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A Proposal for the Routing Organisation of the European ATN

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SUMMARY

As a French contribution to the « ACCESS » European project, STNA has developed a first proposal for the routing organisation of the European ATN. The resulting report is a draft proposal which is currently being discussed in the frame of ACCESS and considered as one option of the possible European ATN routing architecture. A second option is being developed by another partner of the project, following a different approach.
The purpose of this Information Paper is to present the main outcomes of the first proposed option for the European ATN routing architecture and to make the whole report open to analysis of the widest possible audience.
The report is available upon request.

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1. Introduction

1.1 Purpose and scope of this Information Paper

The 'ATN Compliant Communications European Strategy Study' (ACCESS) project that is being run under the European Commission's programme for financial aid in the field of Trans-European Transport Network (TEN-T), ATM Task UK/96/94, aims at defining the initial architecture of the ATN in EUROPE (i.e. selection of the initial applications, definitions of the initial network topology, definition of the routing organisations and of the addressing plan, etc. ..), and will propose initial solutions as regards to the security, safety/certification, network management, institutional, and other issues as well as a transition plan.

As a French contribution to the ACCESS project, STNA has developed a first proposal for the routing organisation of the European ATN. The resulting report is a draft proposal which is currently being discussed in the frame of ACCESS and considered as one option of the possible European ATN routing architecture. The document has not therefore any official status in the European ATN Community.

A second option is being developed by another partner of the project, following a different approach. Evaluation and validation of both options will be performed later. Further analysis and simulations will then allow to validate the assumptions, provide the basis for a comparative assessment of the different architectural options and support the actual design decisions by quantitative figures.

The purpose of this Information Paper is to present the main outcomes of the first proposed option for the European ATN routing architecture and to make the whole report open to analysis of the widest possible audience. The objective is to get the widest possible range of feedback to this proposal.

The report is available upon request.

1.2 Scope of the presented study

The geographical area considered in ACCESS consists of the following countries: UK, Ireland, Benelux, Germany, France, Italy, Spain and Portugal. These States were chosen for the following reasons:

- **They have a direct connection to the CFMU[1] and/or are involved in the control of North Atlantic traffic.** States connected directly to the CFMU - in 1997 - were selected because this enables the major ground/ground data flows in Europe to be included in the study. North Atlantic Region States were selected, as this Region is likely to provide the first operational implementation of ATN services.
- **The study is representative of both Oceanic and Continental ATC**. Including the NAT Region and European States allows routing and architecture issues between boundary Regions to be studied.

With regard to the definition of the routing organisation of the ATN in Europe, it has however been considered that limiting the study to those states was too restrictive and that there was a need to first consider the problem in a more global geographical scope, covering the whole European Region as well as the ATN interconnection of the European Region with other Regions in the world. In a first step, the geographical scope of the study has therefore been broadened to the whole of Europe. In a

1.

[1] *CFMU: Central Flow Management Unit. The CFMU provides an air traffic flow management service throughout the airspace of most European Civil Aviation Conference (ECAC) states.*

second step, the proposed specific ATN routing organisation within the ACCESS geographical area has been derived from the proposed overall pictures of the European ATN topology.

With respect to the considered timeframe, it is assumed that an initial European ATN will start to be deployed and be operationally used during the period 2000-2005. This initial European ATN is considered in the time as the first brick to a global and mature target European ATN that would answer the most of ground-ground and air/ground ATN communication requirements currently identified. This target European ATN is assumed to be progressively deployed in years 2005-2010 where new data link services and new communication networks will be set in operation and additional ground facilities will be equipped.

The initial ATN of year 2005 must consist of the first elements on an expandable ATN infrastructure that will actually allow, in some further implementation steps, the building of the target European ATN of the year 2010. The initial European ATN is therefore viewed as a transition step toward the target infrastructure.

As a practical approach for the definition of the initial European ATN, it is considered that ACCESS must first focus on the definition of the target European ATN and that the initial implementation will be derived in the scope of the ACCESS transition planning Work Package.

Following this approach, the scope of the study document has not been limited to the initial period of the ATN deployment and proposes a routing organisation for the target European ATN, i.e. for the year 2010.

2. Proposed Overall Routing Organisation of the European ATN

The design decisions made by the first study on the European ATN routing architecture are primarily driven by the criteria to minimise the route management load in the ATN routers. The rational for this criteria is that the ATN can only work if the ATN routers are in a position to absorb and process the routing traffic in real time and converge quickly to valid routing decisions. The route update rate to be supported by the ATN routers is hence perceived as one of the main constraining factors.

A first recommended general principle is to implement Home Routing Domains outside the ATN Islands. The analysis concludes that the European ATN should consist at the upper level of one single and global European ATN Island, completed by an independent separate European « Home » Routing Domain Confederation (RDC) formed by the Airlines and their telecommunications service providers. This European « Home » RDC would host the home Routing Domains of the European Airlines. This overall organisation is illustrated by Figure 1 below.

