FAA DATA STANDARDS INITIATIVE:

SYSTEMS ENGINEERING BASE FOR

AIR TRAFFIC MODERNIZATION

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Introduction

The evolution and modernization of the National Airspace System (NAS) relies on collaboration among its participants, and interoperability and integration of existing and new air-and ground-based systems. A key supporting component is the exchange of timely and accurate information among these participants and systems. Traditionally, these information exchanges have been defined in a pair-wise manner, with locally-defined data structures that need to be transformed with each exchange. As the amount of information and the number of exchanges grow, this approach becomes untenable. To address this problem, the FAA and aviation community has begun to develop data exchange standards, reducing or eliminating the need for unique, system-to-system interface definitions.

Background

Increasing demands on the NAS are forcing changes in how the FAA develops and manages the airspace in collaboration with many aviation constituencies. Bringing greater discipline and consistency to the management of NAS information is an important element of both NAS (systems) modernization and operations. The NAS Architecture Version 4.0 calls for the evolution of information services, specifically data standardization and interoperability across applications [1].

The FAA has recently established a number of organizations, policies, and mechanisms to support data standardization. The Office of Information Services (AIO) provides FAA-wide policy and guidance for data management. Also, the NAS Information Architecture Committee (NIAC) has been chartered by the FAA's NAS Configuration Control Board (CCB) to research and recommend NAS information exchange standards; and the NAS CCB will approve and manage the standards as NAS-level requirements.

What is a Data Standard?

A data standard is a recognized and accepted (by usage, by consensus, or by decree) description of a unit of data that includes a name, a well-specified definition, and a prescribed structure, among other descriptive characteristics. For example, one might specify an airport code standard as follows:

- Name: Airport Identifier
- Definition: The ICAO 4-letter identifier for an airport/aerodrome; e.g., KDCA.
- Structure: aaaa (denoting four alpha characters)

Airport code is a relatively simple case, but airport code in many FAA databases and automation systems represents, for major airports, a U.S.-specific 3-letter code instead of the ICAO code described above. There are more complex cases where ambiguity is more of a concern.

In 1998, CAASD analyzed information exchanged by several Traffic Flow Management (TFM) systems, preliminary to defining a TFM information architecture [2]. The study focused on

[1] The contents of this material reflect the views of the author(s). Neither the Federal Aviation Administration nor the Department of Transportation makes any warranty or guarantee, or promise, expressed or implied, concerning the con- tent or accuracy of the views expressed herein.

flight data, including flight schedules, flight plans, flight progress, and related aircraft data. It was found that (1) there were many instances in which the same information was named and/or represented differently by the systems, and (2) data names and definitions were often insufficient for specifying the meaning of the data. Figure 1 illustrates the variety of terms used to describe a flight's position, including its time report, its speed, its altitude, its 2D location, and whether the position is actual, filed, scheduled, or other.

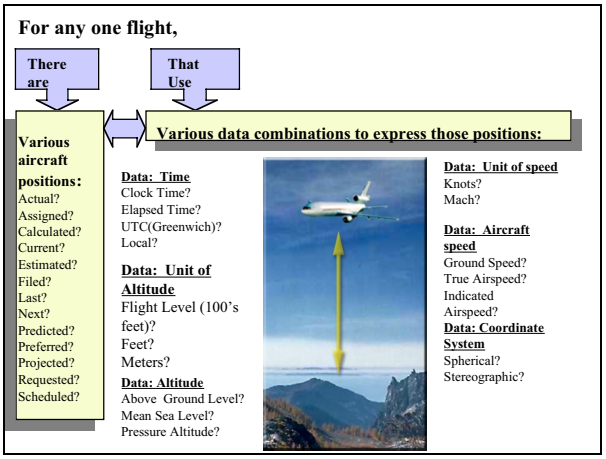

Figure 1. Ambiguity in Flight Position Data

Descriptive characteristics such as name, definition, format, units of measure, and usage, are known as *metadata*, or data about data. Unfortunately, much of the metadata for existing systems gives little insight into how the information should be interpreted, because there is little or no specificity. A data standard, on the other hand, provides the information needed to unambiguously understand the data's meaning. For this reason the FAA chose to represent its operational data standards in a registry based on the ISO/IEC 11179 [3], Information Technology – Data Management and Interchange – Metadata Registries (MDR). This international standard contains a framework, rules, and an extensive set of attributes for describing and managing information about a broad range of shareable data.

