Multi–Purpose Crew Vehicle Program Update

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Orion Exploration Flight Test 1 (EFT–1)
Orion EFT–1 Mission Overview

DRM Ascent Overview
High Energy Entry, High Apogee, 2 Revs

Upper Stage 1st Engine Start
Upper Stage 1st Engine Cut-Off

Upper Stage 2nd Engine Start
Upper Stage 2nd Engine Cut-Off

CM/Upper Stage Separation
Upper Stage Disposal Burn
CM Translation Burn

LV/Upper Stage Sep
LAS Jettison

Upper Stage 1st Engine Start
Upper Stage 2nd Engine Start
Upper Stage 1st Engine Cut-Off
Upper Stage 2nd Engine Cut-Off

CM Translation Burn

TDRS
SARSAT
GPS

Recovery

Day-of-Launch Working Group

Boost Stage 1
Upper Stage Burn
Coast
CM Translation Burn

3
Key Mission Parameters

- Orion EFT–1
  - Launch site: Kennedy Space Center, FL
  - Launch vehicle: Delta IV Heavy (Delta IV–H)
  - Expected launch date: September 2014
  - Mission duration: 4.5 hours
  - Landing site: off coast of Baja peninsula

- EFT–1 work related to potential natural environment placards for launch/landing, including develop of Launch Commit Criteria (LCC) and a Program Requirements Document (PRD), continues.
  - Decision at 12 February 2014 Orion Vehicle Integration Team meeting was to not pursue any change in wind placard from the DSNE surface wind limit already assumed. [DSNE nominal mean wind speed value = 8.2 m/s (15.9 knots)]
Stationary Test  [August 12–16, 2013]  COMPLETED
  ◦ USS Arlington in port at Norfolk, VA.
  ◦ Successful test communication of weather data back to JSC/SMG.

Underway Recovery Test (URT)  [February 18–20, 2014]  COMPLETED
  ◦ Some primary test objectives were not met.
    • Capsule recovery operations in open sea were not demonstrated.
    • Possibility for URT–2 and maybe URT–3 being discussed.
  ◦ Weather test objectives were successful.
    • Surface weather and wave observations from Navy personnel transmitted to MCC/SMG.
    • Weather balloon launches from USS San Diego. Data distributed to onboard users and transmitted to MCC/SMG.

Crew Exploration Vehicle (CEV) Parachute Assembly System (CPAS) testing continues at Yuma Proving Ground in Arizona leading up to EFT–1.
  ◦ Latest test was on 26 February 2014.

EFT–1 launch date: September 2014
EFT–1 Upper Air Requirements

- Orion Flight Test Objectives evaluation and Best Estimate Trajectory construction conducted post flight.
  - Not real or near–real time. Provide data after the mission.
- Ground Ops
  - Real or near–real time data required at the recovery site.
- Mission Ops
  - Highly desirable for real or near–real time data.
  - MOD will produce a post–burn EFT–1 capsule Trajectory update.
    - Will produce a prediction of an EFT–1 capsule descent state vector at 50K ft (TBR).
    - No real–time wind data required for above or below 50K ft.
  - Data transfer in near–real time to JSC/MCC, SMG and others expected to be possible at no or trivial cost. E–mail !!
Underway Recovery Test

Photo credits: NASA

Photo credits: Mark Hendrickson, YPG Met Group
Day 1 at sea (18 Feb):
- Vaisala check out flight.
- IMET-3150 check out flight.
- Inter-comparison flight test.

Day 2 at sea (19 Feb):
- IMET-3150 and Vaisala flights separated by approximately 3 hours.
- Simulates decision point for Sasquatch tool user to choose between using last available landing forecast wind profile and TD-2:45 hour balloon.