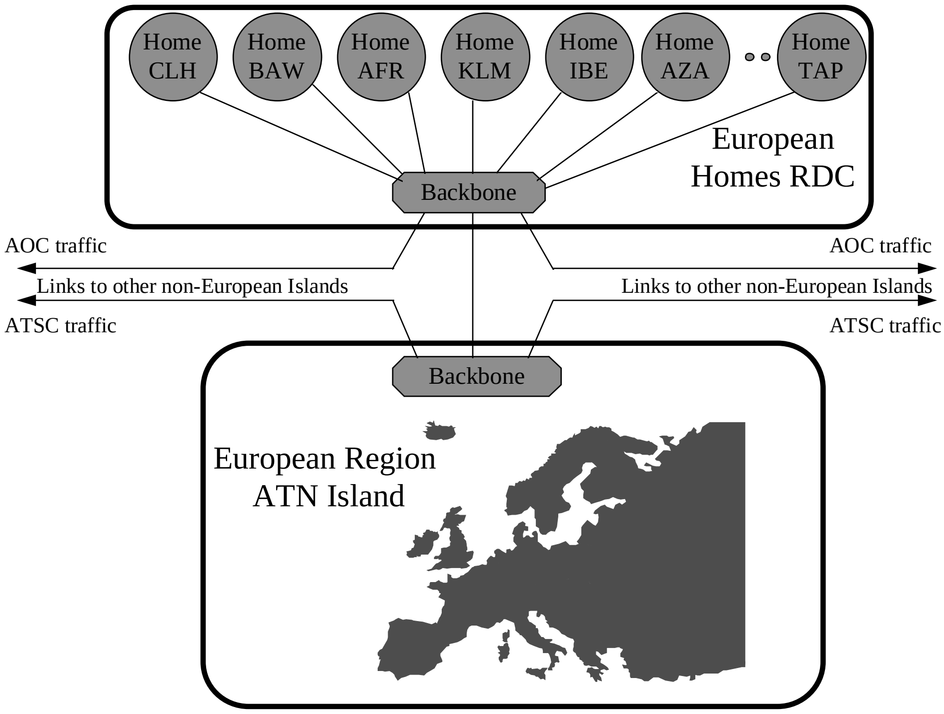


Figure 1

3. Internal organisation of the European ATN Island

The European ATN Island is proposed to be divided in three SubIsland RDCs corresponding to the following three subregions:

1. The Western ATN subregion, which covers the oceanic area and most of the core area, and consists of the following countries: United Kingdom, the Benelux Countries, France, Germany, Switzerland, Ireland, Spain and Portugal

2. The Eastern ATN subregion, which covers a part of the core area, and mostly peripheral area, and consists of the following countries: Austria, Italy, Greece, former Czechoslovakia, Hungary, Romania, Croatia, Slovenia, Bulgaria, Turkey, Cyprus, Malta

3. The Northern ATN subregion, which covers Scandinavia and countries around the Baltic Sea: Norway, Sweden, Denmark, Finland, Latvia, Lithuania, Poland

The interconnection of these three subIsland RDCs is achieved following a hierarchical routing organisation scheme: the three subisland RDCs are proposed to be interconnected via an upper level backbone as depicted in Figure 2.