Why Standardize Data?

Historically, systems at the FAA, as in many large organizations, have been developed to solve a particular problem and have not considered the overall system environment in which other agency systems also run. Information exchanges have typically been arrangements between two systems whereby one produces the locally-defined data, with potential variations as seen in Figure 1, and the other processes the data easily or with difficulty, depending on how much translation and interpretation it has to do to make the data useable. Programmers who have become familiar over time with each system's written and unwritten business rules maintain the translation/ interpretation procedures. The net result is data inconsistency, more expensive system maintenance, more time needed for development (since there is little data structure reuse), and much harder and costly system integration to achieve interoperability.

Opportunities for data sharing have been limited until recently because of communications and transmission costs. Now, however, technology offers new ways to access information rapidly, easily, and cost effectively. FAA's challenge then will not be merely to to ensure that users get the data they need, but that they understand it completely, and that they use it correctly. To meet the challenge, FAA's corporate knowledge of the meaning and usage of NAS data will have to be codified and agreed-upon nationally and internationally.

In the future, the FAA will define common standards for the exchange of information between NAS systems, service providers, NAS users, and other organizations and systems that use NAS information. These standards will be a part of the configuration and acquisition management processes for new systems. As legacy systems are upgraded, it is expected that they will evaluate adoption of data standards as part of the upgrade cycle. Although it is not practical for the data standards to be enforced in systems' internal processing, it is hoped that developers will adopt standards for internal use where feasible.

There are a number of advantages to standardizing data, including these fundamental benefits:

- **Data Quality and Access:** Data quality will be improved by reducing the ambiguity resulting from similar data defined differently across systems. The current use of different geographic coordinate system standards and formats

is an example. Safety is, in part, dependent on data quality.

- **Interoperability:** Today, system interfaces are customized between pairs of systems (rather than among many systems), expensive to build and maintain, and relatively inflexible. Data exchange becomes easier when systems use common data definitions and structures.
- **Cost Effectiveness:** The rate of cost increases to field and maintain new systems can be reduced when common services, in this case data exchange services, can serve multiple systems, rather than when each system develops its own data services locally with non-standard data.
- **Flexibility:** Common data services and application-independent data standards will provide the ability to satisfy new information-related requirements quickly and efficiently.

Operational Impacts & Benefits

There are numerous opportunities in national and global airspace operations where common data standards would meet the goals stated above. Recognizing that these areas have some overlap, a few specifics are discussed here:

- Making uniform the representation and rules for use of aircraft make, model, and series to sharpen accident investigation analysis
- Integrating several of the systems participating in the Free Flight program to modernize the NAS, especially the En Route systems
- Flight data management and trajectory management within traffic flow management
- Aeronautical data exchange with Eurocontrol and other international aviation bodies and systems, as well as NAS stakeholders

Aircraft Type Classification and Naming

A group of professionals from across the aviation world[2] has been working to standardize the references to aircraft. There are many reasons to do this, but a major motivation is to sharpen our ability to analyze accident investigations and assess causal factors across reports of aircraft materiel failures, cockpit design and other systemic issues. The FAA's Office of System Safety (ASY) is very active in this effort.

Today there are many ways of classifying an aircraft type. For example, even an aircraft as common as the Boeing 747 has many similar but inconsistent names, such as "B747", "Boeing 747", "747", "B747SP", not to mention the variations resulting from misspellings of the company name. Additionally, rules for recording “manufacturer name” are not standard, especially where a name has changed, e.g., in the case of McDonnell-Douglas' purchase by Boeing, leading to the "MD-80" and the 'Boeing MD80". The multiplicity of names can lead to misclassifications of mishap data and cause an analyst or engineer searching for the relevant data to miss critical details. It is equally important to identify unambiguously the make and model characteristics of general aviation (GA) aircraft (e.g., engine type and size, and avionics). Generally this is a function of accurately classifying a baseline model and variations to the model reference over time. The FAA takes very seriously its responsibility to oversee aviation programs and contribute positively to public safety and awareness, but poor data can thwart the discovery of accident factors and the causal chain of events.

There is a need to provide a uniform set of information describing aircraft make, model, and series, and to manage incoming flight operations or mishap data so that it is properly stored. Then it can be made available globally for detailed analysis by engineers, manufacturers and designers for aviation product improvement, with an eye on reducing accidents.

