



FIXM Development Guidelines

The Flight Information Exchange Model (FIXM) is a standardised model for the global exchange of flight information. In addition to supporting the future air traffic management concept, FIXM must also allow interoperability with existing standards and legacy systems during the period of transition to Flight and Flow Information for a Collaborative Environment (FF-ICE) operations. This document discusses topics related to the construction of a model that addresses these concerns, and provides guidelines for model development to assist with resolution of issues.

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1 Introduction

The major goal of the Flight Information Exchange Model (FIXM) initiative is to create a data model that supports the future Flight and Flow Information for a Collaborative Environment (FF-ICE) operations [1]. That model should be as simple and clean as possible to provide the best possible support for those operations, without introducing unnecessary complexity and extraneous artefacts.

The transition from today's operations to the future FF-ICE operations is expected to be lengthy, with different stakeholders migrating at different rates. As such, FIXM needs to support stakeholders during the transition period, and therefore to support integration with legacy systems and formats. Indeed, the transition period is one that has been an active topic of discussion by the International Civil Aviation Organization (ICAO) Air Traffic Management Requirements and Performance Panel (ATMRPP) – see [1], section 5.

This discussion paper provides guidelines for the development of FIXM, and addresses the often-competing requirements of a forward-looking 'ideal' model and the support of legacy systems and formats during transition. The guidelines are subordinate to the FIXM change management charter [5] and the FIXM strategy [4].

The guidelines presented in this paper are followed in the development of the FIXM core and verified extensions endorsed by the FIXM Change Control Board (CCB). Stakeholders are free to adopt any convention they choose when developing extensions; it is recommended that stakeholder extensions follow these guidelines.

2 References

- [1] Manual on Flight and Flow Information for a Collaborative Environment, ICAO Doc 9965
- [2] Procedures for Air Navigation Services: Air Traffic Management, 15th edition, amendment 1, ICAO Doc 4444
- [3] ATS Message Content to FIXM Logical Model Map, v4, FIXM CCB
- [4] FIXM Strategy, v1.1, FIXM CCB
- [5] FIXM Change Management Charter, v1.1, FIXM CCB
- [6] FIXM Modelling Best Practices, v4
- [7] AIXM 5.1 web site, www.aixm.aero
- [8] FIXM web site, www.fixm.aero
- [9] PAN Regional (NAT and APAC) Interface Control Document for ATC Interfacility Data Communications (PAN AIDC ICD), version 1.0

3 Content vs. Presentation

The intent of FIXM is to model the information elements and structure of flight information. That is, the concern is what constitutes a flight, and how the elements relate to each other. FIXM does not dictate how that flight information is packaged, transmitted, used or presented to human stakeholders. The physical FIXM model is encoded as Extensible Markup Language (XML). XML is aimed at system-to-system communication. While humans can read XML, it is not designed for human consumption. Certainly, a flight dispatcher or air traffic controller would never be exposed to FIXM XML. Rather, a user interface would be provided for such stakeholders, which presents the content of the FIXM encoded flight information in an operationally meaningful manner.

FIXM reflects modern best practice: content and presentation should be separate concerns. The benefit of such an approach is that development of the FIXM model can focus purely on content. Model development is not distracted by issues such as whether a FIXM encoded flight is directly understandable by a human; the concern is "what is a flight".

The related Aeronautical Information Exchange Model (AIXM) and Weather Information Exchange Model (WXXM) standards for resource and environmental information exchange similarly focus on content and structure.

Another contemporary flight information standard, developed by Eurocontrol, now adopted worldwide, is the All Purpose Structured Eurocontrol Surveillance Information Exchange (ASTERIX) messaging format. ASTERIX provides a framework in which 'categories' addressing different surveillance information is defined. ASTERIX defines a binary format, and, like FIXM, it is concerned only with content and structure, not presentation.

3.1 Example: ATS Messages

Some aviation standards pre-date the practice of separating content and presentation, and indeed pre-date the widespread use of computers. An example of such a standard, and one that is highly relevant to FIXM, is Air Traffic Services (ATS) messages as defined in ICAO Doc 4444 [2]. ATS messages contain considerable information about a flight, as described in appendix 3 of ICAO Doc 4444, but are, in addition, a presentation format that is employed directly by operational stakeholders. As a consequence, changes to ATS message format must address both the concern of content and the concern of presentation.