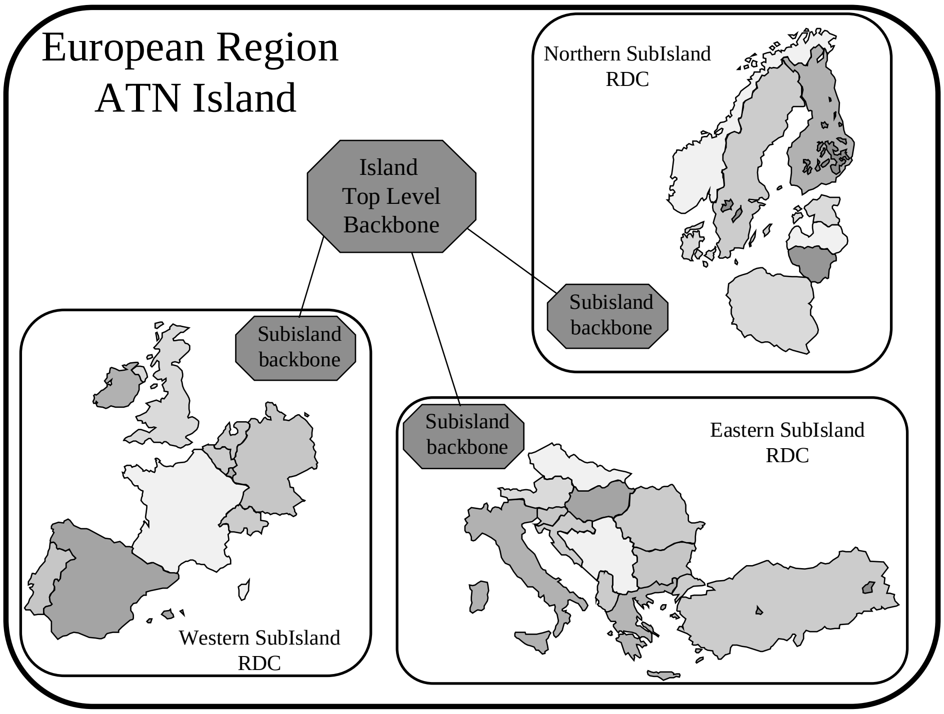


Figure 2

4. Internal Organisation of the European SubIslands RDCs

Each subregion is considered as a SubIsland RDC encompassing a SubIsland backbone and the Routing Domains of the different organisations in the subregion.

Each state is assumed to form one RDC which may consist of one single or several Routing Domains depending on the Administration. As a generic scenario it is assumed that a Routing Domain is created in each country around each national ATC Centre.

Within each national RDC, national RDs are assumed to be directly interconnected.

For transnational ground/ground communication, it is assumed both institutionally and technically unlikely that national ATS Organisations could offer their ATS-dedicated ATN networks to serve as transit network for AOC or long distance ATSC traffic (i.e. ATSC traffic between non-adjacent ATSOs). It is therefore assumed that the national Administration will choose to have their Routing Domain Confederations acting as non-transit RDCs, and that highly multi-national communications between not directly adjacent ATS Organisations will be provided through the backbones. Each national ATS Routing Domain or Routing Domain Confederation will consequently have to be directly connected to the backbone.

However, considering the requirements that will exist in Europe for ground-ground ATN traffic between adjacent ATC centres of the same or different countries, between ATC centres and adjacent airports in the same or different countries, and between adjacent airports of the same or different countries, and considering the current practices by which a CAA already feeds its radar or flight plan data to another one, it may also be assumed that there will be a tendency to establish, for trans-national ATSC communications between adjacent countries, direct bilateral agreement for interconnecting ATN routers.

On the basis of these assumptions, the routing organisation in the three subregions of the European Region ATN Island is proposed to follow the following principles:

1. With respect to the backbone architecture, the use of a route server is considered to be of a major interest. In fact, for a backbone consisting of less than 3 backbone routers, a fully meshed interconnection of these routers may be considered as a reasonable backbone architecture, which can insure a good routing performance level within the backbone and consequently within the region. In such a case, no route server is required. But in the case where more than 3 backbone routers are necessary for achieving the interconnection of the different Routing Domains in the subregion, an architecture based on the use of route servers is recommended. The backbone should then consist of the required number of backbone routers, each being interconnected with a route server (or two, for backup reason).

It is assumed that the control, ownership and sharing of backbone BISs will depend on national and regional implementation strategies.

2. In those European subregions, where no international ATC WAN is available, It is proposed that the ATN be implemented by simply interconnecting the national ATN RDCs to the backbone and by completing when required this simple and basic architecture with possible direct BIS-BIS connections between routers of adjacent countries. Figure 3 illustrates such a basic routing architecture applied to the Western European subregion.

