TDM v3 Thoughts

Four basic categories:

* New (or improved precision) Measurement Types
* Relays
* >> Flexibility
* Updates from operational use

1. Incorporate other data types
   * Optical Imaging Navigation; requires thought on how to implement
   * CelNav – pseudo-angles to celestial objects
   * Crosslink (although not excluded in current message, no specific mention of it; how to represent the pseudo-range not from a GNSS source)
   * XNAV -- pulsars
   * Antenna angles & validity for each participant
   * Extrapolated TDM for Space Network includes “antenna\_Px” keyword, where Px is the Xth Participant’s antenna
   * Range-Rate/Doppler – Doppler is currently identified in the TDM w km/s units, which is really a range-rate unit
   * Optimetrics, SLR (consideration to ensure full rate can be accommodated; SLR’s own format for science vs in TDM)
   * Onboard Sensors (IMU/accelerometer, Magnetometer, DSS, CSS, AST, Star Camera, etc)
   * Point Solution state
2. Incorporate additional precision into existing (& new) measurement types.
3. Consider incorporating data that *enables* validation or correction of the “raw” observations, such as equipment ID for the full user, relay, and ground segment “chain” (effectively for each PATH element) (to ascertain (solve for or look-up) or apply system biases or other parameters introduced by specific components through the entire measurement path).
   * Modem, Time & Frequency Reference source (primary, backup), Data Processing Equipment, Front End (e.g. DSP equipment), local oscillator(s) in path
   * For example, in a Multiple Access system, the parameters associated with a beamformer (Fc of link, beamformer ID for bias/noise/delay/thermal (if one needs that detail)) could be variables defined by the service for a specific Track.
   * Extrapolated TDM for Space Network includes “configuration\_Px” keyword, where Px is the Xth Participant’s signal “path”
   * Receiver lock indicators (Carrier Lock, PN Synchronization, PN Lock)
   * Considerations for onboard measurements, such as data latch, local oscillator in use (and updates applied, relevant temperatures), accelerometer measurements; could even consider Point Solution state as an observation
4. Complexities come into play with relay-based systems.
   * In the SN, there are 5 legs to a “2-way” RF link: UP, FWD, RTN, DOWN, REF.
     1. The REF is based on which relay is in use for PATH participants 2 and 4. This needs to be defined in the message.
     2. The UP/DOWN links are at different Fc than the FWD/RTN links.
     3. In addition, the UP/DOWN links are composite signals, so the REF, FWD, and RTN services are assigned specific sub-bands (Fc) on the composite, and these can vary. Hence, each of these Fc’s need to be defined in the message.
   * Could be complicated by use of two different frequencies on the FWD and RTN links by the User SC
   * Need to encompass envisioned future relay systems with crosslinks
5. Operational Findings
   * Provide a keyword to identify COHERENCY for Doppler
   * RANGE\_MODE – does not only refer to tones, but to PN-based ranging systems
   * Redefine the DOPPLER data type as a frequency-based measurement with units Hz, and add a RANGE-RATE data type that is defined with units km/s (considerations for applying s and RU to range rate)
   * Allow an identification *for each data type* as to whether or not the data corrections are applied or not, as opposed to the general CORRECTIONS\_APPLIED now
6. Allow for real & near-real time messaging.

* Follow up w CSS Transfer Services for Tracking Data Service bc their development revolved around RT (1 obs per transfer) messaging. (Tim Pham/JPL completed doc)
* In line with networks that operate in a real-time status, and for future data transfer across vehicles.

1. As a follow-on, in consideration of modular messaging, consider allowing a file header that hosts multiple instantiations of meta data and data for different modules.

OPTION A:

H-

M(TDM)1-

D1-D2-D3-....Dn-

M(ACM)1-

D1-D2-D3-....Dn-

M(ODM)1-

D1-D2-D3-....Dn-

M(TDM)2-

D1-D2-D3-....Dn-

M(ACM)2-

D1-D2-D3-....Dn-

M(ODM)2-

D1-D2-D3-....Dn, etc

OPTION B:

H-

M

m(TDM)1-

D1-

m(ACM)1-

D1-

m(OCM)1-

D1-

M(TDM)2-

D2-

M(ACM)2-

D2-

M(OCM)1-

D2-

M(TDM)3-

D3-

M(ACM)3-

D3-

M(OCM)1-

D3, etc

OPTION C: (not a lot of overlap among the META data’s from the various msg)

H-

MTDM/ACM/ODM-

TDMD1- (may need sub-meta data in each msg)

ACMD1-

ODMD1-

TDMD2-

ACMD2-

ODMD2-

TDMD3-

ACMD3-

ODMD3, etc

OPTION D: -- other possibilities exist...

1. Consider updates and tailoring needed for SC-to-SC exchange, e.g. via crosslink
   * This may involve a somewhat limited data structure
2. Miscellaneous:
   * Informative annex that covers material from Section 6 of Nav Green Book Defn & Conv (e.g. RMTD explanation… may include other sensor info as needed)

* Consideration for the type of tracking performed by the antenna, whether it is open loop (Program Track) or closed loop (Autotrack with an aided or unaided feedback loop) with a keyword such as “TRACK\_TYPE”
* Identify if data is real, simulated, or test
* FREQ\_OFFSET may apply to any participant in the path because it’s not always the initial Participant that performs the offset; i.e. Doppler compensation can be performed onboard the orbiting user vehicle (perhaps Participant 3) or on the ground by Participant 1 or 5 or...
* Identify which link power parameters (e.g. Pr/No) apply to, esp in relay system (SSL or SGL)
* Include a link to other MESSAGE\_ID that the TDM references (relay-type ephem, almanac…)
* From US Space Policy Directive 3: Data integrity measures to ensure data accuracy and availability
* Standardized formats to enable development of applications to leverage the data.
* but also incorporate sections to address operating practices for large constellations, rendezvous and proximity operations, small satellites, and other classes of space operations
* On-orbit tracking aids, including beacons or sensing enhancements, if such systems are needed;