

Ephemeris and attitude

Anomaly occurs on <i>LANDSAT 5 - 7</i>	Anomaly status <i>OPEN</i>	Related QUISS test: <i>Ephemeris and Attitude</i>	Anomaly slip <i>01</i> Version <i>01.1</i> 16/09/2003
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Related QUISS test

“Ephemeris and attitude” test is dedicated to control the ephemeris state vectors extracted from the input product. These latter are compared to those loaded from an external reference: the Two-Line Elements (TLE) managed by the NORAD.

For a one to one ephemeris record comparison processed in the geocentric system, a defect is noticed on the following cases:

- The latest available TLE is too old (more than 3 days) and then propagation is not accurate enough. The test only edits a warning.
- The position variation between product ephemeris and propagated TLE is over the maximum position error (5000 m). The test fails.
- Quadratic error of the position variations is over 5000 metres. The test fails.
- The velocity variation between product ephemeris and propagated TLE is over the maximum velocity error (10 m/s). The test fails.

For a one to one attitude record comparison processed in the local orbital system, a defect is noticed on the following case:

- Variation on pitch, roll or yaw values are upper than 1 degree. The test fails.

Anomalies description

Ephemeris records have inconsistent values

One or several ephemeris records have inconsistent spacecraft position (x, y or z) and/or velocity (vx, vy or vz) values.

Ephemeris records are shifted

The records of the first and/or the second ephemeris group(s) are shifted. In one group, all records have a constant position (x, y or z) error.

Causes

Ephemeris records have inconsistent values

The inconsistent values anomaly mainly occurs in the first ephemeris group and can rely on a bad transmission and/or transcription problem.

Ephemeris records are shifted

The ephemeris records shift anomaly is mainly correlated with a wrong set of spacecraft positions. For more information about the ephemeris anomaly causes, please refer to the “Some advice to go further” section.

Consequences

Anomaly in the first group

No consequence on the product quality can be noticed concerning the image location because *system-corrected* and *geo-referenced* products are processed using the second ephemeris group.

However, the product is not well formatted and contains some inexact values. Troubles may arise if the user computes an orbital model using the first ephemeris group. In fact, a wrong orbital model leads to important errors on ground location.

Anomaly in the second group

Usually, the inconsistent values anomaly does not occur in the second ephemeris group because the processor has filtered and possibly corrected the inconsistent values found in the first group while interpolating the values of the second group from the ones of the first group. So, the main anomaly of the second ephemeris group could be a global shift.

The local orbital system is useful to estimate the impact of the spacecraft position errors on image location. For example, a negative 7 km shift along the roll axis - namely the along-track direction - implies around 7.5 km scene shift towards the North direction.

The figure below helps understanding the variations of ephemerides and attitudes expressed in a local orbital reference system. It describes the impact on the image location of the variations along pitch, yaw and roll axes.