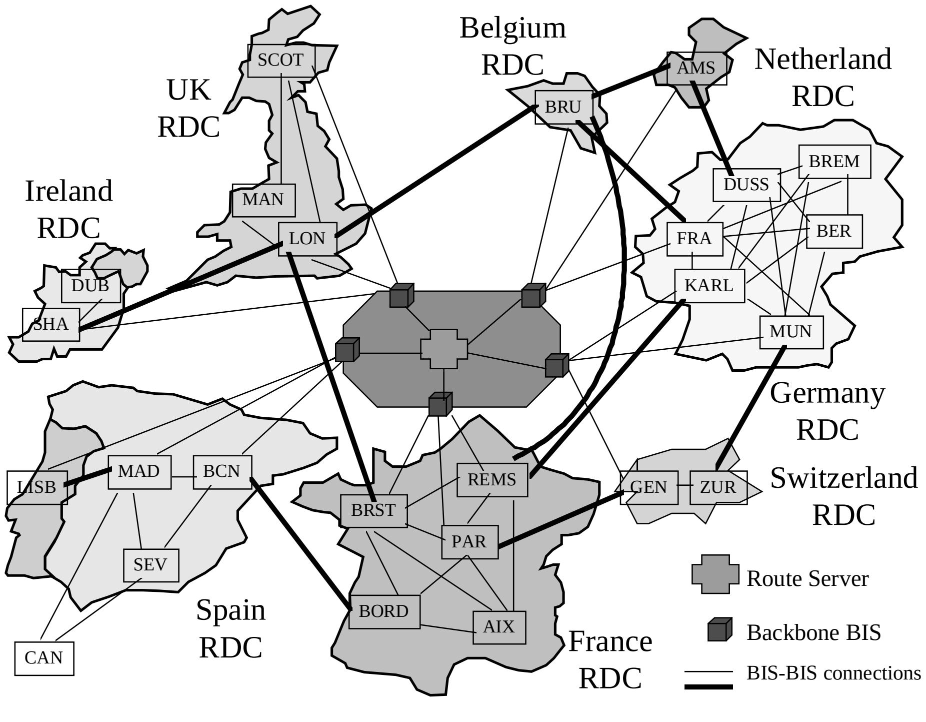


Figure 3

3. For those European subregions, where an international ATC Wide Area Network is available, an « optimal » routing organisation relying on the generalisation of the use of Route Servers is recommended. The proposed approach consists in interconnecting each national RD or RDC with the route server(s) of the backbone. With such a routing organisation, each BIS within the subregion can be informed on the direct path, via the international ATC WAN, to any RD of the subregion. This architecture is represented on Figure 4.

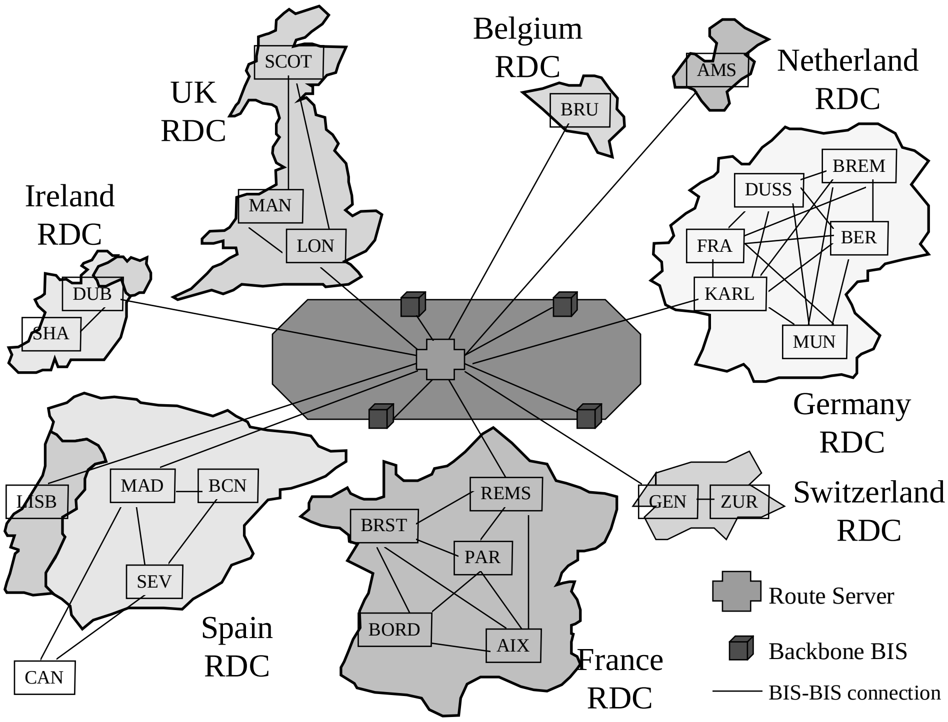


Figure 4

5. Routing AOC traffic within the Island

It is assumed that a number of the A/G BISs belonging to ATS Organisations will be attached to mobile subnetworks upon which AOC traffic exchanges are authorised (e.g. VDL, satellite subnetworks). These ATS A/G BIS will hence be potentially able to advertise AOC traffic permitted routes to Aircraft. These AOC permitted routes must be propagated toward the backbone. In the same way National Airport Operators are assumed to implement A/G BIS with Gatelink connection to parked aircraft, and will hence also provide routes to aircraft permitted for all traffic types that will have to be advertised to the backbone.

The AOC permitted routes to aircraft known by the A/G BISs of the national ATS Organisations and Airport operators could be advertised toward the backbone via the ATN infrastructure and the subnetwork of the ATS Organisations; but this would result in authorising the AOC data traffic to use the same path (and then go through the set of ATN routers and subnetworks of the ATS Organisations). This is unlikely; in general it is assumed that national ATS Organisations will not accept to offer their ATS-dedicated ATN networks to serve as transit network for AOC traffic. The AOC-permitted routes and AOC data traffic transiting between the ATS Organisations or Airport Operators A/G BISs and the backbone must therefore go through an alternate complementary ATN infrastructure.

ATS Organisations will unlikely be candidate for paying the cost of such an alternate ATN infrastructure. It is therefore assumed that this task will be delegated to International Aeronautical Communications Service Providers (IACSPs): the A/G BISs of ATS Organisations and Airport Operators offering AOC permitted routes to aircraft will then be assumed to be connected to an IACSP subnetwork and interconnected with an IACSP BIS. The IACSP(s) will then be responsible of implementing the ATN routers and subnetworks infrastructure necessary for the advertisement of routes to the backbone and for the transit of the AOC data traffic.

