ATNP/WG2-WP/
18 January 1995

AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL

Working Group Two

Melbourne, FL 23.1.95-27.1.95

Proposed Guidance Material in Support of Route Initiation

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SUMMARY

Work has progressed recently on the definition of ATN Package 1. This work has included the development of interim procedures for the optional non-use of IDRP over the air-ground data link, and it has become necessary to develop Guidance material for these interim procedures and putting them properly in the context of Route Initiation. This paper provides proposed Guidance Material for Route Initiation including the optional non-use of IDRP. At the same time, the opportunity has been taken for a general overhaul of this area of the Guidance Material in this area.

DOCUMENT CONTROL LOG

SECTION	DATE	REV. NO.	REASON FOR CHANGE OR REFERENCE TO CHANGE
	16-Jan-95	Issue 1.0	

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1. Introduction

1.1 Scope

This document provides proposed guidance material in support of the draft ATN SARPs, and provides guidance on route initiation procedures for both air/ground and ground-ground communications.

1.2 Purpose of Document

The document has been prepared for consideration by ATNP/WG2. It is intended to take a discursive approach to the specification of Route Initiation in order to complement the normative approach taken by SARPs.

1.3 References

1.	ATNP/WG2-WP1	Draft ATN Standards and Recommended Practices (SARPs) and Guidance Material version 0.0
2.	ATNP/WG2-WP25	Requirements made by early Applications on the ATN Internet, and the consequent Transition Strategy
3.	ATNP/WG2-WP35	Proposed Internet Architecture for CNS/ATM Package 1
4.	ATNP/WG2-WP37	Proposed ATN Protocol Requirements Lists (PRLs) for CNS/ATM Package 1: Profile A

2. Route Initiation

2.1 The Purpose of Route Initiation

ICAO has adopted the use of Policy Based Routing procedures for routing between ATN Routing Domains (RDs), including the support of routing to mobile systems. Dynamic Routing Information is exchanged using the procedures specified in ISO 10747 and used and disseminated according to local routing policies specified in accordance with the ATN SARPs. However, before routing information can be exchanged between any two Routing Domains, it is first necessary to establish a communications path between Boundary Routers[1] in each of those RDs. The establishment of such a communications path is known as “Route Initiation”.

Route Initiation procedures are required whenever two ATN RDs need to be interconnected. Since the ATN SARPs specify that, on board an aircraft, the communications systems and the applications processors that they serve comprises a Routing Domain, Route Initiation procedures also apply to the establishment of air/ground communications.

Route Initiation commences when the decision is made to establish a communications path between two ATN RDs. Route Initiation finishes upon the initial exchange of routing information between the Boundary Routers, or the unsuccessful termination of the Route Initiation procedure.

Note: Boundary Routers within the same RD also exchange dynamic routing information using ISO 10747. The Route Initiation procedures are the same as for inter-domain connections except that both Routers will be under the control of the same administrator.

2.2 Ground-Ground Route Initiation

2.2.1 The Communications Environment

Ground-Ground communications typically use long lasting physical or logical communications paths. Route Initiation can normally be regarded as a rare event and will often be only semi-automated.

The communications networks in the ATN ground environment are outside the scope of the ATN SARPs, but can be assumed to include:

1. X.25 Public and Private Data Networks
2. Leased Lines
3. Integrated Services Digital Networks (ISDNs)
4. Frame Relay Services
5. The Public Switched Telephone Network (PSTN).

The actual choice of communications network is a matter for bilateral agreement between the organisations and states that wish to interconnect their RDs, and will depend on local

[1] The term Boundary Router may be read in most cases, as synonymous with the architectural entity “Boundary Intermediate System” (BIS). In practice, a Boundary Router includes a BIS along with Management Entities and and End Systems component to support such entities.

availability, tariffs and policies. In many cases, high speed (e.g. V.32bis or V.34) Modems and the PSTN will be used as a backup for a dedicated data network.

The communications protocols used to provide the data link will also depend upon the communications network used and bilateral agreement. In the case of X.25 data networks, Frame Relay and communications services provided via the ISDN D-Channel, then the communications protocols are mandated by the data network provider. In the case of Leased Lines and the ISDN B-channel, then HDLC LAPB (ISO 7776) is the likely choice. For the PSTN, the asynchronous communications provided by V.32bis and V.34 Modems makes the Point-to-Point Protocol (PPP) as specified in RFC 1548, the likely choice.

Note: Route Initiation is not necessarily synonymous with the establishment of a communications link between two Boundary Routers. For example, the speed at which an ISDN B-Channel is established is such that it may be practicable to break the communication circuit during idle periods and re-establish it when there is data to send, whilst still maintaining a logical communications path between the two Boundary Routers. Route Initiation is concerned with the establishment of the logical communications path.

2.2.2 Summary of Procedures

The sequence of procedures for a typical ground-ground Routing Initiation is illustrated in Figure 1, and summarised below. They are discussed in greater depth in the following sections. This illustrates the co-ordination of two Systems (“A” and “B”) interconnecting over a common network. The procedures are:

1) Adjacent BIS MOs are established in both Systems. In each case, an MO is established to identify the other system and contains the parameters necessary to create and maintain a BIS-BIS connection with that system. Both systems will also have been configured with appropriate SNDCFs associated with each attached subnetwork.

2) A communications path is established over the subnetwork; typically one system is initiator and the other responder.

3) Establishment of the communications path is notified to the Systems Manager.

4) In response, the Systems Manager for each system adds a route to the local FIB and to the remote System, and

5) invokes the IDRP “Start Event” action, or re-run the decision process if a BIS-BIS connection already exists with the remote system.

6) On successful establishment of the BIS-BIS connection, Route Initiation completes.

Note: while the Systems Manager may be a real person explicitly issuing commands, the “Systems Manager” in the above description may alternatively be a procedural script carrying out an automatic action in respond to a Systems Management Notification.

