



The CCSDS Navigation Working Group and Space Situational Awareness

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Purpose



- Discuss the process of developing standards for the international community within the Consultative Committee for Space Data Systems (CCSDS)
- Introduce the technical program of the CCSDS Navigation Working Group
- Provide examples of the application of CCSDS standards to the objectives of Space Situational Awareness



- CCSDS is a multi-national forum for the development of communications and data systems standards for spaceflight
- Founded in 1982 by the world's major space agencies
- Formally affiliated with the International Organization for Standardization (ISO TC20/SC13)
- www.ccsds.org – general web site of the CCSDS
- Consists of 6 general “Areas”
- Areas are partitioned into approximately 30 smaller groups called “Working Groups” (WG), “Special Interest Groups” (SIG) and “Birds of a Feather Groups” (BOF)
- The Navigation Working Group is chartered to produce CCSDS Recommendations related to the formatting and exchange of flight dynamics data



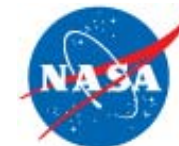
- A “Concept Paper” suggests a need for standardization
- A Working Group develops material via an iterative, consensus process
- Recommendation documents go through several stages: Proposed (“White”), Draft (“Red”), Final (“Blue”)
- White Books are internal to the Working Group
- When White Book matures (1-3 years), promote to Red Book
- Formal Agency Review process commences (3-4 months)
- At least two interoperable prototypes must be developed (6 months to 1 year)
- Promotion to Blue Book (2 months)
- Blue Books are introduced into the ISO standards process at advanced stage (DIS/FDIS)



Navigation WG Community



- The CCSDS Navigation Working Group has had regular participation from several space agencies/organizations:
 - CNES
 - DLR
 - ESA
 - JAXA
 - NASA (JPL, GSFC, JSC)
 - ISO TC20/SC14/WG3 (Nav WG “sister organization”)
- Commercial and military support are sponsored by an agency (e.g., GMV, USAF)
- Note: Not all CCSDS member agencies participate in the Navigation WG (though they are welcome to do so)



- The ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth, with the objective of avoiding collisions
- Prominent concern for all owners/operators of space systems
- Problems with space debris have attracted the attention of military, government, commercial, and international diplomatic organizations
- SSA completely relies on data of several sorts, including:
 - Observational data from tracking spacecraft and debris
 - Trajectories of spacecraft and debris
 - Communicating analyses of potential collisions



- CCSDS emphasis is on development of EXCHANGE formats used for sharing of spaceflight dynamics data
- Exchanging data in standardized formats facilitates rapid processing of complex data
- CCSDS Standards related to SSA
 - Tracking Data Message (TDM)
 - Orbit Data Messages (ODM)
 - Conjunction Data Message (CDM)
 - Spacecraft Maneuver Msg (SMM, White Book)

- Standard message format for exchanging tracking data used in orbit determination
- TDM supports widely used ground-based radiometric tracking data types:
 - Uplink/downlink frequencies
 - Doppler
 - Range
 - Antenna angles
 - VLBI
- TDM also includes ancillary information used in the orbit determination process to remove systematic biases
 - Meteorological data (temperature, pressure, humidity)
 - Media delays (troposphere, ionosphere)
 - Clock bias/drift



- Three standard message formats for exchanging orbit descriptions
- Orbit Parameter Message (OPM) is a state vector
 - Position/velocity at epoch
 - Must be propagated to derive an arbitrary state
- Orbit Mean Elements Message (OMM) is an orbit state
 - Mean Keplerian elements
 - Must be propagated to derive an arbitrary state
- Orbit Ephemeris Message (OEM) is an ephemeris
 - Position/velocity at multiple epochs
 - Must be interpolated to derive an arbitrary state
 - Perhaps best format for SSA



- Standard message formats for transmission of conjunction assessment data
- Warn spacecraft operators of pending close approaches between their spacecraft and another space object
- Provides information spacecraft operators can use to decide whether and how to maneuver to avoid collisions
- Includes:
 - Identification for 2 space objects (spacecraft, debris)
 - Time of Closest Approach (TCA)
 - Miss Distance
 - Object states at TCA in standard reference frames
 - Covariance matrices of the two space objects at TCA
 - Much optional data providing context for analysis
- Promotion to Blue Book should occur in Spring 2013



Spacecraft Maneuver Message (SMM)



- Standard message formats for exchanging maneuver summary information
- Can exchange information on predicted or reconstructed trajectory and attitude maneuvers
- Very early in the standards development process, but it is the next logical step in the SSA related standards suite