Figure 5 below illustrates the proposed scenario for the support of AOC traffic in the European subregions.

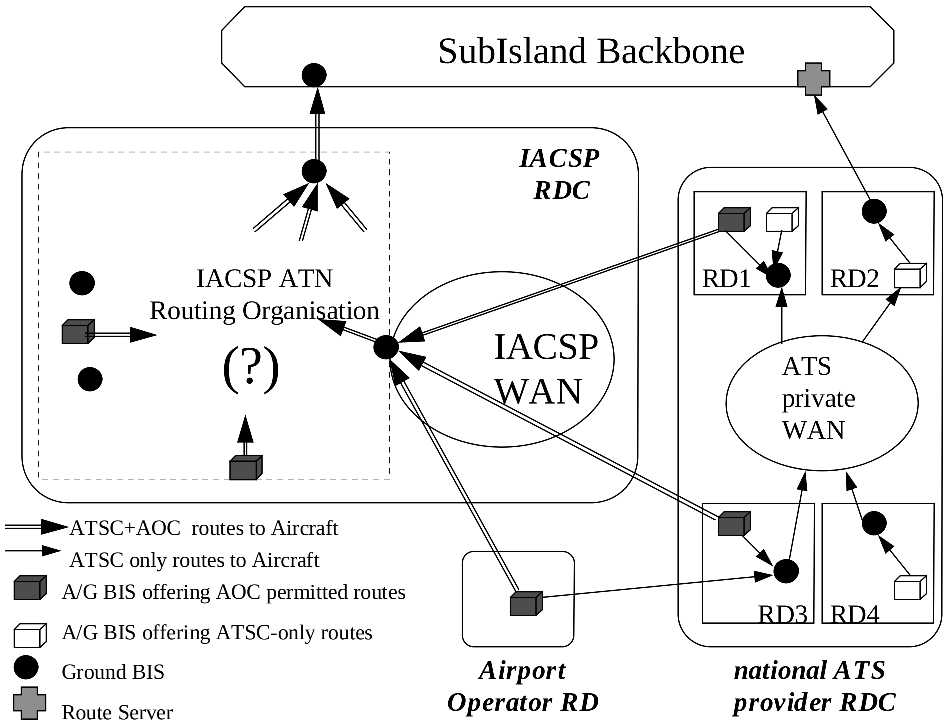


Figure 5: Routing AOC traffic within the Island

6. Routing Organisation for Airlines and IACSPs

Given the assumed unwillingness of ATSOs to open their ATS-dedicated ATN networks to the transit of AOC traffic; IACSPs could be prime actors of the AOC data forwarding task. IACSPs (with aircraft operators) are assumed to participate in the implementation of the ATN, at the following 3 levels:

1. At national level, for the provision of general ATN services (e.g. AOC, AAC communication) complementing the services provided by the national ATSO. Depending on the national strategy of the ATSO, IACSPs may be contracted for the provision of ATN services meeting local ATS communication requirements.

2. At subregional/regional level, IACSPs may deploy an ATN infrastructure meeting airlines communication requirements, and completing potentially the regional ATS communication service by offering alternate/backup ATN routes to the aircraft.

3. At inter-regional level, IACSPs and airlines are assumed to look after the implementation and interconnection of Home Routing Domains and to consequently participate in the routing and forwarding of inter -island data traffic to/from aircraft.

It is assumed that IACSPs and airlines will implement the ATN infrastructure suitable at each level for meeting the particular requirements. The Routing Organisation for this ATN infrastructure is out of the scope of the ACCESS study.

7. ATN Systems Deployment Scenario

7.1 Location of ground End Systems

Recommendations for the locations for ATN End Systems in the 2010 timeframe and in the area considered are expressed in another ACCESS report. The recommended locations are:

