Organización de Aviación Civil Internacional
Oficina para Norteamérica, Centroamérica y Caribe

NOTA DE ESTUDIO

NACC/WG/RAP/02 — NE/06
29/03/23

Segunda reunión de relatores del Grupo de Trabajo de Norteamérica, Centroamérica y Caribe (NACC/WG/RAP/02)

Oficina Regional NACC de la OACI, Ciudad de México, México, 28 a 31 de marzo de 2023

Cuestión 5 del Orden del Día: **Actualización de los Planes de Acción de los Grupos de Tarea del NACC/WG, del Plan de Acción NACC/WG y de las actividades regionales en el Desarrollo de los Proyectos del Grupo Regional de Planificación e Ejecución CAR/SAM (GREPECAS)**

PLAN DE TRABAJO Y PRIORIDADES DEL ÁREA Gestión de Información Aeronáutica (AIM)

(Presentada por la Secretaría)

RESUMEN EJECUTIVO	
Esta nota de estudio presenta actualizaciones importantes del programa de trabajo relacionadas con la Gestión de Información Aeronáutica Digital (DAIM) hacia la implementación de la Gestión de la información de todo el sistema (SWIM).	
Acción:	Acción requerida en Sección 3.
Objetivos Estratégicos:	• Objetivo estratégico 1 – Seguridad Operacional • Objetivo estratégico 2 – Capacidad y eficiencia de la navegación aérea
Referencias:	• Asamblea 41 de la OACI • Plan Mundial de Navegación Aérea (GANP) – 7ª Edición • Marco de los Elementos Constitutivos Básicos /BBB)

1. Introducción

1.1 De acuerdo con sus Términos de referencia (TOR), se espera que el Subgrupo AIM supervise y aborde los desarrollos globales y regionales relevantes. Esta nota de estudio proporciona información sobre la Asamblea 41 de la OACI (https://www.icao.int/Meetings/a41/Pages/default.aspx) y la 7ª. Ed. de actividades del GANP y la nueva edición del Plan mundial de navegación aérea – GANP (ICAO DOC 7950) fue aprobada también por la Asamblea 41 de la OACI. Cuyos principales objetivos del GANP son están en el enlace: https://www4.icao.int/ganpportal/

1.2 Actualmente el Sistema mundial de navegación aérea promueve la inversión en innovación a través de actividades de investigación y desarrollo y alinear los programas regionales de investigación y desarrollo, apoya la implementación a nivel técnico mundial con el Sistema de navegación aérea (BBB) para facilitar un cambio transformacional: marco ASBU para optimizar la asignación y el uso de recursos para la navegación aérea a través del método de toma de decisiones basado en la performance con 4 niveles a considerar:

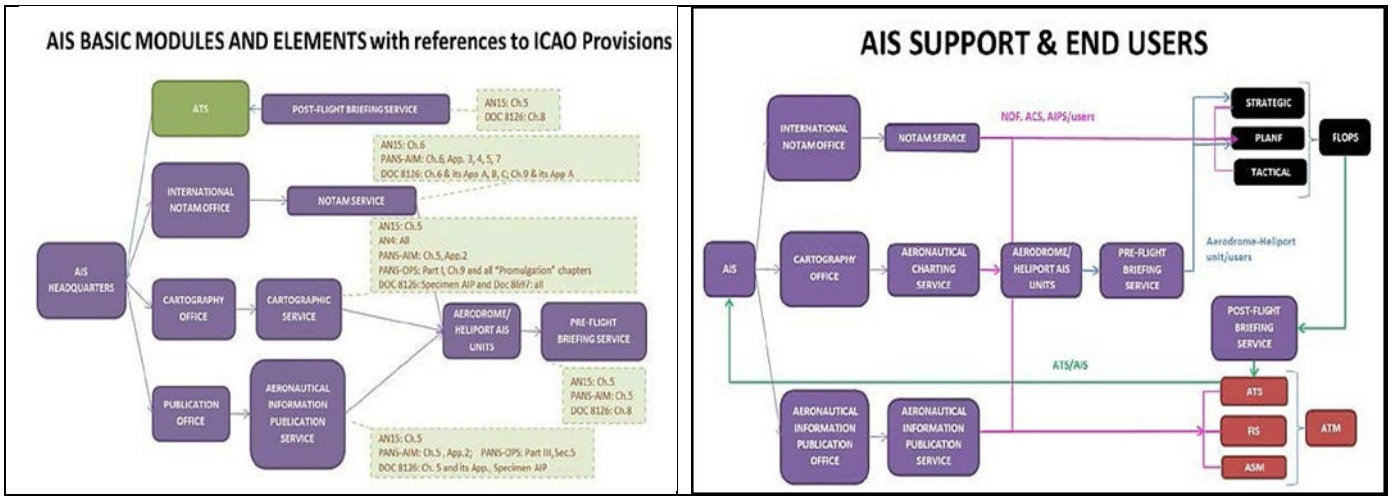
	• Nivel Estratégico Global: incluye el desempeño global ambicioso y la hoja de ruta conceptual AIM
	• Nivel Técnico Global: incluye los BBB, Mejoras por Bloques del Sistema de Aviación (ASBU) y el método de toma de decisiones basado en desempeño
	• Nivel Regional: incluye los Planes Regionales de Navegación Aérea y los Programas Regionales de Informacion y Datos
	• Nivel Nacional: incluye los Planes Nacionales y su despliegue

2. Discusión

2.1 El marco de los BBB: en el nivel técnico global, el marco del bloque de construcción básico (BBB) describe la base de cualquier sistema sólido de navegación aérea. Se trata de la identificación de los servicios esenciales que se prestarán para la aviación civil internacional de conformidad con las **Normas** de la OACI. Estos servicios esenciales se definen en AIM y en las demás áreas ANS. El marco BBB identifica a los usuarios finales de los servicios esenciales, así como los activos de la infraestructura CNS que son necesarios para su provisión.

2.2 Los BBB se consideran un marco independiente del marco ASBU, ya que representan una línea de base en lugar de un paso evolutivo. Una vez que se brindan estos servicios esenciales, constituyen la línea de base para cualquier mejora operativa.

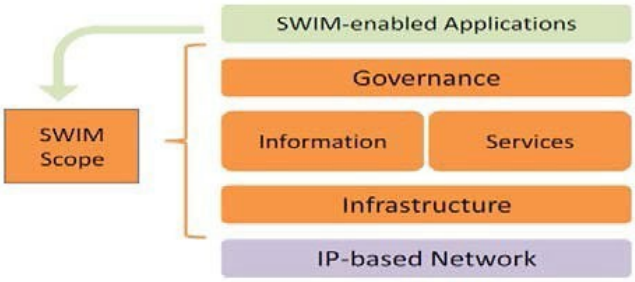
2.3 Los BBB proporcionan dos marcos de referencia para los servicios de información aeronáutica:



2.4 El marco ASBU: la siguiente tabla describe los ASBU en la 7ª edición del GANP en comparación con su versión anterior. Los detalles sobre la séptima edición del marco GANP y ASBU se pueden encontrar en: https://www4.icao.int/ganpportal.

DAIM Gestión de Información Aeronáutica Digital	**B0** **2013-18**	**B1** **2019-24**	**B2** **2025-30**	**B3** **2031-36**	**B4** **2036+**
		X (Nuevo)	**X** (Nuevo)		

2.5 Tal como se ha definido, el SWIM consiste en estándares, infraestructura y gobernanza que permiten la gestión de información para ATM y su intercambio entre partes calificadas a través de servicios interoperables:



2.6 Se informa a la reunión sobre el material preliminar en proceso por parte de la OACI para las Disposiciones SWIM en los nuevos Procedimientos para los servicios de navegación aérea – Gestión de la información (PANS-IM) y el Volumen II del Manual SWIM (DOC 10039). Además, recientemente en la conferencia Mundial 2022 de la Federación Internacional de Asociaciones de Gestión de Información Aeronáutica (IFAIMA) se dieron algunas recomendaciones importantes:

AIS a AIM 2.0 significa aún mejor información (calidad), mayor personal calificado, así como la digitalización de la información para ser difundida a través de SWIM;
AIM 2.0 no es igual a "implementación SWIM"; es un requisito previo como uno de los dominios de información dentro de SWIM;
AIM 2.0 se trata de una prestación de servicios más eficiente y la capacidad de seleccionar proveedores e integradores libremente (es necesario considerar el contexto de prestación de servicios);
Se requiere AIM 2.0 para abordar los nuevos participantes en nuestro sistema de navegación aérea, como drones, vuelos a gran altitud, etc.; y
Antes de embarcarse en la etapa final de la migración hacia AIM 2.0, se debe fortalecer el progreso de la implementación de AIM 1.0 a nivel mundial, ya que aún faltan inversiones para la implementación, los beneficios de AIM como el eje para las mejoras operativas no se han comunicado claramente a los Estados y se debe crear más conciencia entre los ejecutivos/tomadores de decisiones

3. Conclusión

3.1 Realizando una evaluación de la información de esta Nota se obtendrán ajustes al Programa de trabajo del Grupo AIM o bien se adicionarán otras actividades al periodo siguiente hasta la siguiente Reunión (AIM/TF) el próximo año 2024, por lo que se pudiesen modificar las prioridades en nuestra materia dentro de los procesos de implementación de los Servicios de Navegación Aérea (ANS):

a) Se asegure que la implementación AIM en la Región CAR sea coherente y compatible con los desarrollos en las regiones adyacentes, y esté en consonancia con el Plan mundial de navegación aérea (GANP), el marco de Mejoras por bloques del sistema de aviación (ASBU) y el Programa aéreo de la Región CAR estrategia de navegación;

b) Supervisar el estado de implementación de los subprocesos ASBU relacionados con AIM de la región CAR elementos incluidos en el Plan Colaborativo AIM, así

como otras instalaciones y servicios AIM requeridos; identificar las dificultades y deficiencias asociadas y proporcionar informes de progreso, según sea necesario;

c) Mantener bajo revisión los objetivos/prioridades de desempeño AIM de la Región CAR, desarrollar planes de acción para lograr los objetivos de desempeño acordados y proponer cambios a los planes/prioridades AIM de la Región CAR;

d) Tratar de lograr un entendimiento común y el apoyo de todas las partes interesadas involucradas o afectadas por los desarrollos/actividades AIM en la Región CAR;

e) Proporcionar una plataforma para la armonización de desarrollos y despliegues en el dominio AIM;

f) Monitorear y revisar los últimos desarrollos en el área de AIM y cuestiones de diseño de procedimientos asociadas a AIM, proporcionar aportes de expertos para cuestiones relacionadas con AIM; y proponer soluciones para cumplir con los requisitos operacionales de la ATM;

g) Proporcionar informes regulares de progreso al GREPECAS con respecto a su programa de trabajo; y

h) Revisar periódicamente sus Términos de Referencia y proponer modificaciones, según sea necesario

