DATE: April 18, 2012

SUBJECT: EFT-1 Overview

LOCATION: JSC, Regents Park III

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INTRODUCTION

Mr. Mike Marsh convened the April 18, 2012, Network Support Group (NSG) Exploration Flight Test (EFT)-1 overview splinter meeting to provide a high-level overview of the EFT-1 pre-mission testing and flight testing (refer to the presentation, *EFT-1 Mission Overview*).

MEETING

A. Orion. The Orion space capsule is also referred to as the Multi Purpose Crew Vehicle (MPCV) and is being developed by Lockheed Martin (LM). For the EFT-1 flight NASA can be considered a subcontractor to LM as ownership of the capsule will not be signed-over to the government agency. EFT-1 is Orion's first full-scale test flight scheduled for April 2014. Future missions after EFT-1 will be launched on NASA's Space Launch System (SLS) booster rocket currently under development.

B. EFT-1 Mission Overview. EFT-1 will be launched on a Delta-IV from Space Launch Complex (SLC)-37B. The flight duration will last 2 orbits or approximately 4.5 hours. The first orbit is relatively circular while the second orbit is highly elliptical. Splashdown will occur off the coast of Baja. GPS, SARSAT, and the Tracking and Data Relay Satellite System (TDRSS) will be used; there will be no ground sites supporting the Orion capsule. The Delta booster will use the TEL-IV tracking station at Cape Canaveral to receive downlink telemetry for the first few minutes of ascent during the flight.

C. EFT-1 System Overview. The vehicle will consist of the Launch Abort System (LAS), Orion Crew Module (CM), upper stage, and Delta-IV heavy rocket. The second orbit will be at 3671-mile apogee. High-speed re-entry and thermal system checkout are some of the prime objectives of the flight. The CM will remain attached to the Delta-IV upper stage for most of the flight.

D. Mission Critical periods. Ascent and entry critical periods overlap so the entire flight will be considered in critical period. Deorbit burn will occur approximately 1 hour 40 minutes after launch. The CM separation from the booster will occur during re-entry.

E. EFT-1 ConOps Functional Flow.

1. The flow diagram illustrates where components are being built and integrated. The Kennedy Space Center (KSC) Operations and Checkout (O&C) Building is where final testing with the Orion assets will occur. The KSC/O&C Live Sky test will be the final view of the vehicle for several months. During the flow there will be two end-to-end "Live Sky" tests using the TDRS/White Sands assets. The first will be with the LM labs in Denver, and the second with the vehicle at KSC/O&C. Prior to each of those two tests will be a hardline (not using TDRS/White Sands Complex [WSC]) version of the same test. The Denver test is moving to January 2013.
2. Mr. Mike Fanders stated that the Launch Site Support Requirements (LSSR) covers O&C, Astro Tech, and Pad requirements. The Program Requirements Document (PRD) and Mission Support Requirements Document (MSRD) overlap for Range functions. The requirements gap is for recovery operations which no requirements have been received to date.
3. After assembly and testing is complete in O&C, the CM will move to the Astro Tech facility near KSC for mating to the LAS. From there it goes to the pad for integration onto the Launch Vehicle (LV). The LAS is mated on top of the CM and covers all four of the vehicles antenna. The Live Sky tests at O&C will be the last time the

vehicle Radio Frequency (RF) will be seen until the LAS is jettisoned six minutes into the flight. Mr. Jay Lipford asked if there will be an umbilical interface and Mr. Marsh responded that there will be. Operations will be conducted from the Johnson Space Center (JSC) Mission Control Center (MCC). Department of Defense (DoD) ships will be used for recovery. The recovery phase of the mission will be the only phase that NASA will be in charge. The spacecraft will be recovered and de-serviced on the West coast.