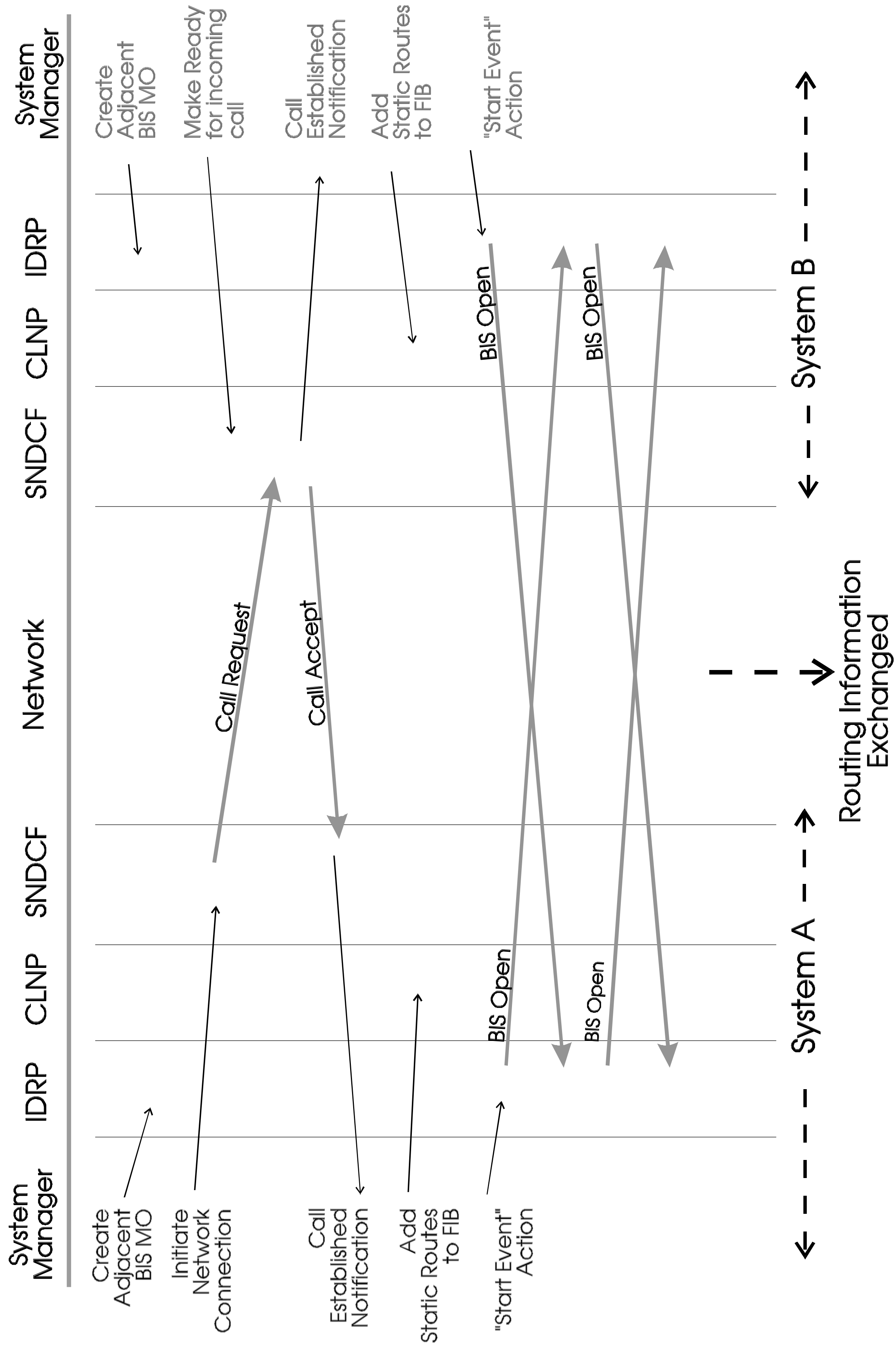

Figure 1 Ground-Ground Route Initiation Sequence

2.2.3 Initial Route Initiation

Route Initiation begins with the decision to establish a communications path between a pair of Boundary Routers, including the decision on which communications networks to use. The first procedure is to establish the underlying communications circuit between the Boundary Routers and hence to establish the logical communications path.

These procedures will be data network dependent and will require some sort of interaction between the respective Systems Managers. Typically, one Boundary Router will need to be in a passive state awaiting an incoming event (e.g. an X.25 call indication or a PSTN Ring Indication), while the other takes an active role and initiates circuit establishment (e.g. by generating an X.25 call request, or “dialling” the telephone call).

When appropriate to the type of data network used, the QoS, Security and Priority requested on any such call request, should be satisfactory for the exchange of routing information.

During this phase, there should normally be some validation to ensure that communications has been established with the correct remote system. This initial phase completes once the data link has been established.

2.2.4 Route Initiation in CLNP

The ATN SARPs specify the use of the Connectionless Network Protocol (CLNP) specified in ISO 8473 for ATN subnetwork independent communications. Establishing a data link (e.g. an X.25 virtual circuit) is a necessary condition for data to be exchanged between two Boundary Routers using CLNP, but not a sufficient condition. In order for the data link to be used by the CLNP Network Entity, and hence as a communications path for the forwarding of data packets, it is necessary to:

1. Assign an appropriate Subnetwork Dependent Convergence Function (SNDCF) to interface the data link to the Network Entity;

2. Update the Forwarding Information Base (FIB) to record statically known routes available over the data link and via the remote Boundary Router.

The former is necessary in order to match the characteristics of the actual network and communications protocol used over that network to the characteristics assumed by the CLNP Network Entity. The second is necessary in order to permit the exchange of dynamic routing information.

The SNDCF is typically specified for a network type and associated at system configuration time with a physical communication port. In most cases, the assignment of the SNDCF is implicit in the network over which communications is established, and no explicit action will need to be carried out to assign the SNDCF. Indeed, most implementations will required assignment of the SNDCF prior to establishment of the data link. However, for some network types there may be alternatives chosen at connection establishment time.