3.2 Para cumplir con los Términos de Referencia, el AIM TF deberá considerar las siguientes acciones:

a) monitorear el estado de implementación de las instalaciones, productos y servicios AIM requeridos en la Región CAR;

b) asistir a los Estados en el desarrollo de Planes/Hojas de Ruta AIM Nacionales a través del desarrollo y actualización continua de la Hoja de Ruta DAIM Regional (2021 – ver **Apéndice** a esta Nota [disponible únicamente en inglés]) identificando las prioridades y plazos para la implementación, en particular para la implementación de Conjuntos de Datos Digitales;

c) evaluar y proporcionar informes de progreso sobre la transición de AIS a AIM en la Región CAR;

d) proporcionar la asistencia y orientación necesarias a los Estados para garantizar la armonización y la interoperabilidad de conformidad con el GANP, el CAR ANP y el marco ASBU;

e) proporcionar los insumos necesarios para la estrategia de navegación aérea de la región CAR a través del seguimiento de los indicadores clave de desempeño acordados relacionados con AIM;

f) identificar y revisar aquellas deficiencias y problemas específicos que constituyen obstáculos importantes para la provisión de servicios AIM eficientes, y recomendar las acciones correctivas necesarias;

g) mantener en examen la adecuación de los requisitos de los SARPS de la OACI en el área de AIM, teniendo en cuenta, entre otras cosas, los cambios y la evolución de los requisitos operacionales de los usuarios y los avances tecnológicos;

h) elaborar propuestas para la actualización de la documentación pertinente de la OACI relacionada con la AIM, incluida la enmienda de las partes pertinentes del CAR ANP, según se considere necesario;

i) monitorear y revisar los desarrollos técnicos y operativos en el área de AIM y promover su implementación en la Región CAR de manera armonizada;

j) fomentar la mejora integral de los servicios AIM a través de la adecuada capacitación y calificación del personal AIM; y
k) Coordinar con los órganos subsidiarios de GREPECAS y RASG-PA relevantes los asuntos de interés común en seguridad operacional particularmente.

4. Acción por la reunión

4.1 Se invita a la reunión a:

a) considerar los desarrollos relacionados con AIM en el programa de trabajo regional AIM, la planificación y los ToR;
b) en ese sentido la Secretaría del AIM/TF y la Relatoría del AIM/TF invitan a la Reunión a revisar y a considerar qué impacto pudiese tener cada propuesta expresada en el párrafo 3.1 y 3.2 de esta Nota de Estudio; y
c) sugerir algunas acciones adicionales relacionadas con el AIM/TF y su programa de trabajo.

— FIN —

- APÉNDICE -

Roadmap for the Transition to Digital AIM

First Edition — 2021

International Civil Aviation Organization

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First edition 2021

Roadmap for the Transition to Digital AIM
NOT FOR SALE

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

FOREWORD

The *Global Air Navigation Plan* (Doc 9750) was developed as a strategic document to guide the implementation of CNS/ATM systems with respect to the *Global Air Traffic Management Operational Concept* (Doc 9854) and the Strategic Objectives of ICAO. The *Global Air Navigation Plan* (Doc 9750) contains near, medium and long-term guidance on air navigation system improvements necessary to support a uniform transition to the air traffic management system envisioned in the *Global Air Traffic Management Operational Concept* (Doc 9854). Doc 9750, Chapter 1, Table 1-1, sets out 23 Global Plan Initiatives (GPI); two are directly related to aeronautical information (GPI-18 – *Aeronautical Information* and GPI-20 – WGS-84) and many of the others have an indirect impact on the way aeronautical information will be exchanged in the future. However, the new edition of the Global Air Navigation Plan has been published to improve the guidance on offer to the aviation community achieving a global interoperable air navigation system which was incidentally endorsed at the 40th ICAO General Assembly (September 2019). A new and improved edition that offers a multi layered structure to address the global, regional, managerial and technical aspects; revising the ASBU framework with a more detailed list of elements to be delivered in each section. The Aeronautical Information Management (AIM) elements in the GANP have been greatly improved to assist States in transforming traditional paper-based aeronautical information services into an evolutionary data-centric AIM program. Global recognition that aviation has entered a new era is a reality that needs comprehension of the embedded challengers. Aviation is ever-changing, trying to achieve sustainable growth of an international nature relies on a high-performance seamless global air navigation system. AIM as an aviation entity embraces the positive elements of an agile, safe secure sustainable cutting edge interoperable global air navigation system.

A RoadMap for the Transition to a Digital Aeronautical Information Management structure has been developed to expand upon the direction given in Doc 9750 for the future development of aeronautical information. The changes foreseen are such that this development is being referred to as the transition from aeronautical information services (AIS) to a data-centric Aeronautical Information Management (AIM) environment.

This roadmap for digital AIM offers practical guidance to regional planning groups and States toward development of the implementation and funding strategies required for a global plan initiative related to aeronautical information. It identifies the major milestones recommended for a uniform evolution across all regions of the world, specific steps that need to be achieved and timelines for implementation. Transitioning to AIM is more than “digitization”; an investment in technology or a simple upgrade from one platform to another. This evolution is a complete enhancement of processes, procedures, products and services to improve data/information to consumers (airspace users) whomever they may be.

This publication is intended to serve as a strategic positioning initiative to drive the continuing improvement of aeronautical information services in terms of quality, integrity, accuracy resolution, timeliness and the identification of new services and products to better serve aeronautical information users. It sets a baseline for establishing strategies and other initiatives to advance the AIM objectives globally and should place the future AIM in a position to better serve airspace users and ATM in terms of their information management requirements.

Expectations are that the transition to AIM will not require many changes in terms of the scope and definition of aeronautical information. The major change will be the introduction of new products & services and an increased emphasis on better data distribution in terms of quality and timeliness in order to meet user requirements and contribute to improved safety, increased efficiency and greater cost-effectiveness of the air navigation system.

TABLE OF CONTENTS

GLOSSARY

TERMS

Aeronautical data. A representation of aeronautical facts, concepts or instructions in a formalized manner suitable for communication, interpretation or processing.

Aeronautical information. Information resulting from the assembly, analysis and formatting of aeronautical data.

[1] ***Aeronautical information management (AIM).*** The dynamic, integrated management of aeronautical information services — safely, economically and efficiently — through the provision and exchange of quality-assured digital aeronautical data in collaboration with all parties.

[1]***Database.*** A usually large collection of data stored in structured digital format so that appropriate applications may quickly retrieve and update it.

Note.— This primarily refers to digital data (accessed by computers) rather than files of physical records.

[1]***Data set.*** Identifiable collection of related digital data.

[1]***Digital***. Involving or relating to the use of computer technology or digital communications.

[1]***Disruptive Technology/Innovation.*** A technology and/or Innovation that significantly alters the way and means which consumers, industry and/or businesses operate. A disruptive technology discards systems and/or habits it replaces given it attributes are recognizably superior.

[1]***Information management (IM).*** The processes defined to ensure the collection, utilization and transmission of quality data that are tailored to the needs of each component of the air traffic management system.

[1]***Interoperability.*** The capacity for diverse systems and organizations to exchange information by transferring data and requesting remote services in a manner that requires the client system to have little or no knowledge of the unique characteristics of the server system.

Note.— This is usually achieved by common understanding of the semantics, the syntax and the protocols for the exchange of data.

[1]***Metadata***. A structured description of the content, quality, condition or other characteristics of data.

NOTAM. A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

1. Not an official ICAO definition (used in the context of this document only).

(x) Roadmap for the Transition from AIS to AIM

ABBREVIATIONS/ACRONYMS

AICM	Aeronautical information conceptual model	
AIM	Aeronautical information management	
AI	Aeronautical Information	
AIP	Aeronautical information publication	
AIRAC	Aeronautical information regulation and control	
AIS	Aeronautical information service”	
ASBU	Automated System Block Upgrade	
AIXM	Aeronautical information exchange model AN-Conf/11	Eleventh Air Navigation Conference (2003)
ATM	Air traffic management	
BBB	Basic Building Blocks	
CDM	Collaborative Decision Making	
CPU	Central Processing Unit	
DAIM	Digital Aeronautical Information management	
EUROCONTROL	European Organisation for the Safety of Air Navigation	
EFB	Electronic Flight Bags	
FMS	Flight Management System	
GANP	Global Air Navigation Plan	
GPI	Global plan initiative	
IM	Information management	
IP	Internet protocol	
PED	Portable Electronic Device (ex. Electronic Flight Bag (EFB))	
PIB	Pre-flight information bulletin	
RNAV	Area navigation	
RNP	Required navigation performance	
SARPs	Standards and Recommended Practices	
SWIM	System Wide Information Management	
TBO	Trajectory Based Operations	
WGS-84	World geodetic system-1984	

PART I

ROADMAP OVERVIEW

WHY AERONAUTICAL INFORMATION MATTERS

1. The Eleventh Air Navigation Conference (AN-Conf/11) held in Montréal in September 2003 endorsed the operational concept and recognized that, in the global air traffic management (ATM) system environment envisioned by the operational concept, aeronautical information service (AIS) would become one of the most valuable and important enabling services. As the global ATM system foreseen in the operational concept was based on a collaborative decision-making environment, the timely availability of high-quality and reliable electronic aeronautical, meteorological, airspace and flow management information would be necessary. Some recommendations of AN-Conf/11 addressed the importance specifically of aeronautical information.

2. In June 2006, a Global AIS Congress was held in Madrid, Spain. The event was facilitated by the European Organisation for the Safety of Air Navigation (EUROCONTROL) in partnership with ICAO. The Congress considered the essential role of AIS in the evolving world of ATM. It noted that computer-based navigation systems, and area navigation (RNAV), required navigation performance (RNP) and ATM requirements introduced a need for new corresponding AIS requirements for quality and timeliness of information. The role of AIS would therefore need to transition to an information management service, changing duties, responsibilities and scope to satisfy these new requirements and to cope with and manage the provision of information.

3. The Congress supported the recommendations of AN-Conf/11 dealing with aeronautical information and began to define a future high-level view as to the shape, nature and content of a strategy for the evolution from traditional product-centric AIS to the enlarged scope of data-centric aeronautical information management (AIM). Realizing the safety-critical nature of aeronautical information and in-order to prevent diverging developments in the future, the Congress agreed that ICAO should take the lead at the global level regarding the transition from AIS to AIM. Accordingly, the Congress developed ten recommendations calling for ICAO action or support from States and international organizations.

4. In September 2007, the 36th Session of the Assembly recognized the need to support the recommendations of the Congress and called for further coordination with States and international organizations.
The Roadmap for the Transition from AIS to AIM was developed in 2009. At the time, the AIM concept was not clearly defined resulting in the said document not fulfilling the effort in guiding stakeholders toward a full AIM. Rather, the Roadmap, directs States and industry toward a “digitized AIS”. It should be noted that an AIM transition is more than an effort at “digitization”; it’s an absolute modification concerning the means of production (processes, procedures, products and services to better satisfy the need of the information consumers).

