



# Multi-Purpose Crew Vehicle Program Update

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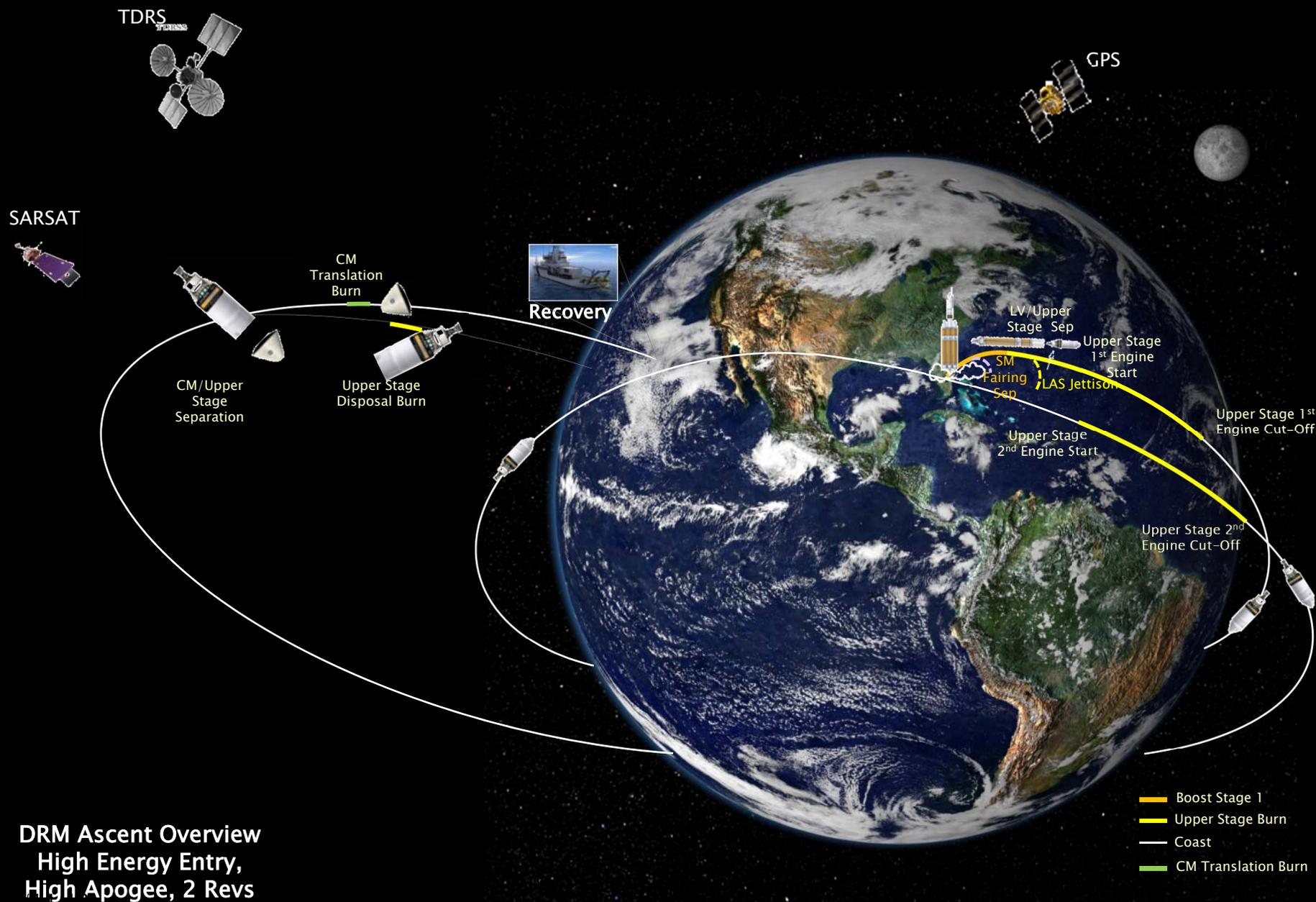
Natural Environments Day-of-Launch Working Group  
20 March 2014



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# Orion Exploration Flight Test 1 (EFT-1)