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[2] Organized as the Commercial Aviation Safety Team under ICAO auspices and known as CAST/ICAO. It is also working on other international standards, including phases of flight.

NAS Modernization

On a related front, the Free Flight program [4] is prototyping and fielding several new Decision Support Systems (DSS). Many of these systems rely heavily on aircraft description and classification for specifying an aircraft's performance capabilities, such as climb rate and speed, in order to forecast the flight trajectory and any likelihood of a separation standards violation. The tools are expected to enhance safety by alerting the controller to any potential violation while considering route changes that would be beneficial. Typically, routing changes are made to reduce flight time or gain fuel efficiency [5]. Due to the lack of standard aircraft type designators, there are a variety of inconsistent aircraft representations in use throughout the NAS. Such inconsistencies create recurring problems in data management as well as system performance.

The NAS Operational Evolution Plan (OEP) [6] has many components that would benefit from data standardization and related information management improvements, such as modification to the NAS infrastructure (additional runways, redesigned airspace, and new arrival and departure routes). All of this new information needs to be validated and captured in the FAA's aeronautical databases and delivered to automation systems as adaptation data, and to aircraft navigation systems to support a common view of the infrastructure. Currently, it is difficult to develop a consistent view of core airspace and aeronautical data because several data sources exist with inconsistent data definitions as well as values.

Common data exchange standards will also improve operational data sharing, including routing options, flight planning, situational awareness, weather, and runway configurations. Otherwise, each system that needs to support the exchange has to be able to interface with every other system's uniquely defined data. These multiple translations, besides being more time-consuming to implement, also increase the chance of error as data are interpreted and transformed.

Flight Planning and Trajectory Modeling

There is a need to identify flight data uniformly across many FAA, industry, and international systems. The control tower, the cockpit, and the decision support systems that manage flight data, including URET and the Host system at the FAA's 21 Air Route Traffic Control Centers, all use alternative data to describe a flight.

Systems exchange flight data to forecast flight position via trajectory modeling, a critical need for maintaining separation and safety, yet these data must be converted from one system to another. In some cases, the conversion will not find an equivalent data element waiting to receive its value or the conversion process is made ambiguous by the data structures on both sides.

ICAO uses and has proposed a common view of flight for global use, but its proposal has not been broadly implemented in the US. Although some FAA decision support systems follow the ICAO structure, many do not, and there is no official FAA standard for flight data. The RTCA has also made similar proposals, and Eurocontrol is considering constructing a flight data server to standardize and integrate the management of flight data across its systems. In the last few years, CAASD and others have developed flight data models and have proposed their use as a standard across FAA systems. That effort is ongoing.

As part of the en route modernization program, the FAA is working toward developing common flight data structures together with the distribution and analysis of flight plans to offer rapid feedback to the airlines. This would enable them to modify a flight plan well before departure, offering cost efficiencies to the industry as well as more accurate system capacity forecasts to the FAA.

For other types of data, a common problem is that similar data is not identical across different FAA systems. In the case of the U.S. NOTice to AirMen (NOTAM) System (USNS) information may vary by value, format, or currency[3] according to the system in which this information is stored. When this information is also managed in an off-line, non-NAS system, such as the cockpit FMS, additional variation may occur, with implications for safety. Safety concerns arise with inconsistencies in the NAS system data, as well as timely notification of change.

With the coming of Free Flight and increased demands for real-time interoperability for

[3] A value at a point in time

collaborative decision-making, the need to standardize views of data are becoming critical. Ideally, data should be managed so that each system 'sees' the same data at the same time — (avionics and FMS in the cockpit, airline operational control, controller display, the Host computer and related decision support systems). This ambitious goal starts with common data standards.

FAA-Eurocontrol Aeronautical Data Exchange

In the FAA there are several *de facto* data sources for aeronautical data [4]whose contents are similar but which differ in important ways. Their use (several sources are often used in one system) can lead to additional processing, confusion, ambiguity and error.

The authoritative FAA source for such data is the NAS Resources (NASR) system. However, the FAA now also produces the Digital Aeronautical Chart Summary (DACS), formerly under NOAA auspices. Jeppesen's [5] aeronautical products are produced using many sources, including NASR. Finally, the Adaptation Controlled Environment System (ACES) [7] consists of aeronautical data from the Host. It is used in many FAA systems.