The FIB may be updated with any statically known routes that are known *a priori* to exist via the newly established data link, where a route consists of an NSAP Address prefix paired with an identifier for a data link. When forwarding data packets, the CLNP network entity locates the longest matching NSAP Address Prefix in the FIB, when matched against the packet’s destination NSAP Address, and then queues the packet for transmission over the associated data link. Multiple FIBs may also exist matching different QoS and security requirements. So that Routing Information may be exchanged, the FIB associated with the QoS level used for the exchange of Routing Information, must be updated to include, as a minimum, a route to the network entity located on each Boundary Router. to which a data link has been established.

Therefore, once a data link has been established to a remote Boundary Router, the System Manager must either directly, or via an automated procedure, insert into the FIB associated with the Security and QoS level used for the exchange of Routing Information, a route associating:

a) an NSAP Address prefix that is a prefix for the NET of the remote Boundary Router at the other end of the newly established data link. As a minimum, this prefix may be the complete NET. And,

b) the data link to that remote Boundary Router.

Note 1: the reverse must also take place when the data link is terminated i.e. the above route must be removed from the FIB.

Note 2: alternatively, such routes may be entered into the FIB at system initialisation. However, this strategy only gives satisfactory results if there is one and only one possible data path to the remote Boundary Router.

2.2.5 Route Initiation in IDRP

The ATN SARPs specify the use of the Inter-Domain Routing Protocol (IDRP) specified in ISO 10747 for the exchange of dynamic routing information between Boundary Routers. Once a communications path has been established between two Boundary Routers and sufficient static routing information entered into the local FIB in order to enable the forwarding of data packets to the remote Boundary Router itself, IDRP may be used to exchange dynamic routing information.

IDRP may only exchange dynamic routing information when a BIS-BIS connection has been established. This is a logical connection established by using the IDR Protocol, which in turn uses CLNP to transfer the protocol data units (BISPDUs) to the remote IDRP entity. A BIS-BIS connection supports the reliable transfer of dynamic routing information between Boundary Routers.

Prior to establishing a BIS-BIS connection it is necessary to create an “Adjacent BIS Managed Object” to provide the information necessary to establish and maintain a BIS-BIS connection with an explicitly identified remote Boundary Router. The information held includes the NET of the remote Boundary Router, authentication data, the specific IDRP procedures used to establish the BIS-BIS connection and timer values. One such MO exists for each remote Boundary Router with which IDRP may exchange routes. Typically, this MO is setup in advance of the underlying communications path, and will usually be created once agreement to interconnect has been reached.

Once the FIB has been updated with a route to the remote Boundary Router, the “start event” action is requested of the Adjacent BIS MO associated with that Remote Boundary Router. This initiates the procedures for creating the BIS-BIS connection and followed by the exchange of dynamic routing information. It is the final action of the Route Initiation procedure.

During establishment of the BIS-BIS connection either or both IDRP entities will take an active role in connection establishment, or one will be active and the other passive. The role, active or passive, is determined by information configured into the Adjacent BIS MO. If one IDRP entity is to be passive, then Systems Managers must ensure that the other is configured in the active role. If both IDRP entities are configured in the active role, then the BIS-BIS connection establishment procedures are less efficient, than if one is in the passive role. However, given that the loss of efficiency is small and typically of no consequence given that ground-ground BIS-BIS connections are usually long lived, Organisations and States are recommended by the SARPs to always configure the Adjacent BIS MOs for BIS-BIS connections between ground ATN Boundary Routers for BIS-BIS connection establishment in the active role. This is to avoid to risk of both being configured in the passive role by mistake.

However, there is one exception to the above. That is when the newly established communications path is to a remote Boundary Router with which a BIS-BIS connection already exists. This is possible when multiple networks are available between the same pair of Boundary Routers. Multiple concurrent connections may be desirable in order to give high availability through redundancy and to provide additional data transfer capacity.

IDRP permits only a single BIS-BIS connection between a given pair of Boundary Routers, irrespective of the number of underlying connections and networks that may join them. Therefore, the Systems Manager should check to see if a BIS-BIS connection already exists to the remote Boundary Router and only invoke the Start Event Action if one does not already exist. This action will in any case, be ignored if issued when a connection does already exist.

However, other action may be appropriate if there is a need to recognise the different QoS that may be available when a new communications path is opened up (or lost), or a change in the Security Types that may be support by alternative communications paths to the same remote Boundary Router. In such cases, the SARPs require that the IDRP Decision Process is aware of the aggregate QoS and Security Restrictions over the communications paths to a given remote Boundary Router (Adjacent BIS). The SARPs require the Decision Process to update the QoS on received routes (when processing the adj-RIB-in) to reflect the QoS of the communications path and to use this updated QoS when determining the degree of preference of the route and when re-advertising it. They also require that the Decision Process does not place in the IDRP adj-RIB-out, any routes with Security Types incompatible with any restrictions that exist on the aggregate communications path. For example, if none of the available communications paths to a given remote Boundary Router permits the transfer of “Administrative” data, then a route with a Security Type reflecting administrative data may not be placed in the Adj-Rib-out for that Router (and hence advertised to it).

Therefore, whenever an additional communications path to a given remote Boundary Router becomes available (or is lost), the Systems Manager must cause the IDRP Decision Process to be re-run, instead of invoking the Start Event.

2.3 Air-Ground Route Initiation

Air-Ground Route Initiation is similar to ground-ground Route Initiation, but differs for the following reasons:

1. ICAO specified subnetworks are used for air-ground communications with their procedures for use mandated by SARPs rather than subject to bilateral negotiation.

2. Route Initiation typically starts as soon as communication is possible e.g. an aircraft coming into range of a Mode S Interrogator, and, in consequence Route Initiation starts as soon as the Systems Manager is notified of the possibility of communications (e.g. capture by a Mode S Interrogator).

