**CCSDS**

The Consultative Committee for Space Data Systems

# TRACKING DATA MESSAGE

## PROTOTYPING TEST PLAN/REPORT

## FINAL REPORT

## 05-Oct-2007

# **Table of Contents**

# 1. Introduction

This document provides a description of the prototype testing of the CCSDS Tracking Data Message (TDM), CCSDS 503.0-R-2 (reference [2]).  The TDM is part of the technical program of the CCSDS Navigation Working Group.  The TDM document completed the second CCSDS Agency Review in March 2007; this process is described in reference [1].

The first sections of this document describe  the Test Plan for the prototyping activity; the last sections of the document provide a Test Report of the realized plan.  This plan has been prepared by the members of the CCSDS Navigation Working Group who are coordinating the prototyping for their respective agencies, specifically:

Jürgen Fertig (ESA)
Siegmar Pallaschke (ESA)
Reinhard Kiehling (DLR)
David Berry (NASA/JPL)

Note that in applicable places the prototyping includes results based on modifications to the TDM document provided via the Agency Review Review Item Discrepancy (RID) process (see reference [3]), available internally through the Navigation Working Group. Changes based on the ongoing working group activity were also incorporated as applicable, and as documented in reference [3].

# 2. Blue Book Promotion Criteria

The CCSDS Procedures Manual states that for a Recommendation to become a Blue Book, the standard must be tested in an operational manner. The following requirements for an implementation exercise were excerpted from reference [1]:

> "At least two independent and interoperable prototypes or implementations must have been developed and demonstrated in an operationally relevant environment, either real or simulated."

It is the intent of this document to outline the Navigation Working Group's approach to meeting this requirement for the TDM.

# 3.   Summary Conclusion

TDM Prototypes were developed at three CCSDS member agencies:  DLR, ESA, and NASA.  A suite of ten test cases covered the interagency exchange and processing of a wide range of typical tracking data types.  The tracking data were collected during operational tracking passes for three different spacecraft managed by three different member agencies.  Operational tracking assets situated on four continents managed by four different tracking networks were used in the data collection.  Based on this operational diversity and the positive test results, the TDM prototyping effort successfully addresses the Blue Book promotion criteria.  It is thus proposed to approve the Tracking Data Message as a CCSDS Recommended Standard.

# 4.   Tracking Data Message (TDM) Testing Goals

The test of the TDM will exercise the following data types:

- 1-way Doppler
- 2-way Doppler
- 3-way Doppler
- Ranging
- Delta-DOR
- Angles
- Media Calibration (Ionosphere, Troposphere)
- Meteorological

The tests described in Section 5 and Section 6 of this plan will be conducted in order to meet the CCSDS requirements.   In Section 7 and Section 8, the results of the testing are presented.

# 5.   Test Plan Overview

Three CCSDS member agencies that are represented in the CCSDS Navigation Working Group have taken on the task of developing and operating TDM prototypes:  DLR, ESA, and NASA/JPL.  Prototyping of the TDM will be done for the following spacecraft, by the agencies and members of the Navigation Working Group shown in the following table:

| Test # | Spacecraft | Agencies, Direction | Data Types | Schedule | %Complete |
|---|---|---|---|---|---|
| 1 | Rosetta | NASA/JPL => ESA | 2-way Doppler Range Delta-DOR | April 2007 | 100% |
| 2 | Rosetta | ESA => NASA/JPL | 2-way Doppler Range Delta-DOR | September 2007 | 100% |
| 3 | TerraSAR-X | DLR => ESA | Angles | September 2007 | 100% |
| 4 | TerraSAR-X | ESA => DLR | Angles | September 2007 | 100% |
| 5 | Dawn | ESA => NASA/JPL | Angles | CANCELLED | N/A |
| 6 | Phoenix | ESA => NASA/JPL | Angles | September 2007 | 100% |
| 7 | Rosetta | NASA/JPL => ESA | Ancillary Data Types: (Ionosphere) | September 2007 | 100% |
| 8 | N/A | NASA/JPL => ESA | Ancillary Data Types: (Troposphere) | September 2007 | 100% |
| 9 | Rosetta | NASA/JPL internal | 1-way Doppler 3-way Doppler | September 2007 | 100% |
| 10 | N/A | ESA => NASA/JPL | Meteorological | September 2007 | 100% |

# 6. Test Plan Details

## 6.1 Test Case #1: Rosetta / JPL => ESA

For this test, NASA/JPL will send TDMs to ESA that contain tracking data for the Rosetta spacecraft. The TDMs will correspond with TRK-2-18 Orbit Data Files (ODF) (reference [4]) that have already been provided from JPL/Deep Space Network (DSN) to ESA (same tracking pass). Data types will be 2-way Doppler, range, and Delta-DOR (ESA uses neither 1-way nor 3-way Doppler). ESA will process the TDMs with their prototype and the TRK-2-18 data through the normal navigation software, and produce IFMS observation files for both. The results will be compared. The details of this test will be discussed at the ESA/NASA Technical Interchange Meeting to be held at Darmstadt 25-April-2007 through 27-April-2007, and in subsequent telecons of the Navigation Working Group. Test Data Sheet will be supplied by ESA.

