C-ATM/BR: A COOPERATIVE ATM CONCEPT PRELIMINARY DEFINITION FOR THE BRAZILIAN ENVIRONMENT

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ABSTRACT

A worldwide air traffic growth is expected for the future. Continuous increases of traffic demand faces limited infrastructural resources such as parking positions, airways, or runways. In general, the capacity extension of those resources is limited. New concepts under development in the Air Traffic Management (ATM) field represent a promising possibility to achieve optimal resources usage. This work provides a preliminary definition of some cooperative approaches of future ATM concept for the Brazilian environment, called C-ATM/BR. To guide the description of the cooperative approaches, this preliminary definition considered the main three pillars of: advanced common situational awareness; decision making process support; and control measures implementation. These approaches are intended to help de Brazilian Air Transportation authorities to deal with and improve its Airspace Control.

Keywords: Common Situational Awareness, Decision Making Process, Control Measures, Cooperative Approaches, Air Traffic Management.

1 INTRODUCTION

This work provides a preliminary definition of some cooperative approaches to support the development of a future ATM concept for the Brazilian environment based on current Research and Development (R&D) activities, called C-ATM/BR (Meinerz et al., 2009). It represents a deliverable of an already finished interchange project between the German Berlin Institute of Technology (TU-Berlin) and the Brazilian Aeronautics Institute of Technology (ITA) as part of the whole project entitled "Feasibility study on implementation and adaptation of a new cooperative ATM concept into the Brazilian ATM environment".

The approaches were described without considering specific requirements of the main involved stakeholders (e.g. Air Traffic Control - ATC, Airport, and Aircraft Operators) on the ATM processes. Activities and trends of future oriented international research programs like the Single European Sky ATM Research (SESAR) (SESAR, 2007) of the European Organisation for the Safety of Air Navigation (EUROCONTROL) and the Next Generation Air Transportation System (NextGen) (JPDO, 2007) of the Federal Aviation Administration (FAA) were examined. Also the Brazilian ATM Operational Conception (DECEA, 2008) and the transition program to the Communication, Navigation, and Surveillance / Air Traffic Management (CNS/ATM) (DECEA, 2009) system concept for the Brazilian Air Space Control System (SISCEAB) have represented important basis.

As a next step after this preliminary definition the main results expected to be achieved are:

- Increasing the capacity of utilization;
- Increasing the punctuality;
- Identification of optimization potentials; and
- Setting up the fundaments for applying the Collaborative Decision Making (CDM) concept.

After this introduction, Section 2 summarizes the short and long R&D activities. Following, Section 3 presents a briefing of the Brazilian Airspace Control Scenario. Section 4 contains a description of some cooperative approaches for a future ATM concept and Section 5 brings the main conclusions.

2 RELATED R&D ACTIVITIES IN EUROPE AND USA

This section presents the main short and long term R&D activities accomplished and still under work in Europe and United States of America (USA).

2.1 Short Term R&D Activities

2.1.1 K-ATM

The Project "Kooperatives Air Traffic Management (K-ATM)" was part of a joint German Aviation Research Program III (LUFO III) supported by the German Federal Ministry of Economics and Technology (AT-One, 2007).

The main objective of this project was to develop a cooperative air traffic management concept supporting all involved stakeholders in a cooperative way, to increase the utilization of limited infrastructural resources (e.g. runways).

A further part of this project was the prototyping and evaluation of a sequence optimization tool able to support different optimization problem (e.g. decrease delay, increase utilization, decrease holding times, and decrease environmental pollution).

The following main benefits were expected to be achieved for each involved stakeholder:

- ATC and Aircraft – Reducing the arrival time and consequently decreasing fuel consumption and environmental impact;
- Airport:

- Aligning traffic demands with predicted capacities by maximizing the usage of available resources, and
- Increasing data quality by enhancing airport stakeholders situational awareness, in order to better coordinate airport and ground operation processes; and
- Aircraft;
- Increasing data quality by enhancing airline stakeholders situational awareness about delays, and
- Optimizing sequence processes and air traffic controls by decreasing overall delays.

The following research recommendations were also identified by the project:

- Searching for new possibilities to increase the accuracy of estimates:
- by calculating and predicting ground data utilization from Radio Detection And Ranging (RADAR),
- by using Flight Management System (FMS) considering on board aircraft performances, current flight plan information and routings, and
- by using current and predicted weather information, e.g. wind correction; and
- Searching also for new possibilities to increase the availability of estimates:
- by using updates generated and transmitted by FMS from aircrafts to the ground, e.g. Automatic Dependent Surveillance-Broadcast (ADS-B), and
- by using new generation ground prediction tools, from aircrafts generated and transmitted RADAR data.