3. It is not realistic to pre-configure Adjacent BIS MOs for every aircraft that may come into contact with a given ground ATN Router; these MOs must be set up as part of the Route Initiation Procedure.

4. Special procedures are necessary to identify the NET of a remote ground or airborne Router during the Route Initiation procedure as, in general, it is not possible to know this in advance.

5. Due to avionics limitations, not all aircraft will be able to implement IDRP and interim procedures inferring route availability over air-ground links must be accommodated.

2.3.1 Communications Environment

The following ICAO Air-Ground data networks are expected to be used to support the ATN:

1. The Aeronautical Mobile Satellite Service (AMSS)

2. The VHF Data Link (VDL)

3. The Mode S Data Network

In each case, ITU recommendation X.25 provides the data network access procedures, and the responsible ICAO Panel's have required that:

a) AMSS communications are "air initiated", that is the aircraft is responsible for initiating communication with the ground

b) VDL communications are similarly air initiated.

c) Mode S communications are "ground initiated" that is a ground ATN Router attached to a Mode S data network is responsible for initiating communications with an aircraft.

2.3.2 Summary of Procedures

The Air-Ground Route Initiation procedures are illustrated in Figure 2, and summarised below. They are discussed in greater depth in the following sections. This figure illustrates the case where a Join Event is generated by the air-ground subnetwork. If the subnetwork cannot generate a Join Event then the procedures start with the Call Request, as part of a polling procedure. System "A" is the initiator and System "B" is the responder. If the air-ground subnetwork is air-initiated then System "A" represents the Airborne Router, and System "B" the Ground Router. If the air-ground subnetwork is ground-initiated, then System "A" represents the Ground Router, and System "B" the Airborne Router.

The Route Initiation Procedures are:

1) When an aircraft attaches to an air-ground subnetwork, a Join Event is generated, potentially to both Airborne and Ground Routers. If received by System "B", the Join Event is ignored; System "B is ready to receive incoming calls as soon as it attaches to the Mobile Subnetwork.

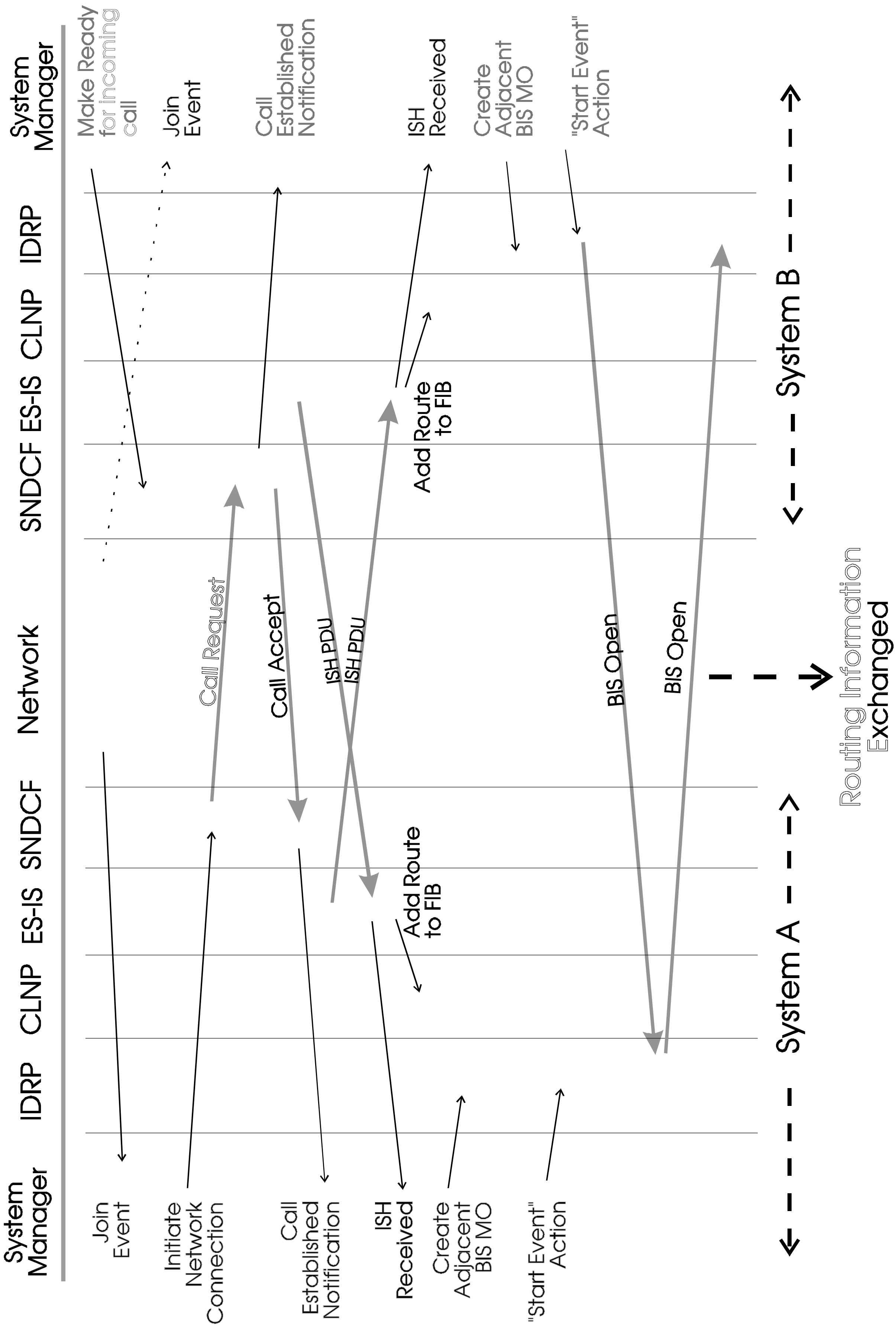

Figure 2 Air-Ground Route Initiation Procedures

2) System “A” acts on a Join Event by initiating the establishment of a virtual circuit to the address given by the Join Event, provided such a connection is permitted by local policy, or

3) if polling, System “A” issues a Call Request to the next address on its poll list.