5. November 2018, the 16th edition of ICAO Annex 15 and a new PANS-AIM had been adopted thereby defining the minimum data scope for interoperable digital data exchanges, fortifying the essential nature of quality controls along the aeronautical data process and supporting the integration of modern aeronautical information products (digital data sets)

6. High-quality aeronautical information in conjunction with the noted considerations could guide stakeholders toward a full AIM environment working in compliance with the latest ICAO plans and provisions. AI is often referred to as a pre-requisite for the development of the many new interoperable tools present and future aircraft will carry to improve their effectiveness in navigating safely and efficiently. Managing airspace constraints will be dependent on a partnership between airspace users – utilizing proper equipment, new business practices, collaborative sharing of data/information and ATC managing that said airspace. To maximize the use of the airspace and minimize inefficient practices Collaborative Decision Making (CDM) founded on aeronautical information will be essential while improving efficiency and maintaining or even enhancing safety. This will result in the provision of more services to more aircraft in the same airspace at the same time.

HOW INFORMATION IS DISTRIBUTED TODAY

7. Civil Aviation, including “new entrants” exist in an expanding electronic age characterized the Internet, satellite navigation, portable electronic devices (PED), disruptive innovation/technology, computer networks and cloud computing, yet our approach to aeronautical information distribution is still based on paper charts, paper documentation and telex-based text messages. Systems still exist in isolation where much of the data is entered more than once in different computers using a keyboard rather than by file transfer or database transactions (although that is quickly changing). As an example, Operators have adopted the Electronic Flight Bags (EFB) as a key flight operations tool. Initially it was utilized simply has a document viewer relieving users of having to carry paper manuals and supporting documentation. However, with the substantial increases in computing power, the EFB can arguably be characterized as the CPU of the modern Flight Deck. When looking at aircraft connectivity trends, the amount of data moving from device to device is MG to GB, messages are in the millions per day, high speed high bandwidth is key, e-enabled aircraft (A350 & B787) are setting the trend concerning big data (capable tools are available) and there is a need to always be connected.

8. In conjunction with the above, the concept of AI involves a vast array of ICAO documents that need to be followed in-order to be compliant with parameters that define AIM. Further efforts will include the implementation of AIM, the provision of digital data sets as a SWIM information service and finally the massive tasks of replacing the current NOTAM system:

   – ICAO Annex 15 and ICAO Annex 4;
   – ICAO PANS AIM (Doc. 10066);
   – AIS Manual Volumes 1-4 (Doc. 8126);
   – Aeronautical Chart Manual (Doc. 8697);
   – WGS-84 (Doc. 9674);
   – AIM Training Manual (Doc 9991).
   – Guidelines for Terrain, Obstacle and Aerodrome Mapping Information (Doc. 9881);
   – QMS AIM Manual (Doc. 9839);

9. Better aeronautical information is essential if we are to have an integrated and interoperable ATM system that enables air navigation service providers to safely handle more traffic in the same amount of space during the same amount of time. Such a system would effectively link the full range of services from airspace design to flight planning, airport operations planning and flight separation assurance while continuing to maintain the safety and security of the travelling public and lessening the environmental impact.

10. Better aeronautical information is essential if we are to have a flexible ATM system that reduces costs and environmental impacts while improving access to congested airspace and remote airports in developing countries. Such a system would allow planners and decision makers to make the right decisions for the development of new tools and techniques based on accurate information available to the right person at the right time.

11. Better aeronautical information is essential if we are to have a system that empowers airspace users by giving them a greater role in shaping the ATM system, and by helping them understand their options and make informed decisions while maintaining public safety and minimizing the impact on the environment. Such a system would be focused on users’ needs.

12. Departures and arrivals are constrained by gate, taxiway and runway capacity while en-route and terminal airspace is restricted by the number of aircraft that can safely operate in the given airspace. Airlines control the majority of the gates, therefore they manage the gate capacity, however to manage forecasted growth and the flow of aircraft there is a need for improved management of aircraft on the ground through an enhanced monitoring system, improved information sharing (CDM) between airspace users and ground controllers. Managing airspace constraints in the future will be dependent upon a partnership between airspace users and state agencies who manage the airspace. A key element of AIM is it allows, in this context, a focus on new system methodologies and systems that foster CDM facilitating Trajectory Based Operations (TBO) while managing the flow of air traffic that results in a minimization of delays and maximizes the use of the airspace in question.

13. Corrupt, ill-timed or erroneous aeronautical information has the potential to adversely affect the safety of satellite navigation, FMS and on-board navigation database just as corrupt or malfunctioning navigation aids adversely affect the safety of ground-based navigation.

14. These improvements are central to the Global Air Traffic Management Operational Concept and justify by themselves the name change from AIS to AIM that identifies the new focus on all aspects related to proper information management as opposed to the traditional way of focusing on the provision of standard products to the pilot only. AI has become a crucial and critical enabler for the implementation of future ATM systems. The global requirement for precise navigation capability will require high quality (accuracy, resolution and integrity) aeronautical data, databases and information.

THE OBJECTIVE OF THE DIGTAL TRANSITION TO AIM

15. Recommendation 1/8 of AN-Conf/11 clearly stated the objective for global aeronautical information as follows:

– That ICAO, when developing ATM requirements, define corresponding requirements for safe and efficient global aeronautical information management that would support a digital, real-time, accredited, and secure aeronautical information environment.

16. The Global Air Traffic Management Operational Concept, which had been developed to be visionary in scope and not constrained by the level of technology available at the time, was also endorsed by AN-Conf/11.

17. Technology has become a basic tenant of the business milieu within aviation thereby has expanded its deployment toward seamless information from gate-to-gate for operational needs. At, present, virtually all global procedures are available in databases whereby charts are no longer the only means for navigation (flight crews rely upon on-board navigation databases). The impact of late information can be mission critical if an aircraft's operation depended upon on-board navigation databases (satellite based RNAV procedures will gradually replace conventional procedures where relative accuracy is no longer sufficient). Present aircraft operations/navigations are based on defined performance requirements, RNP values. ICAO has endorsed the concept of RNP which is a statement of the aircraft navigation performance as defined in terms of accuracy, integrity and continuity of service necessary for operation within a defined airspace. Efforts of all states must be focused at providing positioning and navigation data at the required integrity and performance levels to support the various applications in the ATM landscape. As a service dependency, a digital transition to AIM will encourage the growth an environment where AI is a critical enabler for the implementation of a future ATM system. The global requirement for precise navigation capability will require high quality (accuracy, resolution integrity). The future will make it essential that electronic storage, provision update and interrogation of aeronautical databases and electronic charts (including terrain and obstacle information) are implemented. It should be noted that top quality data integrity requires discarding the manual process. However, some regions are more advanced than others and the need for the adoption of global Standards is becoming more evident now than it was in 2003. Present and future navigation systems in conjunction with other air traffic management systems are data dependent. All require access to global, broad-based aeronautical information of a considerably higher quality and in a timely manner than is generally available today, the timeliness, integrity and quality of AI is an essential component concerning the globalization of ATM. The provision of aeronautical information is a core element of air navigation services where corrupt erroneous AI can potentially affect safety thus the question of a manual process.

18. To satisfy new requirements arising from the Global Air Traffic Management Operational Concept, aeronautical information services must transition to a broader concept of aeronautical information management, with a different method of information provision and management given its data-centric nature as opposed to the product-centric nature of AIS. Roles and responsibilities may need to be adapted as the transition progresses.

WHAT WILL CHANGE – NEW PROVISIONS/REQUIREMENTS FOR AIM

19. The Global Air Traffic Management Operational Concept defines seven interdependent concept components that will be integrated to form a new and improved ATM system. They comprise airspace organization and management, aerodrome operations, demand and capacity balancing (TBO), traffic synchronization, conflict management (CDM), airspace user operations and ATM service delivery management. A part of this effort includes evaluating technologies and potential regulatory changes to a given airspace system and projecting what new capabilities will deliver. Increased efficiency of the airspace systems is essential, however a key metric for future operations will be reduced fuel usage with the associated reduction in emissions that can only be accomplished with new systems, data/information and processes.

20. A result and logical assumption of a digital transformation exercise regardless of the subject matter will be cost. The required increase in quality, timeliness, integrity, resolution and accuracy needed by any digital transformation project, will not come cheap therefore the appropriate investment will be required. Defined the business case with the imbedded business rules is crucial and essential.

21. The management, utilization and transmission of data and information are vital to the proper functioning of these components. An understanding of the role aeronautical data and information plays in the aviation community can contribute to the overall enhanced quality of the services provided, thus improve the safety and efficiency of flight operations and ATM/ATC operations. The exchange and management of information used by the different processes and services must ensure the cohesion and linkage between these nine concept components. Figure 1 illustrates how information management is at the core of air navigation services.

22. Amendments to ICAO Annex 15 and the continued development of the PANS-AIM document have highlighted technical changes toward the advancement of D-AIM:

a*) Split of data origination requirements from data publication requirements.* The end-users who make use of the information transferred by an AIS/AM should not rely exclusively on the structure and format of the messages but need to be free to manage the data and combine it with other data to construct the final view appropriate to their need. The proposed amendment allows the data collection activity to be decoupled from the definition of end-products. This is a fundamental principle that needs to be applied in the transition to a SWIM environment.

b) *Introduction of the Aeronautical Data Catalogue.* The objective of the development of the aeronautical data catalogue is to provide a general description of the AIM data scope and consolidate all aeronautical data and aeronautical information to be collected and maintained by an AIS organization. The data catalogue provides a means for States to facilitate the identification of the organizations and authorities responsible for the origination of the aeronautical data and information. It also provides a common language and facilitates the formal arrangements between data originators and the aeronautical information service. It includes data quality requirements applicable from origination through to publication.

c) *Digital data sets.* The full move into an automated data-centric environment requires the introduction of digital data sets. Providing the data in digital form represents a paradigm shift in the way information is handled along its life cycle. This is an important step forward in the implementation of AIM under the all-embracing SWIM principles.

d) *Aeronautical information product.* The term aeronautical information product has been introduced to compile all the AIS/AIM deliverables to be provided in either digital data sets or as a standardized presentation in either paper or electronic form. The term is supposed to replace the term “Aeronautical Information Package” that is considered obsolete and not in line with the new AIM concepts.

e) *Data quality requirements*. Whilst the industry standards (EUROCAE ED76A / RTCA DO200B) require seven characteristics of data quality (accuracy, resolution, integrity, timeliness, completeness, traceability and format), Annex 15 currently only includes three characteristics (accuracy, resolution and integrity). The proposed amendment aims to solve this inconsistency by updating the data quality definition, adding four additional definitions of the data quality characteristics and updating the provisions to include the new quality characteristics.

f) *New terminology*. This amendment introduces new defined terms. These new definitions will bring further clarity to the introduction of “digital data” and what it means in relation to AIS/AIM provisions.

g) *NOTAM improvement proposal.* In order to make NOTAM more “fit for purpose”, several additional operational conditions are included in the provisions to properly identify when a NOTAM shall or shall not be originated.

h) *CRC performance-based requirements.* The current prescriptive specification for 32bit CRCs can be seen to be difficult and maybe even impossible to comply with. The proposed amendment introduces performance-based requirements to maintain data integrity by implementing a mechanism to detect errors in digital data introduced during transmission or storage.

i) *Clarification of requirements.* The work done with respect to the restructuring of Annex 15 and the creation of a new PANS-AIM has also created an opportunity to provide clarification to existing provisions. Terms that are more in line with AIM concepts have been introduced, provisions have been rephrased and extended to make the requirements more distinct, and redundant elements have been deleted.