Because of their differing data structures, semantics, formats, and values, translation and conversion of the data among these sets is not always straight forward. Typically, an application chooses to use one or two of these sources for fundamental aeronautical data. Data inconsistencies arise when such data are exchanged with other systems and when these data are *adapted*, or customized, for an application or geographic location. Having a data standard would mitigate these inconsistencies and would improve interoperability.

Although the FAA and Eurocontrol routinely obtain aeronautical data from one another in electronic form, each side parses and converts what is received because of differing data standards. U.S. carriers flying to Europe, already receiving FAA's airspace data would welcome access to equivalent data about European airspace in a way that is easily obtainable with a standard form. This also holds for European air carriers flying to the U.S.

At one level, this exchange should be straightforward since both view the airspace in roughly the same way. However, at the detail level, for data naming, semantics (definitions), formats and data values, this exchange turns out to be quite problematic. This was discussed in a recent report examining the feasibility of automating this particular exchange [8].

In Europe, Eurocontrol has created a data model called the Aeronautical Information Exchange Model (AIXM) [9] to offer a common view throughout European airspace. This is part of a project called the European Aeronautical Information System (AIS) Database (EAD). It is based on ICAO's view of the airspace and is not compatible with NASR and other U.S.-based data.

There are many specific examples of data inconsistencies among these data sets. The most visible (and confusing to our international colleagues) is that the FAA uses a set of airport identifiers (e.g., DCA, LAX, DFW) that are unique to the U.S. rather than the standard 4-character ICAO airport ID. In many cases, the NAS IDs are easily translated to the ICAO by adding the international identifier "K" to create KDFW, for example, but in others, the translation rules are not nearly so simple.

The easiest technical solution to improving data interoperability in this case turns out to be the most difficult in practice. This is to make each side's data structures and usage rules identical to the other's, whether by each making modifications or by one changing to resemble the other. Of course, this would create great difficulty and cost for whichever system abruptly changed its internal data structure. Other less disruptive solutions and transition strategies need to be considered.

Just as the concept of standard, interchangeable parts stimulated the industrial revolution, application-independent data exchange standards can stimulate the modernization of system-wide and global aeronautical information systems.

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[4] Aeronautical data describe facilities and structure such as airports, runways, routes, navigation aids and fixes.

[5] Jeppesen is a US registered trademark of The Boeing Corporation

Standards Organizational Authority

The FAA has recently taken steps to move the NAS towards data standards and expects to cooperatively extend the data standards effort into the international arena through participation in the international forums. The FAA's program is built around a group with the essential organizational authority to govern a process that is open and collaborative, that will facilitate moving qualified data elements to standard status.

In 1998 the FAA moved to implement the OMB directive [10] to executive Cabinet departments and created a Chief Information Officer position within the Office of Information Services (AIO) to establish policy and influence the information technology direction of the FAA. AIO has developed, coordinated and published the FAA Strategy on Data Management [11]. The strategy will be implemented through the FAA Data Management Policy [12], which is currently under final review at the FAA.

Data Stewardship

The FAA Data Management Policy institutes a program that calls for each line of business (LOB) to designate individuals as data administrators (DA) and data stewards for the metadata critical to that particular LOB organization. The DA is an information system resource coordinator in the LOB and there may be several stewards supporting the DA. Stewardship is being promoted to convey the message that data consistency and quality is a shared responsibility. Stewards will oversee the metadata that describes the operational data created and maintained by their organization. Ownership of the operational data, that is, content and quality throughout the life of the data, is the responsibility of the organization. The distinction between metadata and the operational data is essential to data management and the data standards process.

Modernization Processes

In addition to AIO, the office of System Architecture and Investment Analysis (ASD) has historically advanced initiatives to promote consistency in data management in the NAS. The recent addition of AIO and its emphasis on FAA-wide data management is expected to complement and facilitate NAS -wide implementation. The NAS Information Architecture Committee (NIAC) was created through an ASD initiative in 1997. It has been a valuable forum for the exchange of concepts and technology advances in information engineering. NIAC support comes from interested managers and staff within the FAA organization, its contractors, and other interested external governmental and industry organizations. In 1999, a movement was started to formalize the NIAC's role by making it a pre-screening body for configuration management issues specific to information technologies and data standardization. That effort was fulfilled in March 2001, when the NIAC was chartered by the NAS Configuration Control Board (CCB) to develop, and recommend NAS data interchange standards.