4) When an incoming call is received by System “B”, it accepts the call if permitted to do so by local policy, and generates and sends an ISH PDU to System “A” over the newly established virtual circuit. This ISH PDU includes the NET of the System “B” Network Entity.

5) When System “A” receives a Call Accept, it too generates an ISH PDU, and sends it to System “B” over the newly established virtual circuit. This ISH PDU includes the NET of the System “A” Network Entity.

6) On receipt of the ISH PDU, both systems update their local FIB to include the routing information received on the PDU, and

7) if one does not already exist, the local IS-SME creates an Adjacent BIS MO for the remote system identified by the ISH PDU, and issues a “Start Event” action to that MO. The Adjacent BIS MO created in System “A” identifies the system as being in the passive role, while the System “B” MO identifies the system as being in the active role. Hence on receiving the start event, System “A” simply listens for an incoming BIS OPEN PDU, while System “B” generates one and sends it to System “A”. System “A” responds to the OPEN PDU, with its own OPEN PDU.

8) Alternatively, if a BIS-BIS connection already exists with the remote system, then the IDRP Decision Process is re-run.

9) Once the BIS Open PDUs have been exchanged, the Route Initiation procedures have been completed.

2.3.3 Initial Route Initiation

In the air-ground environment, Route Initiation starts with the notification that an aircraft has come into contact with an air-ground subnetwork, and that a BIS-BIS connection should be established, so that dynamic routing information may be exchanged. In order to ensure the automatic and timely execution of these procedures, a management entity is required by the ATN SARPs to be implemented in each airborne Router and each ground Router with air-ground connectivity. This known as the “Intermediate System - Systems Management Entity” (IS-SME).

Note: The IS-SME is part of the Systems Management Agent for that Router and may also implement other functions outside of the scope of Routing Initiation.

The IS-SME may have to handle two different classes of air-ground subnetwork:

1) Air-Ground subnetworks that can recognise when an aircraft has come into contact with the subnetwork (e.g. logged on to a satellite, or captured by a Mode S Interrogator) and hence that a communications path may be established with that aircraft, and which report this event.

2) Air-Ground Subnetworks which have no mechanism for recognising the above event and/or reporting it.

In the former case, Route Initiation procedures commence when the air-ground subnetwork reports this event - known as the “join” event. In the latter case, Route Initiation additionally includes procedures to allow support Route Initiation in the absence of such an indication.

Note: Only when air-ground communications are air-initiated is it possible to establish communications without a join event.

2.3.3.1 The Join Event

Ideally, the Join Event should be a Systems Management Notification sent to the IS-SME from a Management Entity in the subnetwork itself. This notification should provide the following information:

1) A subnetwork identifier allowing the Boundary Router to associate the event with an air-ground subnetwork to which the Router is connected.

2) The address on that subnetwork of the remote airborne or ground Router.

3) The expected lifetime of the adjacency i.e. how long a communications path is expected to be available.

A Ground Router will typically receive a join event for each aircraft that joins each air-ground subnetwork to which the ground Router is attached. The receipt of such join events will therefore be a regular activity. An airborne Router will typically receive a join event for each ground Router on an air-ground network at the time it comes into contact with that air-ground subnetwork.

On receipt of a Join Event, an ATN Ground Router will, if communication is ground initiated, issue a call request to the subnetwork Address reported by the Join Event and thence establish a virtual circuit with the corresponding Airborne Router. An ATN Ground Router will ignore any Join Events received from air-initiated Air-Ground subnetworks.

Likewise, on receipt of a Join Event, an ATN Airborne Router will, if communication is air initiated, issue a call request to the subnetwork Address reported by the Join Event and thence establish a virtual circuit with the corresponding Ground Router. An ATN Airborne Router will ignore any Join Events received from ground-initiated Air-Ground subnetworks.

In each case, the QoS, Security and Priority requested on the call request should be satisfactory for the exchange of routing information. A local policy decision may also be taken to ignore a Join Event from certain sources.

2.3.3.2 The Join Event for Subnetworks that do not support ATN Systems Management

It is anticipated that not all ICAO air-ground subnetworks will support the ATN Systems Management protocols. In order to provide the equivalent of the join event, this Guidance Material provides the following guidance describing an alternative procedure for passing a join event to an air-ground Router. Future ICAO SARPs for air-ground subnetworks which do not specify support of ATN Systems Management should specify the following procedures or an equivalent procedure.

1) A communications path (e.g. a virtual circuit) is established between the ATN Router and a subnetwork processor (e.g. Mode S GDLP) by a Systems Manager and kept open as long as both Router and subnetwork are active.

2) Join events are passed from subnetwork processor to Router over this subnetwork connection and as discrete items of data (e.g. as a single packet), and passed to the IS-SME.

3) The Join Event packet is formatted as a sequence of fields according to Table 1.

2.3.3.3 Procedures for Air-Ground Subnetworks that do not Provide a Join Event

With this class of subnetwork, it is necessary to adopt a polling strategy in order to establish air/ground communications, and an Airborne Router must "poll" a list of Ground Routers that has been configured by the System Manager.

A suitable "poll" is a periodically repeated Call Request packet addressed to the DTE Address of a Ground Router. Such call requests are regularly repeated until they are answered with a Call Accept from the addressed Ground Router, and an Airborne Router may cycle through a list of Ground Router DTE Addresses until a connection is established. The QoS, Security and Priority requested on this Call Request should be satisfactory for the exchange of routing information.