2.1.2 Airport CDM

Airport CDM is an operational concept which aims to improve (EUROCONTROL, 2006):

- The Air Traffic Flow and Capacity Management (ATFCM) at airports, by reducing delays;
- The predictability of events; and
- The optimization of resources utilization.

The Airport Operations Program (AOP), under European Air Traffic Management Program (EATMP), is responsible for the development of the Airport CDM Concept under the Airport Operations Team (AOT), and undertakes the promotion and supportability of the pan-European implementation (EUROCONTROL, 2006).

The Airport CDM Project has defined the Airport CDM Concept Elements and their relationships to guide CDM implementation at European airports, facilitating a phased approach to the development of all necessary requirements. This concept is divided into the following elements (EUROCONTROL, 2006):

- Airport CDM Information Sharing;
- CDM Turn-round Process – Milestones Approach;
- Variable Taxi Time Calculation;
- Collaborative Management of Flight Updates;
- Collaborative Pre-departure Sequence;
- CDM in Adverse Conditions; and
- Advanced CDM.

The overall objectives of the Airport CDM project are:

- Developing airport CDM applications to support the EATMP and the Central Flow Management Unit (CFMU);
- Facilitating its initial implementation in partnership with users;
- Validating applications after implementations; and
- Supporting the development of standards at the European level.

In order to develop the Airport CDM processes, the decision making process have to be enhanced by the sharing of up-to-date

relevant information and by taking into account preferences, available resources and requirements from those involved partners at the airport.

The main benefits of an Airport CDM process to the main partners are:

- To Aircraft Operators – increased adherence to schedule and possibility to express preferences;
- To Ground Handlers – improved predictability of turn-round operations and better use of resources;
- To Airport Operator – increased departure and arrival punctuality and more efficient use of stands, gates and terminals;
- To ATC – optimized use of airport side infrastructure and reduced workload and ground congestions; and
- To CFMU – increased adherence to slots and optimized use of airspace capacity.

Established the main benefits, **Figure 1** depicts the main common objectives of the involved partners of an Airport CDM project.

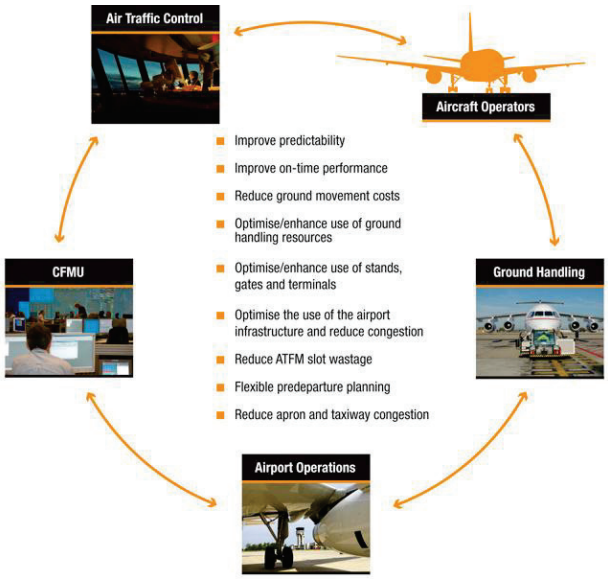


Figure 1: The main Airport CDM common objectives (EUROCONTROL, 2010)

2.2 Long Term R&D Activities

2.2.1 SESAR

The SESAR is the EATMP. According to the primary reference for all future SESAR developments (SESAR, 2007), it aims to develop the new generation air traffic management system capable of ensuring the safety and fluidity of air transport over the next 30 years.

Its key objectives are (SESAR, 2007):

- To restructure European airspace as a function of air traffic flows;
- To create additional capacity; and
- To increase the overall efficiency of the air traffic management system.

It was defined by a representative group of ATM stakeholders with recognized expertise to ensure the decision making level. The SESAR program is organized in three phases (SESAR, 2007):

- Definition Phase (2005-2008) - The 2020 ATM Target Concept is one of the main results of the SESAR Definition Phase. It provides the reference to support the decisions to build the SESAR Master Plan for the 2020 European ATM system. This ATM Target Concept with its identified issues will be further analyzed and detailed during the SESAR Development Phase;
- Development Phase (2008-2013) - Managed by the SESAR Joint Undertaking, the Development Phase will produce the required new generation of technological systems and components as defined in the Definition Phase. The SESAR Joint Undertaking was created under European Community law, to manage the SESAR Development Phase; and
- Deployment Phase (2014-2020) - The Deployment Phase will consist of large-scale production, procurement, and implementation of the new ATM

infrastructure and corresponding aircraft equipments.