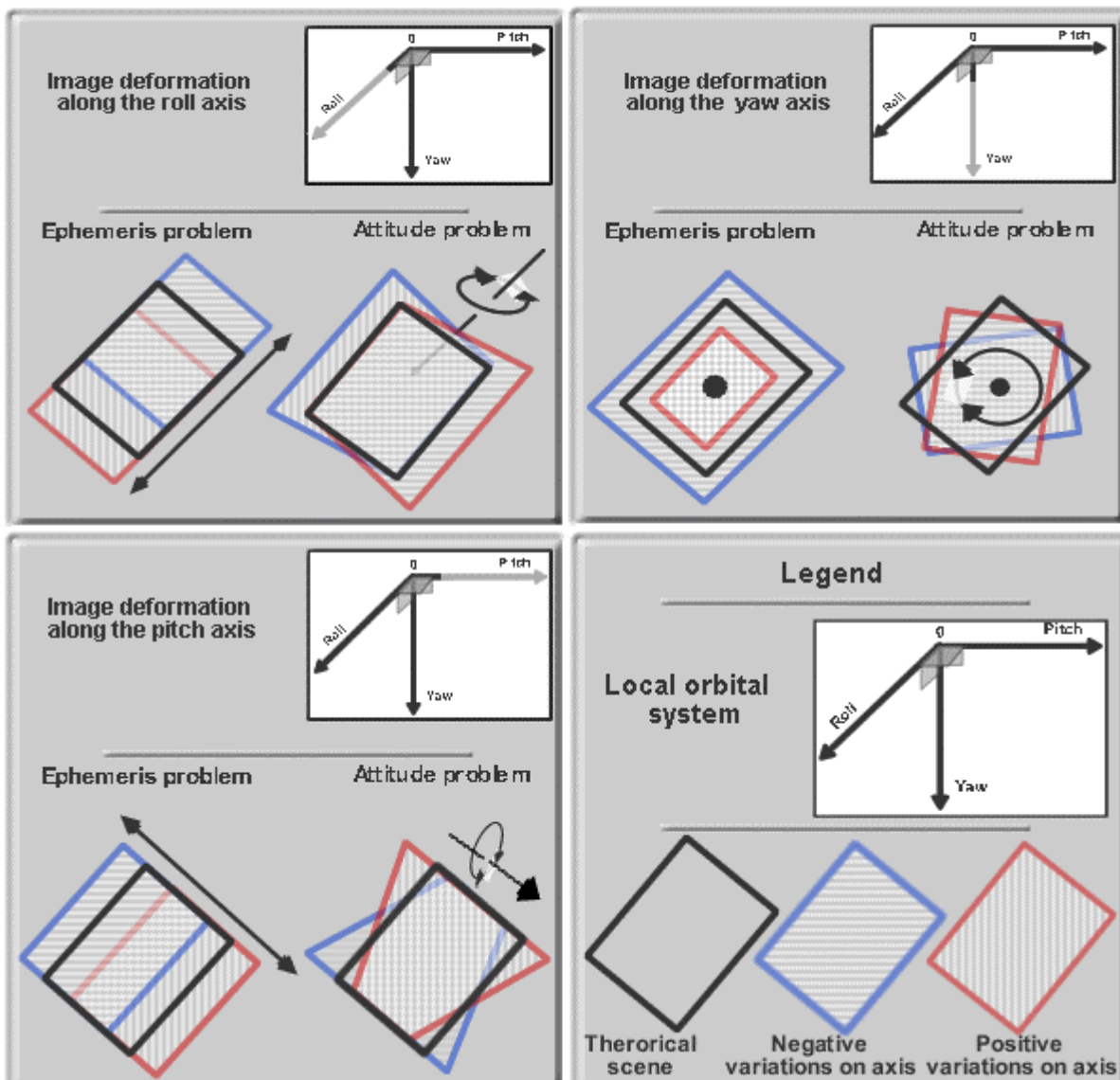


fig.1 - Impact of ephemeris variations on the image location.

Disposition

Anomaly in the first group

GAEL Consultant proposes the “**use as is**” disposition (automatic waiver) and the product has to be sent to the customer.

Anomaly in the second group

GAEL Consultant proposes the “**scrap**” disposition and the product has to be segregated.

Preventive and corrective actions

Preventive actions

GAEL Consultant proposes the following preventive action (not applicable for LANDSAT 5):

- If the product has been processed using the ephemeris from PCD (Payload Correction Data), it can be ordered few days later to ensure a processing with ephemeris from DEF (Definitive) instead. The DEF ephemerides are available since September 2000.

Corrective actions

GAEL Consultant proposes the following corrective action:

- To eliminate the cause of the non-conformance and prevent any recurrence, one should always propose to the customer a product processed with ephemeris from DEF (see Definitive ephemeris) to avoid the scene shift.

Some advice to go further

Ephemeris definition

Ephemeris consists of spacecraft position components X,Y and Z in metres and spacecraft velocity components in metres per millisecond. Spacecraft positions and velocities are defining in Earth-centred inertial true of date (ECITOD) coordinates. In the ECITOD coordinates system, the Z-axis is along a line from the centre of the Earth coincident the true Earth spin axis, positive north. The X-axis is along a line from the centre of the Earth toward the intersection of the true Equator and true ecliptic of date. The Y-axis completes the right-handed set.

Related files and records in CEOS format

In CEOS format the ephemeris records are located in the supplemental file. TM and ETM+ products include respectively one and two supplemental files.

A supplemental file contains these five records:

- File descriptor record (58 fields)
- Interval header record (16 fields)
- TM housekeeping data ancillary record (53 fields)
- Ephemeris and attitude ancillary record (31 fields)
- Raw jitter measurements ancillary record (25 fields)

Ephemeris first and second groups

The ephemeris and attitude data extracted from the PCD stream are always stored first in the supplemental file. This set is called the “first ephemeris group” or “ephemeris PCD group”.

Another set, called the “second ephemeris group”, is created during the first phases of the product generation. These ephemeris records are either interpolated from the ones of the first group, either from the Definitive ephemerides hosted in the station database. The resampling is necessary to discard and replace the ephemeris records found with some inconsistent values. In addition, this process may correct a shift on the first ephemeris group or a shift on the ephemeris group provided by the station database.

The ephemeris and attitude ancillary record includes about 22 ephemeris values. The first half (10 or 11 values) is related to the first group and the second half to the second group. The two halves always have the same number of values.

For a given ephemeris group:

- On TM products, only 5 ephemeris values are significant (one value on two is unchanged).
- On ETM+ products, each ephemeris value is different.

Definitive ephemeris

The Goddard Space Flight Center (GSFC) daily provides definitive ephemeris records. A file is delivered to international ground stations with a one per day frequency. It spans two days before the Definitive ephemeris records are available.

PCD products and DEF products

It depends on the available ephemerides at the processing time compared to acquisition date. For example the “Rush” product orders, close to the acquisition date, are often processed using the interpolated ephemerides from the first group (PCD group). In this case, the product ephemeris type is “PCD”.

For the products processed on the basis of definitive ephemeris records, the product ephemeris type is “DEF”.

In CEOS format, field 39 (“geometric correction designator”) of the scene header record gives the type of ephemeris used (PCD or DEF) to compute the second group.

PCD / DEF and image location

Recent studies on PCD / DEF comparison demonstrated that the use of interpolated DEF ephemeris records slightly improves the image location, providing a better accuracy of the values.

However, if the original ephemeris records (PCD) are corrupted, the use of interpolated DEF ephemeris records considerably improves the image location, ensuring a full correction of the wrong values.

Related URL links

Ephemeris and QL processing

http://earth.esa.int/0xc1cce41c_0x0000069a

USGS definitive ephemeris

<http://LANDSAT7.usgs.gov/ephemeris.html>

Daily orbital elements

<http://ls7pm3.gsfc.nasa.gov/schedules.html>

Celestrak (NORAD TLE)

<http://www.celestrak.com/>