

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

Maneuver Planning Message

1. Use Cases of MPM
 - a. Notification of Future Maneuver
 - i. Request MOC schedule block(s) of tracking network time for maneuvers, notify tracking networks of potential critical event
 - ii. Notify Scientists and other users that data is going to be ratty or unavailable
 - b. Notify Conjunction Assessment team a maneuver will be taking place
2. Required:
 - a. Originator, Object Name, Object ID, Time System, Creation Date
 - b. Maneuver ID, Start Epoch & Duration
3. Optional:
 - a. Purpose of maneuver
 - b. Desired changes in selected elements (apo raise, etc)
 - c. Coord system (Center & Ref Frame), dV or dH magnitude & direction or component in each axis
 - d. OD & Attitude states (with coord sys) used to plan mnvr (can be epoch only, full Cart or Kepl state, or even just ID)
 - e. Initial sc mass, final sc mass or change in mass
 - f. Orbit & Attitude states (with coord sys) at ignition, at end of burn

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

MPM Use Case 1: Notification of Stationkeeping Maneuver/Mnvr Request

CCSDS_MPM_VERS = 1.0
COMMENT Generated by GSFC FDF
COMMENT Maneuver Notification: SK09 Sequence

CREATION_DATE = 2014-10-01T12:33:22.123
ORIGINATOR = NASA
OBJECT_NAME = TerSat
OBJECT_ID = 2009-123A
TIME_SYSTEM = UTC

COMMENT SK09 Maneuver Sequence
NUMBER_OF_MANEUVERS = 5

COMMENT First maneuver: Slew to SK09a attitude
MAN_NAME = SK09a_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:00:00.00
MAN_DURATION = 600.00 [s]

COMMENT 2nd maneuver: SK09a
MAN_NAME = SK09a_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T09:15:00.00
MAN_DURATION = 712.20 [s]

COMMENT 3rd maneuver: SK09b attitude
MAN_NAME = SK09b_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:45:00.00
MAN_DURATION = 1200.464 [s]

COMMENT 4th maneuver: SK09b
MAN_NAME = SK09b_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T10:15:00.00
MAN_DURATION = 687.40 [s]

COMMENT 5th maneuver: Return to Sci Attitude
MAN_NAME = SK09_SCI_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T10:15:00.00
MAN_DURATION = 300.264 [s]

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

MPM Use Case 2: Notification of Future Maneuver to Conjunction Assessment

CCSDS_MPM_VERS = 1.0
COMMENT Generated by Generic Flight Dynamics
COMMENT Maneuver Notification: TerSat StationKeeping 09
CREATION_DATE = 2014-10-01T12:33:22.123
ORIGINATOR = NASA
OBJECT_NAME = TerSat
OBJECT_ID = 2009-123A
TIME_SYSTEM = UTC
COMMENT Spacecraft parameters
MASS = 1234.567 [kg]
SOLAR_RAD_AREA = 10.000 [m**2]
SOLAR_RAD_COEFF = 1.300
GM = 398600.4415 [km**3/s**2]

COMMENT Initial State Vector Cartesian
CENTER_NAME = Earth
REF_FRAME = EME2000
TIME_SYSTEM = UTC
EPOCH = 2014-10-13T00:00:00.000
X = 6655.9942 [km]
Y = -40218.5751 [km]
Z = -82.9177 [km]
X_DOT = 3.11548208 [km/s]
Y_DOT = 0.47042605 [km/s]
Z_DOT = -0.00101495 [km/s]

COMMENT SK09 Maneuver Sequence
NUMBER_OF_MANEUVERS = 2
COMMENT 1st maneuver: SK09a
MAN_NAME = SK09a_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T09:15:00.00
MAN_DURATION = 712.20 [s]
MAN_CENTER = EARTH
MAN_REF_FRAME = EME2000
MAN_DV_1 = -0.00200 [km/s]
MAN_DV_2 = -0.00300 [km/s]
MAN_DV_3 = 0.00100 [km/s]