Global Interoperability is of major importance for the development of the SESAR Operational Concept. It offers different concept features which can be tailored to the specific local needs to meet the local performance objectives and their evolution in the life time of SESAR (SESAR, 2007).

The Concept of Operation (ConOps) defines the entities, their actions, and how they should operate collectively within the future ATM Network. The performance objectives and targets, and the operational vision are addressed with regard to the evolving capabilities and requirements of the ATM service provision.

The scope of ConOps considers the flight planning phases and post-flight activities, e.g. gate to gate, as shown by **Figure 2.**

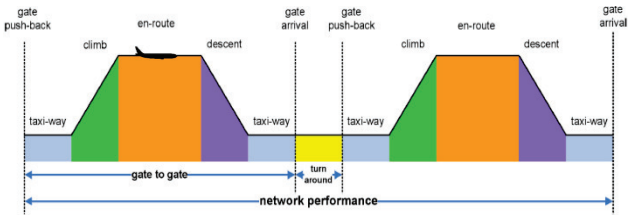


Figure 2: A Network Performance for a Trajectory-based Environment (SESAR, 2007)

The SESAR ConOps is compatible in all aspects with the International Civil Aviation Organization (ICAO) Global Air Traffic Management Operational Concept, as described in (ICAO, 2005), and represents the concrete application of this global concept, adapted and interpreted for Europe regarding the need of global interoperability (SESAR, 2007).

Future developments of the ATM Target Concept should include clarification of the new roles and responsibilities in order to be assessed by legal implications and liability issues, as well as the ATM safety responsibilities and new interfaces between stakeholders (SESAR, 2007).

2.2.2 NextGen

The NextGen is the FAA plan to modernize the National Airspace System (NAS) in the 2025 timeframe and beyond (JPDO, 2007).

The Joint Planning and Developing Office (JPDO) is developing a ConOps for the NextGen and its final version will provide an overall and integrated view of NextGen operations (JPDO, 2007).

The three major goals for ATM in NextGen are (JPDO, 2007):

- To meet diverse operational objectives for all airspace users and to accommodate a broader range of aircraft capabilities and performance characteristics;
- To meet the needs of flight operators and other stakeholders for access, efficiency, and predictability in executing their operations; and
- To be: safe, secure, of sufficient capacity, environmentally acceptable, and affordable for both flight operators and service providers.

To respond to increases in demand and to the overall complexity of operations, the roles and responsibilities of all involved stakeholders need to evolve (JPDO, 2007).

In NextGen, all airspace users are able to collaborate on ATM decisions. Collaboration involves the exchange of information to create mutual understanding among participants of overall objectives and to share decision making among stakeholders (JPDO, 2007).

3 THE BRAZILIAN AIRSPACE CONTROL SCENARIO

At the 10th Air Navigation Conference, on September 1991, in Montreal, CNS/ATM concept, developed by the Future Air Navigation Systems (FANS) committee, was approved by ICAO Council. The same conference recommended the development of a document to guide the implementation of CNS/ATM systems. Thus, a first version of a

Global Coordinated Plan ("Global Air Navigation Plan for CNS/ATM Systems") was published in 1998 and updated and re-titled as the "Global Air Navigation Plan" (ICAO, 2007) in consideration of the operational concept. The Global Air Navigation Plan is a strategic document that describes the methodology for global air navigation harmonization.

Since then, several States started ATM implementation programs to improve their aviation operations by using CNS/ATM technologies. However, later, it was recognized that a comprehensive concept of an integrated and global ATM system based on clearly established operational requirements was needed. Thereby, the "Global Air Traffic Management Operational Concept" (ICAO, 2005) was created, intending to guide the implementation of CNS/ATM technology by providing a description of how the emerging and future ATM system should operate.

The ICAO Global ATM Operational Concept defines seven interdependent concept components that will be integrated to form the future ATM system (ICAO, 2005), shown in **Figure 3**, comprised of the following components:

- The Airspace Organization and Management (AOM);
- The Aerodrome Operations (AO);
- The Demand and Capacity Balancing (DCB);
- The Traffic Synchronization (TS);
- The Conflict Management (CM);
- The Airspace User Operations (AUO); and
- The ATM Service Delivery Management (ATMSDM).