**Expected Results**

It is anticipated that the TDM and ODF will produce identical IFMS observation files (these files are inputs to the orbit determination). It is anticipated that an ODF converted to a TDM can be read back into the TDM prototype, and an identical output TDM produced. Assuming that these criteria are met, the test will be considered successful. In the event of discrepancies, troubleshooting will be conducted by the participants in the test.

## 6.2   Test Case #2:  Rosetta / ESA => JPL

For this test, ESA will send TDMs to NASA/JPL that contain tracking data for the Rosetta spacecraft, along with the corresponding IFMS data. Data types will be 2-way Doppler, range, and Delta-DOR (ESA uses neither 1-way nor 3-way Doppler). JPL will process the TDMs sent from ESA with their TDM prototype, and compare to the IFMS data. The details of this test will be discussed at the ESA/NASA Technical Interchange Meeting to be held at Darmstadt 25-April-2007 through 27-April-2007, and in subsequent telecons of the Navigation Working Group. Test Data Sheet will be supplied by JPL.

**Expected Results**

It is anticipated that the TDM and IFMS data will produce identical residuals in first-order orbit determination. Assuming that these criteria are met, the test will be considered successful. In the event of discrepancies, troubleshooting will be conducted by the participants in the test.

## 6.3   Test Case #3:  TerraSAR-X / DLR => ESA

For this test, DLR will track the TerraSAR-X spacecraft at Weilheim. After performing internal comparisons with the DLR tracking data native formats, DLR will send TDMs to ESA that contain tracking data for the TerraSAR-X spacecraft (antenna angles only). ESA will process the TDMs sent from DLR with their TDM prototype. The results of the testing will be discussed in subsequent telecons of the Navigation Working Group. Test Data Sheet will be supplied by ESA.

**Expected Results**

It is anticipated that the TDM and DLR angle tracking data will compare acceptably. Assuming that these criteria are met, the test will be considered successful. In the event of discrepancies, troubleshooting will be conducted by the participants in the test.

## 6.4   Test Case #4:  TerraSAR-X / ESA => DLR

For this test, ESA will track the TerraSAR-X spacecraft at Malindi, and send TDM's to DLR (antenna angles only). ESA will also send the IFMS data from the track. DLR will

process the TDM with their prototype and the IFMS data and compare the results. Test Data Sheet will be supplied by DLR.

**Expected Results**
It is anticipated that the TDM and IFMS data will compare acceptably. Assuming that these criteria are met, the test will be considered successful. In the event of discrepancies, troubleshooting will be conducted by the participants in the test.

## 6.5   Test Case #5:  Dawn / ESA => JPL

**NOTE:  Due to delays in the Dawn launch, this test was removed from the Prototyping Test Plan.  Since it is essentially a duplicated case (see Test Case #3, #4, and particularly #6), there is no issue.**

For this test, ESA will track the Dawn spacecraft at Perth, and send JPL the tracking data (non-TDM format). This is part of the Dawn launch support. Subsequent to the launch, ESA will also send TDM's of the same data to NASA/JPL. JPL Navigation System Engineering will compare the operational tracking data from the launch support with the same data in TDM format. Of particular interest is the angle data from the initial acquisition at Perth. JPL will process the TDMs sent from ESA with their TDM prototype. Test Data Sheet will be supplied by JPL.

**Expected Results**

Not applicable given the cancellation of the test.

## 6.6   Test Case #6:  Phoenix / ESA => JPL

For this test, ESA will track the Phoenix spacecraft at Kourou, and send JPL the tracking data (non-TDM format). This is part of the Phoenix launch support. Subsequent to the launch, ESA will also send TDMs of the same data to NASA/JPL. JPL Navigation System Engineering will compare the operational tracking data from the launch support with the same data in TDM format. Of particular interest is the angle data from the initial acquisition at Kourou. JPL will process the TDMs sent from ESA with their TDM prototype. Test Data Sheet will be supplied by JPL.

**Expected Results**

It is anticipated that the operational and TDM tracking data will compare identically. In the event of discrepancies, troubleshooting will be conducted by the participants in the test.

## 6.7   Test Case #7:  Ancillary Data Types / JPL => ESA

For this test, NASA/JPL will provide ionosphere calibration data for the Rosetta spacecraft both in the Control Statement Processor (CSP) format (see reference [6]) and in TDM format.  The ionosphere calibration data will already have been supplied to ESA in the CSP format via normal operations.  ESA Flight Dynamics will compare the calibration data in both formats by either (a) applying the corrections to Rosetta tracking data, or (b) reproducing the original polynomial coefficients with the prototype.  Test Data Sheet will be supplied by ESA.

**Expected Results**

It is anticipated that the effects of the ionosphere calibration data in both formats will be identically applied to the Rosetta tracking data.

## 6.8   Test Case #8:  Ancillary Data Types / JPL => ESA

For this test, NASA/JPL will provide troposphere calibration data both in the Control Statement Processor (CSP) format (see reference [6]) and in TDM format.  The troposphere calibration data will already have been supplied to ESA in the CSP format via normal operations.  ESA Flight Dynamics will compare the calibration data in both formats by either (a) applying the corrections to Rosetta tracking data, or (b) reproducing the original polynomial coefficients with the prototype.  Test Data Sheet will be supplied by ESA.