- Eurocontrol Sites: CFMU in Brussels and experimental center in Brétigny (near Paris),
- The main approach ACCs (namely London, Manchester, Paris-Orly, Paris-CDG, Berlin, Dusseldorf, Frankfurt, Munich, Brussels, Amsterdam, Milan, Rome, Barcelona, Madrid and Palma) for CM, CPDLC, ADS, FIS, RVR, and SIGMET services, radar data and flight plan processing, :
- The en-route ACC (namely. London, Manchester, Scottish, Dublin, Shannon, Paris, Reims, Aix-Marseille, Bordeaux, Brest, Berlin, Bremen, Dusseldorf, Frankfurt, Karlsruhe, Munich, Brussels, Amsterdam, Maastricht, Brindisi, Milan, Rome, Padua, Barcelona, Canarias, Madrid, Seville, and Lisbon ACC) for CM, CPDLC, ADS and SIGMET services, radar data and flight plan processing, and flow management.
- The main airports (namely London-Heathrow, London Gatwick, Manchester, Paris-Orly, Paris-CDG, Frankfurt am Main, Munich, Dusseldorf, Brussels, Amsterdam-Schipol, Milan, Rome, Barcelona, and Madrid airports) for CPDLC services, for AIS and MET information access, and for flight plans submission
- The Centre of operations of the main Airlines (namely London Heathrow (British Airways and Virgin), Frankfurt (Lufthansa), Paris-CDG and Paris-Orly (Air France), Amsterdam (KLM), Rome and Milan (Alitalia), Madrid and Barcelona (Iberia), Brussels (Sabena), Dublin (Aer Lingus), Lisbon and Porto (TAP), Luxemburg (Cargolux), Hannover (Hapag Llyod), Dusseldorf (LTU) for flight plan processing and AOC traffic exchange.
- The RMCDEs for radar data exchange
- The AMHS/AFTN Switching Centres

7.2 Deployment of ATN Routers

7.2.1 General

ATN routers will be deployed on the sites where ATN applications are run. In each of these sites, the ATN routers may be intra-domain IS, ground BISs or Air/Ground BISs depending on the adopted routing organisation and on the A/G connectivity requirements.

The sites where ATN applications are run have been identified in the previous section. They are:

- en-route and approach ACC for ATS application
- airports for ATS and AOC applications
- global ATS Sites (e.g. the CFMU, meteo centres or AFTN/AMHS switching centres)

7.2.2 ATN deployment in Airports

Airports are the physical locations where many pre-tactical and tactical ATS and AOC applications are run. This physical concentration makes airports a first choice target for an ATN-based data communication integration effort. Each Airport site are consequently proposed to be equipped with at least two ATN routers:

- an ATS-dedicated ground BIS, managed by the Terminal Air Traffic Authority, (or by another party operating by delegation from the Civil Aviation Authority of the concerned Member State)

- a general purpose Air/Ground BIS, managed by the Airport Authority or by another party operating by delegation from the Airport Authority

This provision allows to establish an ATS-only internetworking subset, so as to alleviate responsibility and liability concerns with respect to ATS applications.

Based on the connectivity requirements identified in the report, the baseline architecture for interconnecting ATN components in an airport, is the generic model depicted on Figure 6:

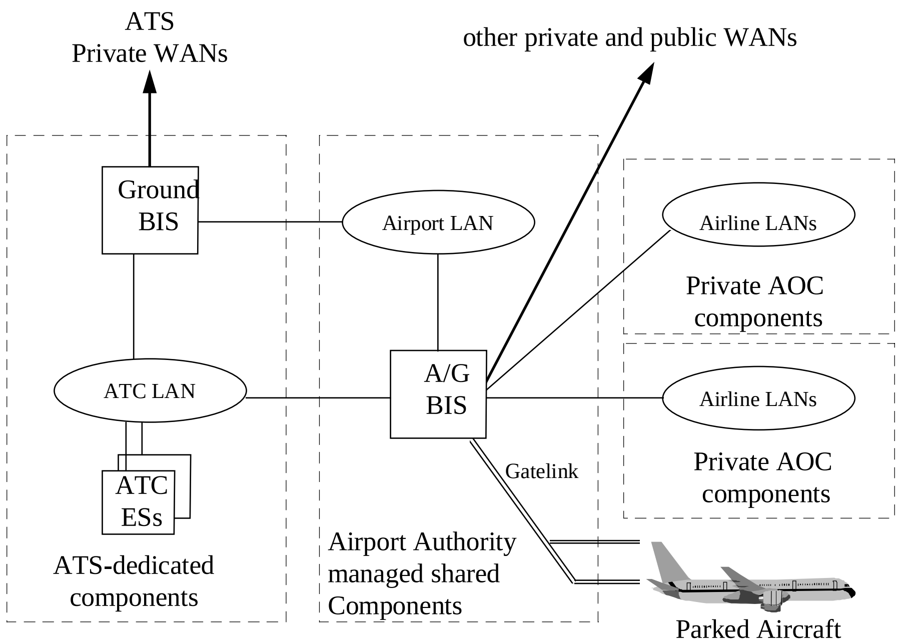


Figure 6: Baseline ATN infrastructure in airports

7.2.3 ATN deployment in ACCs

Each ACC should be equipped with at least one IS for interconnecting the ACC LAN(s) to the national ATS WAN.

In ACCs with A/G connectivity, this IS will be an A/G BIS, thus being additionally connected to Air/Ground subnetworks. If one of the attached mobile subnetwork is furthermore authorised for AOC traffic, this Air/Ground BIS must be connected to an IACSP network and/or to other private or public WANs, for allowing AOC ATN communication between remote Airline Centre of Operations and the Aircraft.

