 Doc 9971

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**Manual on Collaborative Decision-Making (CDM)**

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**FOREWORD**

It is recognized that the air transport industry plays a major role in world economic activity. To maintain a safe, secure, efficient and environmentally sustainable air navigation system at global, regional and local levels, the implementation and operation of an air traffic management (ATM) system that allows maximum use to be made of enhanced capabilities provided by technical advances.

The realization of the vision for the future ATM system requires an environment including significant information content and efficient and effective use of this information must be performed by extensive collaboration among all members of the ATM community.

Collaborative decision-making (CDM) is defined as an explicit supporting process focused on deciding on a course of action in pursuit of articulated objectives between two or more community members. Through this process, ATM community members affected by any decision, share information related to that decision and agree on and apply the decision-making approach and principles. The overall objective of the process is for the ATM system as a whole to improve its performance while balancing against the individual performance needs of individual ATM community members.

The purpose of this manual is to present the CDM concept as a means to reach the performance objectives of the processes it supports in a consistent and harmonized manner.

**Future developments**

Comments on this manual would be appreciated from all parties involved in the development and implementation of CDM. These comments should be addressed to:

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**GLOSSARY**

**ABBREVIATIONS/ACRONYMS**

A-CDM Airport-CDM

AIXM Aeronautical information exchange model

ANSP Air navigation service provider

AOP Airport operator

AP Airspace provider

ASP ATM service provider

ATFCM Air traffic flow and capacity management

ATM Air traffic management

AU Airspace user

CDM Collaborative decision-making

CTOT Calculated take-off time

ESP Emergency service provider

FF-ICE Flight and flow – information for a collaborative environment

FIXM Flight information exchange model

FOIS Flight operation information system

FUM Flight update message

KPA Key performance areas

NOP Network operators plan

S-CDM Surface-CDM

TFM Traffic flow management

TOBT Target off-block time

TSAT Target start-up approval time

**REFERENCES**

**ICAO documents**

*Global Air Traffic Management Operational Concept (Doc 9854)*

*Manual on Air Traffic Management System Requirements* (Doc 9882)

*Manual on Global Performance of the Air Navigation System* (Doc 9883)

*Manual on Flight and Flow – Information for a Collaborative Environment* (Doc 9965)

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**CHAPTER 1**

**INTRODUCTION**

1.1    Need for Collaboration

1.1.1 The Eleventh Air Navigation Conference (AN-Conf/11) was held in Montreal from 22 September to 3 October, 2003. At this meeting Recommendation 1/1 was agreed for the “Endorsement of the global ATM operational concept”. This concept was subsequently published as the *Global Air Traffic Management Operational Concept* (ICAO Doc 9854), First Edition, 2005. Central to this concept is the need to evolve towards a more collaborative environment, as noted in the AN-Conf/11 Report (paragraph 1.2.1.3 in the AN-Conf/11 Report on Agenda item 1):

*The goal, therefore, was an evolution to a holistic, cooperative and collaborative decision-making environment, where the expectations of the members of the ATM community would be balanced to achieve the best outcome based on equity and access.*

1.1.2 The concept further articulates (Doc 9854, Appendix I, 10) a high-level explanation of collaborative decision-making (CDM) including the following attributes:

1. CDM allows all members of the air traffic management (ATM) community to participate in ATM decisions that affect them (i.e. CDM is not limited to any specific domain such as airport or en-route);
2. CDM may apply to all layers of decision-making from longer-term planning activities through to real-time operations;
3. CDM can be applied actively or, through collaboratively agreed procedures, passively;
4. effective information management and sharing enables each participant to be aware of information of relevance to other participants’ decisions; and
5. any member being able to propose a solution; these are of greater utility when enhanced with effective information management.

1.1.3 AN-Conf/11 further articulated the need to develop ATM requirements derived from the global ATM operational concept. This was described as Recommendation 1/3 – Development of ATM requirements:

*That ICAO as a high priority develop a set of ATM functional and operating requirements for a global ATM system on the basis of the global ATM operational concept.*

1.1.4 As a result of the above recommendation, the *Manual on Air Traffic Management System Requirements* (ICAO Doc 9882) was developed. These requirements repeatedly express the need for collaborative decision-making across all time horizons and concept components. Certain requirements focusing on collaboration include:

1. ensure that airspace users are included in all aspects of airspace management via the collaborative decision-making process;
2. manage all airspace, and where necessary, be responsible for amending priorities relating to access and equity that may have been established for particular volumes of airspace. Where such authority is exercised, it shall be subject to rules or procedures established through collaborative decision-making;
3. establish a collaborative process to allow for efficient management of the air traffic flow through use of information on system wide air traffic flow, weather, and assets; and
4. modify the airspace user’s preferred trajectory: when required to achieve overall ATM system performance requirements; and/or collaboratively with the airspace user, in a manner that recognizes the airspace user’s need for single-flight efficiencies.

1.1.5 Further to the development of the requirements, guidance material was sought in the application of a performance-based approach to ATM decisions. This material was described in the *Manual on Global Performance of the Air Navigation System* (ICAO Doc 9883). The manual provided guidance and a process towards addressing AN-Conf/11 Recommendation 3/3 – Performance framework:

*That ICAO:*

1. *formulate the performance objectives and targets for a future global ATM system;*
2. *continue the definition of related performance metrics and elementary characteristics in the context of the overall behavior of the ATM system; and*
3. *coordinate and harmonize all related contributions within the overall performance framework.*

1.1.6 It is expected that the performance-based approach would be applied in a collaborative manner to address the most strategic decisions as described in the manual. The rationale for such collaboration is provided in terms of the consequences of insufficient collaboration:

1. where insufficient coordination between Air Navigation Service Providers (ANSPs), airports, airspace users, manufacturers, regulators and ICAO takes place, the result is a fragmented air navigation system;
2. insufficient coordination at local, regional and global levels lead to less than ideal interoperability and to geographic differences in terms of performance and maturity; and
3. a fragmented approach from an operational perspective (no gate-to-gate and en-route to en-route) leads to less than optimum flight efficiency and airport operations efficiency.

1.1.7 The manual further states that, collaboration and coordination is needed to:

1. come to an agreed vision on the expected results;
2. ensure that everyone delivers their part of (their contribution to) the required performance;
3. ensure that everyone uses a compatible approach, method and terminology; and
4. ensure that everyone’s data can be integrated and aggregated to calculate overall indicators and assess system performance at a higher aggregation level.

1.1.8 While the above establishes the need for collaboration across multiple stakeholders, objectives and time horizons, an additional attribute to collaboration is the degree to which the collaborative processes are harmonized across these. While this document seeks to not be overly prescriptive in specifying collaborative mechanisms and processes, there are clear consequences resulting from a lack of harmonization, example areas include:

1. Date requirements: CDM processes operate in a future information-enriched environment, with exchange of data and information as the primary facilitator of collaboration. Divergence in data requirements to support disparate CDM processes leads to additional required investments on the part of airspace users in information infrastructure and data collection mechanisms.
2. Automation: Increased involvement of automation is expected, particularly in the faster response-time CDM processes. In addition to divergent data requirements, differing CDM processes will require airspace user automation with tailored algorithms. Further, CDM processes that are constantly changing require evolving automation.
3. Airborne scope of CDM: An extension of the collaborative process to the flight deck for the most tactical CDM processes invites greater harmonization of the required data and processes as the aircraft will operate in multiple environments.
4. Training: Similar to the need to develop new algorithms for disparate or changing CDM processes, airspace users operating across boundaries require additional training to handle the variation in these processes.
5. Seamlessness: Flights will operate through boundaries across which differing CDM processes may be applied. Disparate CDM processes and data affect performance through various mechanisms such as inconsistent objectives, obtaining optima piece-wise, different decision times, and lack of visibility into each other’s processes.
6. Consistency across decisions: The different layers of decision-making can lead to inconsistencies. For example, agreement can be reached on broad performance objectives through CDM for strategic decisions. Operational decisions reached collaboratively may seek different operational performance objectives based upon circumstances, effectively working at odds to the strategic decisions. Processes should consider potential inconsistencies and guidelines for mitigating these.
7. Verification and robustness to “gaming”: As the CDM processes are based upon information provided by multiple participants with differing objectives, the provision of false information to “game” the system in their favor is a potential concern. Lack of harmonization may make it difficult to detect or be robust to the impact of these behaviors across disparate processes with the end result a less equitable system.

1.2    Document Objectives and Scope

1.2.1 As the prior Section has indicated, Doc 9854 and derived documents call for increased levels of collaboration across the spectrum of decision-making. While these documents indicate the need for and describe the applicable areas of collaboration, guidance on implementing CDM is not complete. This document seeks to provide additional guidance in areas where it has not been provided.

1.2.2 It is recognized that CDM is applicable to long-term planning activities such as infrastructure investments and procedural changes. For those types of activities, the performance-based approach as described in Doc 9883 provides guidance on the methods for attaining collaborative, performance-focused solutions. Further, given the long time-horizons available for collaboration, rules, methods and roles of individual collaborating participants can be customized to the situation. It is expected that these types of decisions are out of scope of this document and will be covered by ICAO Doc 9883, Part I *– Global Performance* and Part II – *Performance-based Transition Guidelines*, First Edition 2008.

1.2.3 For other types of collaborative decision-making requiring additional guidance beyond the performance-based approach (e.g. agreement on day-of-operations configurations, flight-specific trajectory changes as required for queue or traffic flow management), this document provides guidance material in the following areas:

1. CDM description in addition to overarching collaboration principles and process, this includes:
2. a description of the ATM areas suitable for collaboration;
3. a classification and description of the types of collaboration, and conditions under which they apply;
4. a description of complementary decision-making and conditions under which it may apply; and
5. issues to be addressed when implementing collaborative processes including the use of rules managing behavior;
6. the role of information exchange – information sharing is central to collaborative processes, important considerations in this area are discussed:
7. data standards – why standards at a syntactic and semantic level are necessary;
8. information quality – the impact of information quality is discussed with approaches for mitigating impacts, where applicable; and
9. role of the collaborative environment – how the information for a collaborative environment supports collaboration;
10. articulating a CDM process – identifying what is necessary to describe a CDM process given an objective for collaboration, including:
11. actors – who is participating in the collaboration;
12. roles and responsibilities – what functions do the actors perform and how do they interact;
13. information requirements – description of requirements and standards imposed on information exchanged as part of the above interactions;
14. making the decision – how is a decision made; and
15. rules – what are some rules constraining the behavior;
16. examples of present-day CDM processes are described, these include:
17. airport and surface CDM;
18. network operations planning;
19. coordination of airspace use;
20. CDM under adverse weather;
21. special traffic management programs and security; and
22. use of collaborative workgroups and tools.

