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Guidance Material for Core/SV1 Systems Management

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SUMMARY

This document combines the ATNP standing ATN Systems Management Concept and the ATNSI document “Network Management in the ATN Environment” to form the basis for SV1 and CORE Guidance for Systems Management.

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1. Overview ATN Systems Management

1.1 Objectives

Systems management will provide mechanisms to monitor, control and co-ordinate communications resources with the goal of achieving a seamless communications service in support real world air traffic operations. To achieve this it is required that specific management information, functions and protocols are designed and built into any supporting communications network to provide deterministic and controllable network behaviour.

Systems Management is needed to provide deterministic and controllable behaviour in support of required service levels as the communications infrastructure evolves from simple point to point technology towards increasingly complex inter-networks used for program to program application services.

Systems Management may be distributed, centralised or local and can be achieved by a variety of mechanisms. The total communications management solution will involve a combination of the following approaches:

1. Appropriate design of the communications infrastructure and components to anticipate and provide sufficient capacity.

2. The implementation operational procedures to control resource allocation not requiring specific management functions or networking technology.

3. The implementation of local automated or operator controlled management functions in communications systems.

4. The implementation of management functions in communications systems that allow remote systems management that communicate using a standardised systems management model (e.g. using CMIP/CMIS from the OSI world, SNMP from the TCP/IP world, file transfer mechanisms, messaging services etc.).

The real word situation is complex and will require a practical solution comprised of many building blocks organised into a coherent whole.

1.2 The Operational Concept

MATERIAL REQUIRED

Systems Management is just part of the overall Operational Concept of the ATN. Indeed it is difficult to place requirements on Systems Management in the absence of such a Concept, therefore many assumptions have been made.

Operational Concepts must be defined to enable all the following requirements, constraints and assumptions to be validated within that context.

The ATN community has been waiting for an Operational Concept but it has not yet materialised despite various efforts. Practically speaking, it may only come from a combination of contributions on all relevant subjects from regional and international perspectives (i.e. Systems Management, Security Management, QOS Management, Applications Operation and Network Operation) and with experience with the deployment of CNS/ATM-1 Package.

The most basic assumption is that detailed capacity planning and network design will be conducted in order to deploy a network that provides a sufficient level of service for anticipated operations. It will not be possible for Systems Management to correct deficiencies in this service on anything other than a temporary basis.

1.3 Administrative and Operational Management

Systems Management architecture is as much an organisational and institutional issue as a technical one. The end state concept identifies Institutional authorities which establish policies, make contracts and service level agreements with providers, Administrative managers enforce and monitor these and Network managers at the equipment level manage the day to day operation of the communications infrastructure.

As well as the need for managers to communicate with equipment, managers in a hierarchy must be able to exchange information amongst themselves.

There are 3 basic areas to consider with the transition from today's situation where networks are largely "observed" rather than formally managed, these are:

- management information and the associated operations on that information,
- management communications i.e. how the information is communicated,
- management functions i.e. how the management information is processed and used.

There will be "Administrative" management requirements not directly related to the network management (operation) of ATN equipment. Authorities will require Administrators to collect statistics, make statistical analysis and collate reports for accounting purposes etc.

For these purposes classes of administrative management information and managers are defined.

Administrative management information should present "views" of network operation to system administrators e.g. to:

- administer costs,
- present performance assessment,
- allow the application of a particular policies to groups of ATN equipment,
- administer service agreements (e.g. allow service providers to "present" their services to a user),
- provide an overall picture of network operational status in centres,
- implement access control between institutions.

It is important to realise that Administrators will be able to consolidate fault reports and overall traffic assessments from various Operational Managers at the equipment level. However, direct automated management response (i.e. management of managers) to such reports may not be practical or operationally desirable.

Direct operator to operator dialogue may be more appropriate where the Administrator requests the Operational Manager (who has more detailed local knowledge) to perform a task or informs him of global operational conditions of interest to him.

1.4 Large Scale Structure of the ATN

Figure 2 illustrates the possible large-scale structure of an example subset of the ATN environment.