# Orion EFT-1 Mission Overview





# 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)]



# EFT-1 Program Schedule Update



- ▶ 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

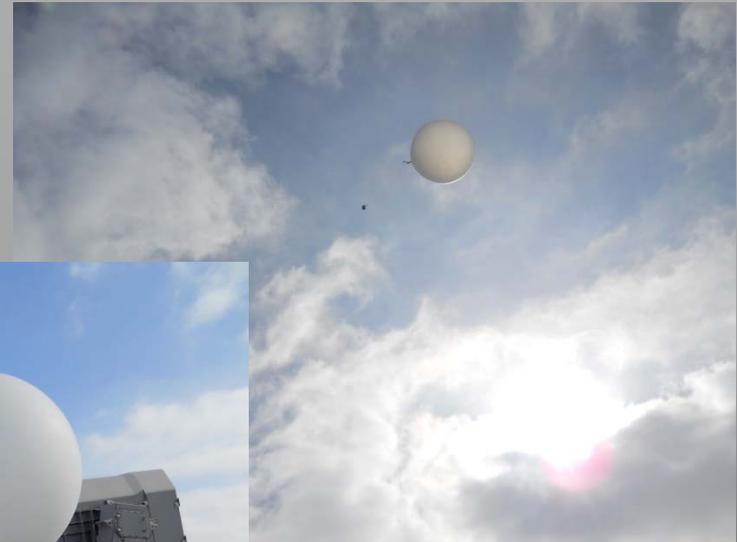


Photo credits:  
Mark Hendrickson,  
YPG Met Group



# URT Balloon Data Schedule



- ▶ **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.

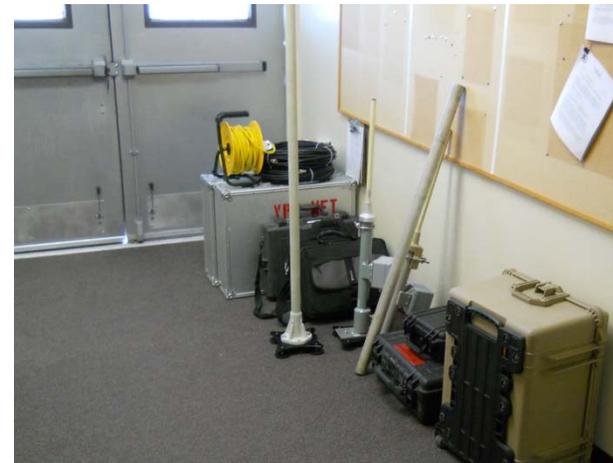
9 rawinsondes released:  
2 IMET  
7 Vaisala



# 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”.



Upper air equipment

Photos courtesy of Mark Hendrickson, YPG

Work area with Vaisala receiver and laptop





# EFT-1 Upper Air Systems IMET-3150 / iMET-1-ABx



- ▶ 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.