NAS Configuration Management

The FAA has pursued a configuration management (CM) process since 1996 under Order 1800.8F. In 1996 the FAA established the Acquisition Management System (AMS) in response to legislative mandates, and during that evolution, the CM activity was linked to AMS. CM is included in AMS and has been further refined by Order 1800.66 dated November 1999, which will eventually replace 1800.8F [FAA CM]. The web site for this policy activity is http://www.faa.gov//cm/.

The CM process has addressed the software and hardware components of the NAS, with the focus on the Integrated Product Teams (IPT) as controlling entities, though the NAS-level CCB adjudicates broad issues. Data has been left out of the CM scope by default, permitting IPT's to formulate their own approaches. With the chartering of NIAC as a member of the FAA configuration management effort, data standards will become NAS-level components whose use is required by new systems. Thus, the CM program is the organizational and policy basis for this data standardization effort and is addressed in more detail in the following sections.

Data Standards Process

Data standards lay the foundation for information interoperability. Standards meet a key objective of the overall strategy, which is to evolve to a seamless interface between computer-based

systems that use air traffic data and information. Getting there won't be easy. The FAA data standards process [13] is shaped to promote the new business practices in data management and also reinforce those other FAA systems engineering and acquisition initiatives such as the NAS CCB and AMS. The data standards process provides several views of the standardization activity: organizational collaboration, a support infrastructure that includes the FAA Data Registry, data requirements, a data model as blueprint, and risk mitigation. The product of the effort, a data standard, is moved through the process as a case file to ultimately be approved by the NAS Configuration Control Board (CCB).

Collaborative Approach

FAA policy is structured to provide organizational empowerment through visible, open, collaborative work activities that treat overarching issues. An acknowledged leading risk to information technology modernization is the lack of collaboration [14]. This stems in part from the lack of commitment, lack of communications, lack of control, and change management. The FAA data standards program infrastructure is there to mitigate these risks. Like other contemporary e-business thrusts, it builds on web-accessibility. It also ties and relates work program activities to meet people's productivity expectations: do more with less investment of time and travel.

The scope of the program places priority on NAS-wide data elements, primarily those involving flight operations such as communications, navigation and surveillance, and status of NAS systems. Local, regional or non-NAS data elements have not yet been given priority though responsible organizations are encouraged to certify these data at the system level.

The FAA has created a process that expedites the discussion-debate-negotiation cycle time, thereby promoting efficient development of data standards. The collaborative approach is based upon the willingness of people to come to the negotiation table and strive to reach closure on data standardization.

Standardization Infrastructure

The people participating will have web-enabled access to the essential tools and information to effectively complete the work of data standardization. The first task of any group setting out to create a standard is a careful compilation and review of the data element metadata. The metadata specification for a standard requires careful, broad review across the organization. Key components of the standardization process infrastructure are:

- FAA Data Registry - FDR
- Groupware Collaboration Tool - CDIMS
- Data Modeling Tools
- Requirements Management Tool - DOORS

FAA Data Registry (FDR)

The FAA Data Registry [15] is an automated capability for publishing, distributing, and maintaining metadata about information shared among FAA's systems. The FDR provides information about the precise meaning of NAS data, and provides a place to capture information during the development of data standards. It will be the authoritative source for FAA data standards.

The FDR will be used by architects of future FAA systems, FAA application developers, standards developers (NIAC working groups, international working groups, and industry), and users of FAA systems.

The FDR will lead to a consistent development of data definitions because it employs a formal procedure for capturing the facts needed to clearly describe, inventory, analyze, and classify data. It also provides for formal configuration management of data standards. Since the Registry is compliant with an international standard (ISO/IEC 11179), the FAA will be able to exchange standards with other ISO/IEC 11179-based registries around the world.

The FDR is a place where data managers or stewards store their metadata so that the information can be freely distributed for all to use. Other information in the registry, essential to data standardization, are things like classification schemes, permissible value lists and data naming

conventions. The FDR will hold those for use in the data standards program.

Collaborative Data Integration Management System (CDIMS)

Collaboration is an important facet of the data standards program. As mentioned earlier, the lack of collaboration is a classic risk [14] to IT projects. Resolving technical issues is not easy, and the discussion - negotiation cycle can be a time-consuming but necessary activity in building data standards.