Day 3 at sea End-to-End Test (20 Feb):
- TD – 8:25 hours (L-4:00) (JSC/SMG)
  - Aid upper wind profile forecast for splashdown (TD-0).
  - Supports pre-launch Heading Alignment input.
  - Initial splashdown prediction post SECO-2.
- TD – 2:45 (L+1:40) (GO)(JSC/DM)
  - Sasquatch tool input for debris avoidance.
  - Updated splashdown prediction.
- TD – 1:40 (L+2:45) (LM)
- Post-process trajectory reconstruction.
  - Persistence calculations and backup for possible subsequent failures.
- TD – 00:55 (L+3:20) (LM)
  - Post-process trajectory reconstruction.
  - CM & balloon near 45kft.
- TD – 00:10 (L+4:15)(LM) (JSC/SMG)
  - Verification balloon.
  - Input for Best Estimate Trajectory.
  - Post-process trajectory reconstruction.
  - Balloon should be at roughly same altitude as CM at main parachute deploy.

9 rawinsondes released:
- 2 IMET
- 7 Vaisala
EFT–1 Upper Air Systems
Vaisala MW31/RS92–SGP

- Yuma Proving Ground (YPG) Met Branch:
  - Same system used for NASA CPAS tests at YPG.
  - Familiar personnel, data formats, equipment, etc.
  - “Worked flawlessly, just like back here on land”.

Photos courtesy of Mark Hendrickson, YPG

Upper air equipment

Work area with Vaisala receiver and laptop

3/20/14
Inexpensive.

Evaluate for use in EM1, EM2 and subsequent missions.

Worked similar as it did on land.

Operator issues:
- Short cable length from antenna to receiver to laptop makes it less practical to track the sonde.
- User must get permission to roam around the ship to maintain signal. Cannot simply mount and track the sonde.

Data gaps:
- Appears system simply averages and smooths data.
- No discernible data loss alert.

Operational analysis and recommendation for future use forthcoming.
E-mail communication worked well.
  ◦ Upper air and surface weather data files are very small.
  ◦ Voice loop comm backup.
  ◦ Manual transfer of e-mail attachment data files to MIDDS and other locations.

“River City” – planned communication outages only hiccup in data comm plan.
  ◦ Request weather exemption from planned data outages.
Complete evaluation of IMET-3150.

EFT-1 and EM weather Flight Rule development.

Further evaluation of upper wind forecast accuracy.
  - Improve estimate of splashdown site wind profile.
    - GDAS or other model analysis at time 0 versus GFS initialization.
    - Evaluate at proposed future landing location versus EFT-1 location.

Continued operations procedures development and documentation.
Exploration Missions 1 & 2 (EM-1/EM-2)
European Service Module Program Design Review (PDR) is scheduled for late spring/early summer 2014 ahead of Orion delta PDR.

Orion delta PDR to occur mid-summer 2014.

Orion Critical Design Review expected to occur August 2015.

Current Mission Schedule (tentative):
- EM–1 scheduled for 2017.
Support Lockheed Martin as they are now on contract for SLS–SPEC–159 Baseline DSNE for EM missions.
  ◦ This version includes specification to use Earth–GRAM 2010.

Need to protect for natural environments along an ascent abort groundtrack that could cover anywhere in the Atlantic Ocean between 35° northerly and 32° southerly launch azimuths.
  ◦ EV44 looking at launch availability based on DSNE specifications.
  ◦ SMG will look at tropical cyclone statistics for the Atlantic ascent abort zones and the Pacific abort–once–around zone.

- area under groundtracks to be evaluated for natural environments (including sea states)
Orion EM Forward Work

- Continue to support Landing & Recovery testing and analyses.
- Support development of integrated Operations & Maintenance Requirements (OMRs).
- Support Orion EDL/GN&C EM Design Analysis Cycle work.
  ◦ Additional natural environment analyses are expected as Orion moves toward EM flights and nominal landings off the coast of San Diego.
- Support Orion launch/landing analyses.
  ◦ Terrestrial environments will affect launch availability, landing availability, pad aborts.
  ◦ Instrumentation such as offshore buoys and 915 MHz profiler may be necessary to support flight rules.