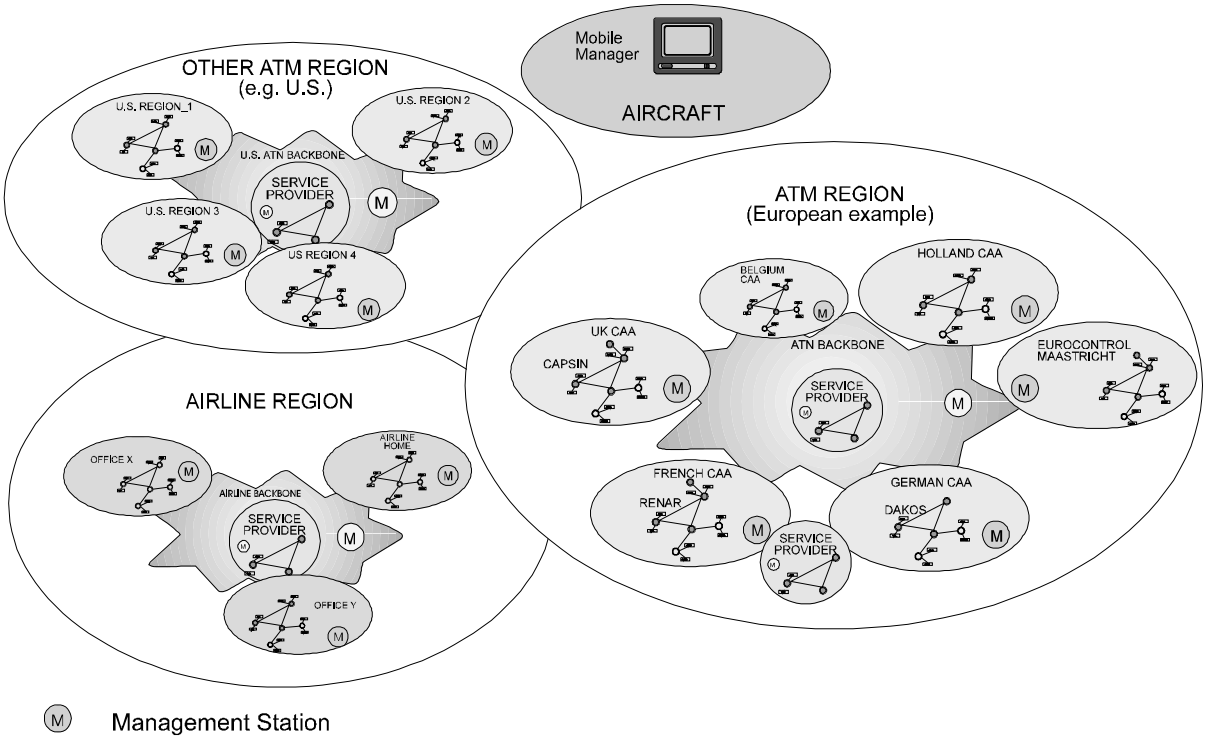

Figure 2 - Large scale ATN structure

There are two basic types of ATN REGION which communicate with AIRCRAFT as shown in the figure:

- the AIRLINE type
- the Air Traffic Management (ATM) type.

The AIRLINE REGIONS and ATM REGIONS are shown in the figure as overlapping to some extent. This indicates that they are logically separate networks expected to exchange management information and traffic according to policy.

Within REGIONs are 2 basic kinds of ATN entity, end users (e.g. CAAs or Airlines) and the ATN BACKBONE which provides connectivity on the ground between end users.

The backbone may consist of a combination of nationally owned facilities and commercially owned facilities (service providers).

1.5 The Structure of Managers, Administrators and Institutions

Figure 3 presents a possible hierarchy of Managers, Administrators and Institutions.

There is a 2 level hierarchy of active managers; Area Administrators and Network Managers which operate according to contracts, agreements and policies made by Regional Institutions.

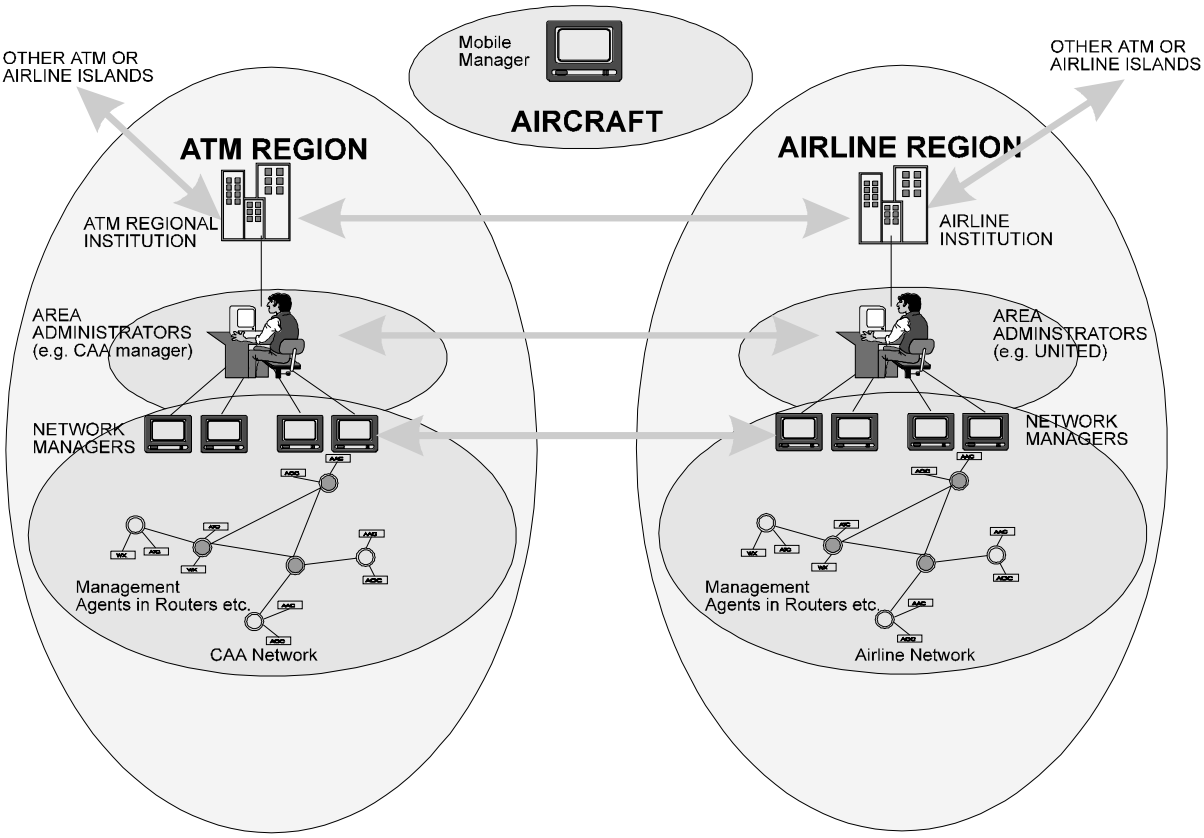

Figure 3 - Structure of ATN Authorities

1.5.1 Management on the Ground

1.5.1.1 Regional Institutions

Every AIRLINE and ATM REGION will have a REGIONAL INSTITUTION which has ultimate responsibility for the operation of the REGION. These Institutions may delegate, by agreement, responsibility for active administration to managers at their disposal (e.g. those in the CAA domains of responsibility).