F. Centers Supporting EFT-1 Network testing, Sims, Mission.
   1. Centers and entities supporting are the Cape Canaveral Air Force Station (CCAFS), KSC, JSC, LM, and WSC.
   2. Facilities include SLC-37B, Morrel Operations Center (MOC), Building X-Y, O&C Building, CD&SC, JSC MCC, Mission Evaluation Room (MER), Exploration Development Lab-Houston (EDL-H), LM Littleton Colorado, and Single Access (SA) support from the Space Network (SN). TEL-IV booster support is covered by the CCAFS.
   3. Two 4.8 kbps windows of Orion data interleaved within the Delta-IV telemetry stream will be stripped and shipped to the MCC.
   4. Mr. Bob Marriott stated that the assumption has been that the Eastern Range (ER) and Western Range (WR) will provide tracking data and vectors to the Goddard Space Flight Center (GSFC) Flight Dynamics Facility (FDF) to supply to the MCC. He stated that he does not know if this has been followed up or if there has been coordination with Evolved Expendable Launch Vehicle (EELV) program. Mr. Jim Bangerter stated that he has not yet engaged the EELV program. That process will begin soon. He will work with the GSFC Network Operations Managers (NOM). The interface will be through the GSFC Spaceflight Mission Managers (SMM). A LM Point-of-Contact (POC) is needed.
   5. Mr. Marriott stated that JSC will put together a list of information it would like to have and asked that GSFC provide what it can. Mr. Bob Marriott accepted an action item to create a list of Delta/TDRSS link information JSC requires and provide to GSFC (action item 0412-NSG EFT1-01).
   6. Mr. Marsh stated that it takes the EDH-L 3 – 5 days to be able to swing their connections back to the Lockheed Martin Intranet (LMI) after interfacing with the MCC. Simultaneous interfaces with LMI and MCC are being investigated.

G. Voice Loops (Talk/Listen/Monitor Listing). Mr .Marsh presented the chart of voice loops going to the various centers, noting that Detachment 3 (Det 3) is the old Manned Space Flight Support Office (DDMS). Coordination on getting voice loops with the recovery ship will go through Det 3. Loops to WSC and GSFC are not in either the PRD or MSRD. Mr. Fanders stated that MSRD Revision A is in work. Voice loops will be needed for testing. Mr. Marsh stated that if GSFC will be expected to participate in troubleshooting, there needs to be loops for GSFC to use that do not require the JSC Ground Controllers (GC) to relay information. Mr. Rick Kraesig accepted an action item to work GSFC/WSC voice loop requirement for EFT-1 testing (ETE tests 2 and 3) (action item 0412-NSG EFT1-02) (due in 30 days).

H. High Level Data Flow (presentation page 10).
   1. The Houston Orion Test Hardware (HOTH) is a simulator/lab in Houston and can be accessed from the MCC. The Serial Conversion Processor (SCP) needs to get integrated into the EDH-L so a full ETE command and telemetry simulation can be conducted. Testing will eventually be conducted with the Denver Integrated Test Lab (ITL)/Comm and Track Integration Lab (CTIL).
   2. OS/COMET is the software platform in the MCC, Denver, and O&C that will be used to process command and telemetry data. The interface with Denver is via the SCP.
   3. The narrow band modem at WSC is also referred to as the Low Density Parity Check (LDPC) modem. This device has significant impact to the GC console and how GCs do operations. The modem is not integrated into WSC as an automated system; it will be manually configured and controlled. It is not configured with TDRS Scheduling Orders (SHO). The narrow band modems are required for Live Sky testing. EFT-1 will use the same SCPs to transfer data and command between the MCC and WSC as the International Space Station (ISS) uses.
   4. Mr. Marriott noted that the whole project is a development project. It is very challenging. What needs to be done to verify the network once the O&C goes away? Is WSC capable of transmitting Orion data to TDRS for testing? How do we get into that posture?
   5. Mr. Bangerter stated that all LDPC/modem work is being done by the SN. Once the modems are incorporated into Space-to-Ground Link Terminals (SGLT) 4 and 5, WSC will be responsible for software updates.
   6. Mr. Marriott stated that at the Operational Readiness Review (ORR), the network will be required to state what has been done to verify that the SN and other elements are ready to support EFT-1.
   7. MCC commands will come from the OS/COMET workstations. There will be only 3 to 4 workstations in the OS/Comet configuration. The Flight Control Team (FCT) will have some of their shuttle legacy display tools available, and most will not have or use OS/COMET displays. JMEWS will be the prime display tool used in the MCC. There will be a bridge from the OS/ COMET to FCT displays. The Instrumentation and Communications Officer (INCO) will have both displays (legacy and OS/COMET).