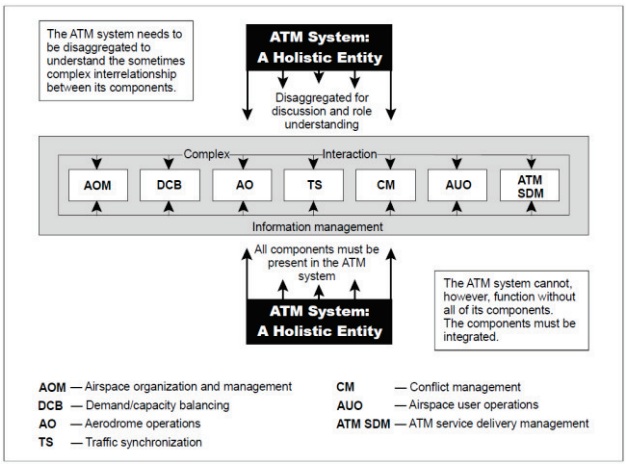


Figure 3: The seven Interdependent ICAO Operational Concept Components (ICAO, 2005)

The Brazilian Flight Protection Service (SPV) has adopted a centralized ATC model where civilian and military air activities are under the same control system. According to Siewerdt (2008), this integrated civilian airspace together with military air defense control is considered as creative and efficient by international civil aviation agencies. Though, this compartmentalized model is not favorable to information exchanges and collaborative decision making processes.

According to DECEA (2008), an effective, coordinated, and gradual implementation for the Brazilian CNS/ATM transition is planned mainly by considering the characteristics of the Global ATM Operational Concept components.

The transition aims the modernization of the SISCEAB. The following two documents were generated by the Brazilian Department of Airspace Control (DECEA) and represent the main references in this transition process:

- The Brazilian ATM Operational Conception (DECEA, 2008); and
- The Brazilian ATM Implementation Program (DECEA, 2009).

The transition also aims to assure the evolution from the compartmentalized model to an interoperable global ATM system, as shown in **Figure 4**.

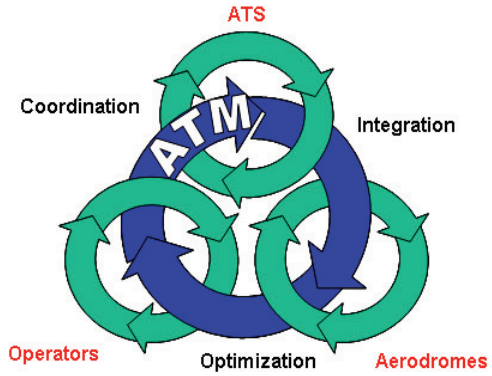


Figure 4: The desired Brazilian Interoperable Global ATM System (DECEA, 2007)

The analytical structure of the Brazilian CNS/ATM transition program is shown by **Figure 5.** It provides the basis for a project management at all levels presenting a decomposition directed to specific areas and their respective projects.

The main areas that compose the structure are:

- Air Traffic Management;
- Communication;
- Navigation;
- Surveillance;
- Aeronautical Services;
- Human Factors; and
- Integration.

The projects are linked to the areas.