# Balloon Release Area



Magnetic antenna mounts for Vaisala system

Photos courtesy of Mark Hendrickson



Release area





# Upper Air / Weather Support Issues and Lessons Learned

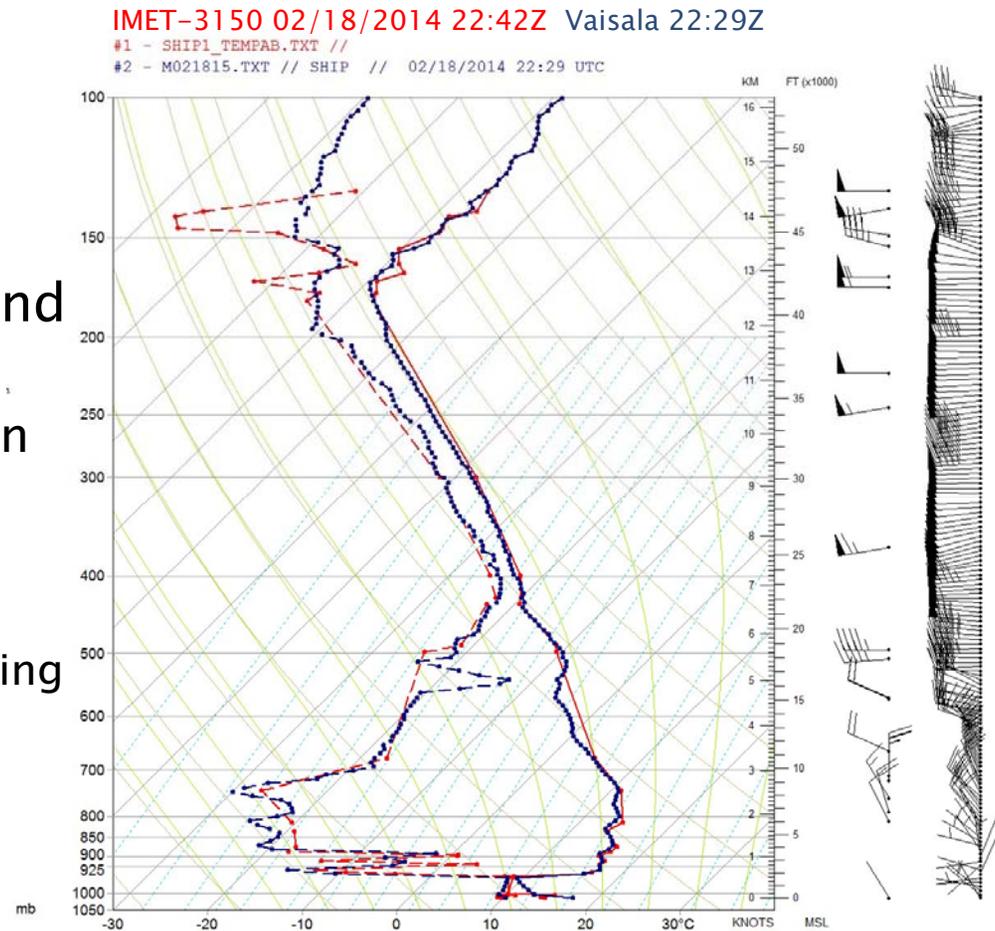


- ▶ E-mail communication worked well.
  - Upper air and surface weather data files are very small.
  - Voice loop comm backup.
  - Manual transfer of e-mail attachment data files to MIDDS and other locations.
- ▶ “River City” – planned communication outages only hiccup in data comm plan.
  - Request weather exemption from planned data outages.