Users

23. The provision of aeronautical information today is mainly focused on requirements for pre-flight briefings. The provision of aeronautical information as a collective transformation to AM will address the requirements of all components and Users of the ATM system for all phases of flight. All stakeholders, traditional or emerging require the ability to move passengers and/or goods from place-to-place without delay at minimum cost in a safe secure environmentally sustainable way. ANSP’s, regulators, traditional and new entrants should provide insight into what AIM can be. With respect of research, development, and planning to establish standards and performance requirements for their inclusion into non-segregated airspace. Technology and the associated applications therein, with the execution of procedures, could provide the origin for further innovation of the air navigation system.

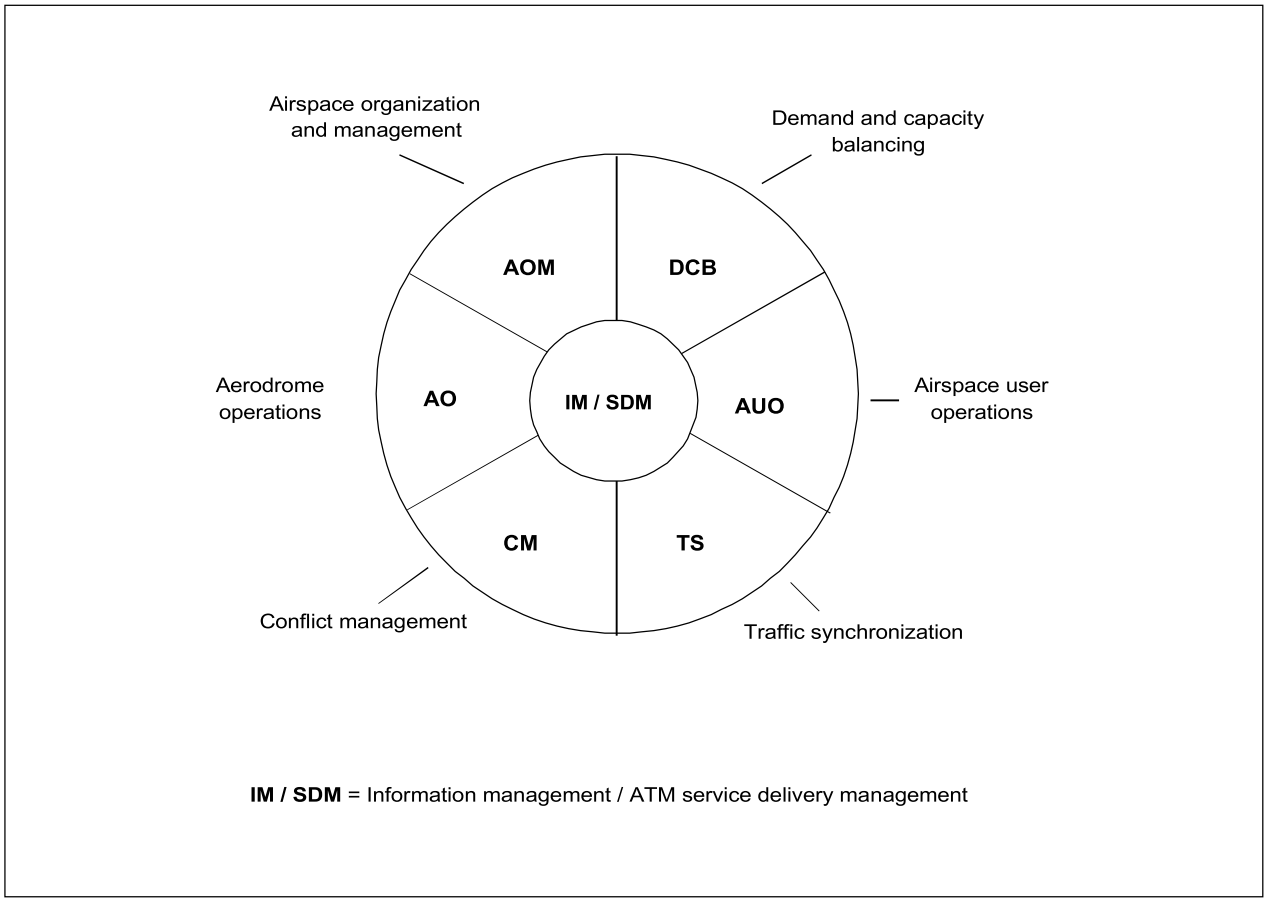

Figure 1. Information Management as a component of the future ATM Operational Concept

Data

24. The shift from standardizing products to standardizing data will enable more freedom in the definition of future products while maintaining a high degree of quality, integrity, resolution and coherency of the information founded on datasets contained in these new products. The initial introduction of digital processing and management of information from origination through to publication/distribution by use of exchange models (AIXM) results in better quality and availability. There is an expectation of reduced cost (justified by business cases) in-terms of data inputs and checks through the data distribution chain.

25. The biggest change in the transition to AIM will be the increased use of computer technology (cloud computing, machine learning, automation and artificial intelligence) in the management of information, with an increased emphasis on the digital form of data that will drive all processes for the management of information.

26. Both graphical and text products will be based on the same underlying, standard definition of geo- referenced atomic data. The definition of a Standard for an aeronautical data exchange model will ensure standardized interfaces between the computers of both providers and users of data. This will enable the definition of new products where both text and graphics will be presented in a more readable form. This will enable the definition of new services where the same data/information will be made available in the decision support tools for all ATM components.

27. ICAO Annex 15 — *Aeronautical Information Services* has had a number of amendments since 2009 (36-40) from a series of different ICAO Panels. A central element in the transition to AIM is the alteration of ICAO Annex 15 to facilitate the incorporation of AIM requirements. There will have to be changes to the technical content to empower the precise standardization of atomic data elements in terms of field names, field types and field definitions. This will be provided in the form of an aeronautical data dictionary (also called metadata registry). Furthermore, the definition of standard structured groupings of fields by features, attributes and associations is necessary. This will be provided in the form of a Standard for an aeronautical information conceptual model. Finally, the mechanisms to maintain an up-to-date data set across different components would need to be agreed upon; this will be provided in the form of a Standard for an aeronautical data exchange model. The evolution of these models will be organized at the global level to ensure continuity of the services in a way that allows innovation and new requirements to be researched, considered, accepted and applied.

28. By using this approach, also defined in the GANP (Block1-DATM and Block2- SWIM) the characterization of the data products is decoupled from the definition of the end- products. The focus is on the improvement of services through digital aeronautical information management and data exchange. The end-user applications, which make use of the information transferred in the form of data sets, do not rely exclusively on the structure and format of the messages but are free to transform the data and combine it with other data to construct the final view appropriate for the end-user. Data and the ability to exchange that data is essential to interoperability coupled with a reduction of inconsistencies results in improved quality.

Products

29. Pre-flight information bulletins are often loaded with information of little relevance to the flight because of the limited filtering capabilities of the current NOTAM format/system. Pre-flight bulletins are often also difficult to read and interpret because of the lack of graphical capabilities based on the current NOTAM format. New products combining textual and graphical information will need to be specified.

30. Electronic chart displays are becoming easier and cheaper to install in the cockpit based on the expanded capabilities of EFB's, and their associated ever-increasing functionality (both as a function of EFB's and the associated electronic charts).

31. The future capabilities of transferring digital data between the air and the ground will be used for providing new products such as in-flight information bulletins by uploading aeronautical and meteorological information directly aboard aircraft during all phases of flight. Data and communications are the mantle on which any interactive data exchange system is built. This will provide direct digital communication services between pilots and ATC thereby enhancing the air traffic control distribution of information to airlines operation centers. Several capabilities will be enhanced: namely safety by reducing communication errors and increasing controller productivity. Efficiency is augmented by increasing airspace capacity while reducing delays, fuel burn therefore carbon emissions. Data communications is critical to the success of NextGen/SESAR enabling technology, tools and efficiencies not possible

with the current voice system.

32. The AIM concept requires that all aeronautical information, including that currently held in aeronautical information publications (AIPs), be stored as individual standardized data sets to be accessed by user applications. The distribution of these data sets will define the new services provided by the future AIM. This will constitute the future integrated aeronautical information package that will contain the minimum regulatory requirement to ensure the flow of information necessary for the safety, regularity and efficiency of international air navigation.

33. Within the ever-developing landscape of Flight Operations, specific technical advances are going to be empowered by AIM. At present, certain features are becoming a reality, such as the connected FMS operating in an adjacent EFB landscape. Currently there is a proliferation of EFB's in conjunction with connectivity solutions, data servers and aircraft interface devices (AIDs) where this convergence will lead to real-time situational awareness tools working together with advanced flight planning infrastructure. This can result in a connected integrated FMS with real-time wind, temperature, traffic for optimized, TBO etc.

34. The current FMS and its association with aeronautical charts offer a complete view of the aeronautical information content and a strategic view of the flight procedure. During operation there is a manual verification of FMS entered procedures/route and constraints also off-line performance calculations (v-speeds, weight/mass and balance, temperatures, and take-off thrust). In this operating environment, it is characteristic for the flight crew to have to often enter information twice (entry of the same information more than once is an activity which is error prone, increases workload and reduces pilot's situational awareness).

35. An AIM landscape allows aviation to contemplate a flight deck environment where ones EFB applications are seamlessly connected to the FMS. Where EFBs'/PED's have full access to the detailed flight plan including flight information, trajectory, speeds, altitudes, constraints and an FMS blended position. This context allows the FMS to provide an open interface and integrated environment, characterized as a "bring your own device" and "bring your own applications" approach to flight management.

36. Near and long terms values concerning the connected FMS based on AIM are profound concerning future products. Consider "Route Synchronization" where several benefits include improved situational awareness, upload of optimal route, reduced pilot workload, improved dispatch coordination and increased probability of decision making on operational insights. With AIM acting as a foundational elements' automatic cross-checks between FMS's and EFB's capturing of aircraft data makes this possible. Future NextGen & SESAR will be essential to the e-enabled or connected aircraft: allowing for flight plan/procedure synchronization and download, automatic or automated flight plan cross-checks, the visualization of lateral & vertical flight route, ETPs WPT trajectory constraints, Navlog support & data entry and finally unified (climb, cruise and decent) route optimization.

37. This approach – toward connectivity through-out the aviation system from ANSP to user with AIM powered products and services is the genesis of a new era of flight management solutions. An investment in AIM can put airlines in control of their flight management and planning solutions. FMS features and capabilities could be developed in the efficient and convenient means be it on the ground, the tablet or in traditional avionics equipment.