**Expected Results**

It is anticipated that (a) the effects of the troposphere calibration data in both formats will be identically applied to the Rosetta tracking data, or (b) the identical polynomial coefficients are produced by the ESA prototype.  The results will depend upon the method selected as described above.

## 6.9   Test Case #9:  1-Way/3-Way Doppler / JPL Internal

For this test, NASA/JPL will process 1-way and 3-way data from a selected ESA spacecraft tracking pass in both ODF and TDM formats.  The TDM printout and ODF printout will be compared.  Residuals will be computed with both ODF and TDM files, and compared.  The test is JPL Internal because ESA uses neither one-way nor three-way data, but it was desired to test these data types in the prototype.  Test Data Sheet will be supplied by JPL.

**Expected Results**

It is anticipated that the ODF and TDM printouts will compare accurately, and that the residuals computed using the two formats for the tracking data are identical.

## 6.10 Test Case #10:  Meteorological / ESA => JPL

For this test, ESA will send meteorological data to NASA/JPL in both TDM and IFMS formats.  The data in the two formats will be compared by JPL Navigation System Engineering.  Test Data Sheet will be supplied by JPL.

**Expected Results**

It is anticipated that the IFMS and TDM weather data printouts will compare accurately.


# 7.    Test Report Overview

Engineers at DLR, ESA, and JPL will prepare test data sheets as noted in the Test Plan Details above, and send them to the Navigation Working Group via email.

The Test Report Details will be found in Section 8 of this document.  A summarization of the test process and the recommendation of the Navigation Working Group may be found in Section 2 of the report.  The report will be posted to the Navigation Working Group Common Working Environment (CWE) on the CCSDS web page at http://cwe.ccsds.org .  The report will be submitted to the CCSDS Engineering Steering Group (CESG) and CCSDS Management Council (CMC), along with results of the Agency Reviews.  At that time, a formal request will be submitted to the CMC for progression of the TDM to CCSDS Blue Book status.

The next page contains a format for the test data sheets that will be used to report the results of individual tests.  A blank test data sheet may be downloaded from the Navigation Working Group CWE at:   http://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Tracking%20Data%20Messages%20(TDM)/Tracking-Data-Message-Prototype-Test-Data-Sheet.doc .

<p style="text-align:center; color:red;">**SAMPLE**</p>

# Tracking Data Message Prototype Test Data Sheet
### Version 1.0

| | | |
|---|---|---|
| 1 | Report Date: | |
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | |
| 4 | Prototype Version # (if applicable): | |
| 5 | Test Engineer: | |
| 6 | Agencies Participating in this Test Case: | |
| 7 | Test Case Number: | |
| 8 | Spacecraft: | |
| 9 | Tracking Data Types: | |
| 10 | Tracking Data Date/Time Range: | |
| 11 | Variances from Expected Results: | |
| 12 | Results (Pass, Partial Pass, Fail): | |
| 13 | Results Reviewed / Approved By: | |
| 14 | Comments: | |

# 8. Test Report Details

## 8.1 Test Case #1: Rosetta / JPL => ESA

**Tracking Data Message Prototype Test Data Sheet**
Version 1.0

| 1 | Report Date: | 2007/04/23 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | TDM generation: NASA/JPL<br>TDM processing: ESA/ESOC |
| 4 | Prototype Version # (if applicable): | n.a., ESOC prototype according to TDM Revision 2.1 |
| 5 | Test Engineer: | Norbert Schlecht |
| 6 | Agencies Participating in this Test Case: | JPL/ESOC |
| 7 | Test Case Number: | 1 |
| 8 | Spacecraft: | ROSETTA |
| 9 | Tracking Data Types: | 2-way Doppler, 2-way range, ramp table |
| 10 | Tracking Data Date/Time Range: | ODFs "07069E069.SC226", "07075E075.SC226"<br>TDMs "07069E069.SC226.tdm.txt", "07075E075.SC226.tdm.txt" |
| 11 | Variances from Expected Results: | ESOC produced binary OBSERVATIONS and binary RAMPTABLE files for input to the ESOC ODP both originating from TDM and ODF format.<br>ASCII dumps of these binary files were compared.<br>The files are identical with two exceptions:<br>1.) Insignificant difference due to double precision representation.<br>2.) The Doppler reference frequency changes in the TDM less often than in the original ODF. This does not affect the mean measured downlink frequency, so it has no effect on the OD. The handling of the Doppler reference frequency was changed by JPL to avoid unnecessary multiple TDM headers. |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Norbert Schlecht |
| 14 | Comments: | The handling of the keywords "RANGE" and "RANGE_UNITS" was changed in the ESOC prototype to be compatible with the updates to CCSDS TDM Revision 2.3. |