Once a virtual circuit has been established, the Router may cease to cycle through its poll list, until the connection terminates (e.g, because the aircraft goes out of range of the mobile subnetwork), when it must resume polling for another connection. However, this may lead to unnecessary gaps in communications availability. Furthermore, not all ground Routers will support all security types required by the aircraft. The airborne Router is thus recommended to continue to cycle through its poll list, even when subnetwork connections exist, and to poll the remaining DTE Addresses on the poll list. Polling need only stop when the Router has made sufficient air/ground connections to satisfy its requirements for each supported traffic type, QoS and availability. Polling may resume when these requirements cease to be met

Note: Typically, there will be many more Airborne Routers on a mobile subnetwork than there are Ground Routers, regardless of the subnetwork's coverage area. Hence, while an Airborne Router can be expected to be configured with a complete list of Ground Router DTE Addresses, it is unlikely to be practicable for a Ground Router to be configured with a complete list of Airborne Router DTE Addresses. This is why subnetworks which do not provide information to DTEs on the connectivity status of other DTEs are only considered suitable for air-initiated BIS-BIS connections.

2.3.4 Route Initiation in CLNP

As a result of the handling of the Join Event or the “polling” procedure described above, a virtual circuit will have been established between Airborne and Ground Routers. The Mobile SNDCF specified in the ATN SARPs should also have been assigned to support the use of this virtual circuit by CLNP. As with ground-ground Route Initiation, it is now necessary for the IS-SME to add to each Router's FIB, a route to the NET of the remote Router's Network Entity, using the newly established virtual Circuit.

Field	Size, octets	Format	Status	Contents
Message ID	1	binary	required	'1'
Length	1	binary	required	Total message length, in octets
Version	1	binary	required	'1'
Lifetime	2	binary	required	Lifetime of link, in seconds
SNPA	var	type/len/value	optional	Remote ATN Router DTE address(es) now available

Notes:

1. The length field defines the length of the entire message, including the message identifier field

2. The value of the lifetime field is determined by the subnetwork processor. This value should be set to the expected time (in seconds) that connectivity over the mobile subnetwork is expected. A typical value would be on the order of 600 - 1200 seconds (10 - 20 minutes). Note that if air/ground connectivity is still possible shortly before expiration of the lifetime, the SP should re-issue the routing initiation event.

3. The SNPA field contains the subnetwork address of the remote Router. For example, the routing initiation event delivered to the aircraft Router contains the SNPA of the ground Router(s). The actual SNPA may have a different format or length for each subnetwork (for an 8208 subnetwork, the SNPA is the equivalent to the DTE address). The three subfields, type, length, and value are set as follows:

   a) a one-octet type field is set to '1', indicating the field as type "SNPA"

   b) a one-octet length is set to the length of the remote Router SNPA address

4. the variable-length value contains the actual DTE address of the remote Router

5. Multiple SNPA fields may be included within a single routing initiation event to report the reachability of several Routers simultaneously .

6. The VER field should be set to '1'.

7. The value of the type field identifying the following data to be of type "SNPA" should be set to '1'

Table 1 Join Event Format

However, all each Router knows at this point is the DTE Address of the other Router. In order to avoid the maintenance problem inherent in managing lookup tables that would enable a correspondence to be made between a DTE Address and a NET, a dynamic procedure has been specified by the ATN SARPs.

An ISO 9542 IS Hello (ISH) PDU is used for this purpose. This is sent either as data, once the connection has been established, or as part of the Call Request/Call Confirm dialogue when "Fast Select" is supported by the air-ground subnetwork. Both Airborne and Ground Routers generate an ISH PDU that reports their NET to the other Router. On receipt of an ISH PDU, each Router updates its FIB with a route to the remote Router, using the NET supplied by the ISH PDU and associating this NET with the subnetwork connection over which the ISH was received, as the forwarding path.

Note: this procedure is also used to negotiate the interim procedures used when IDRP is not supported by the Airborne Router.

2.3.5 Route Initiation in IDRP

Route Initiation in IDRP in the air-ground case is then almost identical to the ground-ground case, except that the SARPs require that one Router is in the passive mode and the other in the active mode. This is because the efficiency improvement gained by this approach is worthwhile in the air-ground environment, and the active and passive roles can be unambiguously identified when ICAO air-ground data networks are used.

The SARPs specify that for air-initiated air-ground subnetworks (i.e. AMSS and VDL), that the Ground Router takes on the active role and the Airborne Router takes on the passive role. For ground-initiated air-ground subnetworks (i.e. Mode S), the SARPs specify that the Airborne Router takes on the active role and that the Ground Router takes on the passive role. This approach will permit the exchange of route initiation data to take place in the shortest timeframe.

The Adjacent BIS MO, if it does not already exist, must be created in response to a notification that an ISH PDU has been received over a new subnetwork connection. It is necessary to create this MO in response to receipt of the ISH PDU, because it is not realistic to pre-configure an Adjacent BIS MO for every aircraft or Ground Router that could be connected to.

An IDRP "Start Event" is then invoked by the IS-SME, provided that a BIS-BIS connection does not already exists with the remote system. If a BIS-BIS connection does already exist then, as in the ground-ground case, and for the same reasons, the IS-SME must cause the IDRP Decision Process to be re-run.

2.4 Air-Ground Route Initiation without IDRP

Due to avionics limitations, the ATN SARPs permit, as an interim measure, the existence of ATN Airborne Routers which do not support IDRP. Modified Route Initiation procedures are specified to identify such Airborne Routers and thence to infer the routes that would have been distributed had IDRP been implemented.

Note 1: The identification of routes by inference is only possible because aircraft are required by the ATN SARPs to be End Routing Domains. That is they do not relay data between ground stations or to other aircraft, and hence only provide routes to their local Routing Domain.