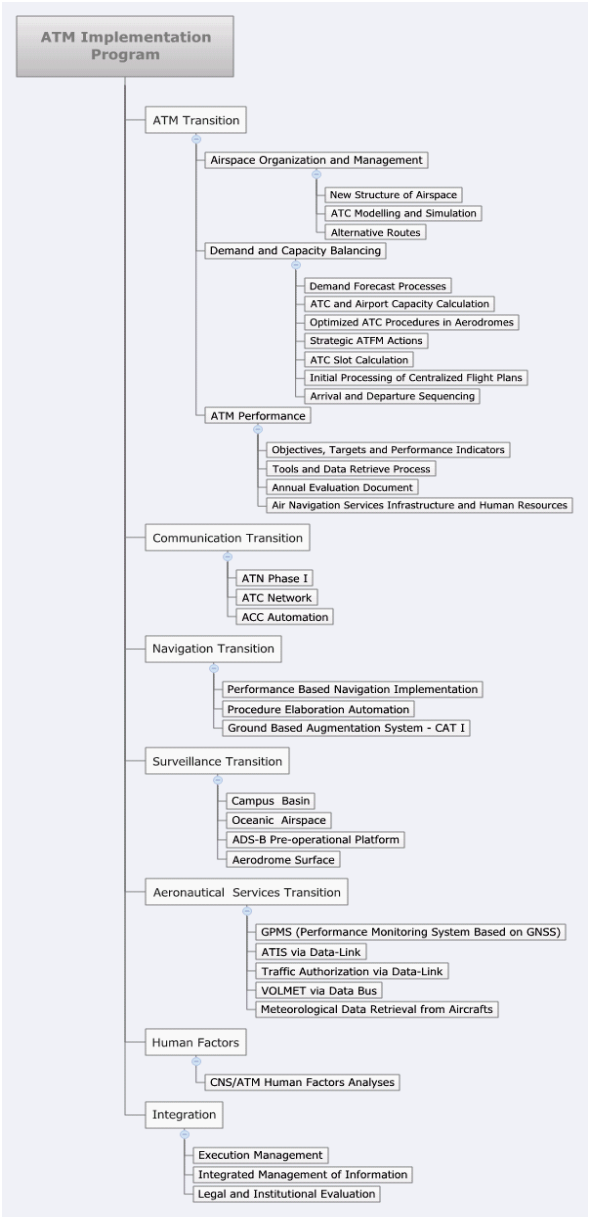


Figure 5: Analytical Structure of the Brazilian CNS/ATM Transition Program, adapted from its original in Portuguese (DECEA, 2009)

4 COOPERATIVE APPROACHES OF A FUTURE ATM CONCEPT FOR THE BRAZILIAN ENVIRONMENT

This Section presents some cooperative approaches of a future ATM concept for the Brazilian environment. These approaches are mainly based on the following main three pillars, as already mentioned by GERHOLD (2008):

- The **advanced common situational awareness** which is essential to fulfill the main preconditions for a cooperative decision making process;
- The **support of decision making process** in a cooperative environment, where different partners are involved in the decision making process; and
- The **implementation of control measures** into the ATM system to influence the air traffic by different partners with the same purpose.

Considering the overall ATM control loop, shown in **Figure 6**, some approaches will cover its all sub-loops-management (i.e. Controller, Control Unit, Disturbance Value, Adjustment Characteristics, and Measuring Unit). It might result in benefits for the Brazilian ATM environment. Notice, in this figure, the three pillars presented above also identified and highlighted.

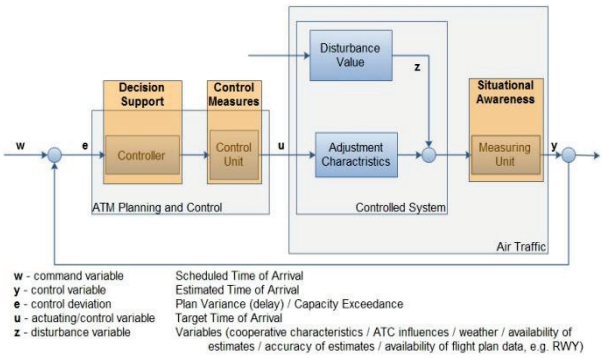


Figure 6: An Overall Control Loop for the ATM Process

This preliminary definition of the cooperative ATM concept is described based on international research results, without considering yet suggestions and requirements from stakeholders.

4.1 The Advanced Common Situational Awareness

In the ATM processes it is essential to achieve a Common Situational Awareness (CSA) to predict future events, making full use of the responsibilities and procedures of all involved stakeholders. Therefore, enabling exchange and sharing accurate information is fundamental for a future cooperative ATM concept. Thereby, when all stakeholders have access to the more up-to-date information, they will have a global overview and hence improve their planning processes.

The scope of the potential information of interest to ATM operations includes, for instance, flight plan data trajectories, surveillance data, aeronautical information, and meteorological information, as well as sensitive civilian and military data.

Aiming to increase the situational awareness, some criteria of data quality and information sharing are presented and discussed in the following sections.

4.1.1 Increasing Data Quality

The ATM community depends extensively on the provision of information[1] to collaborate and make decisions.

The success of a future cooperative ATM Concept depends extensively on the provision of information by all involved stakeholders.

The quality of aeronautical information is a fundamental value to improve ATM processes. The reliability of ATM results depends on the accuracy, availability, and reliability of input data. To improve the performance of ATM processes, the quality of input data has to be increased by using additional data from other stakeholders or increase the accuracy and availability of currently available data.

The availability of accurate data at the right time and in the right place to all stakeholders who need this information leads to improved predictability and consequently to the resource allocation.

In order to reach a higher data quality, some criteria must be assured: Availability; Accuracy; Reliability; Timeliness; Stability; Predictability; and Integrity.

[1] For the purpose of this work, information means aggregated data.

In some cases, agreements may need to be signed among all stakeholders covering such data quality criteria. According to EUROCONTROL (2006), description of the business processes and policies that will be in effect to create and disseminate the required data also should be included in the agreement.

In order to measure the quality of the exchanging data among all stakeholders, a set of procedures should be put in place to routinely evaluate the data against a set of agreed criteria. The results can be made available to the stakeholders to enable them to make improvements as necessary.

Standardization and harmonization of data formats

To reach the global harmonization is essential to manipulate standardized data formats.