The 2012 update to the ATS message definition highlighted the difficulties when content and presentation are inextricably linked. The primary driver for the ATS message definition update was the lack of ability to communicate the navigation, communication and surveillance capabilities and equipment available on modern aircraft. The revision could not simply focus on what new equipment and capabilities needed to be expressed; it also needed to consider how those additions would appear in the presentation format of the messages. The ATS message format is largely unchanged for a considerable time, and is an uneasy mix of well-defined fields and free text-oriented fields. Significant additions can only be added as extra items to field 18.

The FIXM model is not restricted by the legacy message format, and can focus on the content and structure of the information. Field 10a of ATS messages contains navigation and communication capabilities and equipment, but because all such information cannot be encoded in the limited presentation format of field 10a, various items in field 18 provide additional information on navigation and communication; they are NAV, COM, DAT and PBN. FIXM provides a single structure to represent all navigation and communication capabilities related to the aircraft conducting a flight. All relevant information is co-located; it is not distributed throughout the model.

4 Structure vs. Custom Decoding

It is stated in the FF-ICE manual [1]:

Inefficient constraints, such as fixed data lengths or free text information, should be minimized.

The direction espoused by this statement is that representing flight information in a textual format which must be decoded¹ should be avoided whenever possible. Legacy formats in aviation suffer significantly from the presence of text that needs to be decoded. In the present context this is most readily seen in field 15 (route) and various field 18 items in ATS messages. Whenever such text is present, any receiving system, in order to benefit from the operational content, must decode the text to extract the embedded information. In general, the ATS message information is received by multiple stakeholders, and is decoded multiple times, with different systems applying different rules and logic leading to misinterpretation and ambiguity. At worst, this could lead to safety incidents.

¹ In legacy messages this is often driven by the need for the text to be human readable.

The point in employing a formal language such as XML for the representation of information is that the structure and individual data values are delineated by the data representation format. The XML together with the associated schema precisely and unambiguously identify the structure of the information and allow the primitive data values to be easily identified. As a result, the intent of the originator of the information is clear, and the receiver is able to process the information as intended by the originator.

Another example of a problematic legacy format is the Notice to Airmen (NOTAM) that often contains large areas of unstructured or semi-structured free text in the E field. Validation of the content of NOTAM is largely a manual process due to the lack of rules around the free text E field item. The AIXM [7] explicitly addresses this problem with the introduction of the Digital NOTAM concept in version 5. The various changes to the base resource information have been analysed and codified as 'events', allowing the precise and unambiguous representation of the intent of a NOTAM.

FIXM must achieve for flight information what AIXM achieves for aeronautical resource information. As such, the inherent structure of any flight information must be made explicit in the model. Multiple values must never be coalesced into a single data element that requires a receiver to decode via custom business logic.

It is acknowledged that, at times, it is advisable to allow free text items to support legacy systems during the transition to FF-ICE.

4.1 Example: Route

The following example was discussed early in the development of FIXM.

A question was raised concerning the representation of flight plan routes in FIXM. FIXM defines a route structure in which a decoded ICAO flight plan route (field 15c) can be represented. The FIXM route class also includes a string attribute in which the field 15c route text can be stored. It was suggested early on that the route string be mandatory and the decoded route be optional. Such an approach would clearly make the traditional route string of prime importance, and the decoded route of secondary importance.

Were route strings to be passed around as the primary artefact, it would mean recipients of flight information who need to know the details of a route must parse the string to create a decoded structure. Repeated processing of the route string by multiple stakeholders opens the possibility of misunderstanding and error. The originator of a flight fully understands the intent of the route. If the originator provides the route as a decoded structure and that structure is always passed around then there is no ambiguity as to the intent of the route. If the originator provides the route as a string, then downstream stakeholders must rely on parsing of the route in a manner that is consistent with the originator to ensure consistency of meaning.

The decoded structure should be the primary representation of a route, and stakeholders should be encouraged to create and exchange routes using the structure wherever possible. The route string should only be used when necessary to support legacy systems.

Note that while legacy systems may not implement FIXM, they will generally store and provide a route as a decoded structure in a bespoke format (such as database schema, programming language class, or alternate XML schema). In such cases it is more reliable to translate between the bespoke format and FIXM than the route string and FIXM.