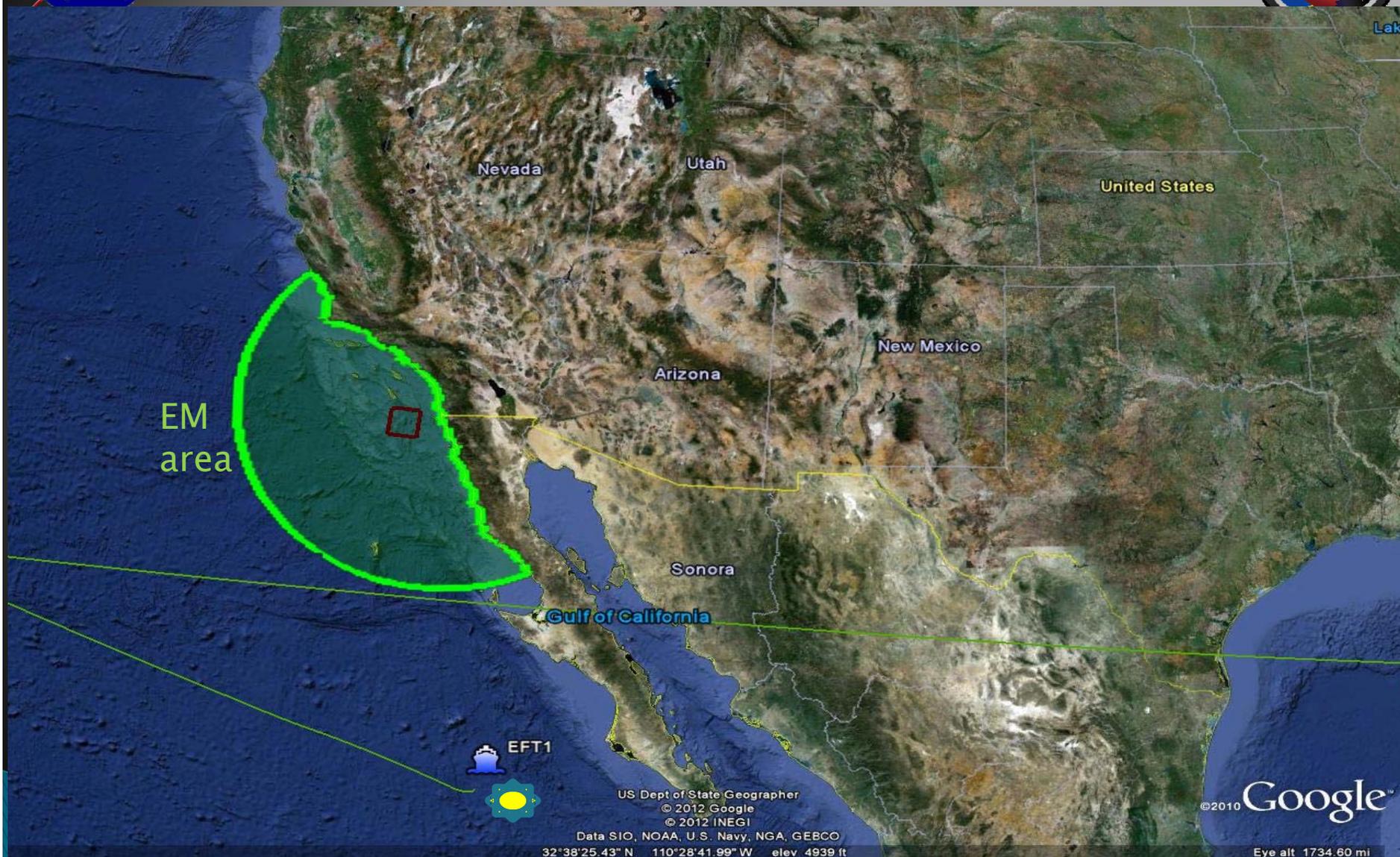
# Forward Work

- ▶ 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.





# Splashdown Locations





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# Exploration Missions 1 & 2 (EM-1 / EM-2)



# Orion EM Program Schedule

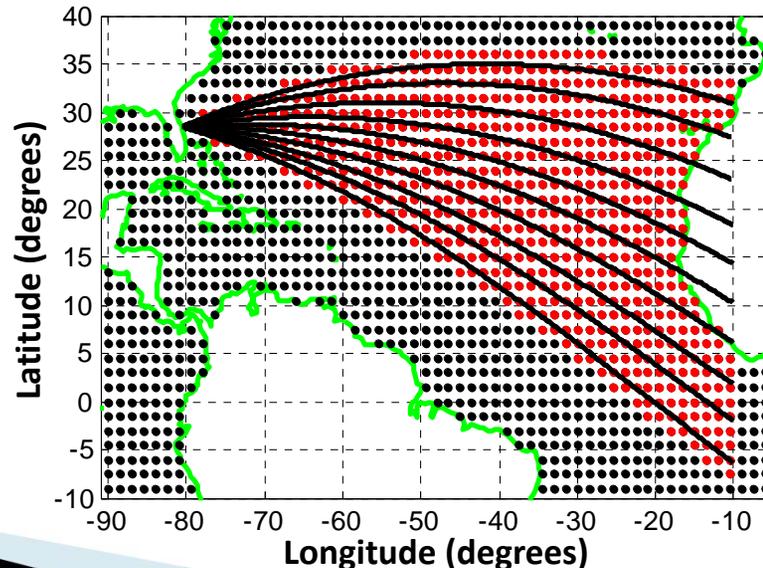


- ▶ European Service Module Program Design Review (PDR) is scheduled for late spring/early summer 2014 ahead of Orion delta PDR.
- ▶ Orion delta PDR to occur mid-summer 2014.
- ▶ Orion Critical Design Review expected to occur August 2015.
- ▶ Current Mission Schedule (tentative):
  - EM-1 scheduled for 2017.
  - AA-2 scheduled for 2018.
  - EM-2 scheduled for 2021.



# Orion EM Technical Work

- ▶ 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.
- ▶ Support Orion Weather Flight Rule development for EM missions.
  - Instrumentation such as offshore buoys and 915 MHz profiler may be necessary to support flight rules.