARPs, Inter-Regional BBISs may be limited to ATN-compliant routers. Bi-lateral agreements between States providing Inter-Regional routing may allow for routers using the IPS.*

2.2.1.2 **End BIS**

End BISs/BGs are connected to one or more BBISs/BBGs and provide routing services to a single routing domain/AS. Further End BISs do not act as a transit router for passing PDUs between other routing domains/AS.

2.3 **CAR/SAM AMHS Ground-to-Ground Routing Architecture**

The CAR/SAM AMHS routing architecture is to the largest degree possible independent of the protocol family (ATN/OSI or IPS) or specific routing protocols. The CAR/SAM routing architecture is based upon several concepts:

1. From the IPv6 addressing specification, “routing-domains” are defined as specific address prefix lengths.
2. Based on the definition of “routing-domain” prefix definitions, each routing domain can be considered an Autonomous System (AS).
3. States will make their own implementation and transition decisions.

The routing architecture can be divided into several distinct parts:

- the definition of the backbone routing structure for passing information between routing domains within the Region;
- the definition of the routing structure between routing domains not on the backbone;
- the definition of the routing structure for use in end-routing domains; and
- the definition of the routing structure for passing information from this Region to other Regions.

The first component is the definition of the backbone routing structure that supports the exchange of data within the Region. This part defines the interconnection of the major communication facilities in the Region and how they cooperate to link all of the systems in the Region.

The second component is the definition of the structure that allows end routing domains to exchange data across the backbone to anther end routing domain. This part defines how the end routing domains connect through the backbone.

The third component defines the routing structure that is used within an end routing domain. This part defines how the individual routing domains may be used to pass data.

The fourth part is needed to define how data will be routed between the systems within the Region and those systems outside the Region. More importantly, the structure describes how all global ATN systems are accessible from systems in the Region.

2.3.1 **CAR/SAM Backbone**

The definition of a Regional Backbone is based upon the efficiencies that may be realized by concentrating AMHS traffic at major communication centers and using the economy of scale in passing this information between major communication centers.

The rationale for defining Regional Backbone sites is based upon existing major AFTN center sites and on the flow of both AFTN traffic and possible future AMHS/ATN traffic.

The CAR/SAM Region is comprised of a large number of States spread over a wide geographic area. Within the Region, there are existing main AFTN communication centers that can be used to simplify the definition of the backbone architecture.

The architecture and communication requirements define a routing plan that incorporates alternate routing and communication paths so that no single router or communication failure can isolate major parts of the Region.

Based on the previous paragraphs, the CAR/SAM Backbone network will consist of at lease on BBIS router at each of the backbone sites identified in Table A-1.

The States implementing a backbone router site needs to select is router(s) based on the expected availability, reliability, capacity, and alternate communication path requirements.

2.3.2 **Inter-Regional Backbone**

The second component of the CAR/SAM Routing architecture is the definition and potential location of Inter-Regional Backbone Routers. The manner in which this architecture was developed was to ensure that the use of the existing communication infrastructure is possible to the greatest degree. The use of the existing communication infrastructure should reduce the overall cost of transitioning to the AMHS.

To re-state from the previous section, the Inter-Regional BBISs provide communication from routers within the CAR/SAM Region to routers in other regions. These Inter-Regional BBISs provide vital communications across regions and therefore need to have redundant communication paths and high availability.

The location of Inter-Regional BBISs is TBD.

Note*: These routers may need to be ATN-compliant*.

2.3.3 **End BISs**

It is assumed that naming and addressing (and routing domain definition) will be done on a Regional basis. Further that for areas within the Region that may utilize an End BIS service more than one State, the naming structure will be based on the Regional IPv6 addressing plan as defined.

2.4 AMHS IPS-Based Ground-to-Ground Routing

The Region has already made the decision to provide ATN AMHS services over an appropriately defined TCP/IPv6 communication infrastructure. The following sections describe the implementation of the Regional routing architecture within the scope of IPv6 routing.