Notional SSA Operations Model

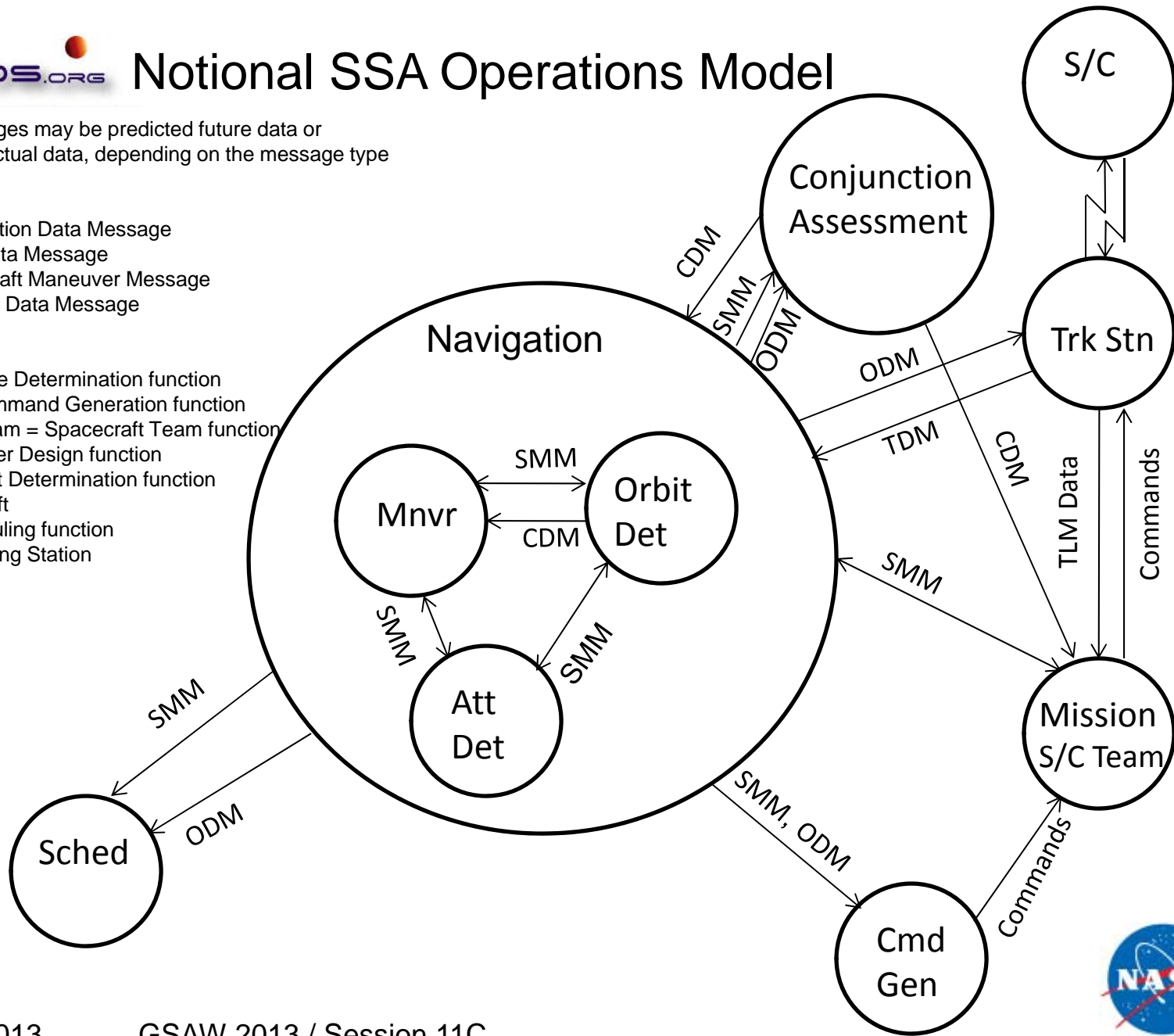
NOTE: Exchanges may be predicted future data or reconstructed actual data, depending on the message type

Messages

- CDM = Conjunction Data Message
- ODM = Orbit Data Message
- SMM = Spacecraft Maneuver Message
- TDM = Tracking Data Message

Functions

- Att Det = Attitude Determination function
- Cmd Gen = Command Generation function
- Mission S/C Team = Spacecraft Team function
- Mnvr = Maneuver Design function
- Orbit Det = Orbit Determination function
- S/C = Spacecraft
- Sched = Scheduling function
- Trk Stn = Tracking Station



Why We Care!