Note: The above does not imply that REGIONAL INSTITUTIONs are active managers of a further hierarchy of managers.

REGIONAL INSTITUTIONS are the responsible authority for:

- Establishing contracts, agreements and polices regarding the structure, integrity and internal administration of the Region as a whole. This will involve co-ordinating communication policies between CAAs, AIRLINEs and SERVICE PROVIDER participants that form the REGION.

- Negotiating policies for communicating with other REGIONs external to itself.

These agreements and policies will not be implemented or checked automatically by managers, responsibility for their active implementation is passed to the Area Administrators.

REGIONAL INSTITUTIONS may provide support facilities to enable the implementation of agreements and policies (e.g. provide an address registration and allocation database accessible to administrators).

Standards Required:

No ICAO ATN SARPs are required unless institutions provide electronic repositories of information (e.g. an address registration and allocation database).

Institutional procedures must be defined to make and administer policies and agreements.

1.5.1.2 Area Administrators

Within ATM REGIONS are organisations:

- CAAs
- commercial telecommunications SERVICE PROVIDERS.

Within AIRLINE REGIONS are:

- AIRLINE AUTHORITIES
- commercial telecommunications SERVICE PROVIDERS.

Every CAA, SERVICE PROVIDER and AIRLINE AUTHORITY will have an ADMINISTRATOR which has responsibility for its own area. These Managers may use lower level managers/agents at their disposal (e.g. managers of networks) involving the collection and organisation of data concerning operations of the network.

The ADMINISTRATOR who operates a management station will for example:

- administer costs,

- present performance assessment,

- take action in response to the analysis of data, events and fault reports collected from the network,

- take action to enforce agreements and policy statements made by REGIONAL INSTITUTIONS,

- be responsible for address administration (including establishing and maintaining the routing structure of the network),

- administer and maintain QOS, secure interaction and other policies common to domains,
- switch SERVICE_PROVIDERs according to operational circumstances (fault reports etc.)

  Note: An agreement with service providers may oblige them to "present" accessible summary information on their services.

- present an overall picture of network operational status in centres,
- implement access control between administrators in different areas.

  Note: When organisations exchange management information, specific administrative managed objects presenting a limited "view" of an organisation may provide a sufficient means for access control.

Standards Required:

As a minimum regional standards are required for the communication of information between ADMINISTRATORs, NETWORK MANAGERs and SERVICE PROVIDERs.

ICAO ATN SARPs will be needed if ADMINISTRATORs in different regions wish to exchange summary information at their disposal.

1.5.1.3 Network Managers

Within CAAs, AIRLINE AUTHORITIES and SERVICE PROVIDERS are:

↳ NETWORKs.

Every NETWORK will have a NETWORK MANAGER which has responsibility for the detailed operation of the equipment in the network.

The NETWORK MANAGER has access to the many pieces of distributed physical equipment. It collects data and administers the Management Information Base for groups of Host Computers, Routers and Subnetwork Components via "Management Agents" resident in those systems.

NETWORK MANAGERs hide the details of the normal operation of network equipment from ADMINISTRATORs.

Distributed systems management of ATN equipment within organisations will be required. It will obviously be impractical to have operations staff manning each piece of ATN equipment, operating it from a local interface. It would also be infeasible to guarantee equipment configuration and operation without such facilities.

Note: The implementation of standard management solutions in ATN equipment may be required by regional certification authorities (and will help manufacturers develop and sell standard certified equipment in the world-wide ATN market).

The pre-CNS/ATM-1 Package draft SARPs of the ATN Manual V2.0 contained detailed specification of requirements for the management of the ATN Internet based on OSI standards. This remains the recommended approach for network management, the material is appended to this document since the ATN Manual V2.0 has not been published by ICAO.

Note: The Administrator and Network Manager are defined above in functional terms. It is possible that these functions could be co-located in a single management station, this will depend on local design issues (e.g. physical topology, network size and complexity).

Standards Required:

Regional standards will be needed for the distributed management of networks within organisations on the ground.

ICAO ATN SARPs will be needed when management information is exchanged over the air ground link (see below).

1.5.2 Management in the Air

AIRCRAFT have MOBILE MANAGERs with responsibility for the detailed operation of the ATN equipment on board (they are similar in function to NETWORK MANAGERs but with a smaller scope).

No management exchanges over the air-ground during flight are foreseen other than real-time event and fault reports of serious operational consequence.

The mechanisms for real-time operational fault and event reporting to ATC authorities over the air-ground link must be standardised (e.g. as ATN application exchanges or as Systems Management application exchanges using specifically designed protocols (e.g. CMIP)). The reports themselves must also be standardised.

Airborne systems will be managed by Airline Managers from the ground but not by ATC authorities. The Airline Manager may provide ATC managers with data concerning the aircraft by ground-ground data exchanges. Systems management exchanges between aircraft and ATC authorities and Airborne systems are limited to event reports initiated by the Aircraft.

In the flight deck environment, mobile managers will need to be autonomous applications requiring a minimal level of human intervention.