COMMENT 2nd maneuver: SK09b
MAN_NAME = SK09b_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T10:15:00.00
MAN_DURATION = 687.40 [s]
MAN_CENTER = EARTH
MAN_REF_FRAME = EME2000
MAN_DV_1 = -0.00600 [km/s]
MAN_DV_2 = 0.00100 [km/s]
MAN_DV_3 = 0.00000 [km/s]

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

Use Cases of MDM

- 1) FDT to MOC to provide maneuver command parameters
- 2) FDT to OD/MOC to generate predicted orbit with maneuvers
- 3) FDT to ACS/MOC to verify attitude plan for maneuver, run through sc simulator
- 4) FDT to Propulsion Engineer/MOC for verification of initial & expected propulsion parameters
- 5) Required:
 - a. Originator, Sat Name, Sat Number, Creation Date
 - b. Maneuver ID, Start Epoch & Duration
 - c. Coord system (Center & Ref Frame), dV or dH magnitude & direction or component in each axis
- 6) Optional:
 - a. Thrusters to be used, Tanks to be used, Pressure, Temp, mass flow rate, pulse width, duty cycle, spin rate...
 - b. Purpose of maneuver
 - c. Desired changes in selected elements (apo raise, etc)
 - d. OD & Attitude states (with coord sys) used to plan mnvr (can be epoch only, full Cart or Kepl state, or even just ID)
 - e. Initial sc mass, final sc mass or change in mass
 - f. Orbit & Attitude states (with coord sys) at ignition, at end of burn

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

MDM Use Case 1: Convey Command Parameters to MOC

CCSDS_MDM_VERS = 1.0
COMMENT Generated by Generic Flight Dynamics
COMMENT Final Maneuver Plan: SK09 Sequence

CREATION_DATE = 2014-10-01T12:33:22.123
ORIGINATOR = NASA
OBJECT_NAME = TerSat
OBJECT_ID = 2009-123A
TIME_SYSTEM = UTC

COMMENT SK09 Maneuver Sequence
NUMBER_OF_MANEUVERS = 5

COMMENT 1st maneuver: Slew to SK09a attitude
MAN_NAME = SK09a_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:00:00.00
MAN_DURATION = 600.00 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = PRY
SEQUENCE = 123
MAN_ANGLE_1 = 30.00 [deg]
MAN_ANGLE_2 = 4.65 [deg]
MAN_ANGLE_3 = -90.00 [deg]

COMMENT 2nd maneuver: SK09a
MAN_NAME = SK09a_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T09:15:00.00
MAN_DURATION = 712.20 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = RTN
MAN_DV_1 = 0.00201500 [km/s]
MAN_DV_2 = -0.00187300 [km/s]
MAN_DV_3 = 0.00000000 [km/s]

COMMENT 3rd maneuver: SK09b attitude
MAN_NAME = SK09b_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:45:00.00
MAN_DURATION = 1200.464 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = PRY
SEQUENCE = 123
MAN_ANGLE_1 = 00.00 [deg]
MAN_ANGLE_2 = 0 [deg]
MAN_ANGLE_3 = 180.00 [deg]

COMMENT 4th maneuver: SK09b
MAN_NAME = SK09b_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T10:15:00.00
MAN_DURATION = 93.60 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = RTN
MAN_DV_1 = -0.0020000 [km/s]
MAN_DV_2 = 0.001900 [km/s]
MAN_DV_3 = 0.00000000 [km/s]

COMMENT 5th maneuver: Return to Sci Attitude
MAN_NAME = SK09_TO_SCI_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T10:15:00.00
MAN_DURATION = 300.264 [s]
MAN_REF_FRAME = PRY
SEQUENCE = 123
MAN_ANGLE_1 = 45.00 [deg]
MAN_ANGLE_2 = 6 [deg]
MAN_ANGLE_3 = 180.00 [deg]

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PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

MDM Use Case 2: Propulsion System to PROP Engineer for Verification

CCSDS_MDM_VERS = 1.0
COMMENT Generated by Generic Flight Dynamics
COMMENT Final Maneuver Plan: SK09 Sequence