The CDIMS Internet portal provides a Lotus Notes[6]-based discussion environment that allows working group moderators to effectively conduct discussions, promote a negotiated settlement and call for votes on the proposed metadata items. In CDIMS, the participants can log into the system at their convenience and present their arguments on behalf of their organizations. This "asynchronous" [16] collaboration is considered more efficient than "synchronous" meetings requiring travel and pre-planning. The "virtual team" members can state their concerns, develop a position, form coalitions and act to convince others to accept their position. It is an open forum and can be viewed at the CDIMS site: https://callisto.cdims.act.faa.gov/.

Data Modeling Tools

The FAA data standards program will use data modeling to provide an important view of the data standards. Data models will exist at various levels with each offering a portion of the overall logical data structure in the NAS information architecture. As data standards are created, the models will grow. It is expected that an inventory of data models will grow and ultimately complete a picture of the NAS enterprise data. Logical data models provide the basis for creating the physical data models typically required in the creation and management of databases, an important component in ATM systems, and they play a fundamental role in the design of future NAS-wide information services.

Dynamic Object Orient Requirement System (DOORS[7])

It is an essential quality for data is to be related to an underlying system or functional requirement. Tracing and documenting the data element requirement is an important activity, and it typically supports the metadata describing the data elements. For example, the value domain, i.e., permissible values associated with a data element is a critical item. DOORS can aid in capturing this dimension. We know an incident [17] in which a flight crew was confused or a software programmer was confused about the unit of measure being used: feet versus meters. The DOORS tool is being used to manage a database of functional, system, and data requirements for the NAS Architecture. DOORS provides a strong working environment for the compilation of requirements. The tool will be extended to the data standards development environment to support the prioritization of data element standards development.

Case File

Data standards, like any other NAS-level standard, are proposed via NAS Change Proposal (NCP) case files, presented to the NAS CCB for approval. The case file is composed of the basic proposal forms followed by appendices to present supporting data and information to the reviewers and decision makers.

The case file composition includes:

- NAS CCB Forms
- Tab A - FAA-STD-060 Data Element Standard
- Tab B - Related Data Element Report
- Tab C - Collaboration Report
- Tab D - Requirements (DOORS) Report
- Tab E - Entity-Relation (Data Model) Report
- Tab F - NAS Data Model Report

The case file is built to present a new baseline or show the intended changes to an existing baseline, thereby establishing a new standard.

[6] Lotus Notes is a US registered trademark of the IBM Corporation.

[7] DOORS is a US registered trademark of QSS, Inc. and Telelogic, AB.

NIAC Organization

As stated earlier, the NIAC has recently completed an evolutionary move to become the FAA organizational entity recognized by the NAS CCB to conduct data standardization work. The charter may be viewed at http://www.faa.gov/cm/. Figure 4 shows the NIAC organization chart. The NIAC expects to continue as a forum on information engineering topics related to the NAS technical architecture, and will constitute a number of working groups and direct data standards development activities. The NIAC is overseeing the development of the FAA Data Registry (FDR).

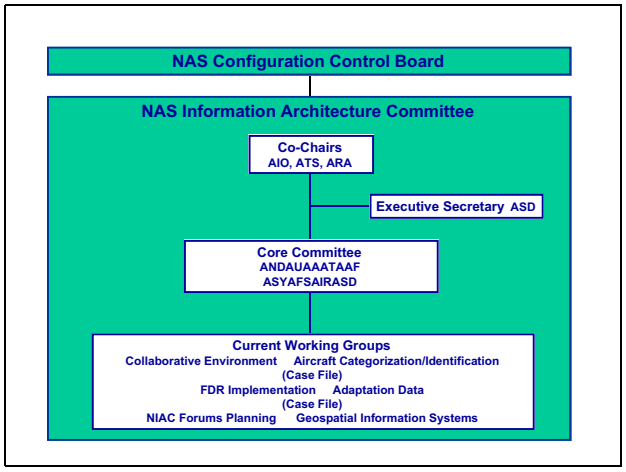

Figure 4. NIAC Organization

Co-Chairs

The NIAC is chartered to work under the direction of three Co-Chairs and they represent the FAA Associate Administrators for Air Traffic Services (ATS), Research and Analysis (ARA) and Chief Information Officer (AIO). Co-Chairs act as prescreening authority for changes presented to the NIAC, and must sign NAS data standard case files before they are submitted to the NAS CCB.