2.4.1 Internet Protocol Suite Routing Protocols

Within the scope of the routing of IPv6 traffic there are defined several different protocols. For the purposes of intra-domain routing typical protocols are RIPv2 and OSPF. For the purposes of inter-domain routing, BGP-4 is the most prevalent.

For that reason and its close relationship with the ATN IDRP, BGP-4 is selected as the Regional Inter-domain protocol.

3. BGP-4

The **Border Gateway Protocol (BGP)** is the routing protocol used to exchange routing information across the Internet. It makes it possible for ISPs to connect to each other and for end-users to connect to more than one ISP. **BGP** is the only protocol that is designed to deal with a network of the Internet's size, and the only protocol that can deal well with having multiple connections to unrelated routing domains.

3.1 BGP-4 Requirements

In order to use BGP-4 for routing within the Region, each BGP-4 router must meet the following minimum requirements.

Each routing-domain/AS must obtain an AS number.

***Note**: The method of obtaining an AS number is within the scope of the IPv6 Address document.*

Each BGP-4 router must have an appropriate MD-5 certificate/password assigned and managed.

***Note**: The procedures for generating, managing, distributing MD-5 certificates are TBD.*

3.2 Policy Based Routing

3.2.1 Types of Policy

The BGP-4 decision process (and thus AMHS routing policy) is conditioned by three types of policy concerns.

- *Route Aggregation* policies permit BGP-4 routers to reduce the amount of routing information propagated.

- *Route Preference* policies determine which routes will be installed in the Forwarding Information Base. Route preference policies thus determine which path a router will select to forward IPv6 pdus on.

- *Route Distribution* policies determine which routes a BGP-4 router will advertise to other BGP-4 routers. Route distribution policies are a key aspect of a routing-domain's/AS's transit policy in that they determine which routes will be permitted in a domain. A BGP-4 router will not propagate a route, which it does not wish to support. By selective advertisement of routing information BGP-4 routers control the use of their own resources since other routers cannot choose a route they do not know about.

4. General Framework for AMHS BGP-4 Routing Policy

4.1 Routing Policy Goal for BGP-4 routers

The AMHS CAR/SAM Regional infrastructure must support a consistent set of routing policies to provide paths to AMHS systems at an inter-regional, intra-regional and local level without an inordinate number of routing protocol updates. Accordingly, the detailed policy requirements and recommendations specified in section 4 are derived from the following general routing policy goal:

- CAR/SAM Regional BGP-4 routers will provide global shortest path connectivity with a minimal exchange of routing information.

- CAR/SAM Regional BGP-4 routers will not exchange any routing information for any IPv6 address not defined as an "ICAO State or Organization" address. (No connectivity to global internet routers or hosts.)

- CAR/SAM Regional BGP-4 routers will not connect to any router not owned or operated by a State or Organization. (No connectivity to global internet routers or hosts.)

***Note**: Providing paths/routes for inter-regional AMHS connectivity may require additional routing requirements based on the need to relay the AMHS message through an MTA that can provide connectivity between ATN/OSI (ATN router-based) infrastructures and the CAR/SAM IPS infrastructure.*

4.2 Network Organization for Routing to Ground Systems

As presented in earlier sections, the AMHS ground infrastructure may be partitioned into various levels of organization. Routing domains at the highest level are associated with an ICAO region. The CAR/SAM IPv6 Addressing Plan should provide an IPv6 address structure that partitions the address space to include NLRI prefixes that vary according to the level of organization. Within the CAR/SAM Region, routing domains are next associated with a particular state or organization. Note that the regional addressing plan should specify a field within the IPv6 address that can be uniquely assigned to the state or organization. Finally, within a particular state or organization there may be multiple local routing domains (which may or may not be visible outside of the particular state or organization).