Airborne systems will not manage ground systems (although fault reports may be exchanged).

Summaries of flight operation (e.g. engine performance) collected by mobile managers or other operational systems may be downloaded at the gate for analysis by Airline ground based managers.

Operational parameters to be used in flight may be uploaded at the gate for use by mobile managers.

Standards Required:

Aeronautical standards will be needed for the distributed management of networks within aircraft.

ICAO ATN SARPs will be needed when management information is exchanged over the air ground link for fault and event reporting.

ICAO ATN SARPs will be needed when information is exchanged at the gate.

2. The ATN Systems Management Model

2.1 Principles

The ATN Systems Management Model is based on the OSI Model described in ISO/IEC 10040, Systems Management Overview, using CMIS/CMIP communications where Network management is accomplished through a system which is made up of at least these five components:

- The *Managed Resources*, which can include network devices such as ATN routers, as well as other equipment and applications (software) which requires management.

- A set of *Managed Objects* (MO). MOs are abstractions of the actual managed resources. These software abstractions provide the management interface to the real resources being managed. For example, a set of MOs have been defined for the management of ATN routers. Each ATN router MO represents specific data associated with the router "managed resource".

- A management database in the form of a *Management Information Base* (MIB). The MIB is composed of the MOs, organised in an efficient manner to allow ease of retrieval of the data contained in each object.

- A management *Agent,* which is a software entity, residing in the device to be managed. The agent accesses management data from the managed device and converts this raw data into a MIB-compatible format. Agents respond to queries (from managers) regarding management data. Agents also notify managers when significant events take place.

- A *Manager* application, which resides on a *Management Workstation*, located at an organization's (e.g. airline, civil aviation authority) operations control center. The manager is responsible for receiving and responding to fault notifications, initiating queries to accomplish the retrieval of management data, and providing an interface (usually a graphical interface) to the personnel in the operations control center.

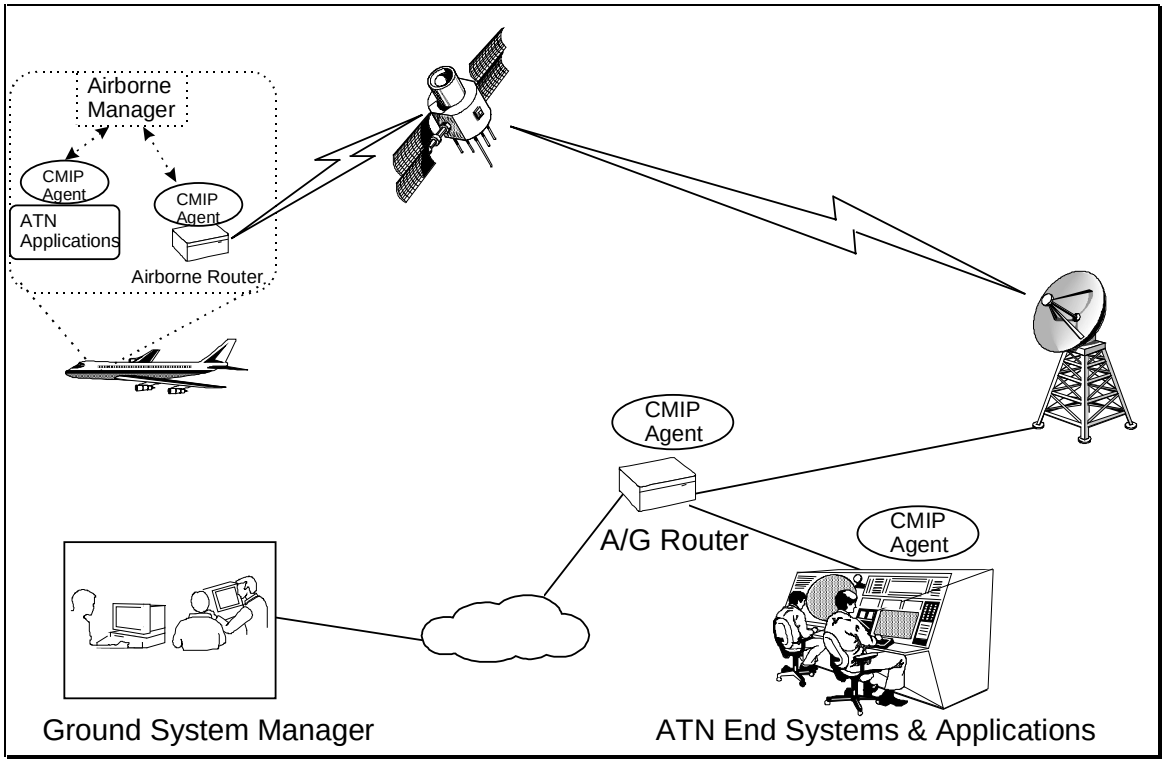

Figure 1-1

Figure 1-1 presents a systems management scenario. *Systems management* refers to the management of equipment resources that include but are not limited to network devices. Systems management also refers to the management of applications. Achieving an integrated *systems* management approach is an important goal. Just as ATN will benefit from NM, the ATN applications, as well as many other aviation systems stand to benefit from an integrated network and systems management (NSM) approach. As a general example, consider the fact that a significant amount of data is collected which relates to the operational status and maintenance of various avionics on aircraft. Collecting this data by using integrated NSM provides the opportunity for immediate correlation of the data, thereby improving efficiency and enhancing fault and performance capabilities.