A higher operational standard for Aircraft Operators and Air Navigation Service Provider (ANSP) is required to ensure the safest global air transportation system. ICAO Planning and Implementation Regional Groups (PIRG) or multilateral agreements coordinate planning and implementation of NextGen transformations to harmonize the application of technology and procedures. This harmonization allows airspace users to perform the maximum benefits of the NextGen transformations (JPDO, 2007).

According to EUROCONTROL (2010), information standard format of the data is essential to avoid inconsistencies or data recognition problems. As different stakeholders have different formats, filters and converters should be specified and developed in order to interface different systems and avoid data problems.

In Europe, the Aeronautical Information Conceptual Model (AICM) and its analog eXtended Markup Language (XML), and the Aeronautical Information Exchange Model (AIXM) were developed by EUROCONTROL to enable aeronautical data standardization and exchange it among European states. AICM and AIXM organize aeronautical data into six data concept areas: Aerodromes, Airspace, Services, Fixes, Routes, and Procedures. Today, EUROCONTROL uses AICM and AIXM to create products such as the European Aeronautical Information Publication (e-AIP). With the recent adoption of AIXM by the USA, the AICM and the AIXM are on their way toward becoming a global standard for representing aeronautical data. Recently, the FAA's Air Traffic Airspace Laboratory has undertaken an effort to modernize the process used to build, validate, and publish the Temporary Flight Restrictions (TFR). An extension to AIXM, currently named xNOTAM, has being used as a standard for representing a TFR (EUROCONTROL, 2006).

Information Management

Information management provides accredited, quality-assured, and timely information used to support ATM operations. Information management will also monitor and control the quality of the shared information and provide information-sharing mechanisms that support the ATM community (ICAO, 2005).

The term Aeronautical Information Management (AIM) is applied to the globally interoperable provision of aeronautical data (Frangolho and Zerkowitz, 2006). That intends to provide the needed data quality, covering the requirements of present and future ATM system for all flight phases, in a data oriented and holistic approach. Its role is to monitor and check the quality of shared data and to provide mechanisms that support the ATM community in setting up and managing information sharing in a collective effort of all suppliers of data.

The AIM strategy was defined aiming to increase the interoperability among systems. It is based on the networking of various ATM databases, and intends to cover data of the following different management levels:

- Strategic Planning;
- Pre-Tactical Planning;
- Tactical Planning;
- Operational control; and
- Post flight activities.

Update rate increases of required data

In some cases the availability of data is represented by the rate of update. To increase the availability of such data it is recommended to check possibilities to increase the update rate. Normally, it depends on technical performance of computing systems (e.g. computing performance).

According to ICAO (2005), an operational analysis represents a necessary part of ATM implementation planning. It culminates in the identification of operational requirements and the establishing criteria for rating alternatives. This leads to the selection of a solution which should be the most effective in fulfilling the ATM objectives, as defined in the operational concept.

In the NextGen project (JPDO, 2007), the update rate of weather information is aligned with the requirement to predict or detect rapidly changing boundary conditions. Infrastructural changes often depend on weather conditions (e.g. realigning sectors regarding a line of thunderstorms). The availability of weather information in the NextGen approach allows a rapid detection of changing weather situations by the decision makers of the strategic and tactical planning level.

Avoidance of data redundancy and integrity problems

Most of communications paths in use today typically provide a secure means of transmitting data. However, it is often not possible for the user to be able to always guarantee this situation. The application of Cyclic Redundancy Checks (CRC) provides a way where each user application may confirm the receipt or extraction of data without a loss of integrity. All data packets shall be individually protected, with a CRC value included as part of the transmission (EUROCONTROL, 2006).

According to ICAO (1944), existing integrity levels of requirements provide a baseline for acceptable data quality. To achieve the necessary levels of integrity, security, and validation, provisions will have to address the following three levels of requirements:

- Level 1 - In this level of requirement, data transfer should be conducted in a manner that ensures the risk of data error is sufficiently low as to enable the safe use of the data for flight operations. This will require, among others, appropriate automated data handling techniques that prevent data from being corrupted;
- Level 2 - Protection shall be employed for data transmission through the mail or using public data networks to prevent inadvertent or deliberate modification; and
- Level 3 - Data need to be validated for correctness, completeness, and to check the validity of information in data fields.

Generation of predictions

A view of the complete ATM network is necessary in order to identify bottlenecks and predicted air traffic based on aeronautical data (e.g. flight plans). Its efficiency depends largely on the quality of the traffic prediction, which is highly influenced by the quality of data. Its inaccuracy is a major source for uncertainty in the overall traffic prediction and this lack of predictability leads to inefficient uses of existing resources. Some further improvements to the flexibility of aircraft and airport operations can be reached by:

- Ensuring information completeness between en route and airport operations;

- Improving ground operations predictability; and
- Improving estimates of take off times for all flights.