4.2 Example: Name-Value Pairs

FIXM v2 incorporated an *additional flight information* attribute that was a list of arbitrary name-value pairs. This allowed a stakeholder to model any custom data in an unstructured manner in the

FIXM core. For example, some regions have additional ATS field 18 items over that defined in ICAO Doc 4444. The additional flight information could be used to model these extensions to ICAO Doc 4444, but any structure in the items would be lost since the values are free text.

Name-value pairs were subsequently dropped from FIXM, recognizing that these stakeholder specific features should not be represented in an unstructured manner in core, and that the correct modelling approach is to create an extension.

5 Model and Legacy Concerns

As a result of the need to support legacy approaches during the transition to FF-ICE operations, at times it may be judicious to introduce components in the FIXM model that do not directly contribute to the FF-ICE operations, but which facilitate integration of legacy systems and formats. This may not always be consistent with a purist FIXM approach, and some guidelines are needed to help resolve such situations.

If a significant change to the model was proposed to provide a relatively small benefit for a legacy approach, we clearly would not want such a change. On the other hand, if a small change to the model provides very significant benefit for legacy systems, then there is strong justification for incorporating the change in the model. Less clear is the situation where the change to the model and the benefits to legacy stakeholders are of a similar magnitude. Such cases should be addressed by the CCB on an individual basis (as in the case of flight rules, section 5.1).

One option available is that when modifications to the model are proposed purely to assist legacy systems, that those modifications be implemented as FIXM extensions. Where this is relevant to individual stakeholders, it is a local concern and would not be considered for the global FIXM. However, where such a change is relevant to multiple stakeholders, then the required change could become a verified FIXM extension, endorsed by the CCB, and included in the FIXM release package.

5.1 Example: Flight Rules

There are two kinds of flight rules: Instrument Flight Rules (IFR) and Visual Flight Rules (VFR). Flight rules are contained in field 8a in ICAO Doc 4444 ATS messages. In that context there are four values: I, V, Y, Z. I and V correspond to IFR and VFR, respectively. Y and Z are not strictly speaking flight rules. They are, rather, compound values that communicate further information. Y indicates the flight will be conducted under IFR initially, changing to VFR at some point, and Z indicates the flight will be conducted under VFR initially, changing to IFR at some point. In the case of Y and Z, the point at which the flight rules change is indicated in the route (field 15c).

Y and Z benefit a human stakeholder in that there is an immediate indication the flight rules will change. However, they are redundant values: knowledge of the initial flight rules (IFR or VFR) together with the route indicating where the rules change provides the same information content. As noted in section 3, FIXM is an information model, not a presentation format. It is concerned with the information content and structure, not with how that information is presented. The conclusion drawn is FIXM should not encode directly values Y and Z.

Up to FIXM v3 this is the approach that was adopted. However, with the release of v4 there is an expectation that many stakeholders with ATS message processing systems will start to investigate migration of implementations to FIXM, or provide FIXM translation layers. In order to minimise implementation effort, it was decided FIXM would support Y and Z as per ATS messages.

A consequence of supporting legacy systems is that FIXM incorporates redundant items, and external business rules are required to ensure model integrity, but this is considered an acceptable trade-off for the benefits provided to stakeholders.

6 Historic vs. Snapshot

During the development of FIXM, there have been discussions concerning whether a FIXM flight document provides a snapshot of a state of the flight, or a historic picture of the flight.

FIXM has adopted the approach that a flight document is a snapshot of the flight containing the information known about the flight at a point in time. However, this approach can be relaxed where specific use cases dictate it is desirable to hold limited historic information. Such information elements must be endorsed by the CCB.

In earlier versions of FIXM a small amount of historic information was maintained, but as of v4 there is none.

If one considers the wide variety of information elements that constitute a flight, and the rate at which these values can change, adopting a 'historic' model would lead to a very large flight information document that could become unwieldy. The maintenance of historic flight information is considered a system implementation concern.

6.1 Example: Flight Position

Consider the location of a flight, which was captured in the FIXM en-route information up to v3. Adopting the snapshot approach would provide a single element in which to record the latest known four-dimensional position (timestamp, latitude, longitude and altitude). Adopting the historic approach would provide a history of all known positions of the flight, from all available sources (e.g. surveillance, aircraft reported). There could easily be thousands of position reports for a single flight. FIXM avoids issues associated with multiple position reports by taking the snapshot approach. Maintenance of historic information is a stakeholder responsibility.