Note 2: The consequence of this procedure is that aircraft cannot be dynamically informed about ground route availability. Therefore, until this interim measure has been withdrawn, the ground ATN environment must be constructed to ensure a higher level of availability than would have been necessary had dynamic information been available to all aircraft. This *is because, when aircraft make assumptions about ground route availability, those ground routes must exist within the margins of tolerance necessary for air safety.*

2.4.1 Summary of Procedures

The procedures for Air-Ground Route Initiation without IDRP are illustrated in Figure 3, and summarised below. They are discussed in greater depth in the following sections. The figure illustrates the case where Air-Ground Routing is ground-initiated. The Route Initiation Procedures are:

1) When an aircraft attaches to an air-ground subnetwork, a Join Event is generated, potentially to both Airborne and Ground Routers. If received by System “B” (the Airborne Router), the Join Event is ignored. System “B is ready to receive incoming calls as soon as it attaches to the Mobile Subnetwork.

2) System “A” (the Ground Router) acts on a Join Event by initiating the establishment of a virtual circuit to the address given by the Join Event, provided such a connection is permitted by local policy, or

3) if polling, System “A” issues a Call Request to the next address on its poll list.

4) When an incoming call is received by System “B”, it accepts the call if permitted to do so by local policy, and generates and sends an ISH PDU to System “A” over the newly established virtual circuit. This ISH PDU includes the NET of the System “B” Network Entity, with the NSEL set to the conventional value of hexadecimal **FE**.

5) When System “A” receives a Call Accept, it too generates an ISH PDU, and sends it to System “B” over the newly established virtual circuit. This ISH PDU includes the NET of the System “A” Network Entity.

6) On receipt of the ISH PDU, both systems update their local FIB to include the routing information received on the PDU, and

7) System “A” generates the derived routes using the NET of System “B”, inserts them into the IDRP RIB, and invokes the IDRP Decision Process.

8) System “B”, generates the derived routes from its local “look up” table and inserts them into its local FIB. If for any derived route, an alternative route exists via a different Ground Router to the same destination then only that with the highest degree of preference as indicated by the look up table is inserted in the FIB.

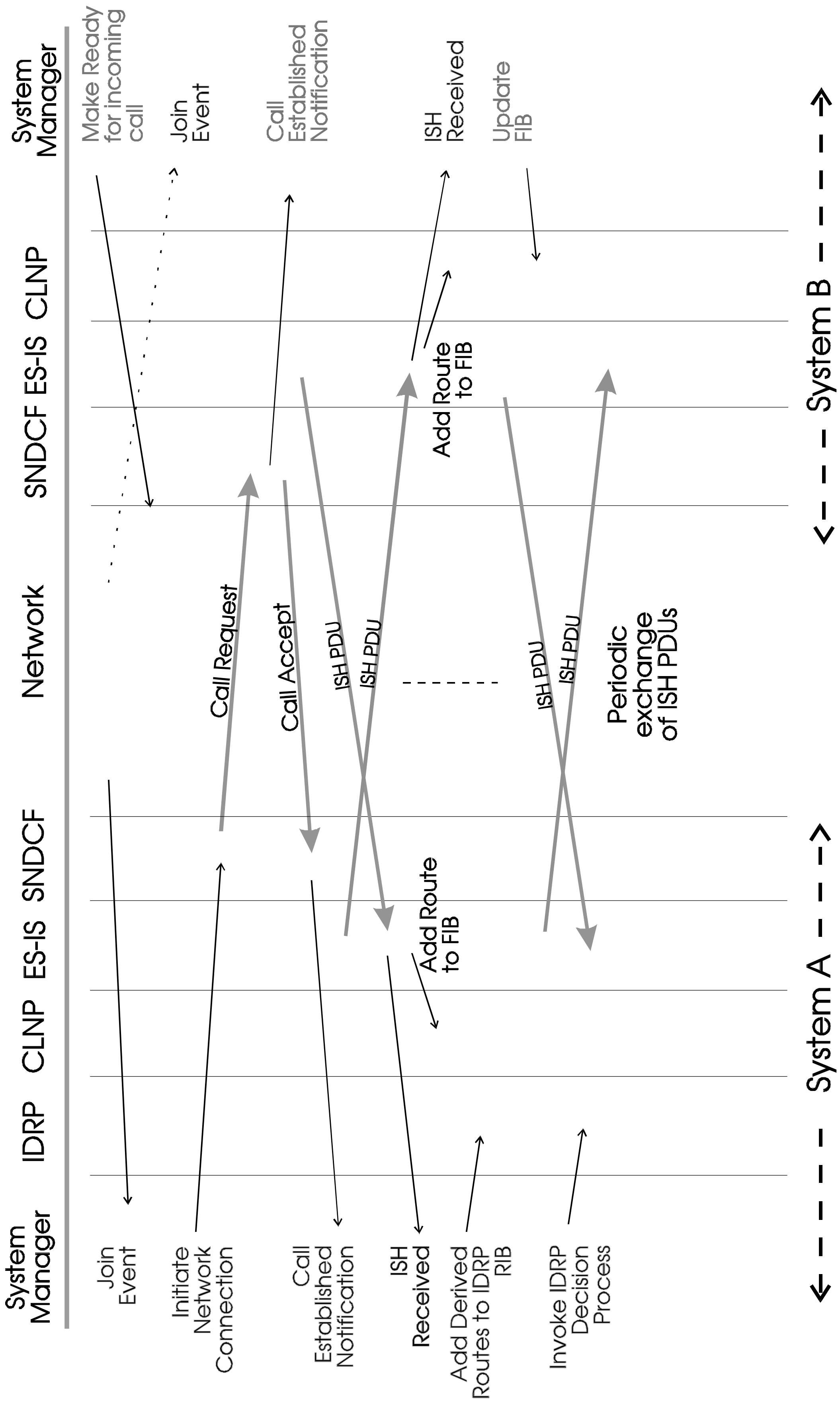

Figure 3 Air-Ground Route Initiation without IDRP

2.4.2 Initial Route Initiation

There is no difference in the initial Route Initiation procedures when IDRP is not used over the air-ground data link.