Executive Secretary

The Executive Secretary provides daily direction and administrative continuity to the NIAC. This activity is supported by the System Architecture and Investment Analysis Office (ASD).

Core Committee

The Core Committee is a set of individuals who represent the key lines of business (LOB) for the FAA's NAS operations. The primary responsibility of Core Committee members is to establish overall goals and direction for each working group and review the case files on behalf of their organizations. Currently, there is representation from NAS Operations (AOP), Planning and Procedures (ATP), Communications, Navigation and Surveillance Systems (AND), Flight Standards (AFS), Regulation and Certification (AIR), System Safety (ASY), and Research and Acquisition (AUA). This representation is vital for the success of the standardization effort.

Work Groups

The basic organization for the compilation and creation of a case file of proposed data standards is the working group. The group operates under a Terms of Reference (ToR) contract with NIAC and is led by a chairperson who has the managerial responsibilities to generate and follow up on the case file. This individual also serves the role of moderator for collaborative activities on CDIMS. There is no requisite size for a group, but the composition should represent those NAS systems that have a vested interest in the metadata under evaluation. It is expected that data stewards will form the necessary group of affected stakeholders to develop promote a new or revised version of a data standard as needed.

Case File Advancement

The case file moves through a defined sequence as depicted in Figure 6. There are four phases in the effort commencing with pre-screening, CCB decision, standards publication, and concluding with status accounting.

NIAC Pre-Screening

This is the first phase of the case file development. During this period, the case file of factual information describing the proposed data standards is composed for presentation to the NAS CCB. The NIAC working group Chair insures the completeness of the case file package through the pre-screen level. Pre-screening, a function of the NIAC Core Committee, ensures that proposed changes are thoroughly evaluated for technical, interface, quality assurance, cost, financial, policy, schedule, safety impacts, supportability, and life cycle implications. The case file is approved by NIAC Co-Chairs and advanced to the NAS CCB control desk.

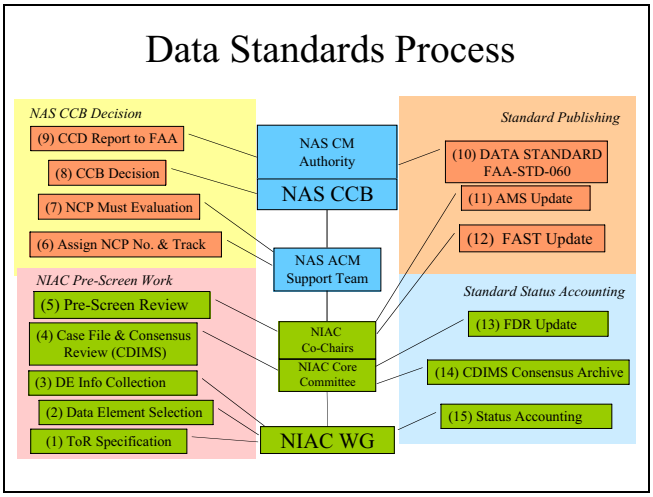

Figure 5. Standards Process

NAS CCB Decision

The NAS CCB decision phase is conducted in the same manner as for any NAS Change Proposal, that is, the proposed data standard is reviewed by a set of "must evaluators" from the major FAA lines of business. When approved by the CCB, the new data standard becomes part of FAA-STD-060, [18]. The purpose of this document is to establish and communicate application-independent data exchange requirements to be applied during the development and support of software systems.

Standard Publication - Notification

The announced CCB decision is reflected in the Acquisition Management System by way of the FAA Acquisition Support Tool, FAST. The FAST and associated materials are located at the Web site http://fast.faa.gov/. The individual data standards are maintained in the FAA Data Registry.

Standard Status Accounting

This step involves cleanup and resolution of any non-approved items in the case file by the NIAC working group.

International Data Harmonization

Movement of aeronautical information, such as flight plan data, at the international level requires the use of data elements considered common to modern ATC systems. Examples are aircraft identification, departure airport, arrival airport, etc. Harmonization is the process of resolving differences among the various host Civil Aviation Authority (CAA) processing systems and the NAS systems. As mentioned earlier in this paper, the FAA has initiatives with Eurocontrol as well as those CAAs in the Americas. Further, the pace of change is growing due to increasing international traffic demands and the associated modernization efforts. The establishment of FAA data standards is a first step in building FAA consensus, which will set the stage for harmonization negotiations at the international level. It is expected that the FAA standardization effort will have an eye on international uses of common data, and where prudent and practical, the effort will move in a consistently open approach toward standardizing those data elements. For example, flight plan data figures prominently in this work; however, efforts to incorporate data link into air traffic communications are also creating urgencies for data standardization.