Static versus dynamic information

38. Static: AIXM for an ATM system where states can define their airspace, airports, NAVAID facilities and their ATM capabilities and service. Thereby sharing data in a defined common data format.

39. Dynamic: FIXM when engaging airspace users' needs to blend the "static" to the dynamic aka Flight Operations especially if we examine concepts for advanced flight planning systems. The FIXM standard will allow a common framework and frame of reference for information associated with all flights accepted in a given airspace.

40. Stability is essential for proper planning of airspace operations in a compliance matrix (train, plan, fly). Examples of changes that must be announced well in advance are:

- the installation or decommissioning of ground-based air navigation aids;
- the opening of a new aerodrome for international flight operations;
- airspace danger and restricted areas; and

– the route structure for major traffic flows.

41. Events of short duration or with little advance notice are inevitable occurrences. These events must be announced quickly in a manner that is comprehensible by the different components of the ATM system.

42. In an interoperable environment based on data Standards, these two types of information will be transferred by common networks under the same data exchange mechanisms using the same data Standard definitions.

AIRAC cycle

43. It is expected that the need for aeronautical data to become effective on internationally agreed upon common dates will remain. Coordination and planning constraints require major changes to be announced well in advance and introduced only at regular intervals.

44. The quality and integrity requirements of databases will define new roles for human intervention such as verification, monitoring and correction before releasing new data. Human factors principles will need to be taken into account to facilitate optimum utilization. Consideration will have to be given to the integrity of information where human interaction is required and awareness to error where risks are identified.

45. The current AIRAC cycle is 28- days long. Aeronautical data and information is distributed to end users under the AIRAC cycle to establish a common effective data for each cycle. The 28-day timeframe provides database manufacturers an established period to produce and distribute databases to end users for loading on their aircraft prior to the expiration of the current AIRAC cycle. The distribution of data products through data networks cannot suffer from a delay in delivery as shorter cycles will become possible to better meet the needs of the user. Transitioning to a modern distribution mechanism will mean that the specifications for new concepts of operation need not be constrained by a 28-day cycle. The future ATM system will be free to identify a better cycle that will adequately balance the need for improved reactivity with the need for advance planning.

EIGHT GUIDING PRINCIPLES FOR THE TRANSITION TO AIM

46. The projects undertaken to achieve the steps identified in the roadmap must be specified and conducted in accordance with the following eight guiding principles. The transition to digital AIM will have to:

a) comply with the process for amendments to the Annexes to the Convention on International Civil Aviation;

b) support or facilitate the generation and distribution of aeronautical information which serves to improve the safe and cost-effective accessibility of air traffic services globally;

c) provide a foundation for measuring performance and outcomes linked to the distribution of quality-assured aeronautical information and a better understanding of the determinants of ATM, safety and effectiveness not related to the distribution of the information.

d) assist States in making informed choices about their aeronautical information services and the future of AIM;

e) build upon developments in States, international organizations and industry and acknowledge that the transition to AIM is a natural evolution rather than a revolution;

f) provide over-arching and mature Standards that apply to a wide range of aeronautical information products, services and technologies;

g) be guided by the *Global Air Navigation Plan* (Doc 9750) and ensure that all development is aimed at achieving the ATM system envisaged in the *Global Air Traffic Management Operational Concept* (Doc 9854); and

h) ensure, to the greatest extent possible, that solutions are internationally harmonized and integrated and do not unnecessarily impose multiple equipment carriage requirements for aircraft or multiple systems

on the ground.

THE ROADMAP TO DIGTAL AIM: CONSIDERATIONS

47. To ensure collective comprehension – defining AIM as it moves away from AIS to satisfy NextGen /SESAR is essential. Some of the associated priorities can be identified as Multiple Runway Operations, Performance Based Navigation Surface Operations, Data sharing and Data communications The purpose of this roadmap is to develop the AIM concept and associated performance requirements by providing a basis upon which to manage and facilitate, on a worldwide basis, the transition from AIS to AIM. The roadmap is based on recognizing a vision as a driver for change where what we know today needs to be developed with sufficient flexibility for the new concepts that will emerge from current technology. The desired change for the AIM community is to migrate towards environments where the origination, management and distribution of quality-assured and digital aeronautical information is done in a safe, secure and efficient manner and the aeronautical information is provided via a System Wide Information Management (SWIM) service that will support an enhanced ground and air decision-making process in all phases of flight. The strategy must be the able to empower the vision.

48. Three phases of action are envisaged for States and ICAO to complete the transition to AIM:

- Phase 1 — Going Digital – Align with GANP (Doc 9750) 6th Ed. BBB concept.
- Phase 2 — Fully Digital – Align with the ASBU Block 1-DAIM module
- Phase 3 — System-Wide Information Management – Align with the ASBU Block 2- DAIM Module

49. The roadmap must proceed with caution when advocating more sophisticated information management initiatives to ensure that they do not impede the obligations of States to correct infrastructure and other deficiencies already identified.

50. In the **first phase**, existing Standards will need to be refined and strengthened and their implementation in all States ensured. This will concern mainly:

- quality requirements;
- AIRAC adherence;
- the implementation of the adopted standard reference system for coordinates (World Geodetic System-1984); and
- the provision of terrain and obstacle data.

The projects in the first phase will be conducted to identify potential gaps in-order to focus on near-term work program activities. Aligning with the GANP 6th Ed. BBB concepts will focus on the given technical framework – which outlines the foundations of a robust air navigation system and focuses on basic services to be provided for international civil aviation in accordance with ICAO standards. The BBB are closely associated with all those ICAO Standards describing the basic air navigation services in the areas of aerodrome, air traffic management, search and rescue, meteorology and information management. Within the AIM domain the BBB's refer to those ICAO provisions requiring high-quality basic aeronautical information services. The BBB can also be understood as a commitment of the State via the Convention on International Civil Aviation (Doc7300), which provides critical air navigation services for the safe and orderly conduct of international civil aviation. Implementation of BBB will enable a given air navigation system to deliver the essential service to be provided for international civil aviation. The resulting performance of the air navigation systems can then be improved and enhanced through the application of the ASBU framework.

51. The **second phase** should be a structed approach driven by performance**.** The ASBU framework is not a collection of all possible solutions, it is a list of operational improvements formulated by means that focus of what is available and what is under development. Based on its demand, those that put the system to work can select with confidence an existing capability or decide to defer implementation until and new solution is found or available if the demand doesn't cause constraint. the introduction of database-driven processes will improve the value of current products by improving their quality and availability for current users. This will concern mainly the creation of a national

database or regional databases to produce the existing products and services, but with better quality and availability. The global deployment of new, already well-specified products (ex. the electronic AIP) will also be.initiated. The projects in the second phase will be conducted to enhance the quality and availability of existing products in the medium-term work program activities. Within the context of this roadmap is the ASBU 1-DAIM module. Roadmap for the Transition from Ais to AIM notes on the establishment of data driven process for the production of aeronautical products, compiled in a standardized presentation (ex. Paper based AIP). Roadmap to D-AIM will go further, expand and introduce the digital transformation of AIS organizations, based on the solid foundation established and defined during phase I. Digital technologies are introduced to change the business model of the AIS organization and new aeronautical products (ex. digital data sets) are integrated with the standard paper-based and electronic ones. The latest ICAO Annex 15 and PANS-AIM provisions will be a good reference for the effective development of phase II.

52. In the **third phase**, new products and services will be developed. Quality control, staff training, and planning will be applied to current and new products and services. This will support a new AIM function for air navigation service providers enabling the provision of new data that will be required by the future ATM components. The projects in the third phase will be conducted to serve new users and to promote continuous improvement. This phase will align with ASBU Block 2- DAIM module. Wherein there will be guidance toward a full AIM environment as defined in the long-term vision. The complete AIM environment will include the dissemination of aeronautical information in a SWIM-enabled environment, user-defined products to be derived from aeronautical information in a standardized information exchange model (Ex. AIXM), information products to be provided alone or integrated with other information domains (ex. meteorological or FF-ICE), a wider use of secure web services, the decommissioning of current distribution mechanism and the commencement of the use of business-to-business services that allows integration of aeronautical information in the ATM system, ICAO Provided descriptions of these elements are yet to be developed, therefore this phase od the roadmap will be developed in conjunction with the new SARPs and procedures.

53. The roadmap will identify the main steps to be achieved in the three phases. Each step will require projects of two types of activities: one will be the development of the Standards required and the other will be the implementation in States of those Standards.

a) ***Development of Standards.*** The development of new Standards often lies on the critical path of the transition. Amendments to ICAO Standards and Recommended Practices (SARPs) are required for uniform implementation of the transition to AIM in all States. Actions related to the establishment of these Standards in Annexes to the Convention on International Civil Aviation and in guidance material will be led by the ICAO Secretariat with the support of States and international organizations. Technical Standards as they relate to AIM how the components perform and behave: ICAO SARP's, ICAO PANS-OPS & PANS-AIM, ICAO PBN, RTCA and EUROCAE.

b) ***Implementation of Standards.*** Implementation of Standards allowing the transition to AIM will be the responsibility of States. Guidance material will be issued by ICAO to assist in the implementation. The implementation of the standards in question must conform with state regulations and the associated enforcement (ex. FAA, EASA etc.). During implementation, there must be assurance that a "Quality Management System" is in place to hold are the pieces in place (technical and regulatory).

54. Part II of the roadmap lists numerous steps of varying complexity. Some will result in the establishment of new databases or the expansion of existing ones. Others will seek to foster better data and technical Standards for gathering information and data protection. Still others will focus on obtaining consensus on the indicators and determinants of quality aeronautical information. Almost all of the projects will involve collaborative efforts with key stakeholders at the national, regional and inter-regional levels. Securing stakeholder participation at the outset of the process and maintaining it throughout the project implementation phase are critical to ensuring that outcomes are relevant and practical and contribute to improving the efficiency and safety of air travel and of the ATM system.

55. Accordingly, consultations through various ICAO working arrangements have been and will remain an ongoing feature of the roadmap. The input of and feedback from all players are key to ensuring that the roadmap contributes to better aeronautical information and a stronger ATM system for the air transport industry.

Phase 1 — Going digital

56. During Phase 1 of the transition to AIM, steps will be taken to strengthen a solid base by enhancing the quality of

the existing products. Fine-tuning and improvement of SARPs for existing products will continue to be conducted in the usual manner in order to respond to near-term user requirements.

57. Since the electronic AIP will have the exact same structure as the paper version, it is important that States make every effort to issue their aeronautical information as specified in ICAO Annex 15 16th Ed.

58. The NOTAM system as it exists today requires ongoing upgrades to cope with new types of information (e.g. GNSS navigation) and to respond to the difficulties being reported by the users. It is not clear at this time when and how the current NOTAM system will be changed. Research and trials are under way and their results will be addressed in Phase 3 of the transition to AIM or later. It is important to continue to improve the current SARPs related to NOTAM to better serve users' needs with the current products. It is also important for States to continue investing the time and effort necessary to comply with these SARPs.