2.2 ISO Standards Overview

There are four main groupings within the set of management standards. They are:

- a set of ISO standards relating to the framework for Systems Management;
- a set of ISO standards relating to the specification of managed objects;
- a set of ISO standards specifying systems management functions;
- a set of application layer service and protocol standards for communicating information relating to management functions.

An overview of the ISO standards for OSI Systems Management is illustrated in Figure 12.1.

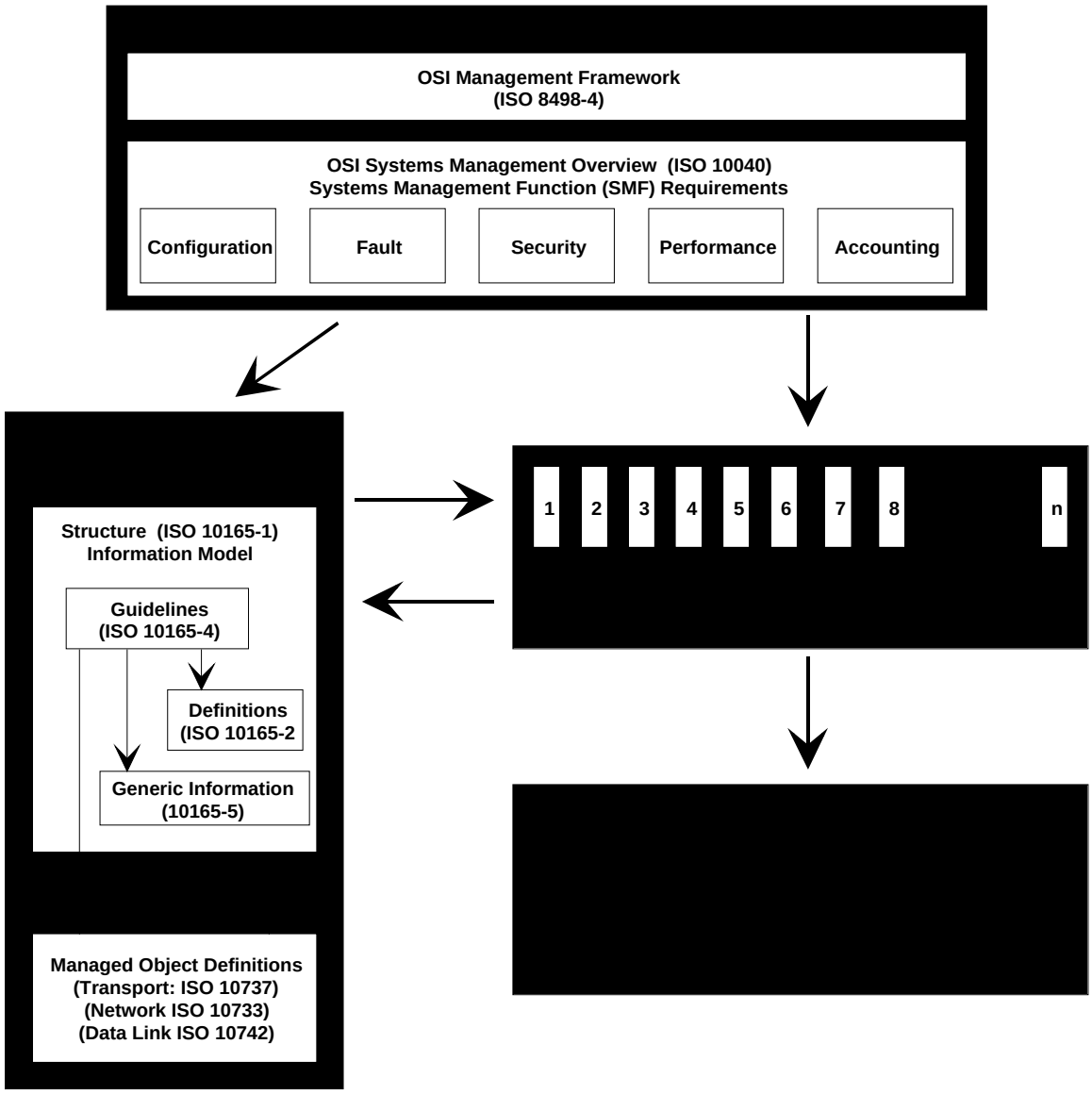

Figure 12.1: System Management Standards

2.3 Model Overview

This section presents a brief description of the basic elements of a network management system. The primary elements of any network management system include:

- Manager Station
- Management Agent
- Managed Resources

- Management Information Base
- Management Protocol

The following sections contain a brief summary of the important aspects of each of the primary elements listed above.

2.3.1 Management Station

A network manager workstation hosts one or more management applications. The application(s) provide the required set of management functions. The most significant functions of a management workstation are:

- Data collection
- Fault diagnosis and recovery
- Resource configuration
- Performance analysis
- Trend analysis and forecasting
- Graphical display of managed resources
- Integration of multiple data sources
- Automated correlation of data
- Integration of management applications

2.3.2 Management Agent

A management agent is usually co-located with the managed resource. The primary elements of a management agent include:

- MIB data structures
- Data retrieval module
- Management communications protocol module
- event-based or polling-based monitoring module
- Management Protocol: SNMP, CMIP, Proxy, Log readers, CORBA, Web Protocols, etc.

Figure 1-2 depicts the relationship between a management workstation, the management application(s), agents and the managed resources.