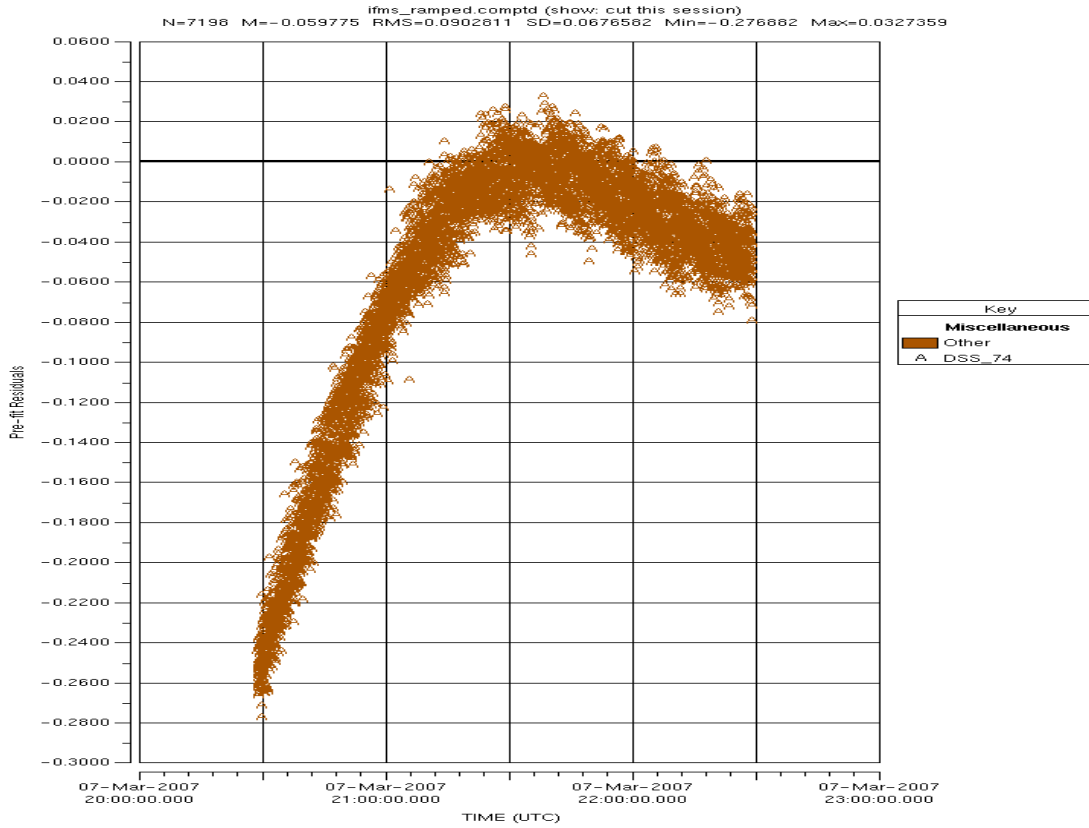# Tracking Data Message Prototype Test Data Sheet
## Version 1.0

| | | |
|---|---|---|
| 1 | Report Date: | 2007/07/06 |
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | TDM generation: NASA/JPL<br>TDM processing: ESA/ESOC |
| 4 | Prototype Version # (if applicable): | n.a., ESOC prototype according to TDM Revision 2.1 |
| 5 | Test Engineer: | Norbert Schlecht |
| 6 | Agencies Participating in this Test Case: | JPL/ESOC |
| 7 | Test Case Number: | 1 |
| 8 | Spacecraft: | ROSETTA |
| 9 | Tracking Data Types: | S/C and Quasar DOR, clock bias data |
| 10 | Tracking Data Date/Time Range: | ODF "AC07053.SC226"<br>TDM "070531925_24DDOR.odf.tdm.txt" |
| 11 | Variances from Expected Results: | ESOC produced a binary OBSERVATIONS files for input to the ESOC ODP both originating from TDM and ODF format.<br>ASCII dumps of these binary files were compared.<br>The files are identical with two exceptions:<br>1.) The handling of the CLOCK_BIAS in the ESOC prototype was adopted so that it write the CLOCK_BIAS data to the field for the differential clock correction. The definition of CLOCK_BIAS.<br> 2.) There is no information whether or not the ambiguity was resolved, so the ESOC prototype assumes for TDM DOR data resolved ambiguity. |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Norbert Schlecht |
| 14 | Comments: | The handling of the keyword "CLOCK_BIAS" in the ESOC prototype will be modified to be compatible with the updates to CCSDS TDM Revision 2.4, which allows for this case two stations in the META_DATA, such that the CLOCK_BIAS data represent explicitly a differential clock delay. |

## 8.2 Test Case #2: Rosetta / ESA => JPL

### Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 12-Sep-2007 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | NASA/JPL |
| 4 | Prototype Version # (if applicable): | 0.12 |
| 5 | Test Engineer: | Tomas Martin-Mur |
| 6 | Agencies Participating in this Test Case: | ESA and NASA/JPL |
| 7 | Test Case Number: | 2 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | 2W Doppler |
| 10 | Tracking Data Date/Time Range: | |
| 11 | Variances from Expected Results: | The statistics on the 2W Doppler are slightly different (less than .01 Hz), probably due to the fact that a ramp record was added to the IFMS data in order to be able to process it in the JPL navigation software, and the ramp frequency was slightly different than the transmit frequency shown in the TDM. |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | David Berry |
| 14 | Comments: | See residual comparison plots next two pages. |