1.3    Relevant Documents

1.3.1 The following documents provide additional background on CDM including its role in the concept, areas requiring collaboration, guidelines for collaboration on strategic planning decisions and an information sharing approach to support it:

1. *Global Air Traffic Management Operational Concept* (ICAO Doc 9854), First Edition 2005;
2. *Manual on Air Traffic Management System Requirements* (ICA Doc 9882), First Edition 2007;
3. *Manual on Global Performance of the Air Navigation System,* Part I *– Global Performance and* Part II*- Performance-based Transition Guidelines* (ICAO Doc 9883), First Edition 2008; and
4. *Flight and Flow – Information for a Collaborative Environment (FF-ICE)* (ICAO Doc 9965)

**CHAPTER 2**

**CDM DESCRIPTION**

2.1    General Approach and Principles

2.1.1 Collaborative decision-making is defined as an explicit supporting process focused on deciding on a course of action in pursuit of articulated objectives between two or more community members. Through this process, ATM community members affected (in all ways) by a decision, share information related to that decision and agree on and apply a decision-making approach and principles. The overall objective of the process is for the ATM system as a whole to improve its performance while balancing against the individual performance needs of individual ATM community members.

2.1.2 CDM is a supporting process always applied to other activities such as demand/capacity balancing. CDM can be applied across the timeline of activities from strategic planning (e.g. infrastructure investments) to real-time operations. CDM is not an objective but a way to reach the performance objectives of the processes it supports. These performance objectives are expected to be agreed upon collaboratively. Since implementing CDM likely will require investments, these will need to be justified in accordance with the performance-based approach.

2.1.3 Although information sharing is an important enabler for CDM, the sharing of information is not sufficient to realize CDM and the objectives of CDM.

2.1.4 CDM also requires there to be pre-defined and agreed procedures and rules to ensure that collaborative decisions will be made expeditiously and equitably.

2.1.5 CDM ensures decisions are taken transparently based on the best information available as provided by the participants in a timely and accurate manner.

2.1.6 The development and operation of a CDM process follows the following typical phases:

1. CDM need identification;
2. CDM analysis;
3. CDM specification and verification;
4. CDM performance case;
5. CDM implementation and validation; and
6. CDM operation, maintenance and improvement (continuous).

It is important that the results of all these phases are shared between the involved community members.

2.1.7 The first phase is the identification of the need to apply CDM to realize a performance improvement. This can relate to current processes/operations or to future processes. A need statement should refer to the process(es) to which CDM should be applied and need to specify the current situation, involved community members and current (or projected) performance shortfall(s). It should include a first assessment (often based on expert judgment) how and through which means, CDM can mitigate the shortfall. Shortfalls should be identified in areas related to all 11 key performance areas (KPA) identified in Doc 9854. While CDM has the ability to influence performance in all 11 KPA, CDM provides a mechanism specifically well-suited to addressing the following performance areas, frequently difficult to quantify:

1. ***Access and Equity*** *- A global ATM system should provide an operating environment that ensures that all airspace users have right of access to the ATM resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely. The global ATM system should ensure equity for all users that have access to a given airspace or service. Generally, the first aircraft ready to use the ATM resources will receive priority, except where significant overall safety or system operational efficiency would accrue or national defense considerations or interests dictate that priority be determined on a different basis.*
2. ***Participation by the ATM Community*** *- The ATM community should have a continuous involvement in the planning, implementation and operation of the system to ensure that the evolution of the global ATM system meets the expectations of the community.*

2.1.8 In the second phase, the CDM analysis, the target process is further analyzed from a decision making perspective. The analysis should make clear what the decisions to be made are, which community members are involved (or affected), which information is used in support of taking the decision(s), which process(es) are followed, how and through which means the decision-making process can be improved and how such an improvement could contribute to a better performance.

2.1.9 The third phase, which builds on the CDM analysis, results in a shared and verified specification of the CDM process. It will address among others:

1. the decisions to be taken, how they are reached and finalized;
2. the community members involved and their roles/responsibilities in the decision(s);
3. agreement on objectives; there may be a shared objective with individual sub-objectives (e.g., resolve congestion while minimizing impact to my operation);
4. decision-making rules, processes and principles including specification of timeline/milestones, interactions, roles and responsibilities;
5. information requirements including data standards, quality, frequency and deadlines; and
6. CDM maintenance process: review, monitoring/verification etc.

The above is further detailed in these guidelines and illustrated through examples given.

2.1.10 The objective of the performance case, developed through the fourth phase, is to justify the decision to implement the CDM process and to make the necessary investments. It should clearly specify what the costs are and the benefits (in the relevant KPA’s) that will result from the operation of CDM. It is important that the results of the performance case are shared between all relevant community members. In case the CDM process is an integral part of a new process, it should be integrated in the performance case for that process.

2.1.11 The CDM validations and implementation phase includes all steps to bring CDM into operation. It includes training and informing staff, implementation/adaptation of systems and information networks etc.

2.1.12 Once the CDM process is operational it should be subject of a continuous and shared review, maintenance and improvement process. In this way performance can be continually improved.

2.2    Governance

2.2.1 Much of the specification of the approach described in the prior Section falls under a broader classification of “governance”. It is essential that a CDM process have well-articulated governance.

2.2.2 Governance is described in the 1994 World Bank report, *Governance: The World Bank’s experience*, as follows:

“Good governance is epitomized by predictable, open and enlightened policy making; a bureaucracy imbued with a professional ethos; an executive arm of government accountable for its actions; and a strong civil society participating in public affairs; and all behaving under the rule of law.”

2.2.3 While the above document clearly is aimed at governance of a different scope, the characteristics of good governance are applicable to the governance of any CDM process.

2.3    Areas of Application

2.3.1 Doc 9965 provides a concept for flight information sharing of relevance to collaborative decision-making. From this document, Figure 2-1 below defines a timeline for information provision that can be used to describe areas to which these CDM guidelines may be applied. Together with the timeline, there are other ways in which areas of application may be described as identified below:

1. position in timeline;
2. ATM process/concept component reference; and
3. CDM objective and type of decisions it supports.

2.3.2 As already defined in the scope statement, this document does not address CDM in the context of performance-based strategic planning. More guidance on this can be found in Doc 9883. Examples of areas of collaboration not addressed by this document, but addressed through the performance based approach include:

1. collaboration on long-term performance outcomes and targets;
2. collaboration on implementation of operational improvements including changes to procedures, airspace organization, and infrastructure; and
3. collaboration on forecasts and post-event analysis used for long-term strategic planning.

2.3.3 Collaboration while applying the performance based approach applies to longer time horizon activities. Given these long lead times; collaboration can be individually tailored to the circumstances.

**Off-block**

**Taxi out**

**Takeoff**

**Taxi in**

**Landing**

**Arrival**

**1 year**

**months**

**1 day**

**hours**

**Scheduling & Strategic Activities**

**Nominal Operational Planning**

**Tactical Operational Planning**

**Flight Operations**

**Schedule**

**Weather,**

**Winds, SUA, Airframes known**

**Post-Operational**

**Review**

**Figure 2-1.    Timeline of information provision (extracted from FF-ICE concept)**

2.3.4 At the other end of the timeline, tactical decision-making during flight operations or just before departure may not provide sufficient time for collaboration to be accomplished effectively. This can come in two flavors:

1. decisions responding to events or new information that provide insufficient time for collaboration between the time of the event and the deadline for a decision; and
2. decisions for which collaboration has occurred at an earlier point in the timeline and as time marched forward, there is insufficient time remaining to continue collaborating.

2.3.5 In both of the above cases, collaboration is applied to agree upon the processes and rules by which these time-critical decisions are made. As a result of these agreements, combined with a future anticipated information-rich environment, the second of the above cases is expected to evolve into CDM.

2.3.6 CDM may also be applied to various concept components as they are executed across the timeline. Doc 9882 identifies requirements for collaboration and collaborative decision-making across multiple concept components including:

1. airspace organization and management;
2. aerodrome operations;
3. demand and capacity balancing;
4. traffic synchronization; and
5. ATM service delivery management

2.3.7 Looking at the requirements for the components across the timeline, some collaboration requirements fall under the purview of the performance-based approach (e.g. definition of airspace structures and procedures under AOM – R04). Other requirements indicate the need to apply CDM to establish rules or procedures.

2.3.8 Beyond the requirements for collaboration, it is clear that decisions on strategic conflict management may also benefit from collaborative decision-making. However, as it is achieved through other concept component (see below, from Doc 9854), CDM as it applies to conflict management is covered through other components.

*Strategic conflict management is the first layer of conflict management and is achieved through the airspace organization and management, demand and capacity balancing and traffic synchronization components.*

2.3.9 Good practices indicate that any decision in ATM is based on the best available information and according to predefined, transparent and agreed criteria and processes. Collaborative decision-making becomes especially relevant when:

1. one or more decisions are required;
2. more than one stakeholder is impacted by the outcome of the decision(s);
3. one or more stakeholders are best suited to evaluating the impact of the decision(s) on their own interests; and
4. time is available prior to the decision(s) deadline to accommodate collaboration.

2.3.10 Decisions may be competitive between stakeholders (e.g. allocation of resources) or may benefit multiple stakeholders (e.g. relaxation of restrictions in airspace redesign).

2.3.11 The above criteria are all applicable to the areas of collaboration specifically identified in the Doc 9882. For example, these lead to:

1. collaboration pre-departure to manage the turn-around process and departure queue;
2. collaboration to manage flows through the control and synchronization of individual flights;
3. collaboration on agreed weather forecasts to implement airspace/airport flow restrictions;
4. collaboration on timing and selection of dynamic airspace configurations;
5. collaboration to determine the relevant performance criteria to be applicable to a given period; and
6. collaboration to determine equitable unilateral responses to event(s) when time does not permit further collaboration in response to the event(s)

2.3.12 Collaboration is an integral part of the ATM system. However, this document provides guidance on a subset of CDM as defined below:

1. CDM applied to any concept component;
2. time is not available to tailor the CDM process for every decision. When time is available to tailor the process to the specific situation, one would expect the performance based approach to provide sufficient guidance.
3. time is available to collaborate before a decision deadline. Collaboration takes time; there must be enough time available to do so; and
4. when time is not available to collaborate on the decision itself, a collaborative process is applied to define the decision-making rules, and to identify the decision-maker that will apply the agreed-upon rules.

