LANDSAT DATA CONTINUITY MISSION (LDCM) ORBIT DETERMINATION

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ABSTRACT

The Landsat Data Continuity Mission (LDCM) is set to launch no earlier than January 15, 2013 and will become the next mission in the Landsat Program of Earth-observing satellites, which collects and provides detailed remote sensing and land imagery data that benefits the Earth science community and beyond. LDCM will operate in the low-Earth orbit (LEO) regime, at an approximate altitude of 705 km, and is equipped with an on-board Viceroy Global Positioning System (GPS) receiver that will provide point solution telemetry to the ground via the Integrated Telemetry Operations System (ITOS). Within the Mission Operations Center (MOC) at NASA Goddard Space Flight Center (GSFC), the GPS telemetry data is converted to a sequential prints format; which are GPS point solution measurements represented as epochs, positions and velocities in a text file. The sequential prints are sent to the Flight Dynamics System (FDS) for orbit determination (OD) processing. LDCM FDS uses a.i. solutions, Inc. FreeFlyer (FF) software to perform ground-based OD. FreeFlyer Orbit Determination (FFOD) uses the extended Kalman Filter (EKF) method on the delivered GPS point solution telemetry data to estimate position, velocity, and coefficient of drag (C_D) values.

The orbit estimation process for the Landsat series has evolved considerably over the past 40 years. All of the previous missions began their mission 'lives' supported by GSFC, processing radiometric data using ground-based orbit determination to support all orbit estimation and prediction capabilities. LDCM is the first in the Landsat series to use high-fidelity space-based GPS data for the core basis of orbit estimation processing. The on-board Attitude Control System (ACS) software filters the data as well, providing accurate orbit (and attitude) data directly to the ground with the science data.

The LDCM flight dynamics support on the ground validates the on-board performance with ground estimation of the orbit and attitude. It also uses the ground estimation to plan for needed orbit and attitude maneuvers as well as special slews required for instrument or sensor calibrations. In the day-in-the-life (DITL) operations in the LDCM MOC ground processing, the day begins with the receipt of a 26-hour GPS telemetry data file. The FDS system, running in a fully-automated mode, detects the updated GPS file, and starts the "OD_Service." The OD Service is an automated series of scripts which run the ground FFOD to filter the data and generate a definitive ephemeris. The OD Service also formulates a long definitive ephemeris over the mission lifetime and calculates OD trending information, as well as providing mission lifetime analysis trends. From the definitive ephemeris, a seed vector is extracted and is

propagated to create a predicted ephemeris, with the newly planned orbit and attitude slews; and associated set of daily predictive products. The FFOD configuration is interfaced with the MySQL database, a commercial off-the-shelf (COTS) product which allows the user to control spacecraft parameters, environmental files, and orbit determination process settings; as well as the ability to update itself everyday with C_D estimates and storing predictive-definitive OD trending information.

In addition to performing OD and making daily products, the FDS performs automated OD on short segments of ITOS–provided GPS telemetry data throughout the day via the "QuickLook_O_Service" service; and performs automated real-time monitoring of the On-Board Computer (OBC) attitude and orbit through the "OBC_Monitor" Services. These features are new and innovative as they permit the near real-time monitoring of the orbit and attitude performance of the spacecraft against ground predicted values. Any deviations outside of expected offsets or tolerances, and the ground FDS will send a notice to the FOT members via an alert message electronically for further investigation of developing problems.

The LDCM FDS is undergoing testing and is actively supporting the mission during the current pre-launch readiness testing period. The required LDCM OD accuracy is 30 meters per axis, 3-sigma. Prelaunch evaluation to test the accuracy has included the processing of GPS flight data from the current NASA mission, Fermi Gamma-ray Space Telescope (FGST), which flies in a similar orbit regime. Other test data includes simulated telemetry data from the Spacecraft/Operations Simulator (S/OS) provided during Mission Readiness Tests by the LDCM spacecraft-manufacturer, Orbital Sciences Corporation, for detailed evaluation and assessment of the FDSS OD capabilities and achievable estimation levels. Some of the S/OS data samples include maneuvers that will be seen during LDCM's lifetime, such as drag make-up (DMU) and inclination (INC) adjustment maneuvers. The inclusion of these maneuvers helps to test the ability of the FFOD to estimate a good solution through these events.

This paper briefly provides an overview of the OD historical trends of the Landsat series. Then the latest innovations of the OD capabilities being deployed for the LDCM mission will be explained. These novel concepts include using FreeFlyer OD; processing GPS point solution data instead of radiometric data as done in the past; applying a MySQL database for configuration control and storing trending data; Quicklook and OBC Services for near real-time monitoring of orbit and attitude performance; and the automation capabilities of the entire FDS system. A brief overview of the FDS will be given, with a focus on how the automated OD, QuickLook and OBC monitoring fit into the day-in-the-life flow. The sources and transfer methods of environmental files, GPS telemetry, and real-time data will also be detailed. Lastly, the results of the OD performance analysis and testing with the current LDCM configuration with real-mission FGST data and S/OS telemetry will be shown.