**Figure 1: 2W Doppler Residuals from IFMS Data**
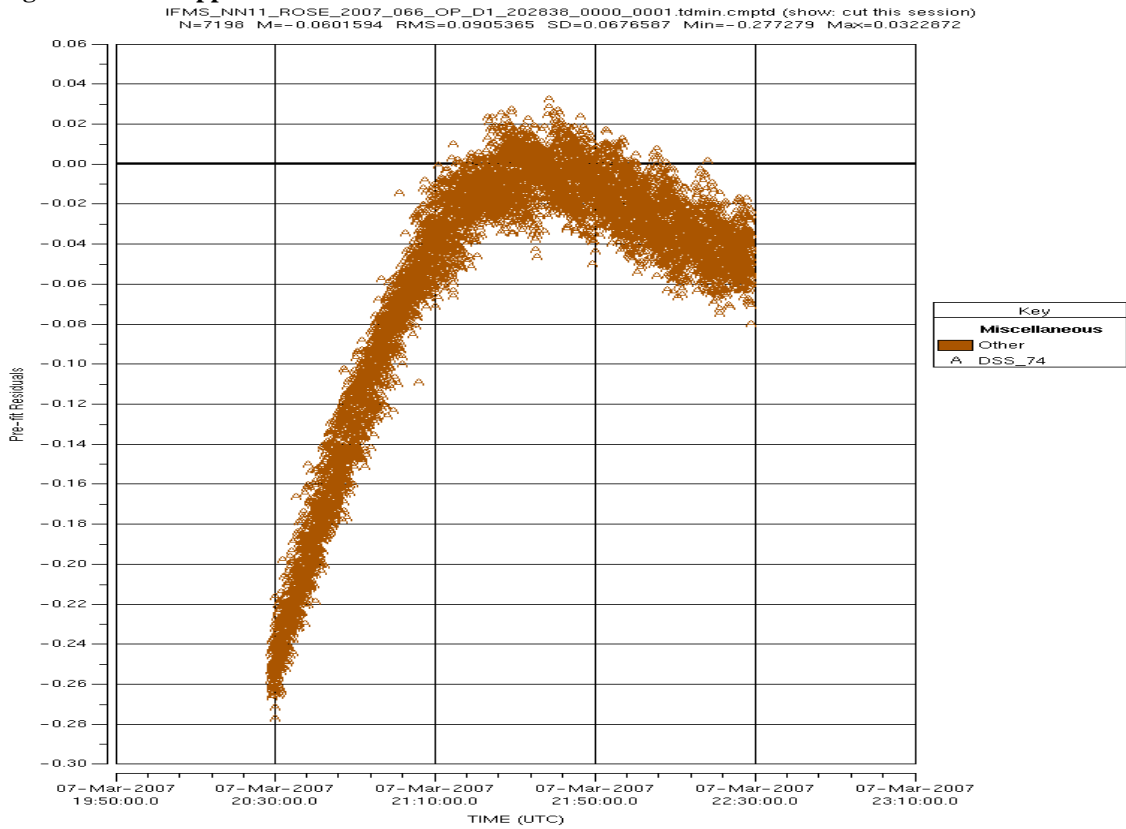


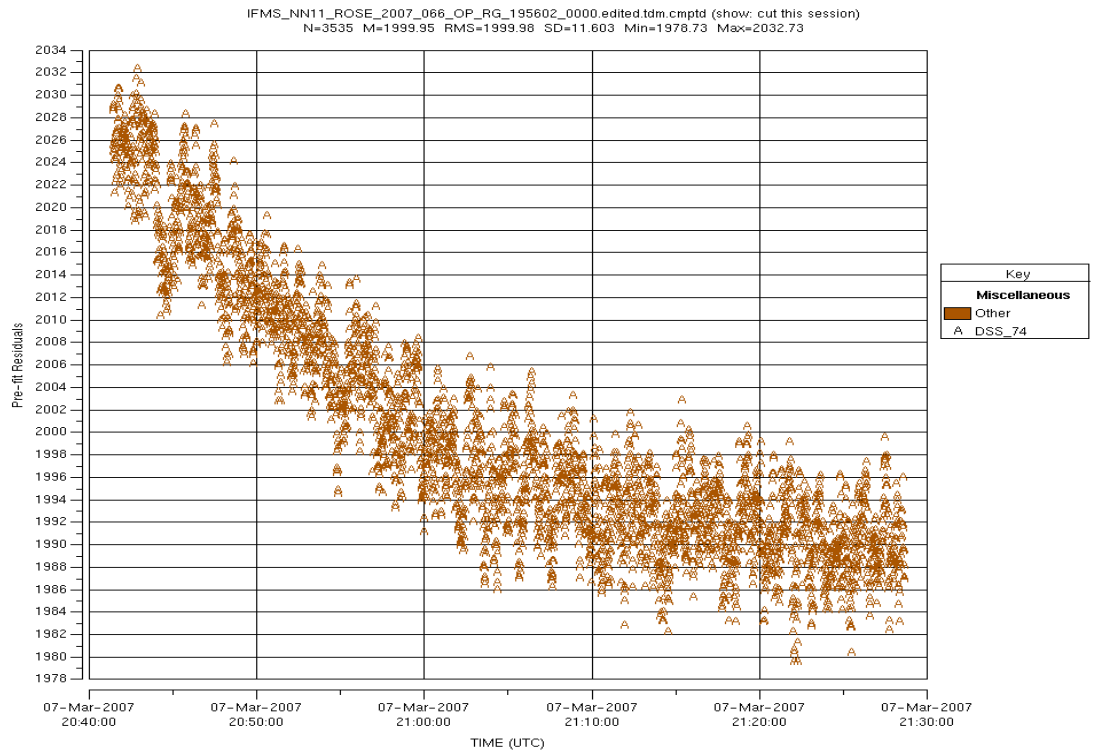**Figure 2: 2W Doppler Residuals from TDM**

# Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| | | |
|---|---|---|
| 1 | Report Date: | 20-Sep-2007 |
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | Producer:  ESA<br>Consumer:  NASA/JPL |
| 4 | Prototype Version # (if applicable): | Producer:  N/A<br>Consumer: 0.12 |
| 5 | Test Engineer: | Producer:  Norbert Schlecht<br>Consumer:  Tomas Martin-Mur |
| 6 | Agencies Participating in this Test Case: | Producer:  ESA<br>Consumer:  NASA/JPL |
| 7 | Test Case Number: | 2 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | 2W Range |
| 10 | Tracking Data Date/Time Range: | 2007-03-07T20:32 to 2007-03-07T21:30 |
| 11 | Variances from Expected Results: | None |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | David Berry |
| 14 | Comments: | The IFMS data does not contain the spacecraft delay, so residuals were initially offset.  When the spacecraft receive/transpond delay as supplied in the TDM were used in processing of the IFMS data, the residuals are identical.  See residual plots next two pages. |
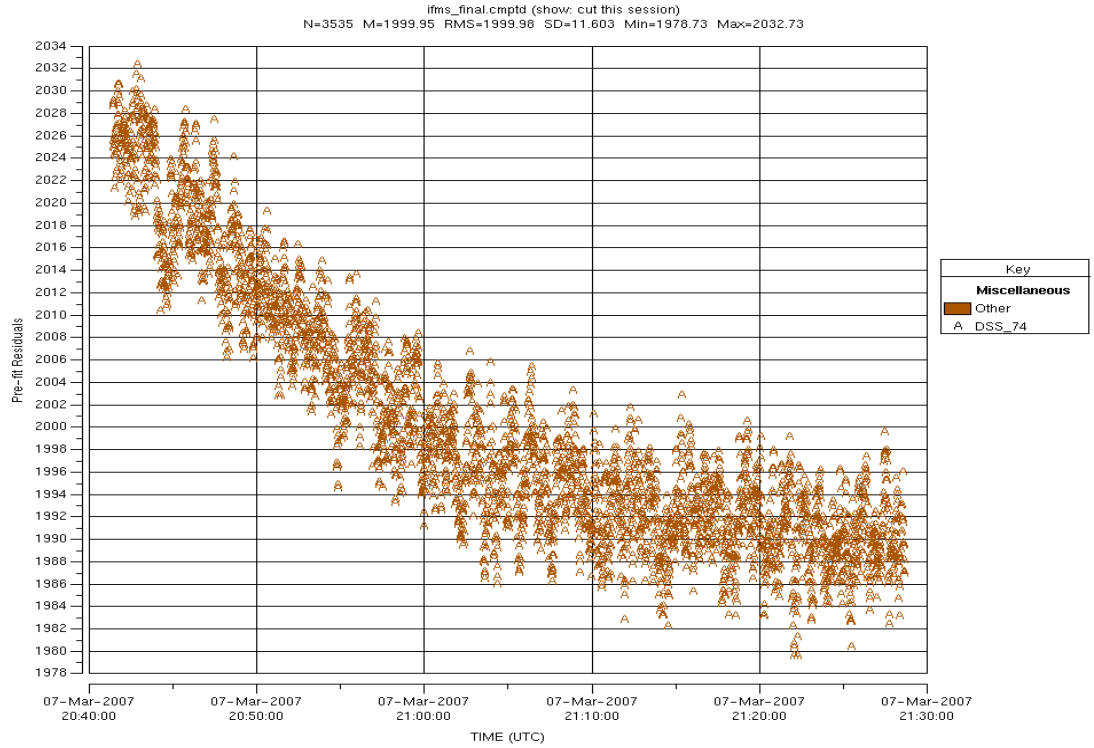
**Figure 3:  2W Range Residuals from IFMS**



**Figure 4:  2W Range Residuals from TDM**

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# Tracking Data Message Prototype Test Data Sheet
### Version 1.0

| 1 | Report Date: | 2007-09-26 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | Producer:  ESOC<br>Consumer:  NASA/JPL |
| 4 | Prototype Version # (if applicable): | Producer:  N/A<br>Consumer: 0.12 |
| 5 | Test Engineer: | Tomas Martin-Mur |
| 6 | Agencies Participating in this Test Case: | Producer:  ESOC<br>Consumer:  NASA/JPL |
| 7 | Test Case Number: | 2 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | Delta-DOR |
| 10 | Tracking Data Date/Time Range: | 2007-02-23T07:06:15.90 to 2007-02-23T07:14:59.99 |
| 11 | Variances from Expected Results: | After switching the order in the values of the PATH_1 and PATH_2 statements, the observables and residuals are consistent.  Note that the input TDM was produced according to TDM R2.1, prior to making the SINGLE_DIFF observable calculation consistent with prior established practice (TDM R2.6) |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | David Berry |
| 14 | Comments: | As the TDM will be used operationally for transfer of ESA Delta-DOR for Phoenix, it will be a good idea to checkpoint before the transfer to ensure that both producer and processor programs observe the adjustment to convention that is noted in #11 above. While it is likely that this adjustment will have already been made, it seems prudent, and basic "due diligence" with new software, to confirm prior to actual operational exchanges. |