I. Feb 2012 Interim Reference Trajectory. The diagram provides a timeline for the entire flight. The timeline shows the TDRSs used, handovers (H/O), pass durations, and antenna switches. The LAS blocks the antennas for the first 6 minutes of the flight. There is the one Zone of Exclusion (ZOE). The red on the timeline indicates expected Loss of Signal (LOS). Ms. Blizzard stated that the umbilical data is available until liftoff and then asked if the expectation is no payload data for the first 6 minutes. Mr. Marsh stated that the Delta-IV will ship two 4.8-kbps embedded data streams the entire time the CM is attached to the LV. After 6 minutes, TDRS will be available. Mr. Erik Richards stated that a CLASS analysis has been done for the Delta and TDRSS; one is needed for Orion. Mr. Bangerter agreed. A link margin analysis will be performed and is a requirement for the ORR. The deorbit burn is 4.5 minutes in duration and will kick the spacecraft to its higher orbit and bring it back in. CM separation is 3 hours 24 minutes after launch. The CM raise burn is a 10-second burn. TDRSS will experience an approximate 2 to 3 minute S-band blackout during re-entry. Mr. Marriott stated that LM

plans on specific TDRSs. This is a disconnect from the SN process. LM is programming the onboard avionics with the satellite data. This needs to be resolved. Mr. Marsh stated that LM needs to be made aware of this issue. Mr. Marriott asked how long LM needs to do the programming. Mr. Bangerter stated that this long prior to the flight, he cannot say which satellites will be available. He stated that 6 months prior would be a reasonable timeframe. By 2014, User Service Subsystem Component Replacement (USS CR) could be complete. The narrow band modems would be integrated into SGLT 4/5 and LM would use those SGLTs. Mr. Mike Marsh accepted an action item to determine how much advance notice is required by LM for reprogramming the Orion avionics (for TDRS views/handovers etc.) (action item 0412-NSG EFT1-03). Mr. Bangerter stated that the 'inner' satellites are first generation satellites. TDRS-S will probably not be TDRS-S by the timeframe of the flight. TDRS-6 is available and in good shape at this time. There is always the possibility of failures and the need to move satellites around, and that takes time. LM needs to keep this in mind as they do their programming.

J. Discussion Points.
   1. CM has four 13-element phased array antenna assemblies. The CM will be performing BBQ rolls during selected segments on-orbit. There may be dropouts when switching from antenna to antenna. LDPC does lock quickly and it is anticipated that it will be improved. Mr. Lipford asked if Denver can simulate switching satellites to see how WSC will react. Mr. Marsh stated that he has heard of no capability or plans. Mr. Marriott stated that this needs to be checked with the testing working group. It was an objective that was submitted. TDRS H/Os were an open item. He stated that he thought Denver could test the antenna switches. Ms. Marcella Mendoza stated that she thought she heard that the opscon for BBQ rolls was being changed. Mr. Mike Sarafin stated that he was not aware of this, but is should be verified. Mr. Mike Marsh accepted an action item to provide an update on the status of the BBQ rolls (are the rolls still part of the opscon) (action item 0412-NSG EFT1-04).
   2. Data Rates. The flight will begin at 192 kbps and switch to 500 kbps. One major objective is receipt of video files of the LAS jettison. The video downlink takes a lot of time. The video file recording approximately 30 seconds in realtime will take as long as 30 minutes to downlink. Mr. Marriott asked what will happen if there are dropouts during the video downlink. Mr. Marsh replied that CFDP supposedly knows and should pick up where it dropped off.
   3. There will be few onorbit commands from the MCC. A command with the spacecraft while on the pad is desired. A coupler or 'lolipop' antenna is being considered to verify the command capability and encryption keys. Any pre-launch commands may have to be sent through the umbilical.
   4. The entire flight will be in Mission Elapsed Time (MET). Mr. Marriott asked if a clock is needed. Mr. Fanders stated that KSC will ship clock. Mr. Bangerter stated that the GSFC Network Integration Center (NIC) has the capability to run clock as well.
   5. The JSC Electronic Systems Test Laboratory (ESTL) will not be supporting EFT-1. Some of the characterization testing ESTL would normally perform will have to be accomplished in the Live Sky testing. A data source is needed to simulate the vehicle for network verification/validation testing. Mr. Marriott asked who has the action to

work this issue. If there is no ESTL, can the Simulation Operations Center (SOC) or WSC do this? Mr. Bangerter stated that he has not begun to work this, as the GSFC Task Order (TO) was just activated. This is one of the issues that GSFC will work. If there is no source outside what is normally done, then the SOC may be used. Ms. Blizzard stated that this was discussed at the TIM and GSFC needs to know this information when writing the verification manual.