2.3.13 Figure 2-2 illustrates the cases when CDM guidance is applicable and the situation that occurs when time is expiring to a decision deadline. Some deadlines may result in a decision having to be made for planning purposes, but still subject to refinement through a collaborative process. It is noted that collaborative decision-making can revert to complementary decision-making when actions at a deadline can be anticipated by all participants because sufficient information is available to determine the outcome of a looming deadline.

2.3.14 It is the dynamic nature of the ATM environment which necessitates decision-making at various time-horizons. This dynamism refers to an environment in which the future is both uncertain and subject to changing objectives and decisions as a consequence. The impact of weather is an example of how uncertainty can require decision-making at several time-horizons. Early decisions (such as planning operations assuming an arrival delay due to forecast snow) can be made taking into consideration the uncertainty and the ability to respond closer to the time of interest. As the situation unfolds and becomes more certain, decisions respond to this more certain information with changing decisions contributing to the dynamism.

*Decision(s)*

*Identified*

*PBA Guidance*

*CDM Guidance*

Time is available to tailor process for decision(s)?

Time is available to collaborate on decision(s)?

*Collaborative Decision-Making*

*Collaboratively-agreed decision-making*

**Y**

**Y**

**N**

**N**

What may begin as CDM will transition as time elapses. In an information-rich environment, this leads to complementary decision making.

Processes agreed-to collaboratively

Processes customized

*Refine*

**Figure 2-2.    Selection of applicable guidance material**

2.4    Types of CDM

2.4.1 Several candidate situations may occur when making decisions affecting a collection of disparate stakeholders. Figure 2-3 illustrates these situations along two principal dimensions:

**Decision-making** – specifies whether decisions are made by one participant (unilateral) or if decisions are made multi-laterally across multiple stakeholders. As applied to ATM, many individual decisions (e.g. across many flights) can be taken to affect an outcome.

**Alignment** – identifies whether the interests of the multiple stakeholders are driven by a single common objective, or whether each stakeholder has individual objectives. In the later case, these can be further decomposed:

**Complementary** – the pursuit of a stakeholder’s individual goals either does not affect or is in alignment with other stakeholders’ goals.

**Adversarial** – the pursuit of a stakeholder’s individual goals is in conflict with another stakeholders’ goal. This is frequently the case when faced with resource contention.

2.4.2 As has already been mentioned in the prior Section, decisions which are multi-lateral at one point may eventually require a unilateral solution as time progresses.



**Figure 2-3.    Classification of types of CDM**

2.4.3 The objective behind this classification is to provide guidance as to some of the important considerations within each type as described below.

**Multi-lateral decision-making with a common goal** – All participants are in agreement on a common, socialized goal driving their decisions (e.g. minimize environmental noise impact given a fixed number of operations). Multi-lateral decision-making can be preferable in this situation when multiple stakeholders hold the best information necessary to make decisions and it may be difficult or undesirable to share the information. In this case, it is necessary to ensure the following:

1. the relationship between the decision and the desired outcome must be known to decision-makers. This can prove difficult when the outcome is the result of many combined decisions, some of which may yet to be announced by other stakeholders;
2. appropriate levels of information sharing must be maintained to ensure that each stakeholder has enough information to make decisions that, combined with other stakeholders’ decisions, achieve the common goal; and
3. since the common goal may be insufficient to close the problem, additional goals including individual goals may be applied to close the problem. If these are adversarial, these need to be considered.

**Unilateral decision-making with a common goal** – As in the case above, all participants are in agreement on a common, socialized goal. In this case, a single decision-maker is provided the authority to make decisions towards this goal. It is necessary to ensure:

1. rules governing the decisions are collaboratively agreed-to prior to engaging in this form of decision-making. These rules must be known to all participants;
2. adequate information must be provided to the decision-maker by all participants to ensure that the common goal can be attained by the decision-maker given the information. Adequate information requires both that the appropriate information items are provided and that the information be of sufficient quality, stability and timeliness to support the required action by the decision-maker;
3. secondary objectives may be addressed through the provision of preferences by other participants to the decision-maker, with rules governing their application; and
4. the relationship between the decision being taken, the goal being pursued and the information supporting the decision must be understood. When this relationship is poorly understood, decision rules will not necessarily be capable of attaining the stipulated goal.

**Multi-lateral decision-making with complementary individual goals** – Similar to the situation with a common goal, all participants take their own decisions towards individual complementary or non-competing goals. Considerations are the same as the common goal case; with the added complexity that it may be difficult to ascertain that goals are in fact complementary. Given that CDM is frequently applied to the allocation of constrained resources this is not likely a common situation between competing participants. However; certain example situations may lead to this case:

1. decisions may have geographically separate impact;
2. as is frequently the case today, different ATM Service Providers (ASP) make decisions affecting flights operating across multiple ASPs. Through the sharing of appropriate information and tailoring of processes to accommodate this information, more globally optimal solutions can be reached, even with different objectives.
3. individual objectives may align with a common goal (e.g. maximize capacity at some location, potentially for differing purposes); and
4. once constrained resources have been allocated to participants, decisions may occur within those constraints (e.g. substitutions) to achieve a secondary objective.

**Multi-lateral decision-making with adversarial individual goals** – The case of multiple participants seeking to make individual decisions with competing objectives is frequent in a capacity-constrained environment. The objective of collaboration is to seek a solution which is considered acceptable (including equitable) to all participants. Several approaches and considerations to this case are:

1. as is the case for collaborative processes described herein, a set of rules governing the process should be agreed-to prior to initiating collaboration;
2. rules should include specified deadlines for decision-making. The consequence of missing the deadline should be known to all participants. One such consequence may be reversion to a single decision-maker acting in accordance with known rules;
3. rules may include a mechanism for constraining the decisions of individual participants. These constraints seek to transform the problem from an adversarial one into a non-competing one. For example, capacity-constrained resources may be allocated to individual participants. Each participant may make decisions within the specified constraints in accordance with individual goals; and
4. with rules implemented through the use of information provided by participants, a verification function may be required to ensure that information is not provided specifically for the purposes of “gaming” the rules.

**Unilateral decision-making with complementary individual goals** – Pre-collaboration is applied to identify the decision-maker and the rules by which decisions are made. Considerations for unilateral decision-making under common goals all apply. Rules may consider the differences in goals between participants through information (e.g., preferences) provided by participants.

**Unilateral decision-making with adversarial individual goals –** As for the case with complementary individual goals, pre-collaboration is applied. In this case, the pre-collaboration must clearly establish rules of behavior and information provision on the part of participants to ensure that rules are not being “gamed” through the provision of false information or through otherwise undesirable actions seeking to trigger an outcome.

2.5    Harmonizing CDM processes

2.5.1 The prior Section described different types of decision-making circumstances and considerations for collaborating under the types of decision-making. In order to collaborate successfully, each type of decision-making requires a process for collaborating; that is, a CDM process. The description of a CDM process requires specification of interactions to a sufficient level of detail to ensure:

1. the process will allow decisions to be reached; and
2. compatibility exists when multiple decision-makers (across the ATM community) are acting and potentially applying different internal processes.

2.5.2 The phased approach described in Section 2.1 results in the definition of a CDM process. The analysis phase of this approach must ensure that compatibility exists when differing internal processes may be interacting. For example, it is not expected that CDM processes will be defined in a manner that are identical across all regions of the globe or across all borders. While CDM processes may not be globally identical, with airspace users operating globally, investments in automation supporting CDM would suggest that a counter-balancing performance benefit should exist to continue to justify these disparities. For tactical decision-making, some harmonization is required to ensure that processes enhance rather than degrade system performance and that the exchange of information in support of CDM can be accomplished with adequate data standards. Below are some examples of the consequences of not harmonizing CDM processes including a lack of cross-border CDM:

1. As part of airspace organization and management, constraints may be provided to a flight across multiple ASPs. Multiple CDM processes may even define these in each locality. Lack of harmonization and collaboration across these multiple ASPs and other participating ATM community members of these constraints may lead to inefficient flight profiles (and potentially infeasible profiles in an extreme case);
2. having different objectives across locations applying CDM processes may lead to neither objective being met. For example, a focus on environment versus airspace user economic performance would not be aligned when time is the driver of economic performance. Collaboration could enable an end-to-end solution to be met that is more acceptable to both than a piecewise solution; and
3. rationing of capacity constrained resources may be accomplished through different means in different locations. Examples include first-come-first-served, ration-by-schedule, or market-based approaches. Priorities may change for flights as they enter into different airspace regions potentially resulting in a “hurry-up-and-wait” situation.

2.5.3 Dealing with the above examples requires that CDM processes essentially “make sense” across boundaries. This necessitates both: a) the definition of a CDM process in each location; and b) the harmonization of those processes across locations so they are not working at odds.

2.5.4 Specific areas for which CDM processes should be standardized include:

1. agreement on process or interacting processes;
2. data/information standards; and
3. rules and compliance monitoring

2.6    CDM Process Details

2.6.1 Whether one is considering the application of CDM within a single location, or one is considering the harmonization of CDM processes across multiple locations (i.e. cross-border CDM), there are some detail-oriented considerations that must be taken into account. This section highlights some of these considerations without providing a recipe for doing so as CDM is expected to be flexible in its implementation.

2.6.2 As one develops a CDM process or attempts to harmonize potentially disparate processes, a detailed end-to-end analysis of the process and interactions will likely be required. This is described in Section 2.1 as the second phase. At a minimum, these analyses will entail the following:

***Understand objectives (shared and individual) –*** identify the overall shared objective(s) of collaboration. Individual objectives may be at odds and may be difficult to establish, but these will affect behavior. Understanding objectives is critical to developing likely interactions so that the proper information exchange and control mechanism can be put in place. Together, these seek to achieve shared objectives, and mitigate potentially adverse behavior. For example, control mechanisms may need to be in place to allow the overall objective to be achieved (for example, constrain flight changes to ensure an equitable process). These control mechanisms are described here as rules governing a CDM process in Section 2.8.

***Understand decisions being made by various participants* –** Once objectives are understood, the next step is to understand the decision(s) that can be made by whom to reach that objective. As one investigates these decisions, the following questions should be considered:

*What are the decisions to be made?* Whatever CDM process is being investigated, there is a set of decision variables that can be affected by certain CDM participants. For example: a decision can be to impose a constraint on a flight or a defined group of flights (e.g., a participant may be allowed to have two flights use a resource within a time window), or a flight itself can be changed (e.g., re-route, departure time, altitude constraint).