Better predicted situations will optimize all ATM operations. Some of interest predictions cover the following aspects:

- Weather information;
- Demand prediction;
- Capacity prediction;
- Punctuality prediction;
- Turn-round time prediction;
- Taxi time prediction; and
- Four-dimensional trajectories (4DTs).

4.1.2 Information Sharing

Information sharing on a system-wide data basis will allow the ATM community to manage the operational processes in a safer and more efficient manner.

Applications of CDM and information sharing represent two key elements for the future cooperative ATM concept.

Airport CDM defines Information Sharing as a logical and distributed data repository from and to the involved stakeholders (EUROCONTROL, 2010). It will allow stakeholders to synchronize their activities by sharing experience, monitoring the coordination, communicating and providing feedback, and backup assistance when needed.

To the SESAR ATM Target Concept, information sharing of the required quality and timeliness in a secure environment is an essential enabler to the development of its concept (SESAR, 2007).

At the heart of the NextGen concept there is the information sharing component known as net-centric infrastructure services or net-centricity (JPDO, 2007).

Its features allow NextGen to adapt to growth in operations as well as shifts in demand, making NextGen a scalable system.

Net-centricity also provides the foundation for robust, efficient, secure, and timely transport of information to and from a broad community of users and individual subscribers.

The result is a system that minimizes duplication, achieves integration, and support distributed decision making by ensuring that all decision makers have exactly the same information at the same time.

SWIM is an information sharing concept supporting the Airport CDM requirements by using efficient end-user applications. Access and usage of shared information should follow predefined agreed procedures, as well as the protected of sensitive civilian and military data must be respected.

Identification of data sources

Most of the relevant information exists in various systems. Some of them are not available to all involved stakeholders. It is necessary to identify all the existing data delivering systems, to implement them into a future cooperative ATM Concept.

According to EUROCONTROL (2006), information sharing, considered as a data source or data destination, any organization or system may generate and/or use data pertinent to ATM decision making in the context of airport operations. Ground movement surveillance equipment can be cited as an example of data source.

To achieve CSA, by facilitating the information exchange among various stakeholders, it will improve the decision making process and the efficiency of operations by using the best available information.

4.2 The Decision Making Support

According to EUROCONTROL (2006) and JPDO (2007), the main CDM objective is to increase airspace and control capacity to improve flight operations by increasing the involvement of aircraft operators in the ATM process, as well as maintaining a high level of safety efficiency. This is achieved by developing information management systems

and procedures, and implementing functions, which take into account specific priorities of aircraft operators and airport operations, during all flying phases using full data available.

An alternative way to address these issues is to apply the CDM by using collaborative technologies and procedures to get benefits associated with both flight and strategic planning. In this case, the decision making by the stakeholders is facilitated by the sharing of accurate and timely information and by adapted procedures, mechanisms, and tools.

In the future cooperative ATM concept the human will be the most important and finally responsible decision maker. The human workload by using system wide information is limited. Therefore, the decision making process needs to be supported by a comprehensible presentation of data.

4.2.1 Traffic Situation Visualization

To observe the current and the expected traffic situation, all decision makers have to be supported by different visualization tools based on the same data. Due to the amount of information it is essential to aggregate some of the values by using suitably visualization items in order to reduce the workload of the users. In this case users and decision makers should have the opportunity to exponentialize all aggregated information in case of they require more detailed level.

The NextGen integrates cooperative and non-cooperative surveillance data and information along with aircraft intent information to create the most accurate view possible of the actual situation. All participants in the system have access to the essential surveillance information needed for the decisions or negotiations concerning their particular activities (JPDO, 2007).

As stated by SESAR (2007), the objective of the surveillance service is to provide a complete picture of the actual traffic situation to ensure a safe separation and efficient traffic flow.

4.2.2 Resources Use Optimization

The air traffic management processes should support an optimized use of limited resources (e.g. airports). The results of these processes should be permanently reflected in a common information sharing platform.

As stated by JPDO (2007), intelligent and improved resource optimization processes enable the efficient management in the enroute, arrival, turn around and departure phases. This offers more abilities to reduce environmental impact on the ground and in the air.

An optimization process, like a runway sequence optimization algorithm, can focus on different target values such as:

- To maximize utilization of runway capacity;
- To minimize the overall on-block-delay;
- To minimize the overall off-block-delay ;
- To minimize the holding/transition time of approaches;
- To minimize the environmental impact; or
- To minimize fuel consumption.