***Note**: For the purposes of the following paragraphs, an AMHS ground router is a router supporting IPv6 routing via BGP-4.*

Within this framework AMHS ground routers may be characterized and their policy requirements specified according to the type of connectivity they have to adjacent AMHS ground routers. AMHS routers connecting to adjacent routers in another region are said to have “inter-regional” connectivity [***Note****: these most likely will be actual ATN/OSI ground routers*]. AMHS routers connecting to adjacent routers in another state or organization within the CAR/SAM Region are said to have “intra-regional” connectivity. AMHS routers connecting to adjacent routers within a particular state or organization are said to have “local” connectivity, i.e. intra-state or intra-organizational connectivity.

4.3 Policy for BGP-4 Routes to AMHS Systems

The policy requirements for BGP-4 routers in the CAR/SAM Region for routes to AMHS systems are specified in this section. The following sub-sections specify the policies according to the classification:

1. the general policy for routes to ground systems; the policy for inter-regional routes;

2. the policy for intra-regional routes; and

3. the policy for local routes.

Note 1*. – This section specifies routing policy requirements for backbone routers in the CAR/SAM region. A backbone router is a BGP-4 router which has been designated by the operating state/organization to provide an appropriate level of performance and support the routing policies for inter-regional and intra-regional connectivity, and whose operation as a backbone router has been approved by the ICAO regional office as agreed-to by all other member states/organizations. This section also contains a number of recommended policies non-backbone routers.*

Note 2*. – This document and companion documents specify requirements for AMHS ground routers in the “Caribbean and South America (CAR/SAM) region”; however, from the perspective of the AMHS Ipv6 Addressing Plan, there is/may not be a single “CAR/SAM region” but rather there is a distinct Caribbean region and a distinct South American region each with a unique region identifier.*

4.3.1 General Policy

If a backbone router receives multiple routes to an aggregate or specific destination, the route with the shortest path ([i.e., shortest list of AS)] shall be selected.

All BGP-4 routers in the Region shall authenticate the identity of peer ATN routers.

Note*. – Authentication may be accomplished via the mandatory MD-5 option.*

4.3.2 Policy for Inter-Regional Aggregate Routes To Ground Systems

Inter-Regional route aggregation is only possible where a bi-lateral agreement exists between the two States to operate BGP-4 routers.

4.3.3 Policy for Intra-Regional Aggregate Routes to Ground Systems

Intra-regional route aggregation permits advertisement of a single aggregate route which identifies all systems in a particular State or Organization of an ICAO region. Aggregation at an intra-regional level refers to aggregating NLRI fields in the IPv6 address prefix up through the complete [TBD] field.

Note: The IPv6 addressing plan needs to develop the appropriate NLRI prefix hierarchy.

4.3.3.1 Intra-Regional Route Aggregation Policies

Backbone routers with intra-regional connectivity shall be configured with aggregate routes to AMHS system at an intra-regional level.

4.3.3.2 Intra-Regional Route Preference Policies

Backbone routers with intra-regional connectivity shall accept intra-regional aggregate routes to AMHS systems from adjacent ATN routers.

Recommendation. Backbone routers with intra-regional connectivity should only accept inter-regional or intra-regional aggregate routes on these connections.

4.3.3.3 Intra-Regional Route Distribution Policies

Backbone routers with intra-regional connectivity shall distribute intra-regional aggregate routes to adjacent AMHS BGP-4 routers.

Routers with local connectivity shall distribute intra-regional aggregate routes to adjacent AMHS BGP-4 routers.

Recommendation. Non-Backbone routers with local connectivity should distribute intra-regional aggregate routes to adjacent AMHS BGP-4 routers.

4.3.4 Policy for Aggregate Routes to Ground Systems for Distinct Routing Domains within a State/ Organization

Distinct Routing Domain-level aggregation permits advertisement of a single aggregate route which identifies all systems in a specific routing domain of a particular State or Organization of an ICAO region. Aggregation at this level refers to aggregating NLRI fields to an agreed IPv6 address prefix [TBD]. AMHS BGP-4 routers connecting to adjacent routers within a particular state or organization, i.e., with intra-state or intra-organizational connectivity, are said to have “local” connectivity.