*Who makes the decision?* The allocation of responsibilities for decision-making is central to defining a CDM process. In the examples provided previously, an ASP might alter the flight in accordance with CDM rules and provided information, or might allocate resources to a participant that then alters flights to meet the resource allocation. The resulting performance may be very different depending on who has access to what information. Who decides is critical to understanding the outcome since the decider will seek to meet their individual objectives within required constraints. If system performance improvement (across all KPAs including access and equity) is the overall goal, then the process may have to define constraints on select groups of participants to ensure that the pursuit of individual objectives leads to system performance improvements.

*What does the decision affect?* The relationship between the decisions being made, the goals of the participant making the decision (subject to constraints) and the performance outcome of those decisions should be understood. These enable an analysis of candidate processes to define a CDM process that will be feasible and best meet performance objectives.

*How does one achieve convergence?* When a CDM process is defined to make decisions across multiple participants, decisions may need to be collaboratively reconciled. It is important to define a process that enables this reconciliation to occur in a manner that does not lead to stalemates. One approach is to pre-collaborate to define a process to be applied when a deadlock has been reached (e.g., an algorithmic approach, or guidelines for a single unilateral decider to break any deadlock).

***Determine the compatibility of interacting processes of various types –*** When multiple CDM processes interact, or when the time evolution of the decision process requires an evolving process, it is necessary to ensure that these processes are compatible. Section 2.4 described various types of CDM processes with considerations for each individual type.

*Time Evolution* – When the process changes type across the decision-time horizon, decisions made at an earlier point in time may conflict with later decisions if the processes are incompatible. For example evolution from multi-lateral to unilateral decision-making should ensure that decisions do not get reversed by the unilateral decision-making with associated deleterious performance effects.

*Differences across ASPs* – A single flight or flow may operate through multiple (areas of) jurisdiction each with CDM processes of different types. It is important to ensure that the overall end-to-end solution can be achieved at acceptable levels of performance. For example, when multiple ASPs encounter capacity constraints affecting a shared flow, the modification of trajectories to deal with each constraint independently is not a desirable situation. It is preferable that an end-to-end solution be developed for each flight, yet this is difficult to accomplish unless the processes have methods to prioritize constraints, to allow trading between flights, or are flexible in the timing of constraints.

***Ensure compatibility of interaction between various participants –*** CDM occurs through a continuous process of information provision and individual decision-making by various interacting participants. The process must be analyzed to ensure compatibility of these interactions across boundaries. This includes:

*Timing of events –* Decisions made by various participants may have to be synchronized, as may the sharing of information. For example, all constraint information would ideally be provided prior to decision altering a trajectory to meet constraints one at a time. Poor timing of decisions in one area affecting the decision in another area would lead to sub-optimal trajectory choices.

*Information exchange* – Information that is exchanged should be subject to standards to ensure interoperability and to minimize required data translation. The link between local airport processes and broader ATM network processes is ensured through execution of the CDM phases described in Section 2.1. This is especially true as described in the second phase as analysis of which ATM Community members are affected by the outcome of decisions and the need for supporting information made available through defined exchanges.

*Consistency of rules* – CDM processes may allow individual participants to make individualized decisions within the confines of rules (e.g. substitutions within a resource allocation). These rules are frequently defined to ensure that system performance is not adversely affected by individual participant optimizing their own performance. When multiple CDM processes interact, the rules must be investigated to ensure that the overall system performance is still not adversely impacted.

2.7    Harmonizing Data

2.7.1 Data exchange is critical to CDM by allowing participants in the decision-making process to have the information necessary to make decisions consistent with sought objectives. However, in order for information exchange to be effective information standards must be defined to ensure compatibility and common understanding across participants and decision-makers. These standards should address the following:

1. Syntactic interoperability – Data formats, communications protocols and so on must be defined to ensure the successful exchange of data between systems. Units must be considered. Formats should not be at the simplest data item but may also apply to complex data structures;
2. Data definition – Data items should be defined in a consistent manner across CDM processes that use the data. Ambiguous or duplicative data elements should be avoided;
3. Update requirements – Requirements on frequency of cyclical information updates, and definition of events triggering information updates should be established. This includes requirements on the update of data whose content is derived from other updated data elements; and
4. Information quality – There are many dimensions to information quality, these include: accuracy of provided data, precision with which it is provided, stability of the data in a changing environment, and latency of information provision.

2.7.2 The application of data standards not only helps to reduce incompatibilities in decisions due to conflicting interpretation of information, but reduces development costs for automation systems interacting across disparate locations (i.e. cross-border CDM). An analysis of CDM processes to ensure that data update requirements are sufficient for successful decision-making may also be required when interacting CDM processes have disparate information and timing requirements.

2.8    Harmonization of Rules and

Compliance Monitoring

2.8.1 As the time horizon for decision-making shortens into the more tactical decision-making, there is less time available for negotiation, and collaboration is expected to be more structured. This structure consists of rules of behavior during collaboration including:

1. description of information to be provided by which participants;
2. indication of deadlines for provision of information;
3. identification of quality of information to be provided including accuracy;
4. allowable use of provided information and requirements on protection of provided information; and
5. identification of decision-makers and constraints on decisions, these constraints can include:
6. parameters for user-responses to resource allocation (e.g. bounds on departure times, treatment of substitutions);
7. algorithms or rules for unilateral decision-making (e.g. use of information for prioritization of resource use); and
8. deadlines for decision-making and potentially switching between types of decisions (e.g. from multi-lateral to unilateral decision-making).

2.8.2 This structure including rules is expected to be defined through pre-collaboration between the expected participants of the CDM process. With a structure comes the expectation that participants will abide by it; however, it may not always be in their interest to do so. As a result, a compliance monitoring function may be required to ensure that rules are followed. For example, this can include the verification of the accuracy of information when that information is used for allocation of constrained resources.

2.8.3 The rules that are agreed to for a CDM Process will likely have a strong effect on the behavior of the participants in response. In particular, the process for prioritization can be based upon:

1. observation of actual behavior such as a first-come-first-served approach;
2. information provided reflecting intent such as a ration-by-schedule. Observations must be consistent with the intent; and
3. global performance considerations, such as a best-equipped-best-served approach when equipage is deemed to provide system-level performance gains.

2.8.4 In each of the above, individual stakeholder performance will be affected by their behavior in response to the prioritization approach. For example, scheduling decisions will reflect a desire to be prioritized highly. First-come-first-served will suggest that a “hurry-up and wait” strategy will be preferable. This indicates the need to ensure that participants in the definition of the CDM process consider the impact on individual behaviors when developing the process.

2.8.5 When dealing with the interaction between different locations, potentially with differing CDM processes an overall “meta” CDM process should be considered by the union of participants in each individual CDM process. The interaction of different constraints and rules may adversely impact the performance of the overall ATM system. As a specific example, the allocation of priorities (for assignment of access to capacity-controlled resources) across different ASPs may lead to airborne delays if a flight is considered high-priority in one constrained airspace only to fly into airspace where it is considered low-priority.

2.9    Complementary Decision-Making

2.9.1 With time elapsing, a multi-lateral decision-making approach may not be reaching a solution that solves known capacity imbalances because individual participants seek their individual objectives in lieu of a collective one. An example includes decisions on routes required to deal with airspace congestion prior to a deadline such as a flight’s planned departure time. Airspace users may be unwilling to re-route their own flights if other users may do so.

2.9.2 Prior Sections have discussed the evolution of decision-making from multi-lateral to unilateral as time elapses to a decision point. In the prior example, at some point a unilateral decision might be reached by the ASP assigning re-routes to the various impacted flights. This can be accomplished in an equitable manner by pre-collaborating on the precise method by which flights will be re-routed in such a situation, or by specifying an allocation of flights to each participant to be re-routed.

2.9.3 Complementary decision-making occurs when the outcome of the unilateral decision-making is known to all participants because the information and methods for deciding are also known to all participants. Another approach may be for the unilateral decision-maker to preemptively broadcast the action before it is taken. The consequence of such a situation is that decisions made multi-laterally will only be taken if they provide an improvement over the expected unilateral outcome. As a result the performance to each individual is improved over the unilateral situation. However, it is important that the CDM process be defined in such a manner that all such decisions taken by an individual participant are Pareto optimal; that is, they cannot harm the performance of other participants.

**CHAPTER 3**

**ROLE OF INFORMATION EXCHANGE**

Without information exchange, it is difficult to imagine collaboration. This exchange can occur with various degrees of structure. At one end, an unstructured approach to information exchange might involve teleconferences between collaborating parties affording an opportunity to ask for clarification. As more structure is incorporated, information exchange could be at a system-to-system level with algorithms on both ends exchanging information to reach individual decisions. When time is at a premium, many parties are involved, or automation requires data, more structure is required for information exchange. This chapter focuses on the information exchange in this more structured environment.

This chapter discusses:

1. a future collaborative environment envisaged to support the Global ATM Operational Concept,
2. what is meant by data standardization in such an environment; and
3. defining quality of information.

3.1   The Collaborative Environment

3.1.1 Doc 9965 describes the flight and flow – information for a collaborative environment concept. The future vision of this collaborative environment follows from the vision provided through Doc 9854, which states:

Information management will assemble the best possible integrated picture of the historical, real-time and planned or foreseen future state of the ATM situation. Information management will provide the basis for improved decision-making by all ATM community members. Key to the concept will be the management of an information-rich environment.

3.1.2 Figure 3-1, extracted from the Doc 9965, describes at a high level that participants would collaborate by providing and consuming information across various information domains. The high-level categories of participants that may be included in collaboration are:

1. ATM service provider (ASP);
2. airport operator (AOP);
3. airspace user (AU);
4. airspace provider (AP); and
5. emergency service provider (ESP)



**Figure 3-1.    Example Information in a collaborative environment**

3.1.3 One purpose of the collaboration is to enable the concept component functionality to be delivered. Each information domain would be subject to specific information requirements at a global level and potentially at a regional level as well. These requirements on information are expected to consist of:

*Data Specification* – Successful data exchange requires specific standards for data items including the definition and the structure with which they will be exchanged. In a performance-based environment, data is also subject to requirements on quality enabling it to be applied to deliver Doc 9854 components within a target level of performance. These two aspects: data standards and information quality are discussed in more detail in subsequent subsections.

*Authorization Requirements –* The provision and consumption of information will be subject to context-sensitive authorization requirements. Participants will be able to provide, modify and obtain data only when certain conditions are met. These conditions will depend on the circumstance and the participant requesting authorization. For example one airspace user will not be capable of modifying information on other airspace users’ flights. As a flight transitions through multiple ASPs, authorization requirements will change.