6. Dual SHOs. The project is requesting dual SHOs, but it is not desirable to have two satellites radiating at Orion at the same time. Mr. Glasscock stated that the primary frequency should be scheduled on the primary TDRS in use and the alternate frequency scheduled on secondary TDRS satellite forward link. Frequency changes will be via GCMR.
7. LDPC. The Orion will be using LDPC. WSC will be installing narrow band modems on one TDRS-West sting and one TDRS-East sting. JSC is waiting to hear which strings will be modified. The modems require manual configuration, unless USS CR is in place. The GCMRs will be done by WSC or GSFC and not the GCs. There will be no User Performance Data (UPD) or TDRS tracking data, and there will be no TDRS-Z support due to the lack of LDPC modems on those ground equipment strings.
8. SCPs. EFT-1 will use existing ISS communications infrastructure. There are three SCPs at each WSC ground terminal also used by ISS. SCPs cannot be simultaneously shared between ISS and EFT-1.
9. Minimum Equipment List. The Flight Director (FD) office asked the GC's to develop a list of the minimum equipment needed to support mandatory command and telemetry data through TDRS/WSC to the MCC. This list will be used for the Flight Rules. The FDs want to know what is required for a GO/NO GO decision. Mr. Marriott stated that the Space Shuttle Section 3 had a list in a table used for decision making. Mr. Fanders stated that it was just a 'capability' list. Mr. Sarafin stated that he is good with capabilities; he needs to know redundancies. Mr. Bangerter stated that the SN provides a suite of equipment in a chain that includes backup. Stating East or West includes all the equipment with that asset. Mr. Marriott stated that his main concern is the LDPC modems. These assets are limited. Mr. Bangerter agreed that the modems are the exception. There will be restrictions on what can and cannot be doe and these restrictions will be known. This will be documented. Mr. Marriott stated that it needs to be known what will happen and how long it will take should it be necessary to switch from one terminal to another.

K. SN Architecture as of May 2011. Blue equipment in the diagram is legacy and will configure automatically. Orange equipment will be configured manually. There are two uplink rates. Each GCMR will be manual. JSC needs a full-time WSC controller to be on the voice loop prepared for real-time reconfigurations. Orion is preprogrammed; almost all activities will occur at a set MET.
L. Current SCP Configuration. Currently used by ISS only. Three SCPs at each ground terminal (prime, backup, and playback).
M. Desired Live Sky Test SCP Configuration. CTIL will talk to a satellite. Narrow band modems are in place. ISS will not use the SCPs on the test SGLT.

N. Desired SCP Configuration for O&C Live Sky and EFT-1 Mission. Dr. Norman Kluksdahl wants to add another SCP at each ground terminal. Having another SCP allows greater flexibility. It would be possible to have both ISS and Orion on one ground terminal. It is not known if this will occur. The playback is fanned out in the JSC equipment. Mr. Bangerter stated that if more infrastructure is needed, this needs to be coordinated with WSC. There are things that need to be coordinated via Engineering Changes (EC) (e.g., power, rack space, etc.). Mr. Lipford stated that to run simultaneously on one ground terminal, two more ports at the terminal are needed. The number of ports is the real obstacle. WSC needs to do cabling from the SCP to the LRDS. Dual SHOs does not get you additional ports. New codes will be needed as well. Mr. Bangerter stated that a lot is involved and there is a lot going on at WSC as well. SN approval is needed and there is a process that needs to be followed. Mr. Bangerter reminded JSC that JSC gave up ports for Obsolescence-Driven Avionics Redesign (ODAR). Additional ports may not be available. It may be necessary to keep ISS on a separate ground terminal from Orion. East and West will be spread out accordingly when TDRS-K and USS CR are done. The current MCC software configures the SCPs at both ground terminals; we will need to break them apart. FDOC engineering needs to change MCC software. This needs to be evaluated. Mr. Dave Theriault stated that MCC-21 will handle this.