CREATION_DATE = 2014-10-01T12:33:22.123
ORIGINATOR = NASA
OBJECT_NAME = TerSat
OBJECT_ID = 2009-123A
TIME_SYSTEM = UTC

COMMENT SK09 Maneuver Sequence
NUMBER_OF_MANEUVERS = 5
SC_MASS = 1234.229 [kg]
INITIAL_FUEL_MASS = 198.317 [kg]
PROP_MODE = BLOWDOWN

COMMENT 1st maneuver: Slew to SK09a attitude
MAN_NAME = SK09a_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:00:00.00
MAN_DURATION = 600.00 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = PRY
SEQUENCE = 123
MAN_ANGLE_1 = 30.00 [deg]
MAN_ANGLE_2 = 4.65 [deg]
MAN_ANGLE_3 = -90.00 [deg]
THRUSTER1 = AT1
THRUSTER1_ISP = 230.584
THRUSTER1_SCALEFACTOR = 0.97
THRUSTER1_DUTYCYCLE = 0.66
THRUSTER1_INIT_THRUST = 16.315 [N]
THRUSTER1_END_THRUST = 16.215 [N]
THRUSTER2 = AT2
THRUSTER2_ISP = 232.385
THRUSTER2_SCALEFACTOR = 0.988
THRUSTER2_DUTYCYCLE = 0.88
THRUSTER2_INIT_THRUST = 21.417 [N]
THRUSTER2_END_THRUST = 21.317 [N]
THRUSTER3 = AT3...
THRUSTER4 = AT4...
TANK1 = FUEL1
TANK1_PRES_START = 315 [psi]
TANK1_PRES_STOP = 314 [psi]
TANK1_TEMP_START = 20 [degC]
TANK1_TEMP_STOP = 19 [degC]
FUEL_USED = -0.211 [kg]

COMMENT 2nd maneuver: SK09a
MAN_NAME = SK09a_ORB

MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T09:15:00.00
MAN_DURATION = 92.20 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = RTN
MAN_DV_1 = 0.00201500 [km/s]
MAN_DV_2 = -0.00187300 [km/s]
MAN_DV_3 = 0.00000000 [km/s]
THRUSTER1 = OT1
THRUSTER1_ISP = 219
THRUSTER1_SCALEFACTOR = 0.96
THRUSTER1_DUTYCYCLE = 1.00
THRUSTER1_INIT_THRUST = 70.315 [N]
THRUSTER1_END_THRUST = 69.215 [N]
THRUSTER2 = AT1
THRUSTER2_SCALEFACTOR = 0.98
THRUSTER2_DUTYCYCLE = 0.07
THRUSTER2_INIT_THRUST = 16.215 [N]
THRUSTER2_END_THRUST = 15.100 [N]
THRUSTER3 = AT2...
THRUSTER4 = AT3...
THRUSTER5 = AT4...
TANK1 = FUEL1
TANK1_PRES_START = 314 [psi]
TANK1_PRES_STOP = 306 [psi]
TANK1_TEMP_START = 20 [degC]
TANK1_TEMP_STOP = 18.2 [degC]
FUEL_USED = -3.6 [kg]

COMMENT 3rd maneuver: SK09b attitude
MAN_NAME = SK09b_ATT
MAN_TYPE = ATTITUDE
MAN_EPOCH_IGNITION = 2014-10-14T09:45:00.00
MAN_DURATION = 1200.464 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = PRY
SEQUENCE = 123
MAN_ANGLE_1 = 00.00 [deg]
MAN_ANGLE_2 = 0 [deg]
MAN_ANGLE_3 = 180.00 [deg]
THRUSTER1 = AT1...
THRUSTER4 = AT4...
TANK1 = FUEL1...