*Operational Requirements –* In addition to requirements on the data and the access to the data, there may be operational requirements. An example would be the requirement to provide data in order to qualify for a procedure or access to some constrained resource (e.g. level of RNP to access airspace with criteria, permissions information for access to certain airspace, equipage and crew qualifications for advanced procedures, etc.). Another example involves the need for information to comply with specified constraints (e.g. trajectory complies with airspace constraints). These requirements are not expected to be static (temporally or geographically) as service delivery management will modify these as necessary to achieve performance levels in accordance with anticipated demand.

3.1.4 Given the collection of requirements that information exchange in this collaborative environment is expected to comply with, a system of checks should be in place to ensure compliance. Some checks, such as whether the document is valid and well-formed (in XML parlance), can be accomplished through the availability of appropriate standards document (e.g. schemas). Other forms of compliance verification will require definition during establishment of the requirements.

3.1.5 With appropriate information management, a collaborative decision-making environment is created through the following:

1. the information infrastructure supports the sharing of information across a wider, extensible set of participants, thereby allowing greater participation by the ATM community and reaching shared situational awareness. Decisions can be made in a more collaborative manner with greater knowledge to determine their consequences;
2. an extensible information infrastructure supports the addition of new information items such as preferences to enable all participants to extend their information needs as decision-making processes evolve; and
3. international data standards and information requirements enable decision automation to be developed once without customization across multiple regions. Through lower participation costs, collaboration is increased.

3.2    Data Standardization

3.2.1 Section 2.7 indicates the need for data harmonization. Further, the operational concept document indicates that “information management will use globally harmonized information attributes”. One stage of data harmonization is the development of globally applicable data standards.

3.2.2 As it pertains to collaborative decision-making, data standardization is pertinent to several areas within which we would expect decisions to be made through collaboration:

1. those areas (e.g. agreement on performance outcomes, operational improvement deployment, airspace redesign, projections and post-operational analysis) falling under the purview of the performance-based approach. For these areas, decisions are expected to be supported with data with standardization necessary to enable performance evaluation. These considerations are described in Doc 9883*,* Appendix D, First Edition, 2008; and
2. areas involving more tactical CDM for which information is expected, in many regions, to be exchanged system-to-system. These areas include:
3. tactical airspace organization (e.g. collaborating on defining airspace configurations for capacity);
4. tactical capacity management (e.g., collaborating on airport/airspace configurations potentially trading capacity for efficiency); and
5. trajectory management (including management of priority, sequences, access);
6. these areas are expected to require information as illustrated by the five information domains as shown in Figure 3-1. These domains are:
7. aeronautical information – standards for aeronautical information would be described through the aeronautical information exchange model (AIXM);
8. flight and flow information – the evolution of Doc 9965 would provide initial material to define standards for the flight information exchange model (FIXM);
9. surveillance information – standards for the ground-to-ground exchange of surveillance information exist today;
10. meteorological information – standards exist for the global dissemination of weather products. Further standards development work may be required for new aviation weather products and to make these applicable to aviation CDM (e.g., see WXXM); and
11. infrastructure status – standards for infrastructure status could largely be expressed using modified AIXM standards.

3.2.3 Data standardization in each of the above domains seeks to address the following, among other things:

1. data item identification – defines the universal name for the data item;
2. definition – an unambiguous definition of the data item is required. This refers to a plain language definition of the data item;
3. syntax – this describes how the data is expressed. Descriptions of syntax should, to the extent possible, apply repeatable data types (e.g. integer, decimal, string, data, etc.) as defined in existing standards (e.g. FML per ISO 19136 for standards defined in XML):
4. the syntax of one data element may be defined as a collection of nested data elements. For example, a data element may be a list comprised of multiple data elements each with their own definitions and syntax. A trajectory would likely be composed of many other nested data elements; and
5. valid lexical representations of the data should be identified (e.g. 10e3 and 1000 represent the same numbers);
6. constraints on syntax – these bound the set of possible data elements that can be defined within the given syntax:
7. default values for the data type, if applicable;
8. range and domain of the data item. This may include an enumeration of valid categorical data such as wake categories or aircraft types;
9. maximum and minimum level of precision of the data (e.g. decimal places);
10. restrictions on the order of appearance of data; and
11. repeatability – how many of this data element are allowed (e.g. multiple equipment codes, but only one aircraft type); and
12. additional information about data items:
13. approved units – what are valid units and how they will be expressed. Constraints on syntax will vary depending on the selected unit; and
14. accuracy and information quality – if information quality is required, how is this expressed.

3.3    Quality of Information

3.3.1 Decision-making is improved with accurate information; where such data is not available, good decision-making makes use of knowledge of uncertainty to condition decisions based upon expected outcomes. There are many reasons why information may be of lower quality. The reasons for this determine the manner in which the information is treated. Examples include:

1. accuracy of forecast or predicted information is affected by the look-ahead horizon. It is useful to have metrics indicating the prediction accuracy together with the information. The most basic approach to dealing with such inaccuracies is to seek improvements in forecast ability, but this may be prohibitive or infeasible. Alternatively, decision-making may consider the expectation of error in a variety of manners:
2. expectation-based decision-making;
3. allocation of decisions between strategic and tactical based upon uncertainty; and
4. exemption from decision-making;
5. information quality is expected to vary as a function of location in part due to differences in available infrastructure. Any CDM process spanning localities with disparities in information quality must be able to accommodate these. It is expected that a performance-based approach would be applied to ameliorating the infrastructure where necessary;
6. when information is provided by participants for the purpose of informing decisions pertaining to the information providers, and where interests are competitive, the possibility exists that misleading information will be provided, essential information will be omitted, or information may not be provided in the timeliest manner. These would be guided by the desire of a participant to obtain a beneficial outcome. In particular, the provision of intent information could be subject to interpretation. Section 2.8 has discussed the need for rules in this area;
7. ATM deals in a dynamic environment. As a result, information may change frequently and significantly. Knowledge of the stability of information is important when making decisions based upon this information. For example, knowing that a user may significantly change their desired trajectory provides information to be used in determining demand/capacity imbalance likelihoods. In the limit of highly unstable information, the information may prove of little utility. The stability of information can be managed through: a) providing indications of stability with information; and/or b) requiring that decisions be stabilized by certain deadlines. These would be defined collaboratively when identifying the CDM processes; and
8. additional technical quality details. These include the accuracy of measured data, the fidelity or resolution of reported data, the frequency or events leading to updates, and the basis for reporting the data (such as a specific grid). For these, one would expect requirements to be in place to define the level of quality required from information providers.

3.3.2 As part of the definition of CDM processes, one would expect the specification of data sharing agreements between collaborating participants to be documented through memoranda of understanding, data specifications, and data quality documents. Reporting measures on data quality may also be explicitly articulated and reported on a regular basis.

**CHAPTER 4**

**ARTICULATING A CDM PROCESS**

In a collaborative process, the goal is not only to achieve a desired outcome, but to achieve that desired outcome in the most efficient and effective way possible for the organization(s) and for all collaborating parties involved. This can only be achieved if the collaborating parties give as much attention to how they work together throughout the process as they do to the process itself. Without one or the other, true cooperation, synergy and teamwork cannot occur.

The description of a CDM process requires the identification of:

1. what is the objective of the collaboration? This includes identifying the end product of the collaboration. CDM leads to decisions, including agreements;
2. who are the collaborating participants?
3. how are they collaborating? This includes addressing:
4. what are the roles and responsibilities of the individual participants towards reaching the objective?
5. What is the exchange of information required? This includes addressing how the CDM process interacts with the overall collaborative environment.
6. What are the rules? How are they enforced?
7. How is a decision reached/finalized?
8. Disagreements
9. What process is used to handle disagreements within the group?
10. How will disagreements that seem irresolvable be handled?
11. If a decision has a deadline, how are deadlocks arbitrated?

It is important that the CDM process be defined considering the aspects described herein, but also be detailed in unambiguous governing documents that are agreed-to by all participants.

4.1    Collaborating Participants and Objective Setting

4.1.1 One of the first steps in articulating a CDM process is to first understand what the objective is of the collaboration. An initial objective can be high-level, such as improving the allocation of delays when resource constraints require delays. With an initial objective identified, a set of participants can be defined. Participants may include both human and automation systems.

Objective

Participants

*Refine*

*Define*

**Figure 4-1.    Iterative process identifying participants and objective(s)**

4.1.2 The phases described in Section 2.1 can be classified into two stages of collaboration: 1) the setting up of the CDM process (phases 1-5); and 2) the execution of the agreed upon CDM process (phase 6). During the initial stage, identified participants collaborate on refining the objective of collaboration as illustrated in Figure 4-1. This may lead to changes in the required participants as well. Examples of objectives include:

1. agreement on flight-specific trajectory information (e.g., pushback times, departure times, routing) in order to mitigate demand/capacity imbalances;
2. agreement on collaborated forecast products as input to capacity estimates; or
3. agreement on airspace configuration changes including timing.

4.1.3 As previously described in Section 3.1, Figure 4-1 illustrates the high-level categories of participants that may be included in collaboration, these are:

1. ASP;
2. AOP;
3. AU;
4. AP; and
5. ESP.

4.1.4 In addition to the collaborating participants listed above, depending on the specifics of a collaborative process, additional participants may include:

1. information provider – for example a weather provider may be included for decisions impacted by weather forecasts;
2. flying public – information may be provided to the flying public to enable improved decision-making on their part; and
3. regulators – particularly during the definition of the CDM process, regulators in all areas including economic, environment, and safety may need to be involved.

4.1.5 The identification of collaborating participants will require some iteration as well. With the purpose for the collaboration defined, the impact of the types of decisions that are anticipated should be understood. An initial list of collaborating participants would be those participants that are expected to be impacted by the decisions, and those that are required to provide information or make related decisions. In this manner, one can feel confident that the right people are part of the process.

4.1.6 With participants and objectives established, roles and responsibilities for each stakeholder may be identified as per Section 4.2. These will establish the manner in which the CDM process will be executed during the second stage of collaboration.

4.2    Roles and Responsibilities

4.2.1 In a collaborative decision-making process, participants typically have the following overall types of roles and responsibilities:

1. consume and interpret information;
2. provide information, including the updating and sharing of data due to processing triggered by received information;
3. making a decision and sharing the result of that decision;
4. executing on a decision that has been made. The executing participant may or may not be the participant that made the decision; and
5. providing a service consistent with decisions that have been made.