O. 3-Hour Launch Window. The orbits are non repeating. Launch window planning is more difficult for this mission. The plan is for two TDRS' for long periods of time.

P. Orion beyond EFT-1. There are two missions Exploration Mission (EM)-1 and -2. EM-1 will be an un-crewed circumlunar flight of approximately 7 days. The objectives of the mission are to test integrated spacecraft systems and high-speed re-entry. EM-2 will be crewed lunar orbit mission of approximately 10 - 14 days. The objective is to demonstrate crewed flight beyond LEO.

Q. Other

1. Ms. Karen Rogers asked how many will be trained on the narrow band modems at WSC. Mr. Glasscock replied that it is not known yet. Mr. Bangerter stated that the technicians will be trained to maintain and manage the modems. Tech Operations & Analysis (TO&A) will need to understand the ops configuration. Manual operations will require training. The specific staffing will have to be determined.
2. Ms. Rogers stated that it will be challenge for the GCs to manage the GCMRs. There will be a lot of GCMRs required.
3. Mr. Marriott asked if a test plan and Network Operations Support Plan (NOSP) will be developed. He asked if a DRAFT will be ready by the next NSG. Ms. Blizzard stated that the document will not. Mr. Marriott asked when and Mr. Marsh stated that the documents are needed for the Live Sky tests. Mr. Marriott stated the DRAFT documents will be used for the testing. Ms. Blizzard stated that the HSF team has a Live Sky test plan in development. The NOSP development will start at the end of the year. Ms. Blizzard asked if GSFC will have the resources to develop the NOSP earlier than their normal template. Mr. Bangerter stated that the current emphasis is on Live Sky 1. This was not included in the GSFC plan. GSFC was viewing this as engineering tests. If you are planning operations, you will need network participation and funds are needed. Mr. Marriott stated that during the Denver tests the data rates will be stepped through and there will be ETE ops. Mr. Bangerter stated that the tests

will be RF. GSFC will write a test plan. GSFC will work the compatibility testing section. Mr. Marriott stated that this is an issue. This is a heads up that GSFC operations personnel are not planning on participating. The EFT-1 team expects to run through all the data rates and sequences. Ms. Blizzard stated that participation is planned for compatibility testing and Mr. Marriott stated that the plan is for compatibility testing the first day of the planned testing. Mr. Marsh stated that the test can't be supported without test procedures and Mr. Bangerter stated that the SN will provide the procedures. Mr. Roy Harris stated that all the parties are not on the same page. This needs to be followed up.

4. Mr. Bangerter stated that when Risk Mitigation (RM) was planned, all was developed by the SN engineering team. The testing was purely engineering testing. JSC added more into the plan and this was not communicated to the program. Additional funds are needed for the network to participate. He stated that he is not against the participation. Mr. Marriott stated that the whole program is development and testing and is not operational and not repeatable. Mr. Bangerter stated that there is a point when the network will get involved. An NOSP will be ready by end of the year. The document is usually due at Launch minus 30 days.

ACTION ITEM REVIEW

The following action items were assigned at the April 18, 2012, NSG EFT-1 Overview splinter meeting.

AI No.	Assignee	Action	Status
0412-NSG EFT1-01	Bob Marriott/ JSC/NOIT	Create a list of Delta / TDRSS link information JSC requires and provide to GSFC.	**Open**
0412-NSG EFT1-02	Rick Kraesig/ GSFC/HSF	Work GSFC/WSC voice loop requirement for EFT-1 testing (ETE tests 2 and 3).	**Open**
0412-NSG EFT1-03	Mike Marsh/ JSC/NOIT	Determine how much advance notice is required by LM for reprogramming the Orion avionics (for TDRS views/handovers etc.)	**Open**
0412-NSG EFT1-04	Mike Marsh/ JSC/NOIT	Provide an update on the status of the BBQ rolls (are the rolls still part of the opscon).	**Open**
0412-NSG EFT1-05	Mike Marsh/ JSC/NOIT	Discuss (with Joe and Jewel) the role that GSFC ops personnel will perform in the Denver Live Sky test and the need of ops procedures for that test	**Open**

(Original Approved By)
Mr. Mike Marsh
JSC/NOIT