COMMENT 4th maneuver: SK09b
MAN_NAME = SK09b_ORB...:

PROPOSED CCSDS STANDARD 511 SPACECRAFT MANEUVER MESSAGE
USE CASES AND EXAMPLES

Use Cases of MAM

- 1) FDT to MOC to provide maneuver reconstruction/calibration.fuel usage
- 2) FDT to Propulsion Engineer/MOC for comparison
- 3) Required:
 - a. Originator, Sat Name, Sat Number, Creation Date
 - b. Maneuver ID, Start Epoch & Duration
 - c. Coord system (Center & Ref Frame), dV or dH magnitude & direction or component in each axis
- 4) Optional:
 - a. Thrusters to be used, Tanks to be used, Pressure, Temp, mass flow rate, pulse width, duty cycle, spin rate...
 - b. Purpose of maneuver
 - c. Desired changes in selected elements (apo raise, etc)
 - d. OD & Attitude states (with coord sys) used to plan mnvr (can be epoch only, full Cart or Kepl state, or even just ID)
 - e. Initial sc mass, final sc mass or change in mass
 - f. Orbit & Attitude states (with coord sys) at ignition, at end of burn

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USE CASES AND EXAMPLES

MAM Use Case 1: Maneuver Reconstruction Report for MOC

CCSDS_MAM_VERS = 1.0
COMMENT Generated by Generic Flight Dynamics
COMMENT SK09 Maneuver Calibration Report

CREATION_DATE = 2014-10-15T20:00:12.123
ORIGINATOR = NASA
OBJECT_NAME = TerSat
OBJECT_ID = 2009-123A
TIME_SYSTEM = UTC

COMMENT SK09 Maneuver Sequence
NUMBER_OF_MANEUVERS = 2
SC_MASS = 1234.229 [kg]
INITIAL_FUEL_MASS = 197.000 [kg]
PROP_MODE = BLOWDOWN

COMMENT 1st Orbit Maneuver: SK09a
MAN_NAME = SK09a_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T09:15:02.256
MAN_DURATION = 91.80 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = RTN
MAN_DV_1 = 0.00201400 [km/s]
MAN_DV_2 = -0.00187200 [km/s]
MAN_DV_3 = 0.00000000 [km/s]
THRUSTER1 = OT1
THRUSTER1_ISP = 218.9
THRUSTER1_SCALEFACTOR = 0.985
THRUSTER1_DUTYCYCLE = 1.00
THRUSTER1_INIT_THRUST = 70.315 [N]
THRUSTER1_END_THRUST = 69.715 [N]
THRUSTER2 = AT1
THRUSTER2_SCALEFACTOR = 0.98
THRUSTER2_DUTYCYCLE = 0.088
THRUSTER2_INIT_THRUST = 16.215 [N]
THRUSTER2_END_THRUST = 15.100 [N]

THRUSTER3 = AT2...

THRUSTER4 = AT3...

THRUSTER5 = AT4...

TANK1 = FUEL1
TANK1_PRES_START = 314 [psi]
TANK1_PRES_STOP = 307 [psi]

TANK1_TEMP_START = 20 [degC]
TANK1_TEMP_STOP = 18.9 [degC]
FUEL_USED = -3.567 [kg]

COMMENT 2nd Orbit maneuver: SK09b
MAN_NAME = SK09b_ORB
MAN_TYPE = ORBIT
MAN_EPOCH_IGNITION = 2014-10-14T10:15:02.512
MAN_DURATION = 93.612 [s]
MAN_CENTER = BODY
MAN_REF_FRAME = RTN
MAN_DV_1 = -0.0020000 [km/s]
MAN_DV_2 = 0.001900 [km/s]
MAN_DV_3 = 0.00000000 [km/s]
THRUSTER1 = OT1
THRUSTER1_ISP = 218.7
THRUSTER1_SCALEFACTOR = 0.980
THRUSTER1_DUTYCYCLE = 1.00
THRUSTER1_INIT_THRUST = 69.000 [N]
THRUSTER1_END_THRUST = 68.715 [N]
THRUSTER2 = AT1
THRUSTER2_SCALEFACTOR = 0.98...
THRUSTER4 = AT4...
TANK1 = FUEL1...

etc