4.2.2 Prior to describing a collaborative process, the set of specific circumstances under which the described situation may occur should be defined. There may be several sets of circumstances with different roles and responsibilities (e.g. with short time-to-go, decision-making may be more unilateral). This effectively defines how and when collaboration is expected to begin. This may involve the specification of a participant that has the authority to determine, through a set of established rules or guidelines, when collaboration is initiated for a specific objective.

4.2.3 In an effort to better understand the collaborative process roles and responsibilities, it is frequently useful to express the process through interaction diagrams (e.g. sequence diagrams, activity diagrams) that allow an unambiguous representation of the interactions between participants. These can be used to describe:

1. which participants are providing and receiving what information and when. Information may be provided based upon identified events, an update cycle or at the discretion of the provider. It is useful to identify compulsory versus optional interactions. Deadlines on the provision of information should be specified. Standards for quality of information provision and requirements on information are expected to be in place in accordance with Chapter 3.
2. participants expecting to react to provided information should be identified, together with what the information is used for (e.g., recompute flight-specific pushback times, determine flights impacted by congestion). This may lead to the provision of additional information to be used by other participants, or may lead to a decision to act; and
3. in some cases, the use of information may be constrained by a set of rules governing the application of the information. For example, operators may be constrained to modify flight times such that only a certain number of flights use a resource. Unilateral decision-makers may be constrained to assign resources or modify departure times subject to precise algorithms based on provided information; and
4. different participants may be assigned the responsibility to decide on different portions of the problem space (e.g. airspace users may decide on individual flights and ASP on the allocation of capacity to airspace users);
5. once decisions have been taken, it is expected that execution of those decisions will follow by the responsible parties.

4.2.4 The above applies to a more structured collaborative process with emphasis on information exchange. Some less-structured collaborative processes may involve participants in a teleconference discussing information. Still, the roles and responsibilities would be defined in a similar manner as described above.

4.3    Information Requirements

4.3.1 Requirements for information, as detailed in Chapter 3, must be defined in detail (for example, through interface requirements where automation may be involved) when describing a CDM process.

4.4    Making Decisions

4.4.1 The collaborative process must indicate which participants are responsible for making which decisions as part of the definition of roles and responsibilities (see Section 2.4). When the CDM process is first defined, the allocation of decisions into sub-problems with the best decision-maker responsible for their own decisions is critical. One example for distributed decision-making is to let a unilateral decision-maker assign a portion of constrained resources to participants, in accordance with pre-collaborated rules ensuring an equitable process. Participants are then able to make decisions within the allocation as suitable for their own operations.

4.4.2 The process for making decisions is not expected to be static in all cases. As a deadline approaches, collaboration may not be quick enough to ensure convergence to a solution. In these cases, pre-collaboration may establish a process for timelier decision-making. This includes identifying a unilateral decision-maker, defining roles and responsibilities in accordance with Section 4.2, and unambiguously specifying a deadline for switching to unilateral decision-making. In the example provided above, a unilateral decision-maker may only get involved at a specified time prior to planned arrival time. Prior to that, other participants may propose their own changes. In an environment with shared situational awareness, complementary decision-making would follow as per Section 2.9.

4.4.3 Once a decision is made, the mechanism for communicating these decisions to participants must be defined. Typically this will be through the provision of some information (e.g. flight pushback time, desired route of flight) subject to information standards as defined in Section 3.

4.5   Rules and Accountability

4.5.1 Rules and the mechanisms for accountability must be described as part of a CDM process. Additional discussion is found in Section 3.

4.5.2 The CDM process is governed by rules defining the participants, provision and consumption of information, quality of that information, expected decisions and times/events for those decisions, requirements as part of the collaborative process (see Section 3.1) and constraints which must be followed for decision-making. These rules and requirements are expected to be set during the CDM process definition stage and may use a collaborative performance-based approach to do so.

4.5.3 In addition to describing the rules, the consequences of not following the rules should be established a priori through the collaborative process. These may include pre-collaborated penalties (e.g. under-allocation of resources in the future) when a participating member is not demonstrating accountability. This may require the need for participants to provide additional information and to have an arbitrator acting as an independent party to enforce the rules. Where possible, real-time monitoring would be preferable, but this may be prohibitive.

**APPENDIX A**

**CDM EXAMPLES**

This Appendix contains a collection of examples of CDM applied across the globe. These examples are taken from present-day operations at the time of authoring this document. It is fully expected that as the global ATM community adopts the global ATM operational concept, these processes would become more inter-operable and harmonized.

1.    Airport and Surface CDM

This Section describes a collection of CDM examples applicable to the airport and airport surface movement.

1.1 **Airport CDM (Europe)**

1.1.1 The specific application of CDM to Airports is known as Airport-CDM (A-CDM). Experience gained with A-CDM in Europe is provided in this example, which is based on conditions defined in the European Community Specification (CS) EN 303212.

1.1.2 A-CDM is about improving the way operational partners at airports and European air traffic flow and capacity management (ATFCM), air traffic control, airlines, ground handling agents/units and airports work together at an operational level. Transparency and predictability are improved leading to better planning and efficient allocation of airport and network resources.

1.2 **A-CDM – concept description**

1.2.1 A-CDM aims to improve the sharing of information between A-CDM partners and to pre-define procedures and rules for collaboration. It is an enabler for ATFCM at airports, reducing delays, improving the predictability of events and optimizing the utilisation of resources. Implementation of A-CDM allows all A-CDM partners to optimize their operations and decisions in collaboration with each other, knowing their preferences, their constraints and the actual and predicted situation. The decision-making by the A-CDM partners is facilitated by the sharing of accurate and timely information and by adapted procedures, mechanisms and tools. An essential feature of all CDM processes, is that there should be pre-defined procedures and rules for collaboration which is agreed between the partners before the start of operations. These procedures and rules describe how the CDM partners will cooperate, and how decisions will be taken in order to assure efficient operations and equity between the interests of the partners.

1.3 **A-CDM elements**

1.3.1 The A-CDM concept includes the following elements:

1. information sharing;
2. milestone approach;
3. variable taxi time calculation;
4. collaborative pre-departure sequencing;
5. CDM in adverse conditions; and
6. collaborative management of flight updates.

1.4 **Information Sharing**

1.4.1 Transparency and information sharing serves as a basis for the A-CDM process. Information sharing is in fact the connecting element that ties the partners together in their aim to efficiently coordinate airport activities, and forms the foundation for other A-CDM concept elements.

1.4.2 A-CDM information sharing supports local decision-making for each of the partners and facilitates implementation of A-CDM elements by connecting A-CDM partners’ data processing systems and providing a single, common set of data describing the status and intentions of a flight, serving as a platform for information sharing between partners.

1.5 **A-CDM – milestone approach**

1.5.1 The Milestone Approach Element describes the progress of a flight from the initial planning to the take off by defining milestones to enable close monitoring of significant events. The A-CDM procedure fits all milestones together and is the basis for the description of alerts, publication and necessary IT-system adaptations. The Milestone Approach combined with the information sharing element is the foundation for all other concept elements.

1.6 **Variable taxi time calculation**

1.5.3 At complex airports the layout of runways and parking stands can result in a large difference in taxi time. Instead of using a standard default value, a calculation of the different permutations based upon historic data, operational experience and/or integrated toll will provide a set of more realistic individual taxi times. The variable taxi time calculation will ensure highly accurate target times for arriving and departing aircraft.

1.7 **Collaborative pre-departure sequencing**

1.7.1 The A-CDM collaborative pre-departure sequence has a favourable effect on start-up and push-back procedures. The basis for pre-departure sequencing calculations are the target times as target off-block time (TOBT) and target start-up approval time (TSAT). TSAT calculation takes into consideration TOBT, calculated take-off time (CTOT), the operational capacity and possible local restrictions. Based on aircraft progress by using the TOBT, as well as the operational traffic situation on the aprons, taxiways and near runways, ATC can provide a TSAT which places each aircraft in an efficient pre-departure sequence from off-block. This results in regulated traffic flows towards the runways more steadily, with less queuing at the runway holding point.

1.8 **CDM in adverse conditions**

1.8.1 Many different events, both planned and unplanned, can disrupt the normal operations of an airport and reduce its capacity to levels substantially below that of normal operations. There are adverse conditions which can be foreseen with more or less accuracy and both their scope and likely effects are predictable. Snowy conditions, industrial action allowing the maintenance of elementary services, etc. would fall in this category. A fire or aircraft incident/accident is more difficult to prepare for in terms of procedures. In fact too detailed, pre-arranged procedures may even be more of a hindrance than a help. The adverse conditions element aims to enable the management of reduced capacity in the most optimal manner possible and to facilitate a swift return to normal capacity once adverse conditions no longer prevail, by using the improved information sharing resulting out of the previous elements. The CDM cell or coordinator who is fully familiar with the A-CDM principles may facilitate operations during adverse conditions.

1.9 **Collaborative management of flight updates**

1.9.1 The coordination between ATFCM and A-CDM during the turn-round process by constant exchange of flight messages is called A-CDM collaborative management of flight updates. The exchange includes flight update messages (FUM) for arriving flights sent by the network to the CDM airport, as well as departure planning information messages (DPI) for departing flights sent from the airport to the network. The slot allocation process is improved, CTOTs match better the target off block times (TOBT), resulting in reduced delays, less wasted slots and better management of network resources.

1.10 **Relevant documents**

1.10.1 The following documents provide additional background on Airport CDM:

1. *European Airport CDM* [*http://www.euro-cdm.org/*](http://www.euro-cdm.org/)
2. *European Community Specification EN303212*

[*http://www.euro-cdm.org/library/a-cdm\_community\_spec\_doc\_etsi.pdf*](http://www.euro-cdm.org/library/a-cdm_community_spec_doc_etsi.pdf)

1. *Airport CDM Implementation “The Manual”*

[*http://www.euro-cdm.org/library/cdm\_implementation\_manual.pdf*](http://www.euro-cdm.org/library/cdm_implementation_manual.pdf)

d) *Example airports* [*http://www.euro-cdm.org/airports\_cdg.php*](http://www.euro-cdm.org/airports_cdg.php)

e) *Flight Crew Briefing and Brief Description Document Frankfurt*

[*http://www.cdm.frankfurt-airport.com*](http://www.cdm.frankfurt-airport.com) *(library)*

1.11 **Gate/spot allocation meeting (Republic of Korea)**

1.11.1 To effectively manage the airport capacity, every airport has its own gate/spot allocation meeting which is hosted by the Airport Corporation and participates airlines, ground handling agencies etc. Before holding the meeting, each airline submits its seasonal schedule which contains aircraft disposition message (ADM) information and Airport Corporation input ADM information to the gate/spot allocation system which is called iFIS. Upon completion of ADM information input, iFIS assigns gates/spots for all flights automatically. Based on this information, the meeting arranges gates/spots and finalizes the gate/spot allocation plan and the plan is used as a basic ramp operation reference during the season.