4.3.4.1 Distinct Routing Domain Route Aggregation Policies

Recommendation. AMHS BGP-4 routers serving individual routing domains should be configured with aggregate routes to all other AMHS systems.

4.3.4.2 Distinct Routing Domain Route Preference Policies

Recommendation. AMHS routers with local connectivity should accept state/organizational-level aggregate routes from adjacent AMHS BGP-4 routers within the same state or organization.

4.3.4.3 Distinct Routing Domain Route Distribution Policies

Recommendation. AMHS BGP-4 routers with local connectivity should distribute state/organizational-level aggregate routes to AMHS ground systems only to adjacent AMHS BGP-4 routers within the same state or organization.

4.3.4.4 Local State/Organizational Routing Policies

Individual states/organizations may have additional routing policies consistent with the above policies for routes to ground systems. Such policies may include various local preferences or Quality of Service based routing, for example, routing based on line error rates, expense, delay, capacity, and priority.

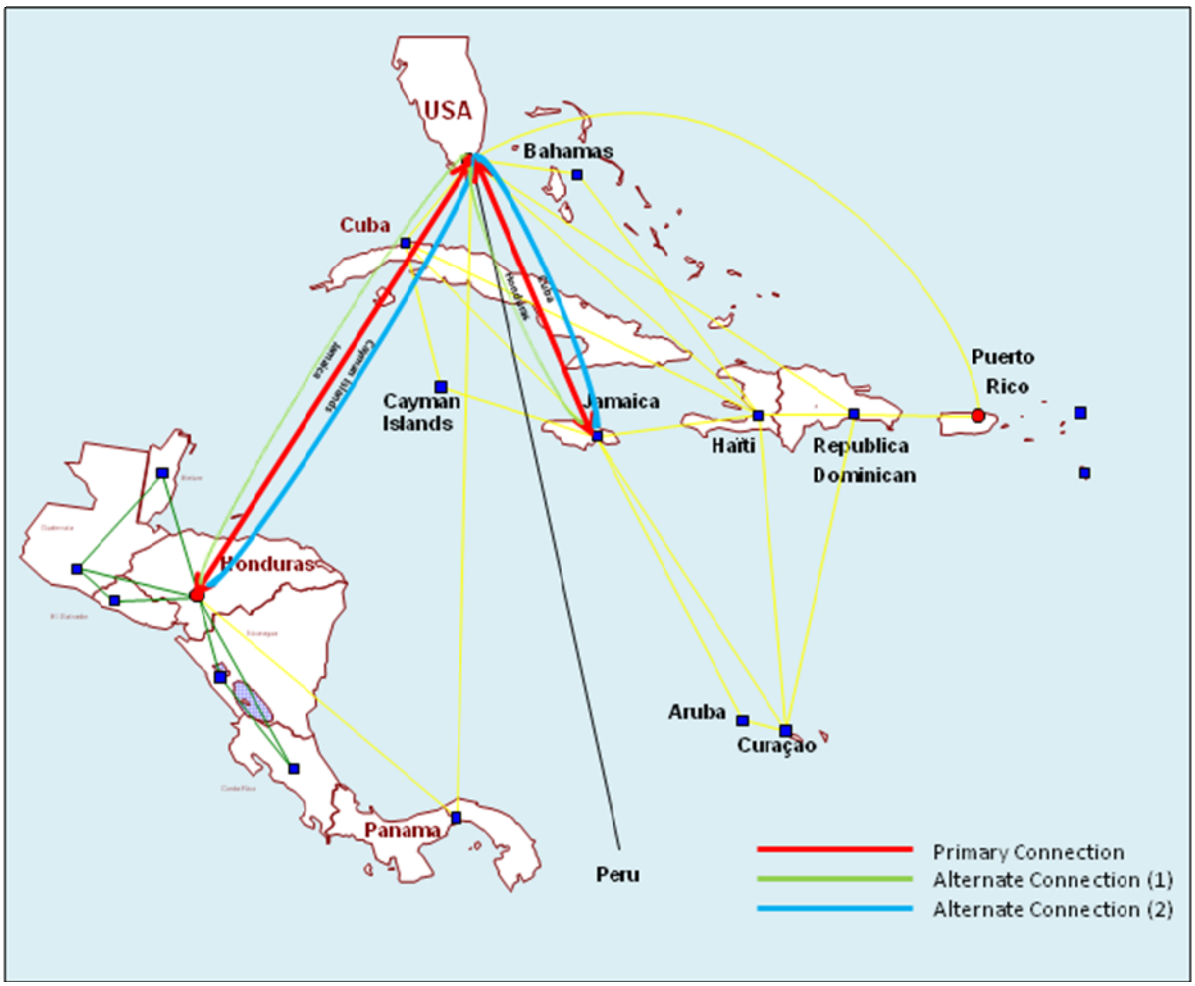
ANNEX A – Backbone Router Sites

Proposed AMHS Routing

Major Backbones in the region

Honduras-USA (Primary route)
Honduras-Jamaica-USA (Alternative Routing 1)
Honduras-Cayman Island-USA (Alternative routing 2)

Jamaica-USA (Primary routing)
Jamaica-Honduras-USA (Alternative routing 1)
Jamaica-Cuba-USA (Alternative routing 2)



Venezuela-USA (Primary routing)
Venezuela-Trinidad-USA (Alternative routing 1)
Venezuela-Peru-USA (Alternative routing 2)

Venezuela-Trinidad (Primary routing)
Venezuela-USA-Trinidad (Alternative routing 1)

Venezuela-Brazil (Primary routing)
Venezuela-Peru-Brazil (Alternative routing 1)
Venezuela-USA-Brazil (Alternative routing 2)

Venezuela-Peru (Primary routing)
Venezuela-Brazil-Peru (Alternative routing 1)
Venezuela-USA-Peru (Alternative routing 2)

Trinidad-USA (Primary routing)
Trinidad-Antigua-USA (Alternative routing 1)
Trinidad-Venezuela-USA (Alternative routing 2)