The example of flight position reports applies not only to the flight information domain, but also to the surveillance information domain. The exact relationship between the flight and surveillance information domains is yet to be clarified.

7 Core vs. Extension

The distinction between FIXM core elements and FIXM extensions is defined in the FIXM strategy document [4]. The definition seeks to provide a guideline to remove, where possible, subjectivity when deciding whether an element is justified for inclusion in the FIXM core. An extension may be classed as 'verified' by the CCB, meaning it is subject to the same governance process as the core, and potentially may be promoted to core at a future date. Verified extensions are included in a FIXM release package.

Other extensions that are specific to individual or small groups of stakeholders may be developed, but they are not subject to the FIXM governance, are not endorsed by the FIXM CCB, and not included as part of a FIXM release package.

7.1 Example: ATC Interfacility Data Communications (AIDC) Messaging

AIDC messaging concerns the exchange of information between ATM Services Providers (ASPs) for boundary crossing and transfer of control of flights as they pass between different areas of responsibility. The PAN AIDC ICD [9] provides global guidance for AIDC messaging and is published by ICAO, but it is not a document that has been formally endorsed by an ICAO panel, nor is it in scope for FF-ICE Block 1. As such, it does not meet the criteria for inclusion in FIXM core. However, the information is of relevance to stakeholders in multiple ICAO regions so AIDC message content is a candidate to become a verified extension.

8 Reuse of Standards

FIXM does not exist in a vacuum. It co-exists with many other standards, the two most closely related being AIXM and WXXM. FIXM development should be cognizant of the content of these related standards, and seek to re-use definitions where possible rather than creating its own definition for the same concept. Redefinition leads to redundant elements, and ambiguity if the competing definitions are not consistent.

The harmonization of AIXM, FIXM and WXXM is a desirable goal. However, such harmonization is a large undertaking with significant impact on the model. As of FIXM v4 the focus has been to create semantically equivalent elements in the FIXM model.

The same approach applies to standards that have more of a foundational nature. For example, the Geography Markup Language (GML) captures generic definitions that are applicable to aviation, such as the location of an aerodrome, the route of a flight, or the description of the bounds of airspace.

An associated standard is the International Air Transport Association (IATA) Aviation Information Data Exchange (AIDX) standard. This standard is widely employed by aircraft and airport operators, but is also applicable to ASPs for information exchange with these operators. AIDX has a different focus than FIXM; for example, it incorporates data elements for baggage handling and catering. However, there is an overlap between AIDX and FIXM, and where they overlap semantic consistency should be achieved. Different design approaches have been adopted for AIDX and FIXM, and it seems unlikely they will be harmonized in the manner planned among AIXM, FIXM and WXXM.

8.1 Example: Aerodrome

An aerodrome is comprehensively defined by the AIXM feature *AirportHeliport*. FIXM has its own, far simpler, definition of aerodrome. FIXM is only concerned with a small set of aerodrome information (such as designator, name and location), whereas AIXM is concerned with all aspects (such as runways, aprons and taxiways).

9 Guidelines

Based on earlier discussions, this section provides guidelines to assist with model development. The guidelines are presented at a high level, providing general principles. The guidelines are not concerned with how the content is expressed using the Unified Modelling Language (UML). That topic is addressed in the FIXM Modelling Best Practices [6].

These are guidelines rather than requirements. As such, exceptions are possible. However, exceptions should be made explicit and justified.

1) The FIXM model should at all times be driven by content and structure concerns.

As discussed in section 3, FIXM is only concerned with information modelling. The presentation of that information does not influence the construction of the model. Other considerations like how the information is packaged, transmitted or used should not influence the way the information is modelled.

As FIXM evolves it will become necessary to address messages and services to ensure global interoperability. A first step towards addressing message packaging concerns has been incorporated in FIXM v4.

2) The FIXM model should avoid unnecessary complexity.

Complexity inhibits understanding and increases implementation effort. The less complex the model, the less likely information exchange results in different or ambiguous interpretation.

3) The FIXM model should be compatible with existing ICAO standards.

Existing standards, even if it is planned they be phased out through FF-ICE, will continue to be employed for some time. FIXM must be able to interoperate with these standards during transition.