Ex) Example of ADM Message;

Message) HL7240 1002 1209 1210 1851 1852

Description) HL7240 (Registration Number) will be connected as KAL1002, KAL1209, KAL1210, KAL1851, KAL1852

1.11.2 Once the gate/spot allocation plan was confirmed, each airline establishes its own gate/spot allocation plan and submits it to Airport Corporation by one day before operations. This information goes into the iFIS again to fix the gate/spot for each flight. The finalized gate/spot information is forwarded to air traffic control units and flight information services stations through dedicated flight operation information system (FOIS).

1.11.3 If an abnormal situation causing the change of gate/spot, i.e. cancellation of flight, long delay, diversion etc. happens, each airline informs the situation and its intention of the Airport Corporation using dedicated system or telephone. Upon receiving the information, related parties which are Airport Corporation, airlines, ground handling agencies discuss the re-arrangement of gates/spots and reassign a gate/spot considering situations.

1.12 **Surface collaborative decision-making (S-CDM) operations (USA)**

1.12.1 In today’s complex air traffic system, a holistic approach to the totality of surface operations and not individual phases of flight may provide solutions to synchronizing all surface components to one another. The principal objective of S-CDM is to improve demand predictions, thereby enabling stakeholders to efficiently manage aircraft movement and make optimum use of available airport capacity.

1.12.2 Traditionally, ATC airport surface operations have been modeled on a “first come, first served” basis. Barring some exceptions, today’s surface operations are tactically oriented and reactive in moving aircraft from “pushback to take-off” and from “landing to taxi-in to the gate”. This is further exacerbated by traffic management initiatives (TMI) and weather events, which inevitably create long queues and delays on the airport surface and adversely affect the en-route stream. Furthermore, there is minimal linkage between surface operations and the en route and terminal domains as well as limited situational awareness between ramp operations and the ATC facility. The residual affect is extra fuel consumption, emissions and on board passenger delays.

1.12.3 S-CDM is the sharing of flight movement and related operational information among airport/flight operators, flight plan service providers and stakeholders to improve demand predictions and to maximize the use of available airport and airspace capacity, thus minimizing adverse effects on stakeholders, passengers and the environment. Collaborative S-CDM provides the basis for the safe and efficient management of traffic flows on the surface (movement and non-movement areas) of an airport. It is founded on the premise that access to aircraft surface surveillance data, coupled with the timely sharing of accurate operational data among participants affords the opportunity to better understand and manage “real” demand on the airport surface.

1.12.4 When departure metering procedures are in effect at a specific airport, the focal point for coordination and entry into the movement area for the purposes of this document will be referred to as the “metering point”. Surface operations in the non-movement area continue to remain under the control of the ramp tower or flight operator, as appropriate. The objective is to maintain a sufficient amount of aircraft at the end of the runway to allow the tower controller to efficiently sequence and clear flights for departure. Due to the complex sequencing and spacing constraints that controllers must meet, it is important to provide a reservoir of flights with different characteristics, i.e., departure fix, aircraft type, weight class, engine type, runway requirements, etc. which will allow controller’s to select the best sequence for the given conditions. Departure metering procedures focus on establishing a flexible queue in regard to length and other characteristics as determined by the local S-CDM stakeholders group at the given airport. This ability to adjust the target queue length in real-time in accordance with the preferences of the local S-CDM stakeholders is a high value attribute. In recognition of the variances in surface operations at U.S. airports, S-CDM provides stakeholders with two options; time-based or count-based departure metering procedures.

1.12.5 In the time-based metering model, the procedures involve the assignment of an entry time to each flight operator to the designated metering point on the airport. These assigned entry times are not single points in time, but rather a time window. A specified amount of time before and after the indicated time is within the acceptable range. This provides the operator flexibility and control over the final assignment of flights subject to operational needs and constraints.

1.12.6 In the count-based metering model, in lieu of assigning a specific time to flight operators, they receive an allocated total number of flights that can enter the metering point during a specified time bin. A separate count is provided to each flight operator for each metering time bin. The time bin is expected to be relatively short in duration – approximately 10 minutes. The departure metering time bin must be long enough to allow multiple flights to enter the movement area and also permit the flight operator to exchange flights within this period.

1.12.7 The S-CDM concept is scheduled for integration into U.S. airports with the procedures reflecting the basic tenets of the U.S. National Airspace System. Although tailored to address the regulatory requirements, it is founded on the very same principles as other A-CDM programs, such as the European airport CDM program. While the tactical procedures are likely to vary from one program to another, the goal is to achieve continuity and consistency across programs. The interoperability of airport CDM “programs” are essential to long-term global harmonization of all S-CDM Stakeholders.

2.    Network Operations

2.1 **Network operations plan (Europe)**

2.1.1 Originated on a regional concept approach to oversee European ATM in a network perspective, where it will be fundamental to maintain an overview of the ATM resources availability required to manage the traffic demand, to support the ATM partners on collaborative decision-making. It will provide visibility of the Network demand and capacity situation, the agreements reached, detailed aircraft trajectory information, resource planning information as well as access to simulation tools for scenario modelling, to assist in managing diverse events that may threaten the network in order to restore stability of operations as quickly as possible.

2.1.2 The network operations plan (NOP) is continually accessible to ATM partners and evolves during the planning and execution phases through iterative and collaborative processes enabling the achievement of an agreed network, stable demand and capacity situation.

2.1.3 The NOP is still under evolution and currently works using web media (portal technology) to present ATM information within European area, increasing a mutual knowledge of the air traffic flow situation in the aviation community from the strategic phase to the real-time operations contributing to anticipate or react to any events.

2.1.4 The NOP portal was launched in February 2009 and as it exists today is a recognised major step on simplifying the ATM partners’ access to ATM information. It evolved from a situation where collection of information was disseminated around via multiple web sites and using several applications, towards a fully integrated access, with a single entry point to the European ATM information, contributing for improving decision-making at all levels.

2.1.5 The NOP portal through one application provides one single view for all partners of several relevant ATM information, such as:

1. a map displaying the air traffic flow information, including the status of the congested areas in Europe and a corresponding forecast for the next three hours;
2. scenarios and events enriched with context and cross-reference information;
3. the collaborative process for building the season operations plan is now formalised; and
4. the summary information of the preceding day is now immediately available with access to archive reports.

2.1.6 ATM partners, while waiting for further NOP portal developments are already using it to monitor the ATFM situation, to follow the ATFM situation in unexpected critical circumstances, get online user support, validate flights before filing, to view regulations and airspace restrictions, to evaluate most efficient routes, to accede to pre-tactical forecasts (daily plan, scenarios, etc), plan events, post event analysis, forecast next season, view network forecast and agree adaptations, evaluate performance at network level and for each particular unit, conferencing for collaborative decision-making.

2.2 **CDM conference and provision of ATM operations plan (OP) (Japan)**

2.2.1 Having a clear grasp of the impact that adverse weather has on traffic flow is one of the important factors in traffic flow management (TFM) field. As imbalance between demand and capacity seriously diminish on flight efficiency such as fuel consumption, greenhouse gas emission and punctuality, it is necessary to improve demand prediction and maximum use of available capacity of airspace and airport after due consideration for the impact. As an approach of capacity prediction with high accuracy, weather products dedicated to Japanese ATM operations, for instance, air traffic meteorological category forecast with respect to each airspace or airport provides four colored levels indicator according to the severity of the impact and six hours forecast in tabular and graphic forms, and air traffic meteorological summary contains interactive radar graphic and time-series forecast of wind components for airports with forecaster’s comments, are provided to ATM personnel by weather specialists. Furthermore ATM personnel are working with metrological specialists in the same ATM operation room to obtain an explanation about this information in a face-to-face interaction.

2.2.2 Collaborative web conferences using the internet (CDM conference) are conducted on a regular basis twice a operational day by CDM partners actively involved not only to share the information, which include weather conditions and forecasts, operational conditions of sectors and airports, air traffic situation, traffic demand predictions, plan of TFM and ASM and flight operation plan of airline operators but also to exchange their intents among them, such as runway operation plan, estimation or possibility of flow control and flight priority or cancellation. If necessary, there are opportunities of ad hoc CDM conference occasionally throughout the operational day in case of pronounced or unexpected decrease in ATC capacity affected by significant weather conditions such as severe thunderstorm, gale force winds, typhoon and heavy snow.

2.2.3 ATM operations plan (OP) is distributed to CDM community, which reflects contents of CDM conference containing capacity and constraints of airspace and airport, traffic management initiatives and other adequate information. CDM conference and OP is contributory to facilitate the common situational awareness and to achieve more collaborative ATM operations for the related CDM partners. Furthermore, sharing real-time operational data through the ATM workstation encourage mutual understanding among them. Each CDM partner conducts themselves in a manner fully consistent with OP to keep efficient and effective ATM operations.

2.2.4 Through these processes, our community has tried to minimize an impact on traffic flow, in fact flight efficiency and punctuality by an abrupt change in airspace or airport capacity because of significant weather. These activities are improved continuously within a framework consisting of CDM partners for a post evaluation during periodic intervals.

3.    Coordination and Management of Airspace Use (Japan)

3.1 In order to efficient use of airspace, the JCAB Air Traffic Management Center (ATMC) established a coordination procedure between ATM personnel and the military liaison officers for military training and testing areas. ATM personnel can realize the situation of these areas based on their schedule from military liaison officers and coordinate for available time period and altitude. In consequence of this coordination, civil IFR flights are able to fly through the area under following ATC instructions. Also taking into account requirement which civil IFR flights enter the area for avoiding adverse weather, ATM personnel coordinate with military liaison officers for using military training and testing areas temporarily.

3.2 ATMC also manages the civil training and testing areas which is often established at lower altitude in the vicinity of airports. At these areas ATMC usually keeps VFR flights separate from IFR flights laterally or using time slot. Meanwhile, under adverse weather conditions, IFR flights are enabled to use these areas according to instruction of ATC who recognize activities of VFR training/testing aircraft.