59. Many ICAO chart types form an integral part of the AIP. Amendments to specifications are also envisaged for electronic chart display but most of the SARPs in Annex 4 — *Aeronautical Charts* will remain applicable after the transition to AIM. It is important that States comply with the existing Annex 4 SARPs.

60. The requirement to use a common horizontal, vertical and temporal reference system remains essential to facilitate the exchange of data between different systems. Therefore, the expression of all coordinates in the AIP and charts using WGS-84 is important and should be pursued during the first phase of the transition to AIM.

61. Provision of terrain and obstacle data becomes applicable during Phase 1 of the transition and will be an important project to be conducted by States. Feedback from States on the implementation experience may require adaptation of the relevant SARPs. Since these SARPs also relate to digital data set products, the achievement of these steps will also contribute to Phase 2.

62. Quality requirements on information are covered by current SARPs in terms of accuracy and integrity. The steps in Phase 1 aim to meet these requirements. Should the requirements prove difficult to implement, they would have to be reassessed to verify that the risk of harm to persons or damage to property for not achieving the requirements is reduced to, and maintained at or below, an acceptable level (definition of safety). In addition, States will implement and continuously improve their quality management system in view of its increasing importance for future products and services.

63. The requirement for States to adhere to the aeronautical information regulation and control (AIRAC) process must be emphasized. The quality of the future service to be provided under information management will rely on the proper mechanism for distribution and synchronization of information. Shorter response times will be required in the future and this can only be achieved if the current requirements can, at the very least, be met.

Phase 2 — Fully digital

64. During Phase 2 of the transition to AIM, the main focus will be on the establishment of data-driven processes for the production of the current products in all States. States that have not yet done so will be encouraged "to go digital" by using computer technology or digital communications and introducing structured digital data from databases into their production processes. The emphasis will, therefore, not be on the introduction of new products or services but will be on the introduction of highly structured databases and tools such as geographic information systems.

65. The aeronautical information conceptual model, in conjunction or embedded in the GANP will provide guidance for States to implement such digital databases. Guidance material will include advice on a minimum data set to begin a phased development of the database.

66. Many States are already providing electronic equivalents of their AIPs, e.g. on CD or on the Internet. These electronic AIPs may be accessible for printing and/or for navigation via a web browser tool. Guidance material that will be based on existing best practices will be provided to States to ensure that new types of media will be harmonized for users.

67. Phase 2 – Fully digital means the utilization of advanced technology whose capabilities vary from automated support-systems (autopilot and remotely piloted aircraft) to sophisticated systems using machine learning that enable aircraft and air navigation systems to perform complex tasks. Aviation is moving toward full connectivity, meaning anything that can be connected will be connected. This places a premium on the performance of data/information in a globally shared infrastructure. Connectivity also means exposure; therefore, cyber vulnerabilities will arise. Impacts range from unauthorized access, disclosure, disruption and critically, the potential

for safety to be compromised. Therefore, cyber resilience of the SWIM system is critical for AIM.

68. Industry organizations and associations are increasing working together to address the cyber threat. The aim of these collaborative efforts is building cyber resiliency across the air transport network. Being a partner in this endeavor means collaboration on cyber threat intelligence, actionable data, best practices, and lessons learned. It should be noted that a collaborative industry specific approach is essential to progress, namely, to address the shortage of cybersecurity professionals, risk management and the comprehension of contextual industry awareness. The Aviation Information Sharing Analysis Centre (A-ISAC) was established to provide an aviation-focus information sharing and analysis function to help protect aviation business, operations, and services. A-ISAC analyses and shares information on cyber threats, vulnerabilities, and incidents. Its membership ranks are growing with airports, airlines, equipment manufacturers, industry suppliers, in-flight entertainment companies, avionics, and satellite communication providers amoung its membership. Recently, The European air navigation organization partnered with A-ISAC with the objective of sharing aviation cyber security information, hopefully to build cyber resiliency across the air transport network. The partners will collaborate on cyber threat intelligence, actionable data, best practices, and lessons learned.

69. ICAO has taken a very serious approach to the cyber security/safety landscape. The ICAO Assembly requested and tasked ICAO with building a comprehensive cyber security plan and associated governance structure giving rise to the Secretariat Study Group on Cyber Security (SSGC). Generally speaking, the SSGC's strategy is international cooperation, which includes governance, effective legislation and regulation. The SSGC Study Group is made up of three entities which report to Trust Framework Study Group:

- Trust Reciprocity Operational Networks (TRON);
- Digital Identity (DI);
- Global Resilient Aviation Interoperable Networks (GRAIN).

70. ICAO as an to the organization hosts the Trust Framework initiative in collaboration with Sates, industry and other aerospace stakeholders, the objective is the protection of SWIM of which AIM is a critical enabler.

71. The following are architecture principles based on "The Open Group Architecture Framework" (TOGAF). Data collection and mobilization are integral to system and architecture principals, highly relevant to the aviation domain, as they are in others which require strong technical requirements.

- 1 Develop leading standards to meet aggregate future multiple operational requirements: The rational being international standards must be focused to solve specific challenges, but also meet a broad range of needs from a variety of different operations. They (standards) must have an impending characteristic in order to meet aggregate requirements and operational models that may not yet be clearly articulated. The core of this implication is that standards cannot be based upon requirements from a single, or even necessarily a set of related operations. It takes time to develop standards therefore due consideration both on the near terms and long terms must be given to their development. New operations and requirements may demand new approaches that break with the past (interdependent systems, relaying data and interoperability).
- 2 Provision of cross support capabilities amoung different organizations (airspace users). A fundamental reason for standardization is to allow data assets to be shared amoung various users (whose definition is expanding) and re-used amoung the different players within the air-space landscape. This enables efficiency and risk-reduction.
- 3 Minimizing disruption to existing standards and installed systems. Standards are typically developed using a layered approach that associates well-defined functionality with each layer or set of elements. Standards developed in a suite are intended to operate together in specific ways, and care must be taken to not disrupt the agreed architecture unless driven by new requirements. It is preferable to build upon existing, tested and documented (sets) of standards rather than adopt new potentially disruptive, technology or approach. However, there may be situations where "unforecasted" requirements or operating modes will mandate consideration of otherwise disruptive approaches. It's important to balance the benefits, costs, risks and look for a means to keep inconsistencies to a minimum.
- 4 Adopt, Adapt and Develop – this mantra is foundational whereby new standards should only be developed when necessary. First, adopt whenever possible; Second, adapt only when it is not possible to Adopt; Third, develop only when it is not possible to adopt or adapt. Using adoption or adaptation is a cost and risk-reduction technique that has frequently yielded good results. Sometimes this approach

requires adaptation to enable smooth integration with the rest of the suite, or to support characteristics essential to a given operation. These techniques do require a continuing survey of other technologies and careful analysis for applicability. When it's necessary to develop new standards, they will often be identified by benefits from this step-by-step analysis effort.

- 5 The utilization and application of available technology, whereby defined standards are related to open source non-proprietary technology, independent of a specific vendor. There may cases when commercial technologies have significant advantages in comparison to the open-source offering, whereby cooperation with a vendor is required. Otherwise alternatives are needed.
- 6 Adopt modular boundaries to reduce integration complexity. This is a general principle in programming that can be promoted with subsystems, systems, and systems of systems principles. To facilitate re-use and adaptation to specific deployments and integration careful attention should be paid to the identification of interfaces and layering. This is especially the case where interfaces are being defined for cross support between interdependent systems.
- 7 Interoperability is essential and must be demonstrated by testing which will be important to standard validation, error evaluation and elimination. One of the key capabilities that standards enforce is the ability of systems elements developed by one organization which can integrate and operate successfully with elements of another. This interoperability may occur at different levels, from the physical to the logical. It's essential that interoperability be demonstrated by having at least two independently implemented instances of the standard. This is key to ensuring that the standards can be interpreted (see simplicity and clarity principle) and that they operate as expected. Standards development and validation processes must include adequate time and resources to carry out this part of the task. It is essential to ensuring that the standard can adequately describe the desired functionality and that any new implementations will be able to be validated for correct behavior. In some cases, it may be necessary to have two separate implementations made by one organization, but in general, there should be two different organizations involved in this process, which may be waived for experimental specifications.
- 8 Scalability and extendibility needs to exist across different operations. Standards must satisfy a broad range of operational needs. Designs are too narrowly focused upon a single operation may neglect the consideration related environments that could well be served by a broader standard. Where possible the standard should include adequate options and configuration parameters to permit its ready adaptation to multiple related operational uses. Standards can also be defined too broadly, or with too much complexity, and not be adopted as a result. Consider this principle in conjunction with the Simplicity and Modularity Principles
- 9 The need to strive for simplicity and clarity in design and documentation is paramount given simplicity and clarity are characteristics of good design, especially in the development of standards where the expectation is that any standard specification must be able to be correctly interpreted.
- 10 Use of common vocabulary and definitions are critical to the understanding and comprehension of complex concepts and specifications. Related operational environments could well be served by a broader standard. Where possible the standard should include adequate options and configuration parameters to permit its ready adaptation to multiple related operational uses-cases. Standards can also be defined too broadly, or with too much complexity, and not be adopted as a result. Consider this principle in conjunction with the "Simplicity and Modularity Principles".

Phase 3 — System-Wide Information Management

72. The SWIM infrastructure is the digital data-sharing foundation of Next Gen and SESAR. This infrastructure concept will enable air-traffic management-related information sharing amoung diverse, qualified systems. One of the many key functions of a SWIM environment will be a collaborative air traffic management environment based on increased sharing of data between ANSP's and airspace-users powered by the exchange models AIXM, FIXM (Flow information and aircraft performance relate data) and iWXXM (for meteorological data). SWIM in an aviation context means sharing all data/information and components/elements with all air-space users. This starts with managing airspace constrains through the conceptualization of an active partnership between airspace users/managers (through the utilization of modern equipment) and new business practices (and associated business rules).

73. During Phase 3, steps will be taken to enable future AIM functions in States to address the new requirements that will be needed to implement the Global Air Traffic Management Operational Concept in a net- centric information

environment.

74. The digital databases introduced in Phase 2 will be used for the transfer of information in the form of digital data. This will mean adoption of a standard for an aeronautical data exchange model to ensure interoperability between all systems not only for the exchange of full aeronautical data sets, but also for short-term notification of changes.

75. As new products are introduced, organizational changes will need to be made to implement better management of information in terms of:

- staff planning and staff training;
- formalization of agreements with data providers to ensure a high degree of data quality;
- introduction of an extensive amount of explicit meta-information;
- impact on cost-recovery mechanisms; and
- explicit traceability of the changes to information and identification of liabilities.

76. ATM systems will need a common information reference model with quality procedures for the management of seamless information flow to ensure not only interoperability between States but also interoperability between different systems within the State. New digital data products and services will be specified to serve these interoperability requirements.