The application of a weighting function allows using a mixture of different target values to generate an optimization result. However, during the optimization process some boundary conditions have to be considered among others:

- Separation minima;
- Aircraft performance limits; and
- Infrastructural constraints.

4.2.3 Advanced Decision Support Tools

The migration from the present system to more advanced ATM systems is based on technologies that should be carefully planned. Assurance is needed at each step on which continued levels of safety will be maintained

and improved upon where necessary (ICAO, 2005).

Camargo Junior, Cugnasca and Almeida Jr (2008) state that considering the CNS/ATM concept, new management and control forms should be investigated with special attention to the decision support systems by which pilots and air traffic controllers should be advised. They also mentioned that the new air traffic control systems will depend more heavily on computer systems, considering the functions of control and decision support.

New technologies have been introduced in daily operations to enhance decision support for safety systems. Some examples are advanced ATC tools from Europe like Arrival Manager (AMAN), Departure Manager (DMAN), and Advanced Surface Movement Guidance and Control System (A-SMGCS). In this case, according to EUROCONTROL (2010), they cooperate with the Airport CDM concept by sharing and optimizing information about arrivals, departures, and ground movement. The integration by using advanced technologies will enhance and extend CSA and increase collaboration between airport stakeholders.

According to SESAR (2007), from the safety performance improvement point of view, the major contribution will come from better planning, increased situational awareness, and automated tools by detecting all aircraft interactions at a far earlier stage than current methods allow. In order to show evidence of these expected safety benefits, the potential risk contributions need to be identified by continuous appropriate screening for any safety issues during the development and deployment of the ATM Target Concept and by developing appropriate safety assessment methodologies and procedures.

4.3 Control Measures

The results of Decision Making Processes are represented by different control values. These control values are used as a target value. Different control measures can be applied to reach the defined target. In a cooperative ATM concept it is required to identify all currently used control measures, which influence the operational and the ATM processes. Additionally, it is possible to implement new advanced control measures (e.g. new procedures like Continuous Descent Approach - CDA) to support the future cooperative ATM.

As already known, a CDM environment allows all stakeholders of the ATM community to participate in the ATM decision making process achieving an acceptable solution that takes into account the needs of those involved. In this case, the ANSP are responsible for resolving competing demands for an ATM resource and to organize a safe sharing of that resource among the requesters.

Some of the control measures, based on previously agreed procedures, are described as follows:

- Insertion of ground delays on departure airport;
- In flight acceleration or deceleration;
- Prioritization between departures and arrivals;
- Reallocation of infrastructural resources (e.g. rerouting, runway-change, position-change, ground handling processes);
- Adaptation of descent profile (e.g. CDA); and
- Reallocation of personal resources (e.g. loading of baggage).

4.3.1 Continuous Descent Approach (CDA)

The CDA is an advanced operating procedure for arriving aircrafts. Much of positive effects can be recognized by using this procedure by reducing noise pollution and fuel burn. In contrast to a conventional approach with a CDA procedure, the aircraft stays higher for longer and descend continuously from the top to the bottom level by avoiding level segmentations.

According to EUROCONTROL (2008) the proportion of aircraft achieving CDA will depend on local traffic conditions and local airspace characteristics, although a good success rate may be achieved in high traffic density situations.

The ICAO Working Arrangements are in the process of assessing CDA on a global scale and may also produce CDA guidance. However, the basic CDA techniques described which have been harmonized on a European basis, are not expected to change substantially (EUROCONTROL, 2008).

5 CONCLUSION

The focus of this work is a preliminary definition of some cooperative approaches for the future ATM concept in the Brazilian environment. These approaches are resulting from an interchange project between researchers of ITA and TU-Berlin.

The description was based on current short and long term R&D activities in Europe and USA, taking into account their bad and mainly good experiences, as well as their past experiences, without considering however suggestions and requirements from the main involved stakeholders.

This research work presented a short view about the Brazilian airspace control scenario status and its intentional transition process. To guide the description of the cooperative approaches, this preliminary definition was based on the main three pillars of: the advanced situational awareness; the support of decision making process; and the implementation of control measures.

Although on its initial phase, this work is aligned with the objectives of the Brazilian ATM Operational Conception and the transition program to the CNS/ATM system concept for the SISCEAB. It is trying to help on the development of a National ATM Operational Concept applicable to the Brazilian airspace.

As a next step, it is recommended: to identify new requirements from specific stakeholders of the Brazilian environment and to adapt its approaches. The authors believe that much future potentials are possible to be aggregated to this environment depending on the insights gained from the evolution of these approaches.

This work is intended to support the definition of future operating and management processes, procedures, and tools for the Brazilian ATM environment.

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