## 8.3 Test Case #3: TerraSAR-X / DLR => ESA

### Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 2007/09/17 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | TDM generation: DLR/GSOC<br>TDM processing: ESA/ESOC |
| 4 | Prototype Version # (if applicable): | 0.12 |
| 5 | Test Engineer: | Isidro Muñoz (ESOC), Florian Meissner (GSOC) |
| 6 | Agencies Participating in this Test Case: | DLR, ESA |
| 7 | Test Case Number: | 3 |
| 8 | Spacecraft: | TerraSAR-X |
| 9 | Tracking Data Types: | Angles (azimuth and elevation) |
| 10 | Tracking Data Date/Time Range: | 2007/08/28 15:22 – 2007/08/29 06:05 |
| 11 | Variances from Expected Results: | None |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Isidro Muñoz |
| 14 | Comments: | GSOC provided a TDM containing antenna pointing data together with an OPM. An orbit determination was done using MSSSORB software.<br><br>The results of the orbit determination were as expected. |

## 8.4 Test Case #4: TerraSAR-X / ESA => DLR

### Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 2007/09/17 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | TDM generation: ESA/ESOC<br>TDM processing: DLR/GSOC |
| 4 | Prototype Version # (if applicable): | |
| 5 | Test Engineer: | Florian Meissner (GSOC), Isidro Muñoz (ESOC) |
| 6 | Agencies Participating in this Test Case: | DLR, ESA |
| 7 | Test Case Number: | 4 |
| 8 | Spacecraft: | TerraSAR-X |
| 9 | Tracking Data Types: | Angles (azimuth and elevation) |
| 10 | Tracking Data Date/Time Range: | 2007/06/15 02:29 – 2007/06/18 15:12 |
| 11 | Variances from Expected Results: | None |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Florian Meissner |
| 14 | Comments: | ESOC provided a TDM containing antenna pointing data. The GEOSC file resulting from the processing of the TDM was compared to the original GEOSC file received during LEOP.<br><br>Both GEOSC files are in agreement. |

## 8.5   Test Case #5:  Dawn / ESA => JPL

**NOTE:  Due to delays in the Dawn launch, and the fact that the data types are being prototyped in other test cases (see Test Case #3, #4, and particularly #6), this test was removed from the Prototyping Test Plan.  Thus there is no test sheet for this test.**

## 8.6 Test Case #6: Phoenix / ESA => JPL

### Tracking Data Message Prototype Test Data Sheet
#### Version 1.0

| 1 | Report Date: | 18-Sep-2007 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | Producer: ESOC<br>Consumer: JPL |
| 4 | Prototype Version # (if applicable): | |
| 5 | Test Engineer: | Producer: Isidro Munoz<br>Consumer: David Berry |
| 6 | Agencies Participating in this Test Case: | Producer: ESOC<br>Consumer: JPL |
| 7 | Test Case Number: | 6 |
| 8 | Spacecraft: | Phoenix |
| 9 | Tracking Data Types: | Angle data |
| 10 | Tracking Data Date/Time Range: | 2007-08-04T10:58:36.031 to 2007-08-04T15:43:06.027 |
| 11 | Variances from Expected Results: | None |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Tomas Martin-Mur |
| 14 | Comments: | The ESOC produced TDM was input to the JPL prototype, which created a tracking measurement file that can be used by JPL navigation. From the tracking measurement file, a TDM was then created using the JPL prototype. The 2 TDM's were compared. The only differences were in the presence/absence of optional fields between the 2 prototypes. The order of the PARTICIPANTs on the JPL TDM was reversed with respect to the ESA prototype, however, the corresponding PATH statement was also reversed (and thus compatible). Of the 271 page TDM, the first page, middle page, and last page of the TDM's were compared, with all timetags and data comparing correctly (timetag rounding to the millisecond in JPL case, microsecond in ESA case). All angle measurements compared exactly. |

## 8.7   Test Case #7:  Ancillary Data Types / JPL => ESA

## Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 2007/09/10 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | ESA/ESOC |
| 4 | Prototype Version # (if applicable): | N.A. |
| 5 | Test Engineer: | Norbert Schlecht |
| 6 | Agencies Participating in this Test Case: | NASA/JPL, ESA/ESOC |
| 7 | Test Case Number: | 7 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | STEC |
| 10 | Tracking Data Date/Time Range: | 2007/07/01 |
| 11 | Variances from Expected Results: | To the meta data  "PATH = 2,1" was added. |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Norbert Schlecht |
| 14 | Comments: | The ESOC TDM processing generates CSP from the TDM data. When the number of polynomial coefficients is higher than the number of TDM data points an interpolation is done. So the software reproduced the original CSP command/coefficients. |