Note this does not mean FIXM must directly mimic those standards, just that it be semantically compatible.

4) The FIXM model should delineate primitive values in the structure of the model.

It should not be necessary to decode or parse primitive values in the model to extract information content. Multiple primitive values should not be coalesced into a single compound value encoded in a string.

5) The FIXM model should not be influenced by the concerns of a single or small group of stakeholders.

FIXM is a global standard for information exchange. The incorporation of requirements for individual or small groups of stakeholders would inevitably lead to an explosion in the complexity of the model. The extension mechanism is available to address the specific needs of stakeholders.

6) The FIXM model should allow the representation of a snapshot of the most up to date information known about the flight.

The FIXM model allows the most accurate known information about the flight to be disseminated. All stakeholders will not necessarily hold all information about a flight, but the model should allow each stakeholder to represent the most up to date information they hold.

7) The FIXM model should not contain historic information about a flight except where specific use cases make such information desirable.

Modelling should include specific historic information in the core where the inclusion of such information is justified and of common interest. That justification must be explicit and documented to avoid excess complexity, and avoid FIXM XML documents growing to an unmanageable size.

8) The FIXM model should limit redundancy of information.

Redundant information is a source of model inconsistencies that can result in misunderstanding, ambiguity, and incorrect information usage. Redundancy also increases object size and entails business rules external to the model.

9) The FIXM model should be constructed to facilitate the creation of extensions.

As is noted elsewhere, there are cases where it is necessary to allow the model to be extended to support legacy operations/systems/standards. The model should not place an undue burden on those who would create extensions.

10) Content must be in scope.

Each release of FIXM incorporates new elements as defined in the FIXM roadmap. All content added must trace to the scope approved by the CCB.

11) If an entity in FIXM is directly related to an entity in AIXM, FIXM will import the AIXM definition, or define its own version, semantically equivalent to the AIXM definition.

Ideally FIXM would directly import concepts from AIXM, but such incorporation is a significant undertaking and has wide reaching consequences. For practical purposes, FIXM (as of v4) defines its own constructs, which are equivalent to AIXM.

12) If an entity in FIXM is directly related to an entity in WXXM, FIXM will import the WXXM definition, or define its own version, semantically equivalent to the WXXM definition.

Ideally FIXM would directly import concepts from WXXM, but such incorporation is a significant undertaking and has wide reaching consequences. For practical purposes, FIXM (as of v4) defines its own constructs, which are equivalent to WXXM.

13) If an entity in FIXM is directly related to an entity in GML, FIXM will import the GML definition, or define its own version, semantically equivalent to the GML definition.

Ideally FIXM would directly import concepts from GML, but such incorporation is a significant undertaking and has wide reaching consequences. For practical purposes, FIXM (as of v4) defines its own constructs, which are equivalent to GML.

14) Information elements of the model must be based on concepts from the ICAO ATM Information Reference Model (AIRM).

The AIRM captures concepts for all features that eventually will be included in FIXM. A model element must trace to the AIRM, except where the model element is introduced purely as a 'container' element.

As of FIXM v4 the AIRM is still under development so the mapping from FIXM to AIRM has yet to be performed.

15) Information elements in FIXM must be semantically consistent with corresponding elements in AIDX.

AIDX is widely used by airport and aircraft operators. To facilitate interoperability, FIXM should ensure semantic consistency with concepts in AIDX where the two standards overlap.

16) Exceptions are possible.

Notwithstanding the previous guidelines, exceptions are possible where justification is provided. Exceptions must be approved by the FIXM CCB.

10 Definitions

AIDC	ATC Interfacility Data Communications
AIDX	Aviation Information Data Exchange
AIRM	ATM Information Reference Model
AIXM	Aeronautical Information Exchange Model
ASP	ATM Service Provider
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ATM	Air Traffic Management
ATMRPP	Air Traffic Management Requirements and Performance Panel
ATS	Air Traffic Services
CCB	Change Control Board

FF-ICE	Flight and Flow Information for a Collaborative Environment
FIXM	Flight Information Exchange Model
GML	Geography Markup Language
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
NOTAM	Notice To Airmen
UML	Unified Modelling Language
VFR	Visual Flight Rules
WXXM	Weather Information Exchange Model
XML	Extensible Markup Language