In ACCs without A/G connectivity, this IS may be either an Intra-Domain IS or a ground BIS depending on whether the IS is at the boundary of a routing Domain or not.

For an ACC with A/G connectivity, the baseline architecture is the one depicted on Figure 7. It is simpler than for an airport as there is only one main actor and one category of applications involved.

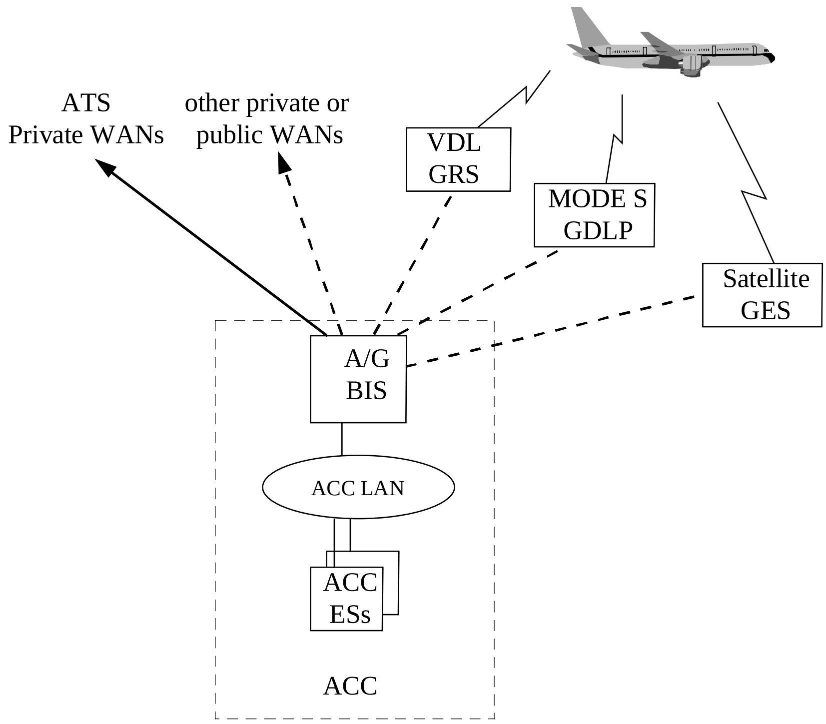


Figure 7: Baseline ATN infrastructure in ACCs

7.2.4 ATN deployment in global ATS Sites

Other ATS Sites should be equipped with at least one IS for interconnecting the LAN(s) to the national ATS WAN and possibly to other private and/or public WANs if connectivity is required with non-ATS actors.

Assuming that these ATS Sites have no A/G connectivity, the IS may be either an Intra-Domain IS or a ground BIS depending on whether the IS is at the boundary of a routing Domain or not.

7.3 Generic national ATN deployment scenario

Within a given European country, the resulting generic and overall interconnection scenario is as follows:

1. national ATS Organisation

   - an ATS Routing Domain is created in each national ATS RDC around each national ATC Centre. This Routing Domain encompasses the ATC Centre, and all airports and other possible ATS sites in the related FIR. Within each such Routing Domain, all BISs are directly interconnected with each other, as required by the IDRP standard.

   - It is assumed that the national RDs will be directly interconnected with each other national RDs by interconnecting the A/G BIS of each ACC with each A/G BIS of other ACCs.

   - The A/G BISs that accept AOC traffic will be interconnected with a BIS of an IACSP

2. national Airport Operator

    - In the main airport, the airport operator will form a Routing Domain consisting of the A/G BIS offering Gatelink access to the aircraft, of its possible ESs, and of possible ESs of other local non-ATM organisations having a requirement for ATN communication (e.g. Access Control Authorities (Police, Custom, Immigration, Tax & Duties,..) Commercial Service Providers (car rental services, Gift Shops...)).

    - The Airport Operators A/G BIS will be interconnected with the local ground BIS of the national ATS Organisation and with a BIS of an IACSP. The national ATS Organisation will accept the transit of ATSC traffic to/from the RD. The IACSP will accept the transit of all types of traffic to/from the Airport Operator.

3. national Military organisations

    - It is assumed that the military organisation will access the European ATN by direct interconnection with their national ATS Organisation. Secure gateways should be used to provide interoperability between ATN End-Systems and military operated End Systems. It is assumed that the military End Systems are located on a secure network operated and managed by the military for operational purposes. The ATN side of the Gateway should act as an ATN End System of the national ATSO, located within the routing organisation of the national ATSO and as such should appear in the national ATSO ATN addressing plan. The ATSO should be responsible for management of the ATN side. The military organisation should be responsible for the management of the non-ATN side and of the security implications.

