Background on the Aeronautical Information Exchange Model (AIXM) “Temporality Model”

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Temporality Modeling

• What this *is*:  
  - Applying a time-based schedule to individual aspects of an information or data model  
  - Allowing for absolute-time and periodic (*e.g.* daily and weekly) state changes  
  - Following existing best practices and interacting with existing scheduled data sets, tools, and workflows  
  - An interface that isolates the *producers* of state from *users* of state information

• What this *is not*:  
  - Explaining *why* a feature is changing, only *how* it changes over time  
  - Co-relating changes across multiple features, which can be *expressed* by a temporal model but not *enforced* by it  
  - Forcing a specific information- or data-model on to TVR  
  - Forcing a specific notion of periodicity on to TVR
AIXM Origination

• The Aeronautical Information Exchange Model (AIXM) has existed in current form since 2010
  - The Temporality Model is an extension developed specifically to communicate permanent and temporary planned states for aeronautical systems forward in time

• The temporality model is a joint standard developed by US FAA and EUROCONTROL to enable digital Notice To Air Missions (NOTAM)
  - From AIXM version 5 documentation:
    “Time is an essential aspect on the aeronautical information world, where change notifications are usually made well in advance of their effective dates. Aeronautical information systems are usually requested to store and to provide both the current situation and the future changes. The expired information needs to be archived for legal investigation purposes.”

• The original application was NOTAM but the concepts apply generally to any scheduled time-varying system

• This same technique has been employed in link planning tools for GEO, MEO, and LEO satellite fleets
  - Use cases are commercial and cruise shipping as well as passenger airliners
  - No additional standardization activity has been attempted in those domains

Later figures are excerpted from “AIXM version 5.1 Temporality Concept” document https://aixm.aero/sites/aixm.aero/files/imce/AIXM51/aixm_temporality_1.0.pdf
AIXM Temporality Model Structure

• Information areas of AIXM include:
  - Aerodrome/heliport areas, services, facilities
  - Airspace structures
  - Points and Navigation aids
  - Procedures
  - Routes

• These all vary with time, and are inherently planned
  - Test events and outages are planned
  - Failures and emergencies still occur

Features represent AIXM information areas (e.g., an airport runway)

Feature properties include status or operational parameters (e.g., runway status or frequency of comms coordination)

These are communicated through NOTAMs, though before the temporality model this was freeform text
AIXM Temporality Model Terminology

- **Feature**: the model entity representing a single independent object
- **Property**: individual part of a feature which can change over time
  - **Value**: the atomic state of a property
- **Schedule**: the time-varying nature of a property value, including
  - **Valid** start and stop absolute time
  - **Active** time intervals with repetition; both weekly and daily
- **Overlay**: a time-bounded change to an individual property value
- **Time Slice**: a set of property values at a scheduled time instant which are aligned with a change in at least one value
  - **Baseline**: all properties valid and active at that instant
  - **Temporary**: overlay states as a change from the last-in-time baseline
- **Snapshot**: the combination of a baseline with temporary time slices at a specific instant, not necessarily aligned with any property value change
Example Schedule with Time Slices

Figure 6 – The four types of TimeSlices
Example Schedule with Repetition

Overlapping schedules with repetition can be combined for complex situations
Parameter Interpolation

• AIXM Temporality model assumes that all property values are discrete

• This may not be so for TVR use cases

• Example:
  - One way latency that changes as a function of time and position
  - Pointing vector of an antenna that is constrained by a slew rate

• Adopting something like the AIXM temporality model, may require parameters to be defined as function
  - The data model, would need to specify which functions were in scope
  - The information model, needs to define allowance of a function, and all properties for definition and interpretation
Planning Horizon Concept

• One additional aspect not defined in AIXM is the concept of a planning “horizon” which is a limit on the absolute time interval considered by the processing system.

• The purpose of a horizon is to limit computation and bookkeeping.

• This does not affect the data model, but does affect how a system processing the data will interpret it.
  - States and time slices that are outside of the planning horizon are not considered as part of the planning universe.

• In practice, a planning horizon could be designed to include the entire schedule time interval or limited in total duration.
  - For example: a system that is expected to receive schedule updates every minute may keep a planning horizon of one hour from “current real time.” That one-hour becomes a sliding window as updates occur and should be sized to capture the most relevant effects to that network.

• An important point is that this concept is not part of the data model but part of configuration of the system processing the data.
Application to TVR

- A schedule can be added to a property or group-of-properties to extend existing data models
  - For example: a MANET OLSRv2 address block could have a schedule added (as a TLV item) to indicate for what time intervals a peer link is expected to be available

- The system handling TVR data can ingest and adapt schedules and scheduled data into a consolidated time-aware data model

- Periodicity is implicit in all TVR use cases stated thus far, and defining as a model allows for compressibility and interoperability
  - The periodicity of each source of data does not necessarily need to be in exact alignment with the system processing them
  - Given a limited schedule horizon, periodic active times can be used to synthesize a set of valid times yielding the same states and same time slices
  - The AIXM model necessarily follows daily and weekly periods because that is how aviation schedules operate, a TVR model can choose differently
Conclusions

• The small number of core AIXM concepts allow expressing rich behavior in large-scale systems
  - Common terminology can make reasoning about disparate systems much easier and consistent
  - The existing model can be treated as a “menu” of available expressive capabilities from which some things could be left out (e.g. weekly variability)

• There are many different possible ways to parameterize and represent these concepts in an information or data model
  - Each representation can be tailored to specific needs of the affected protocol
  - The granularity of scheduled scope (whole feature vs. single property) can be tailored to the system

• Periodicity is important to capture, and likely needs more investigation

• TVR properties and their possible need for, or benefit from, interpolation needs more investigation

• Even temporality models that aren’t designed with AIXM in mind may be able to be adapted (possibly just terminology mapping) to interoperate with an AIXM-aligned system