2.4.3 Route Initiation in CLNP

The ATN SARPs require that the NET of an ATN Router's Network Entity has a Network Selector (NSEL) of zero. This is in accordance with ISO 10589. The SARPs further specify that Airborne Router's that do not support IDRP over the air-ground data link, have an alias NET with an NSEL value of hexadecimal '**FE**', and that this NET is used in the ISH PDU passed over the air-ground data link.

Note: that support of an NET with an NSEL of zero is necessary in such Airborne Routers when, for example, they also support ISO 10589 within the aircraft.

Receipt of an ISH PDU with an NET that has an NSEL of hexadecimal '**FE**' indicates to the receiving Ground Router that the sending Airborne Router does not support IDRP. The IS-SME must then apply the special procedures discussed below.

2.4.4 IS-SME Procedures without the use of IDRP

2.4.4.1 In the Ground Router

When the IS-SME receives a notification that an ISH PDU has been received from an Airborne Router that does not support IDRP, it must derive the routes that are available via the Airborne Router and add these routes to the local IDRP Routing Information Base (RIB). IDRP may then update the FIB and distribute these routes in the normal fashion.

The derivation of routes is possible because the aircraft is known to comprise an End Routing Domain, and from knowledge of the ATN Addressing Plan it is possible to determine an NSAP Address Prefix common to all systems in the aircraft from the NET of the Airborne Router. Further, from *a priori* knowledge of ITU restrictions that may apply to each air-ground data network and the Quality of Service offered by each such data network, the distinguishing path attributes appropriate to the routes may also be determined.

The number of routes derived by the Ground Router in respect of a specific Airborne Router will be determined by the number of different Application Security Types permitted by ITU restrictions to pass over the air-ground subnetwork multiplied by the number of QoS metrics appropriate to the network. Each such route will have as its Network Layer Reachability Information (NLRI), an NSAP Address Prefix constructed from the first eleven octets of the received NET. That is because the ATN Addressing Plan results in a common eleven octet prefix for all NSAP Addresses and NETs in one aircraft's Routing Domain, which may therefore be determined by inspection of any NSAP Address or NET from any system in that Routing Domain.

The IS-SME must then add those routes to the IDRP RIB and run the IDRP Decision Process, which then disseminates those routes and adds them to the FIB in line with the existing Routing Policy, and provided that they are a preferred route to the Airborne Router.

The actual strategy for doing this is implementation specific. However, a likely strategy is for the IDRP implementation to allocate special "adj-RIB-ins" (one per RIB-ATT) for holding routes received by mechanisms outside of the scope of IDRP. The Decision Process will then consider such routes along with those in "normal" adj-RIB-ins. The only distinguishing aspect of such routes is that they will include the "EXT_INFO" path attribute. This is a flag that enables Routing Policy to differentiate between routes that have been advertised by IDRP throughout and those which have been learnt through some other mechanism, perhaps less reliable. As in the general case, the Decision Process must be able to associate this special Adj-RIB-in with the connections to the Airborne Router, and the QoS provided by these connections . This is so that when computing the degree of preference for each such route, or when copying them to the loc-RIB, the Decision Process can update their QoS to reflect the current communications paths that exist to the Airborne Router.

If additional subnetwork connections are opened up (or lost) to an Airborne Router then, instead of generating the derived routes, as before, the IS-SME must cause the IDRP Decision Process to be re-run.

Finally, in this interim role, the IS-SME must also determine when the assumed routes are no longer valid. This event occurs when either the air-ground subnetwork connection is lost or when the periodic exchange of ISH PDUs ceases. On the occurrence of either such event, the routes generated above must be withdrawn.

Note: that in contrast with the use of IDRP over an air-ground data link, when the ATN SARPs recommend that for reasons of efficient bandwidth utilisation, ISH PDUs are not periodically transmitted, in this case they must be periodically transmitted in order to maintain the “liveness” of the routes.

2.4.4.2 In the Airborne Router

The IS-SME procedures are in this case, similar to the ground case, except that:

a) the NLRI of the generated routes cannot be simply derived from the Ground Router’s NET. This is because the Ground Router is typically part of a Transit Routing Domain, and the destinations of the onward routes that it offers will not have any known relationship to its NET.

b) The generated routes must be directly added to the FIB as IDRP is not present to do this on behalf of the IS-SME, or

c) if ISO 10589 is implemented, the generated Routes are used to generate Reachable Address MOs and the ISO 10589 entity is used to update the FIB.

In order to determine the NSAP Address Prefixes for the generated routes, lookup tables will have to be provided so that given the NET of a Ground Router, the Airborne Router can identify the NSAP Address Prefixes for destinations reachable via that Ground Router. Furthermore, such look up tables will have to provide:

i) restrictions on Security Types for such destinations that are additional to ITU restrictions imposed by the Air-Ground Subnetwork;

ii) The Capacity, Hop Count and QoS information for such destinations in a manner sufficient to enable alternative routes to be discriminated between. i.e. an indication of relative preference for each supported metric.

Operationally, there will be a need to ensure that such tables are up-to-date with information appropriate to the Flight Region(s) through which the aircraft will fly, prior to each flight. The actual implementation of this procedure is dependent on the systems involved.

The IS-SME will have to keep dynamic information on which routes are available via each Ground Router with which it is in contact. This information is derived from the look up table and *a priori* information for each Air-Ground Subnetwork supported. When multiple subnetwork connections exists to a given Ground Router then the routing information will be determined taking into account the characteristics of each such subnetwork.

When routes to the same destination are available via different Ground Routers, then the IS-SME will have to choose between them based on the degree of preference given by the look up tables.

i) The IS-SME is also responsible for maintaining the FIB with an up-to-date set of available preferred routes determined as above. It must add such routes to the FIB when they become available, and remove them when the reverse is true, Alternatively, if ISO 10589 is implemented, then the IS-SME may make such routes available to 10589 by creating a Reachable Address MO for each such route, and removing the MO when the route ceases to be available. The ISO 10589 implementation may be relied upon to maintain the FIB with this routing information.