Intra-governmental Initiatives

Within the US government, there are significant data standardization activities requiring attention and coordination by the FAA. The Department of Defense (DOD) has considerable control over national airspace. The airspace allocated to DOD operations is called Special Use Airspace (SUA) and refers to Warning Areas, Restricted Areas, Prohibited Areas and Operations Areas. The FAA maintains a communications interface to the military commands that schedule this airspace through the NOTAM system. The frequency and intensity of coordination about air operations forces a significant level of interoperability at the system and command communications level.

The National Aeronautical & Space Administration (NASA) is an active stakeholder in both system interoperability and communications, and like the DOD has control over certain special use airspace. This role includes coordination of air operations through the NOTAM system. NASA is an active collaborator with the FAA in the aviation safety programs, and has the lead in the Aviation Safety Reporting System (ASRS) that is available to all at http://asrs.arc.nasa.gov/. The ASRS program allows and encourages controllers and pilots to submit their observations and concerns to the database for consideration and evaluation. The purpose of ASRS is to identify preventive actions and improve aviation safety with non-attributable

information. Data quality and correct classification are imperatives to the success of this effort.

International Organization for Standardization (ISO)

The ISO is a basis for many data standards that affect our routine business and personal activities today. The FAA has no intention of developing new standards where this world body of experts has successfully established a working model. ISO 8601 [20], *Information Exchange - Representation of Dates and Time*, is suitable for FAA adoption and standardization. Other federal agencies are implementing data standards, and the FAA may choose to adopt standards established by other agencies. An example of such standards suitable for import exchange is the Geospatial Information System (GIS) standards employed by the US Geological Survey (USGS). These standards will be balanced against ISO 6709 [21], *Standard Representation of latitude, longitude and altitude for geographic point locations*.

Potential Application to Data Link

One of the needs to extend the initial implementation of data link is a common vocabulary for the conveyance of data among ground systems and then up to the aircraft/FMS. The ICAO Manual of Air Traffic Services Data Link [21] includes the full ICAO message set that the FAA is partially implementing through a series of incremental builds. A sample uplink clearance message is: **CROSS (*position*) AT OR GREATER THAN (*speed*)**. The document also includes a glossary that provides the definitions for the variables used in the message set, as well as a list of parameters, units of measure, range and size, and resolution associated with each variable. For the example message above, "position" can be specified as a fix name, a navaid, an airport, a latitude-longitude, or a place bearing distance. "Speed" has several possible meanings, as shown in Table 1.

This is a small example of information commonly used and exchanged by air- and ground-based systems. As seen earlier in the paper, ground systems have many ways of expressing the same or similar information. When the meaning and structure of the information are not precisely defined, e.g., what is "speed?" and "position?" can be ambiguous. Developing and publishing well-defined data standards will provide a common reference by which information in air- and ground-based systems can be related, and reduce or eliminate the ambiguity of information exchange.

Table 1. CPDLC Parameters, Range and Resolution for "Speed"[22]

Parameters	Unit of Measure	Range/size
Ground Speed SI	Kilometers/hr	-100 to +4000
Ground speed non-SI	Knots	050 to +2000
Mach	Mach number	0.5 – 4.0
Indicated SI	Kilometers/hr	0-800
Indicated non-SI	Knots	0-400
Speed true SI	Kilometers/hr	0-4000
Speed true non-SI	Knots	0-2000

Conclusion

The evolution and modernization of the NAS depends upon the exchange of more information among a growing number of systems and people. Continuing to define data at the local level and to establish point-to-point interfaces in the face of more complexity not only increases the cost of software maintenance and makes achieving interoperability more difficult, but also raises the chances for data inconsistency and its inherent safety risks. As a solution, data standardization provides the starting point for ensuring that the information being exchanged is well understood and correctly interpreted. A framework for developing data standards has been established by the FAA, and it is recommended that the aviation community identify high-priority needs and initiate work on key standards.

As Jane F. Garvey, FAA Administrator, states in the Operational Evolution Plan (OEP) [6] introduction letter: "… progress depends on a coordinated set of investments and commitments."

Data standardization is one of those essential commitments that make modernization possible.

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