4. national Meteorological Service Providers

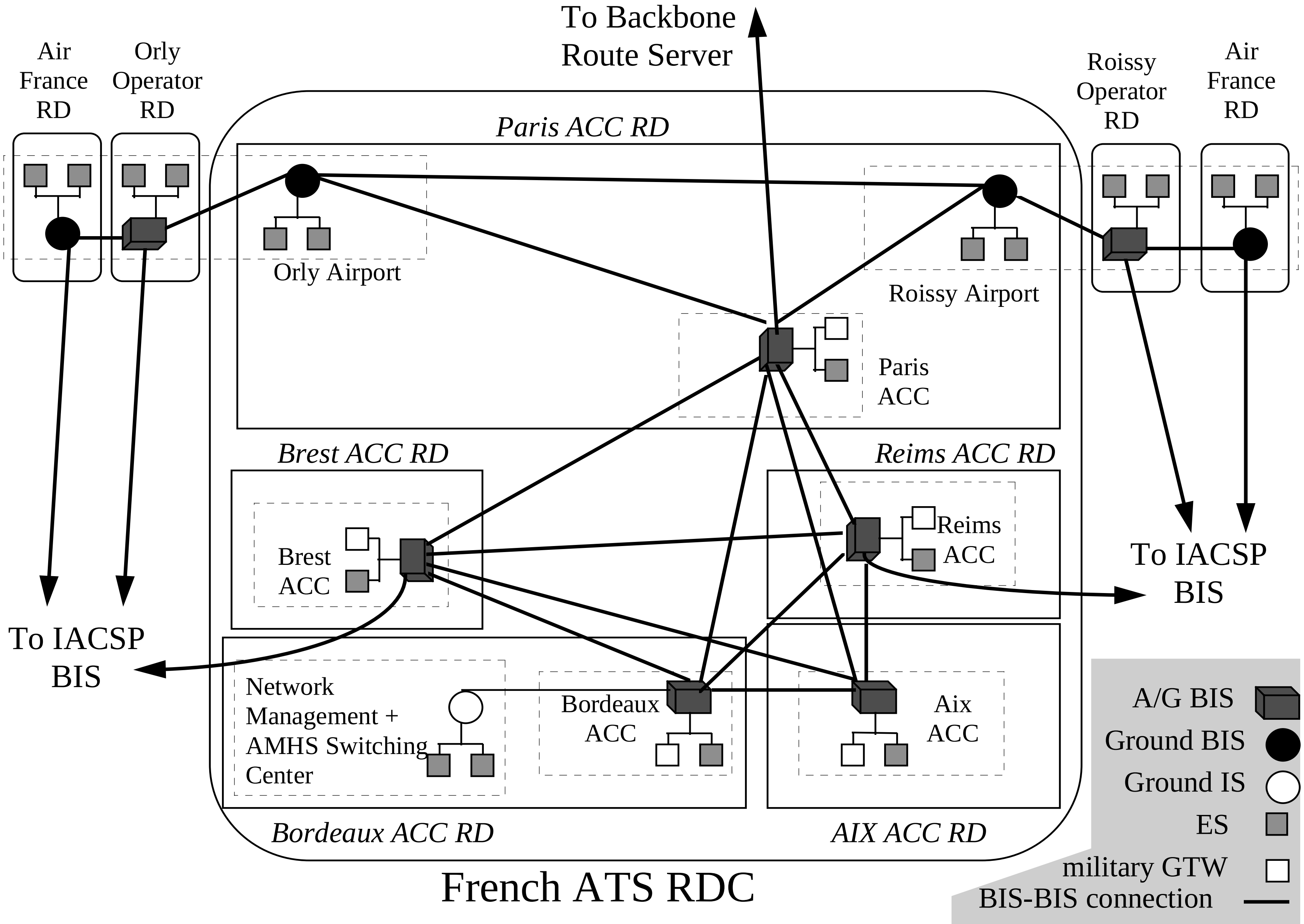
    - It is assumed that the Meteorological organisations will access the European ATN by direct interconnection with their national ATSO. The meteorological End Systems should act as ATN End Systems of the national ATSO, located within the routing organisation of the national ATSO and as such should appear in the national ATSO ATN addressing plan.

5. Local Aircraft Operators

    - In Airports serving as their centre of operation, the airlines are assumed to implement ESs and form a Routing Domain. They may implement a Ground BIS or prefer to rely on the ATN service provided by an IACSP. Airlines ground Routing Domains will be interconnected with the local Airport Operator and with the IACSP.

The next figure is an application of this generic intra-national routing organisation scenario on the French case.

Note: This is just an example of application of the generic deployment scenario and not an approved topology for the French ATN.



French ATS RDC

8. Conclusion

It is believed that the complex subject of this study deserves the analysis of the widest possible audience. WG2 members are invited to request and distribute the ACCESS document to persons in their organisation who are interested by ATN implementation issues. We would like to thank in advance for any comments that could be sent by e-mail at the following address: tamalet_stephane@stna.dgac.fr