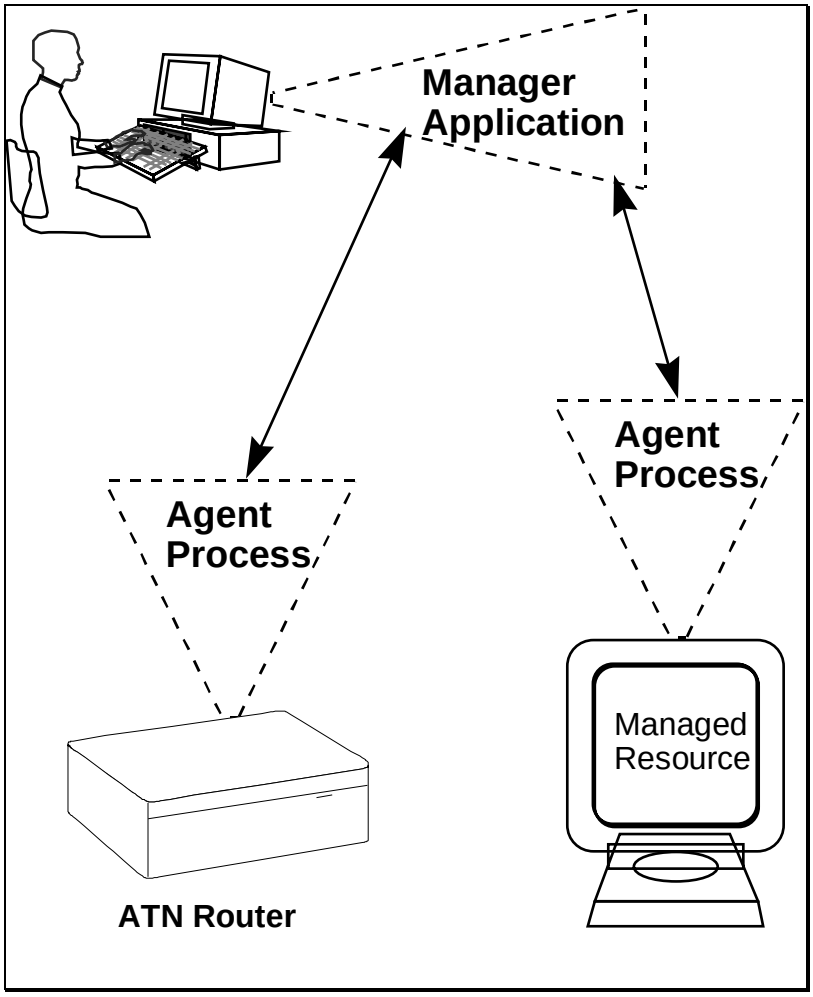

Figure 1-2

2.3.3 Managed Resources

Examples of managed resources:

- Host Computers
- Network devices like routers, switches, hubs
- System resources like memory, disk space, software licenses
- Applications
- Distributed Applications (e.g., ATN apps.)

2.3.4 Management Information Base

The Management Information Base (MIB), is a standardized, structured abstraction of the managed resources of interest. MIBs function as collections of access points at the agent, for the manager.

Within the agent, the MIB is a data structure providing access to specific resources in the form of variables or objects. Managers must implement the same MIBs as the agents with whom they need to communicate. Figure 1-3 illustrates the concept of a MIB.

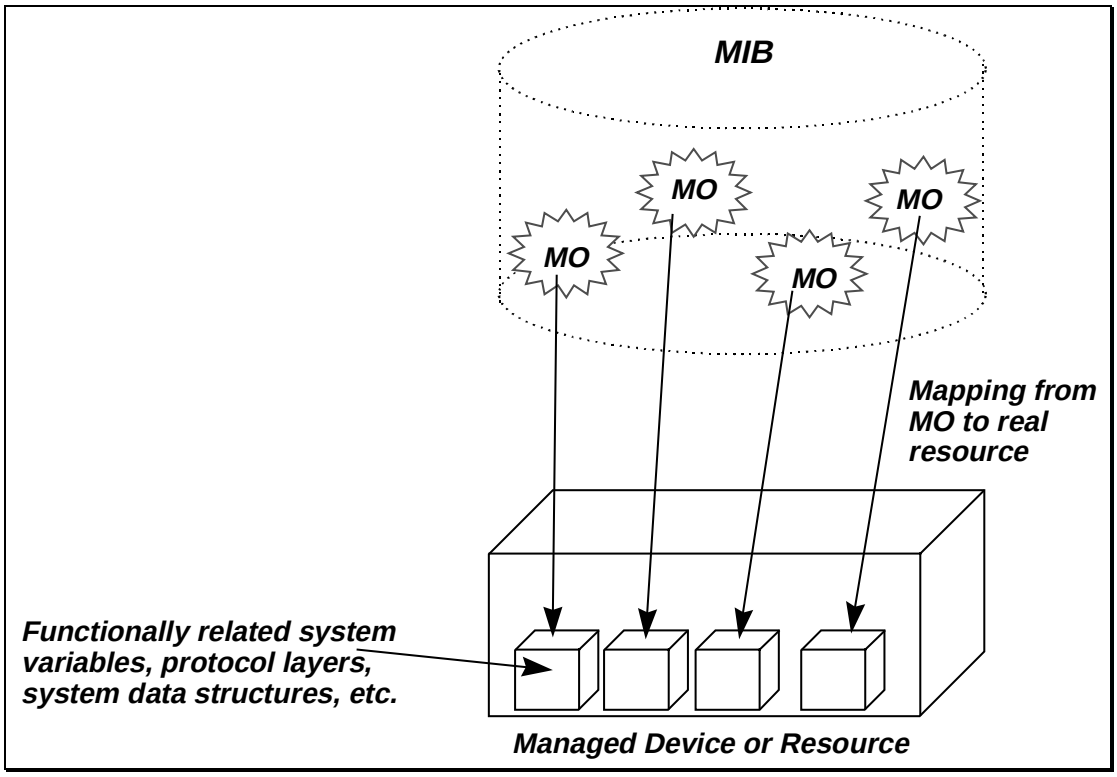

Figure 1-3

Given the Managed Object (MO) concept, several primitive types of MO have been identified:

OSI specific MOs: those defined in international standards to represent OSI protocol and system resources;

OSI generic MOs: those defined in OSI Systems Management standards for use in defining specific protocol and system MOs;

ATN MOs: MOs defined in ATN standards to represent ATN-specific protocol and system resources;

Administrative MOs: MOs defined to represent a selection or summary of information or a modification of the behaviour available in one or more other MOs, so as to meet a specific requirement for systems management.

2.3.5 Management Protocol

The management protocol provides the communication mechanism for the network manager and agent, by specifying the message format, command set and flow of control. Examples of network management protocols include:

- Common Information Management Protocol (chosen for the ATN)
- Simple Network Management Protocol (SNMP)
- Proprietary Protocols
- New emerging protocols

2.3.6 Management Functions

The user requirements for systems management must be satisfied by systems management functions. These functions may be used by an application in a centralized or distributed management environment to interact for the purposes of system management.

Management information is used by the system manager to assist in making management decisions and to communicate those decisions to the system resources. Functionality is required in the following areas:

- fault management,
- accounting management,
- configuration management,
- performance management,
- security management.

3. Subnetwork Management

MATERIAL REQUIRED

Standardised management information is defined for the probable ground subnetwork protocols (eg, ISO/IEC 8208, ISO/IEC 7776). There is currently no generic specification of management information to support mobile subnetworks.

Management information will be defined as guidance material for CNS/ATM-1 Package

Local systems management facilities will be provided to manage subnetworks

4. Transition Issues

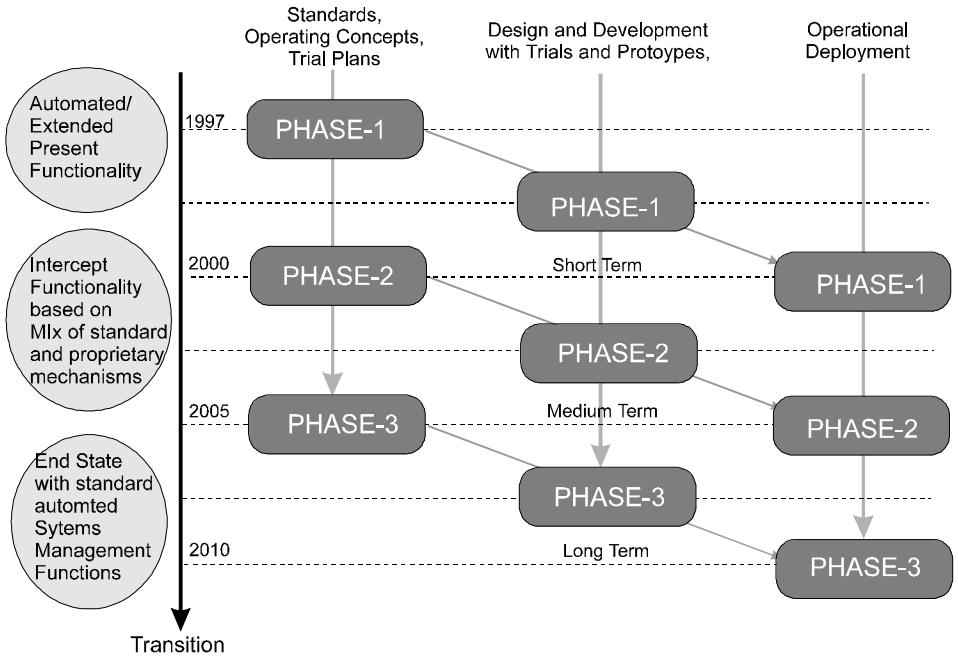

Fig. 1 - Incremental Systems Management Implementation

It is essential that Systems Management functionality is introduced in a phased manner taking into account the transition from simple point to point technology towards increasingly complex inter-networks used for program to program application services.

Phase1 short term - Today's operational equipment offers mainly proprietary local system management functionality, this needs to be collated and formatted into standard formats such that it may be incorporated into a common management scheme. These "proprietary systems" can be put on the transition path to standard systems management by introducing "proxy managers". These "proxy managers" can be built as separate units to take the proprietary information from single systems or groups of systems and present (re-format) this into a standard form of the information to a manager by standard management protocols such as SNMP and CMIP.

Phase 2 medium term - As new communications means are introduced, they should be provided with standard management information and functions "built in" to the associated equipment such that it can be gathered remotely by systems managers. These systems will co-exist with the older systems offering the proprietary style of local management. The standard Systems Management solution which is the goal of the medium term is based on the OSI model and CMIP/CMIS.

Phase 3 long term - As automation and use of ground-ground and air-ground datalink increase, supporting program to program application services, the communications infrastructure evolves towards a homogeneous management solution where system managers may be presented with a complete picture of network service and operations. The desirable end state for systems management is for fully inter-connected systems with standard management information and functions "built in" communicating by one standard systems management protocol. The standard Systems Management solution which is the goal of the long term is still based on the

OSI model and CMIP/CMIS but may move towards “object request/broker” technology on the ground as this becomes available.