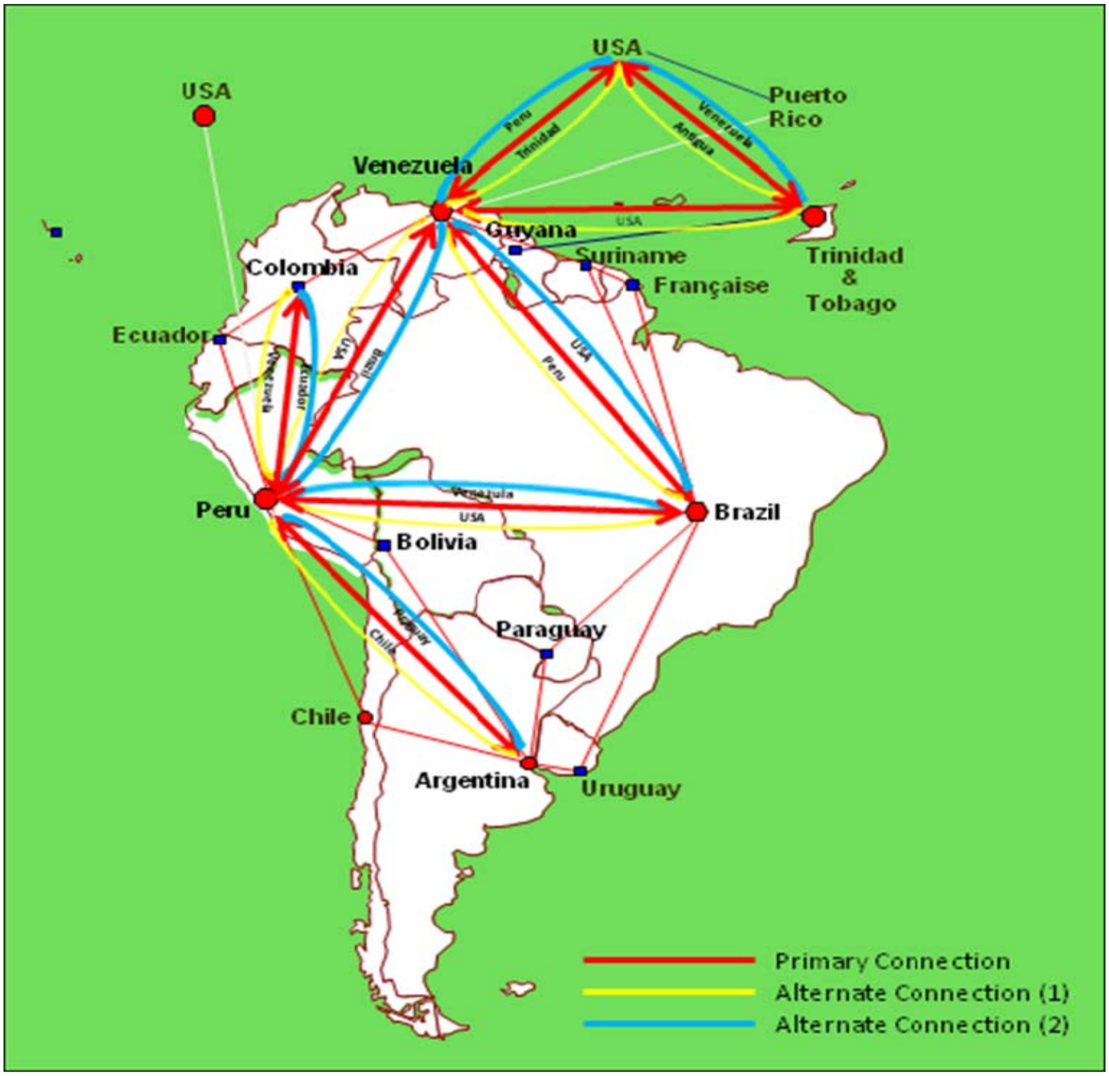
Colombia-Peru (Primary routing)
Colombia-Venezuela-Peru (Alternative routing 1)
Colombia-Ecuador-Peru (Alternative routing 2)

Peru-Brazil (Primary routing)
Peru-Venezuela-Brazil (Alternative routing 1)
Peru-USA-Brazil (Alternative routing 2)

Peru-Venezuela (Primary routing)
Peru-USA-Venezuela (Alternative routing 1)
Peru-Brazil-Venezuela (Alternative routing 2)

Argentina-Peru (Primary routing)
Argentina-Chile-Peru (Alternative routing 1)
Argentina-Paraguay-Peru (Alternative routing 2)

Brazil-Peru (Primary routing)
Brazil-USA-Peru (Alternative routing 1)
Brazil-Venezuela-Peru (Alternative routing 2)


USA
USA
Puerto Rico
Venezuela
Trinidad & Tobago
Guyana
Suriname
Française
Colombia
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Argentina
Uruguay
Peru
Trinidad
Venezuela
Antigua
USA
Venezuela
Ecuador
USA
Brazil
USA
Peru
Venezuela
USA
Chile
Primary Connection
Alternate Connection (1)
Alternate Connection (2)

Brazil-USA (Primary routing)
Brazil-Peru-USA (Alternative routing 1)
Brazil-Venezuela-USA (Alternative routing 2)

Peru-USA (Primary routing)
Peru-Venezuela-USA (Alternative routing 1)
Peru-Brazil-USA (Alternative routing 2)