77. The evolution from AIS to AIM is a unique digital transformation which, coupled with automation powered by artificial intelligence and machine learning will require a parallel and structured approach that gives proper consideration and thought to the role of the human and the human machine interface (HMI). The object must be to enrich utilization of human strengths and the capacity of humans to control tools while using the support of machines to manage situations which are unexpected quickly and safely.

78. Within Phase 3 and integral to SWIM functionality is human capability and capacity. HMI is a critical and integral piece of a digital transformation toward AIM as a keystone of an advanced air navigation system. In an increasingly automated/autonomous environment, humans remain part of the system's design and management. Complex operational ecosystems and dynamic system designers cannot anticipate all possible situations therefore humans are necessary for real time innovations that meet unique situational demands, which the air navigation system as designed and anticipated cannot at this time address. Increased automation empowered by disruptor-based technology will:

- Relieve operators from simple, mundane and repetitive tasks which will enable individuals to focus on decision making tasks;
- Increase interaction within a collaborative landscape which will allow humans and machines to cooperate and achieve operational goals;
- The analysis of massive amounts of data/information presented in new was by new means to support human decision-making, understanding; and
- Enable all of the above to be undertaken when the technology and human a geographically separated from one-another.
-

79. The definition of new AIM data products and services will be based on requirements identified for each ATM component. A structured approach to the development of these new requirements for AIM will be followed to ensure that any Standards recommended for AIM are derived from agreed information exchange models; these models will specify the minimum information required to support business services defined for ATM functions that are identified to fulfil desired outcomes in terms of performance requirements. This structured top-down approach of deriving specific data Standards from high-level objectives will ensure that the new requirements for States introduced in the transition to AIM will clearly relate to identified enablers for the future ATM system as illustrated in Figure 2.

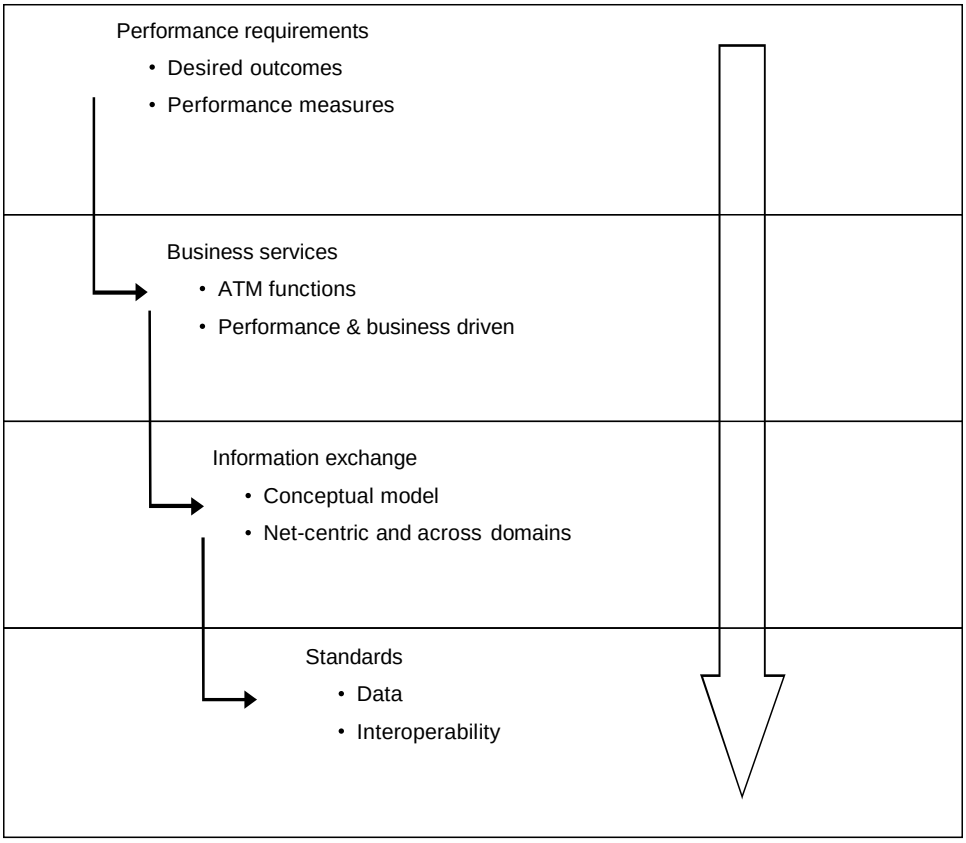

Figure 2. Performance-driven approach

The regional dimension

80. During the complex transition to AIM, industry, regulators, manufacturers, service providers and other organizations will need to work together to achieve the best results. In Europe, the SESAR Master Plan and the Single European Sky initiatives have assembled a multitude of partners to define a modernization program to significantly reduce costs and increase service capabilities. In the United States, the NextGen program is also under way to modernize the national air transportation system to allow increased capacity and reliability, while improving safety and security and minimizing the environmental impact of aviation. In many parts of the world, States are grouping their resources to introduce new equipment and new structures for the provision of common services over their common airspace.

81. These are only three of the many examples of modernization program that are under way in different regions of the world. All initiatives are primarily directed towards improving safety and security and minimizing the environmental impact of aviation. They all seek a more efficient and reliable exchange of information between the various components of the future ATM system. They refer to new concepts such as system-wide information management, increased automation for collaborative decision-making, better integration of systems, and 4-D trajectory.

82. These initiatives are all using the Global Air Traffic Management Operational Concept as a guide to ensure a common reference and are referring to the Global Air Navigation Plan as a common planning framework. All of these initiatives need some assurance of stability in the development of new techniques. This is the purpose of the Global Air Navigation Plan and this roadmap.

83. This roadmap provides a structured framework for States to plan and to monitor their progress with reference to other States in the same region and across regions of the world and supports regional and national plans to implement the transition to AIM.

84. It is not the intention that this roadmap be used alone to formulate a national or a regional plan. Neither milestones nor description of deliverables are provided in the roadmap since these will be included through the usual planning process.

PART II

ROADMAP STEPS

INTRODUCTION

1. ICAO Annex 15 requirements are defined by means that allow for the data collection activity to be decoupled from the definition of the end-products; this means, to facilitate an AIM environment, SWIM principles need to be engaged, thereby providing the strategic direction with characterized principles for the transition to AIM. The three phases introduced in Part I need not be followed in a waterfall approach; for example, steps may be taken to introduce the digital elements even though the consolidation steps have not all been finalized. Similarly, it is not necessary that all steps for going digital be achieved before introducing new measures related to information management. The phases, however, give an indication of how to address the transition.

2. A minimum list of major steps to achieve the transition to AIM is provided in Part II. A broad positioning of the steps in relation to the three phases is also provided in Figure 3. The transition to AIM will be effective at the global level when these steps have been achieved. Most steps in Phases 2 and 3 of the transition require new Standards and Recommended Practices to be adopted at the global level; an indication of the time required for these new texts to be available is provided in Part III. It should be noted, an effort to update associated manuals could be vital but is certainly beneficial (ex. PANS-AIM to include material from ICAO Annex 15 and the Aeronautical Information Services Manual (Doc. 8126))

STEPS

3. The steps listed in Part II constitute a minimum list of areas of activities for States to coordinate the transition to AIM between themselves and with ICAO. The steps are to be taken as a checklist of high-level actions. Failure to take action on any of these steps would increase the duration of the transition and negatively affect the enabling role of AIM in the future ATM concept of operation.

4. The list may evolve during the transition, especially when we get closer to Phase 3. This roadmap will be updated with the further evolution of the overall ATM concepts and system requirements.

B1/1	Provision of quality-assured aeronautical data and information
B1/2	Provision of digital Aeronautical Information Publication (AIP) data sets
B1/3	Provision of digital terrain data sets
B1/4	Provision of digital obstacle data sets
B1/5	Provision of digital aerodrome mapping data sets
B1/6	Provision of digital instrument flight procedure data sets
B1/7	NOTAM improvements
B2/1	Dissemination of aeronautical information in a SWIM environment
B2/2	Daily Airspace Management information to support flight and flow
B2/3	Aeronautical information to support higher airspace operations
B2/4	Aeronautical information requirements tailored to UTM
B2/5	NOTAM replacement

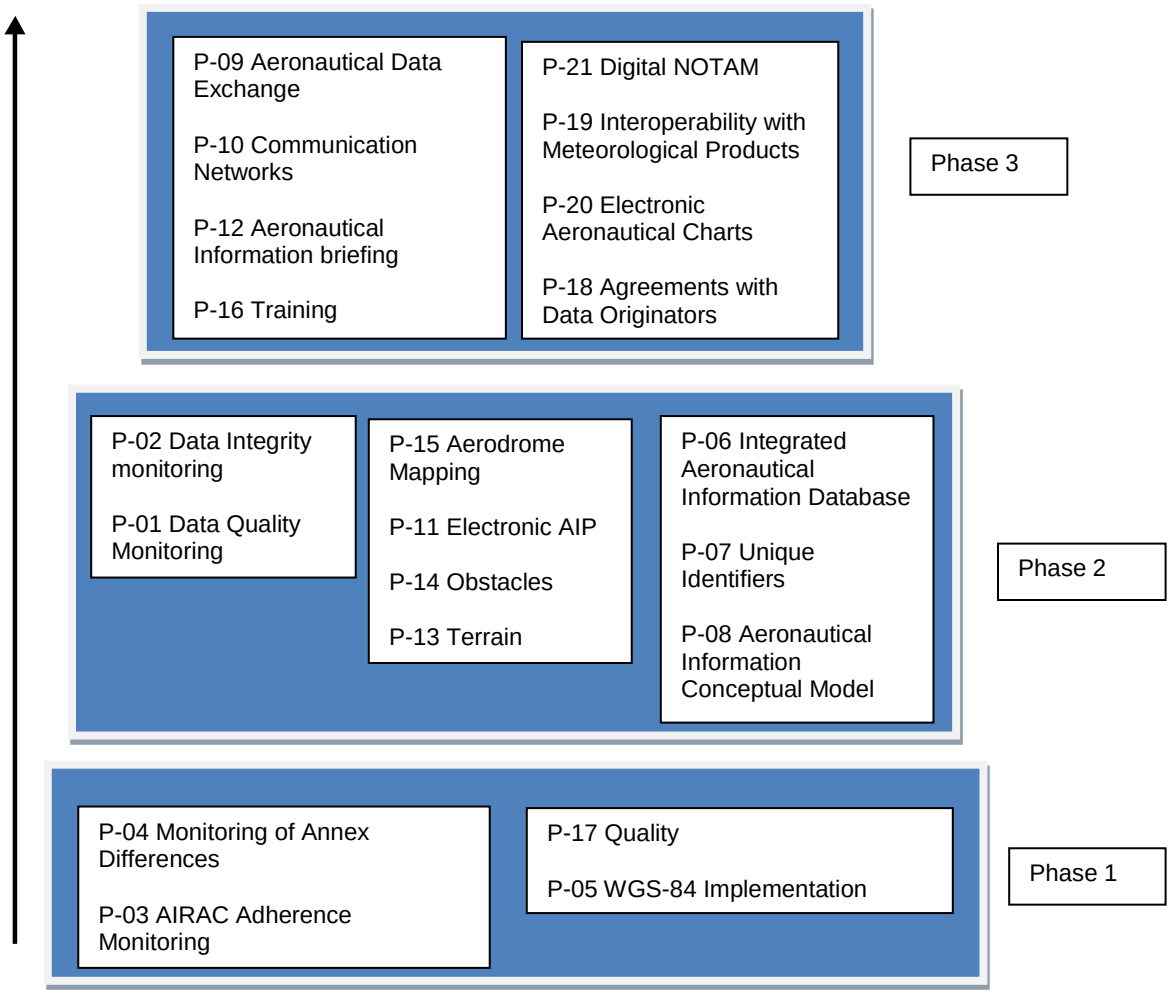

Figure 3. Positioning of the 21 steps of the roadmap in the three phases

B1/1 Provision of quality-assured aeronautical data and information

This element ensures that processes, procedures and systems are improved to allow for an enhanced quality of aeronautical information products and services. This element includes:

1. Implementation of quality management systems to ensure that aeronautical data and information comply with the required standards.
2. Use of common reference systems (spatial – WGS84 and temporal- AIRAC) to facilitate consistent interpretation of aeronautical data and information and facilitate their timely exchange.
3. Full move into an automated data-centric environment so that the management, processing, verification, usage and exchange can be done in a structured, automatic manner and human intervention is reduced.
4. Aeronautical data and information is of high quality if it is aggregated and provided by authoritative sources. This requires to properly control relationships along the whole data chain from the origination to the distribution to the next intended user (formal arrangements with data originators, neighboring States, data and information service providers and others).

B1/2 Provision of digital Aeronautical Information Publication (AIP) data sets

The need for interoperable exchange of AIP data and information requires providing them in digital form and complying with digital data exchange requirements. This element consists in the replacement of existing sections of the AIP by digital AIP data sets. Therefore, this element supports the migration to a data-centric environment where aeronautical data and information (AIP) will be provided in a structured and digital form through the use of information exchange models (e.g. AIXM).

B1/3 Provision of digital terrain data sets

The need for interoperable exchange of terrain data requires providing the data in digital form and complying with digital data exchange requirements. This element consists in the replacement of existing terrain data by digital terrain data sets. Therefore, this element supports the migration to a data-centric environment where terrain data will be provided in a digital form and in a structured way.

B1/4 Provision of digital obstacle data sets

The need for interoperable exchange of obstacle data requires providing the data in digital form and complying with digital data exchange requirements. This element consists in the replacement of existing obstacle data by digital obstacle data sets. Therefore, this element supports the migration to a data centric environment where obstacle data will be provided in a structured and digital form through the use of information exchange models (e.g. AIXM).

B1/5 Provision of digital aerodrome mapping data sets

The need for interoperable exchange of aerodrome mapping data requires providing the data in digital form and complying with digital data exchange requirements. This element consists in the replacement of existing aerodrome mapping data by digital aerodrome mapping data sets. Therefore, this element supports the migration to a data centric environment where aerodrome mapping data will be provided in a structured and digital form through the use of information exchange models (e.g. AIXM).

B1/6 Provision of digital instrument flight procedure data sets

The need for interoperable exchange of instrument flight procedure data requires providing the data in digital form and complying with digital data exchange requirements. This element consists in the replacement of existing instrument flight procedure data by digital instrument flight procedure data sets. In addition, it includes consistent coding of procedures to match the procedure design intent and ensure more repeatable flight paths. Applying new rules for coding Instrument flight procedures will limit the number of allowable path terminators for PBN procedures in compliance with the PBN Navigation Specifications. Therefore, this element supports the migration to a data centric environment where instrument flight procedure data will be provided in a structured and digital form using information exchange models (e.g. AIXM).

B1/7 NOTAM improvements

In order to meet the operational needs of the users, it is essential to provide information that is timely and it for purpose. This can be done by reining the criteria to ensure that the users receive the right information. This element consists in the identification of clear operational conditions under which a NOTAM shall or shall not be originated and replacement of paper NOTAMs by a digital version through the use of information exchange models (e.g. AIXM).

B2/1 Dissemination of aeronautical information in a SWIM environment

This element represents the full integration of aeronautical information into the SWIM environment. The use of AIM SWIM services will allow the user to access relevant and mutually understood aeronautical information in an interoperable manner. This will include the ability not only to communicate and exchange aeronautical information but also to interpret it in a meaningful manner. AIM-SWIM information services will support request/reply or publish/subscribe access mechanisms and will provide quality & timely information to users in a range of formats to best enable their optimal decision making. AIM-SWIM information services will also include web-services supporting the graphical representation of aeronautical information in a geo-referenced environment.

B2/2 Daily Airspace Management information to support flight and flow

Airspace Management, in daily operations, will continuously adjust airspace status, adjust airspace volumes (e.g. advanced flexible use of airspace) and add temporary airspace initiatives. This element mirrors the modernization efforts ongoing for scheduled AIP modifications with global best practices for packaging and making this information available for dissemination to improve local and regional flight planning in keeping with the flight and flow initiatives engendered in Block 2 FICE and NOPS. This best practice DAIM service enable by SWIM will ensure that information regarding status airspace configurations (Fixes, FIR Boundaries, static zones etc.) and information regarding airspace evolution (re-routings, sector configurations, airspace use plan and updated airspace use plan, airspace reservations, route restrictions and availability, dynamic zones etc.) will be available in formats that support NOPS and FICE automation.

B2/3 Aeronautical information to support higher airspace operations

Long endurance and near space tourism operators' space crafts are subject to all applicable AIS. In addition, there may be a need to manage operations in the airspace by changing the status of volumes of airspace solely related to these operators. Since this information is applicable only to these operators, there is limited value in including this as information in ATM airspace management. A complementary, separate service is desired.

B2/4 Aeronautical information requirements tailored to UTM

UAS flying in UTM are subject to all applicable AIS. In addition, UTM will manage UAS in the airspace by changing the status of volumes of airspace solely related to UAS operations. For example, the publishing of maps where UAS may operate near airports in class B, or locations where state operations are occurring for which UAS need to stay clear. Given the manner in which UAS operations occur it is likely that the operator must be in continuous contact with the network to access this information. Since the volume of such airspace management information would overwhelm ATM airspace management, a complementary, separate service is desired.

B2/5 NOTAM replacement

This element consists in the establishment of an information service through SWIM that serves as a replacement for the information currently provided by NOTAMs. The replacement of the current NOTAM system by this information service is expected to solve identified deficiencies such as NOTAM proliferation or the operational irrelevance of the information provided.

PART III

D-AIM ROADMAP TIMELINE

This roadmap provides a general indication of what the air transport industry may be expecting from States in their implementation of the transition to AIM. The timeline below indicates to States the major milestones that ICAO envisages to support the transition to AIM and the Global Air Traffic Management Operational Concept initiatives related to the management of aeronautical information.

December 2008 Phase 1 — Consolidation began with the establishment of the AIS-AIM Study Group. More information on the work and planned actions of the Group may be found on the ICAO website at www.icao.int/anb/aim.

The consultation process for Amendment 36 to Annex 15 and Amendment 56 to Annex 4 was initiated in the first quarter of 2009.

The development of Amendment 2 to the AIS Manual (Doc 8126) and Amendment 30 to the PANS-ABC (Doc 8400) introduced guidance material on best practices already available.

November 2009 Phase 2 — Going digital will begin by the development of new, related guidance material (electronic AIP, aeronautical information conceptual model, training, quality) that will be developed with the support of the AIS-AIMSG which will hold its second meeting at the end of 2009.

November 2010 Amendment 36 to Annex 15 and Amendment 56 to Annex 4 will become applicable. The preparation of Amendment 37 to Annex 15 and Amendment 57 to Annex 4 and any consequential amendments required in other annexes will progress with the help of the AIS-AIMSG.

October 2011 **Phase 3 — Information management** will begin with the fourth meeting of the AIS-AIMSG which will finalize the proposals for Amendment 37 to Annex 15 and Amendment 57 to Annex 4. These amendments will set the scene for the future requirements for States to produce data sets. It is not envisaged that new data products will be required for mandatory provision by the future ATM systems by this date, but if States choose to provide the data identified in scope at that time, they will be able to base their development on recommendations, ensuring global harmonization.

The consultation process of Amendment 37 to Annex 15 and Amendment 57 to Annex 4 will be initiated in the first quarter of 2012.

November 2013 Amendment 37 to Annex 15 and Amendment 57 to Annex 4 will become applicable,

A divisional-type meeting may be held, should a substantial number of subjects of worldwide scope involving meteorological, aeronautical information and supporting communication network fields need to be agreed upon in order to finalize the transition to AIM. This could

include a substantial enlargement of the scope of aeronautical information required by ATM and an obligation to provide the information in the form of digital data.

November 2016 Amendment 38 to Annex 15 and Amendment 58 to Annex 4 will become applicable including the recommendations of the divisional meeting.

November 2018 Amendment 40 to Annex 15 concerns the restructure of Annex 15 to facilitate the incorporation of AIM requirements. Changes to the technical content of Annex 15 to enable the transition from AIS to AIM and consequential amendments in support of space weather information.

January 2019 The 2019 Edition of The ICAO Global Air Navigation Plan (GANP) will assess the status of all Modules based on the level of deployment and the updates availability of the technology and standards. ICAO will continue to develop guidance material for the implementation of ASBU and more material will be available for the 2019 update of the GANP.

September 2020 Develop Training Manual content in line with Annex 15 amendment 40 and PANS-AIM edition 1. Use of competency-based Training and Assessment (CBTA) methodology of the PANS TRG as the context for AIS/AIM training and competency guidance. Consider what training and competency content should be placed in the Training Manual, and the AIS Manual (Doc. 8126).

May 2021 Ratification of ICAO PANS-IM.

January 2022 Illustrate links between ASBU Modules and KPIs, exchange of experience and best practices at regional and subregional levels. Update of performance relates ICAO Manuals (Doc. 9883 and Doc 9161) and development of additional guidance material on data collection, data analysis, etc. Define a global performance baseline, based on States performance monitoring and reporting, against which future progress will be measured.

2022 -Beyond Standardization of performance data and enhanced data exchanges to automate and reduce the cost of performance data collection and processing. This work could benefit from existing work on exchange models.

November 2024 Applicability date for future proposals for amendments to ICAO Annex 15, ICAO Annex 4 and PANS-AIM.

January 2025 Flight and Flow Information for a Collaborative Environment (FF-ICE) – full implementation.

The adjustment of dates for the Blocks in the most visible change (B0 = 2013 – 2028, B1 = 2019 – 2024, B2 = 2025 – 2030, B3 = 2031 onward). This will allow better synchronization with the ICAO Assembly and amendment cycles.

— END —