4.    CDM Under Adverse Weather

4.1 **Air Traffic Coordination Committee (Republic of Korea)**

4.1.1 To cope with abnormal air traffic situations and traffic congestions, Incheon ACC established the Air Traffic Coordination Committee in 2006. The Committee comprises of ATC units, Meteorology Agency, airport corporations and airlines. The committee usually uses dedicated teleconference system to discuss the urgent matters such as weather deviation, flow control, airspace restriction, aircraft/ATC contingency etc. to find out the solution. Especially, flow control is in effect from either China or Japan, this information is also disseminated to the committee members through the teleconference system. If the committee cannot reach an agreement to the solution, Incheon ACC decides one solution based on the discussion.

4.1.2 In addition, Incheon ACC exchanges air traffic flow information with China and Japan to maintain efficient and orderly traffic flow. Also, Incheon ACC uses AIDC with Fukuoka ACC to reduce the operational error between ATC units and to expedite the exchange of flight information.

4.1.3 In terms of civil/military cooperation, Incheon ACC has been sending 2 liaison officers to Air Force Master Control Reporting Centre (MCRC) who controls VFR military aircraft and combat training aircraft. At the same time, Incheon ACC assigned one control position to air force that stationed in Incheon ACC to facilitate civil/military coordination. The result of coordination such as the change of airspace condition will be shared with the Committee members through the dedicated system immediately.

4.2 **Collaborative convective weather forecast (USA)**

4.2.1 Since the inception of air travel in the United States, thunderstorm activity (or “convection”) has been the single most disruptive weather factor to air traffic control (ATC) operations. By the 1990s, government, airline industry, and private sector organizations alike employed meteorology departments to produce weather forecast information to support ATC. While these convective forecasts had the potential to aid both tactical and strategic ATC planning, they often described different thunderstorm duration, movement, and intensity expectations for the same geographical areas. The resulting confusion often produced less than desirable results.

4.2.2 As ATFM became more precise and refined, the aviation community realized the numerous forecasting tools available and the importance of having a single source reference which industry could accept as the main forecasting product. The stage was set for a collaborative forecasting product which was developed by subject matter meteorologists for ATFM personnel to utilize in their daily strategic planning.

4.2.3 The purpose of the collaborative convection forecast product (CCFP) is to aid in the reduction of air traffic delays, reroutes, and cancellations influenced by significant convective events. From a system user’s perspective, CCFP is designed for strategic planning of ATFM particularly during the en-route phase of flight. It is not intended to be used for ATFM oversight in the airport terminal environment, nor for tactical traffic flow management decisions. From a producer’s perspective, CCFP itself is designed to address two major purposes:

1. an accurate representation of the convection of most significance for strategic planning decisions of ATFM; and
2. a common forecast baseline, as consistent as possible, shared among all meteorological organizations responsible for providing forecasts of convection to traffic flow managers within the FAA and/or commercial aviation organizations.

4.2.4 The primary users of CCFP are ATFM personnel which include both FAA and industry partners. CCFP is the primary convective weather forecast product for collaboratively developing a strategic plan of operations (SPO). The SPO is finalized during the collaborative TELCONS hosted by the Strategic Planning Team and conducted approximately every two hours immediately after the issuance of the CCFP.

4.2.5 CCFP, a strategic planning tool for a two to six hour time frame, is available via the National Weather Service Telecommunications Gateway circuit in an ASCII coded text format. It is a graphical representation of expected convective occurrence at two, four and six hours after issuance. Convection for the purposes of the CCFP forecast is defined as a polygon of at least 3 000 square miles that contain:

1. a coverage of at least 25% with echoes of at least 40 dBZ composite reflectivity; and
2. a coverage of at least 25% with echo tops of FL 250, or greater; and
3. a forecaster confidence of at least 25%.

4.2.6 All three of these threshold criteria combined are required for any area of convection of 3 000 square miles or greater to be included in a CCFP forecast. This is defined as the “minimum CCFP criteria”. Any area of convection which is forecasted “not” to meet all three of these criteria will not be included in a CCFP forecast.

4.2.7 With the recent development of radar-based tactical decision aids and an increasing need to have convective initiation forecasts as early as possible in the operational day, CCFP coverage must be moved to the four to eight hour time frame. In addition, an extended CCFP, known as the ECFP, was created last year to address the growing need for longer-term planning in the 24-36 hour period. The ECFP is an automated version of the CCFP, based on an ensemble of short-term model information. Both the ECFP and CCFP create common situational awareness, improve teleconference planning coordination, promote harmony and cooperation amongst planners, and is the official weather forecast product for ATC convective planning. It has been embraced by the FAA and US airline industry as the cornerstone of severe weather planning for US airspace operations.

4.3 **Coordination of rerouting to avoid adverse weather (Japan)**

4.3.1 Adverse weather conditions cause major impact on traffic flow for Japanese ATM operations by reasons of excessive concentration of traffic demand within small airspace. Under these severe circumstances rerouting procedure is absolutely essential.

4.3.2 Although, in the rerouting for avoidance of airspace capacity saturation CDM partners are possible to conduct coordination from a few months before the operational day based on flight schedule to the moment before departures based on flight plan, in the rerouting for adverse weather conditions that coordination will be mainly conducted on the day of operations it is required to improve efficiency that various parties involved, the JCAB Air Traffic Management Center (ATMC), rerating ATC facility(s) and airline operators must complete their coordination within a limited amount of time. Therefore, they share preliminarily and use “Rerouting List” of the flight routes between city-pairs, which has been established and updated after making the necessary coordination among CDM partners. Using the “Rerouting list” makes coordination simple.

4.3.3 CDM partners are possible to coordinate their rerouting via ATM workstation which provides traffic demand, detailed data and position information on each flight. Rerouting in this process exerts a positive effect on decreasing the demand of congested airspace and identifying the variation of air traffic flow.

5.    Special Traffic Management Programs and Security (USA)

5.1 Special traffic management programs (STMPs) are particular events attracting thousands of people and aircraft to participating airports. These events have the potential of creating additional demand for air traffic controllers handling this traffic. In order to safely manage aircraft during these events, a STMP requires pilots to make arrival and/or departure reservations prior to their flights to or from these airports. Pilots can make reservations via the telephone to a toll free number or if more convenient, utilize a Web base Interface that is available to anyone with INTERNET connection and a web browser. This electronic web‑based application is commonly referred to as an eSTMP. This collaborative tool is a good representation of how the CDM organization has been able to tap into the collective intellect of its constituency to create, construct and modify ATFM tools and technologies as conditions warrant.

5.2 The ANSP may typically use this STMP at high density locations that host high profile sporting events, business conventions, air shows, and international global events such as the World Cup and Olympics. A recent event where STMP was successfully implemented was the Vancouver 2010 Winter Olympics and the South Africa 2010 World Cup Finals. These examples typify the amount of pre-planning that occurs amongst stakeholders prior to the event taking place in order to harmonize the needs of the various aviation community participants.

5.3 STMPs are generally managed by the overseeing national command center or the regional area control center (ACC) where the event is taking place. The ATC governing facility shall transmit an advisory that contains the reason for the program, airport(s)/sector(s) involved, dates and times the program will be in effect, telephone numbers to be used, and any special instructions, as appropriate. The affected ACC shall be responsible for monitoring the special TM programs to ensure that the demand to the center/terminal facilities does not exceed the declared capacity. Aircraft are expected to arrive within +/- 15 minutes of their slot reservation time. If a reservation requires change or cancellation, pilots must do so as early as possible in order to release the slot reservation for another flight.

5.4 The end results are mutually beneficial since they serve both the ANSP and the system user, by providing predictability, minimizing delays and contributing efficiency to the airspace system.

5.5 In today’s dynamic, complex and volatile aviation industry, maintaining the continuity of a robust and redundant flow management system requires more than balancing demand with capacity issues. Information exchange, real-time communication and a teamwork approach is essential in confronting potential threats to vital resources which provide support to both domestic and global ATFM assets. Establishing a central focal point that can provide subject matter expertise as to how the ATFM system functions is essential to the vitality and security of the air traffic system. In an effort to meet these challenges, the FAA command center has established a designated position that serves in this capacity and more importantly functions as a liaison to the civilian and military security organizations. Whether it’s a common daily occurrence such as a radio or transponder outage, or a singular or plural event that has the implications to threaten national security, the command center is prepared to successfully navigate through these challenging events.

6.    Collaborative Workgroups and Tools (USA)

6.1 CDM has evolved into a collaborative methodology with respect to traffic flow management operations. It has brought together operators, government, air navigation service providers, private industry, military and academia with a shared vision that improves decision-making. As a result of this evolved environment, the greater aviation community will ultimately benefit from information exchange, data sharing and development of sophisticated tools and technologies.

6.2 This evolution has led to the creation of an eclectic, collaborative environment which is capable of dynamically addressing systemic issues through highly specialized workgroups that are tasked to specifically address problematic issues impacting the TFM community.

6.3 The success of these workgroups stems from a variety of reasons. First and foremost is the capability to collaborate with subject matter experts across a wide spectrum of stakeholders. Their contributions and personal commitment is reflective of the core values shared by the organizations. Empowerment, transparency, and trust are just some of the characteristics that promote a collaborative culture of ingenuity amongst members. This model of soliciting input from the experts and end users of tools, technologies and procedural guidelines then becomes the cornerstone of its own success.

6.4 The organizational hierarchy is composed of a high level oversight committee consisting of both ANSP and industry stakeholders. They provide oversight, tasking and prioritization of projects for the various focused workgroups. The workgroup teams are then tasked to generate solutions by incorporating innovative technologies for cutting edge tools that flow managers can use in the airport, terminal or en-route domain. This degree of fluidity is complementary and quite instrumental in addressing the complex issues which confront the aviation industry on a daily basis.

6.5 Examples include “ground delay programs” to balance demand and capacity issues at specific airports by delaying assignments for departing aircraft in order to arrive at destinations within a specified time slot. Another example is using “flow evaluation area, flow constraint area” tools which can measure the throughput of a specific sector or geographical area. These examples have migrated into more sophisticated enhancements, such as airspace flow programs which assess and manipulate en-route volume to achieve the optimum equilibrium that the system can safely manage.

6.6 This constant assessment of the needs of the system coupled with the pairing of the end users of these tools is the cornerstone of the CDM organization.

7.    Additional Information

Additional information on collaborative decision-making in the USA may be found through:

<http://www.flycdm.org/>

Topics covered within the site include:

CDM Leadership Guide

CDM MOA 2009

New Member Process

CDM Participant Code of Conduct

CDM Training Documents

Points of Contact

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