5. Institutional Issues

MATERIAL REQUIRED

Who owns what ?

Who is legally liable for what ?

Who is allowed to see what ?

The use of commercial service providers for safety critical data transfer,

The use of state ATS or communications services by other states,

The use of state communications facilities by airlines,

In the ATN environment, systems management will be primarily the responsibility of each participating organisation.

Note: Even with no overall operational authority, there may be mutual benefits to groups of ATN organisations in establishing specific systems management centres, perhaps on a regional level.

In ATN ICAO standards do not apply internally to an organisation although the implementation of standard management information in ATN equipment is encouraged in order to facilitate transition to the longer term.

In the ATN distributed systems management of ATN equipment within organisations will be required but this is not subject to ICAO standards.

Note: It will obviously be impractical to have operations staff manning each piece of ATN equipment, operating it from a local interface.

In ATN administrative management information will be required by organisations (and between organisation) for report generation and accounting purposes but will not be communicated using ICAO standard mechanisms.

In the ATN Service providers will typically negotiate a service level agreement with their customers and will charge accordingly, but this will not be enforced or supported by dynamically gathered data or communicated by systems management.

When organisations exchange management information in the future, specific administrative managed objects presenting a limited “view” of an organisation may provide a sufficient means for access control.

The exchange of standardised administrative ATN management information across organisational boundaries requires the implementation of bespoke managed objects. There are no standards for Administrative MOs.

6. Acronyms and Definitions

List of Acronyms

AAC - Aeronautical Administrative Communications
ACARS - Aircraft Communications Addressing and Reporting System
ACSE - Association Control Service Element
ADS - Automatic Dependence Surveillance
AEEC - Airlines Electronic Engineering Committee
AIDC - ATC Interfacility Data Communication
AOC - Airline Operational Control
ATC - Air Traffic Control
ATN - Aeronautical Telecommunication Network
ATNP - ATN Panel
ATNSI - ATN Systems, Inc.
CAA - Civil Aviation Authority
CLNP - Connectionless-mode Network Protocol
CLNS - Connectionless-mode Network Service
CM - Context Management
CMIP - Common Management Information Protocol
CMIS - Common Management Information Service
CMU - Communications Management Unit
CORBA - Common Object Request Broker Architecture
CPDLC - Controller Pilot Data Link Communication
CLTP - Connection-Less Transport Service
COTP - Connection-Mode Transport Service
COTS - Commercial Off The Shelf
ES-IS - End-System to Intermediate System
FIB - Forwarding Information Base
FIS - Flight Information Services
IATA - International Air Transport Association
ICAO - International Civil Aviation Organizaton
IDRP - Inter-Domain Routing Protocol
IEC - International Electrotechnical Commission
ISO - International Organization for Standardization
MIB - Management Information Base
MO - Managed Object
NM - Network Management
NSAP - Network Service Access Point
PDU - Protocol Data Unit
PIB - Policy Information Base
NSM - Network and Systems Management
RIB - Routing Information Base
RRI - Router Reference Implementation
SARPS - Standards and Recommended Practices
SME - Systems Management Entity
SNDCF - Subnetwork Dependent Convergence Facility
SNMP - Simple Network Management Protocol
TP - Transport
TSAP - Transport Service Access Point
VHF - Very High Frequency
WG - Working Group

Definitions

Agent - A software entity, residing in the device to be managed. The agent accesses management data from the managed device and converts this raw data into a MIB compatible format. Agents respond to queries (from managers) regarding management data. Agents also notify managers when significant events (e.g. fault condition in managed device) take place.

CMIP - Common Management Information Protocol; the management protocol defined in ISO 9596-1, Information Technology - Open Systems Interconnection - Common Management Information Protocol Specification. This specification contains the communication protocol which network management software modules (managers and agents) use when exchanging messages and data.

Managed Object (MO) - An abstraction of a real managed resource in the form of software data structure. MOs provide a uniform, easily accessible interface to the resources within an enterprise which are to be managed. By standardizing MOs, flexibility, portability and interoperability between management systems can be achieved. A set of MOs constitutes a MIB.

Managed Resources - Resources within an enterprise which require management, such as: host computers; network devices like routers, switches, hubs; system resources like memory, disk space, software licenses;

configuration control; applications; distributed applications (e.g., ATN applications).

Management - Management consists of monitoring (i.e. collecting statistics), detecting and diagnosing fault conditions, and exercising control over resources through the issuance of management commands and the re-configuration of managed resources.

Management Domain - A management domain can be described as a set of resources, software agents which interface to the target resources, and a set of managers which interface to these software agents. This kind of infrastructure is usually associated with an organization or institution. Management domains serve to delineate an area of responsibility. Within a domain all of the resources are managed by the same set of network and systems managers, and administered by the same organization.

Management Information Base (MIB) - Data structure containing MO abstractions and providing access points to real managed resources

Manager - A manager is application software which resides on a management workstation. At a minimum a manager application must include: support for one or more management protocols, knowledge of the relevant MIBs, knowledge of the agents present in the management domain, and a user interface. The manager is responsible for collecting management statistics, receiving notifications from agents and alerting personnel, and issuing specific queries and other management commands.

Network Management - The management of network devices, such as routers, host computers, switches, bridges and other network communication devices.

System Management -

The ISO definition of system management defines System Management Functional Areas (SMFA). These SMFAs include: Fault, Configuration, Accounting, Performance, and Security Management. The Internet definition of system management refers to the management of

specific system resources associated with host computers, such as memory, disk space, and even applications.