## 8.8   Test Case #8:  Ancillary Data Types / JPL => ESA

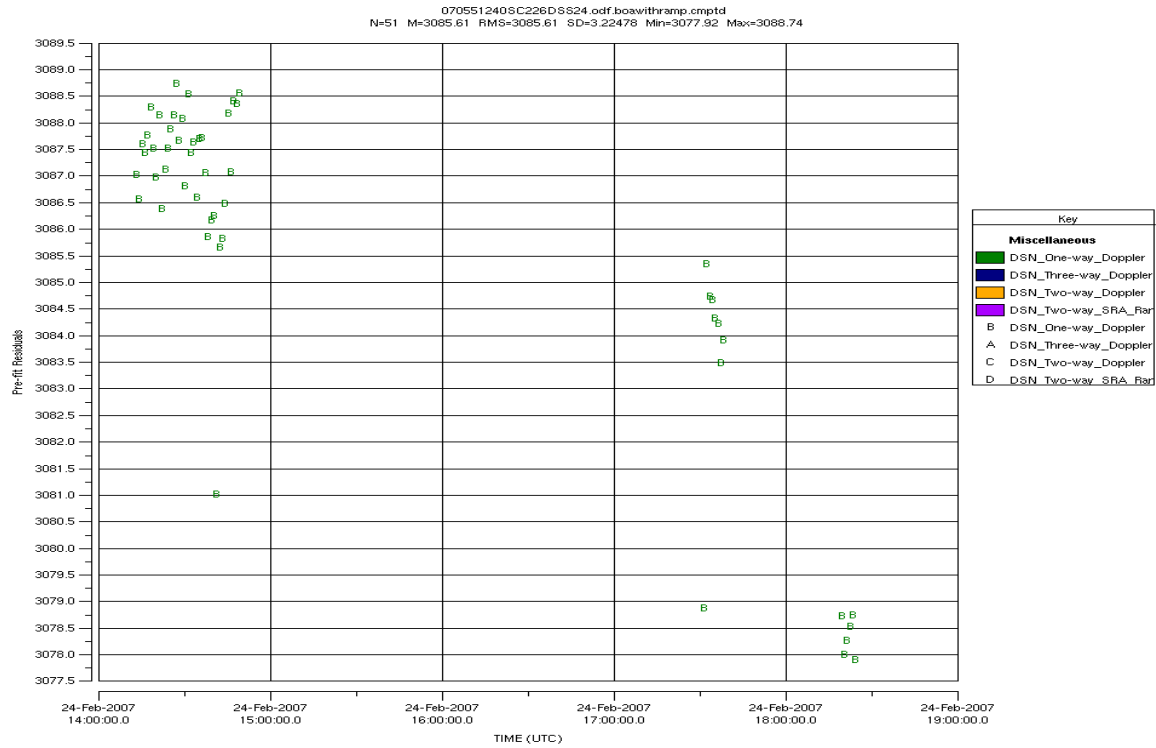### Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 2007/09/10 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | ESA/ESOC |
| 4 | Prototype Version # (if applicable): | N.A. |
| 5 | Test Engineer: | Norbert Schlecht |
| 6 | Agencies Participating in this Test Case: | NASA/JPL, ESA/ESOC |
| 7 | Test Case Number: | 8 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | Troposphere delay corrections |
| 10 | Tracking Data Date/Time Range: | 2007/07/01 |
| 11 | Variances from Expected Results: | Seasonal troposphere TDM data not processed (see below). |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Norbert Schlecht |
| 14 | Comments: | ESOC has hardcoded in their OD software the seasonal JPL model for DSN stations. So the seasonal troposphere TDM data were not tested. The ESOC TDM processing generates CSP from the TDM data. When the number of polynomial coefficients is higher than the number of TDM data points an interpolation is done. The software reproduced the original CSP command/coefficients for the troposphere corrections. |

## 8.9 Test Case #9: 1-Way/3-Way Doppler / JPL Internal

**Tracking Data Message Prototype Test Data Sheet**
**Version 1.0**

| 1 | Report Date: | 14-Sep-2007 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | NASA/JPL |
| 4 | Prototype Version # (if applicable): | 0.12 |
| 5 | Test Engineer: | David Berry |
| 6 | Agencies Participating in this Test Case: | NASA/JPL |
| 7 | Test Case Number: | 9 |
| 8 | Spacecraft: | Rosetta |
| 9 | Tracking Data Types: | 1W Doppler, 3W Doppler |
| 10 | Tracking Data Date/Time Range: | 2007-055T13:22:52 through 2007-055T18:23:55 |
| 11 | Variances from Expected Results: | None |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Tomas Martin-Mur |
| 14 | Comments: | Manual checks of the 1W and 3W data were performed using printouts of the ODF and TDM.  Also, the ODF was processed using the navigation software, and a TDM was produced.  The TDM output from the prototype was then fed back into the navigation software.  Comparison residual plots for 1W and 3W data follow this test data sheet.  There was also 2W Doppler and Range on the ODF and TDM, but they were not checked in this test due to the fact that 2W data types were already checked in Test Case #1 and Test Case #2. |

**Figure 5:  1W Residuals from TRK-2-18 ODF**
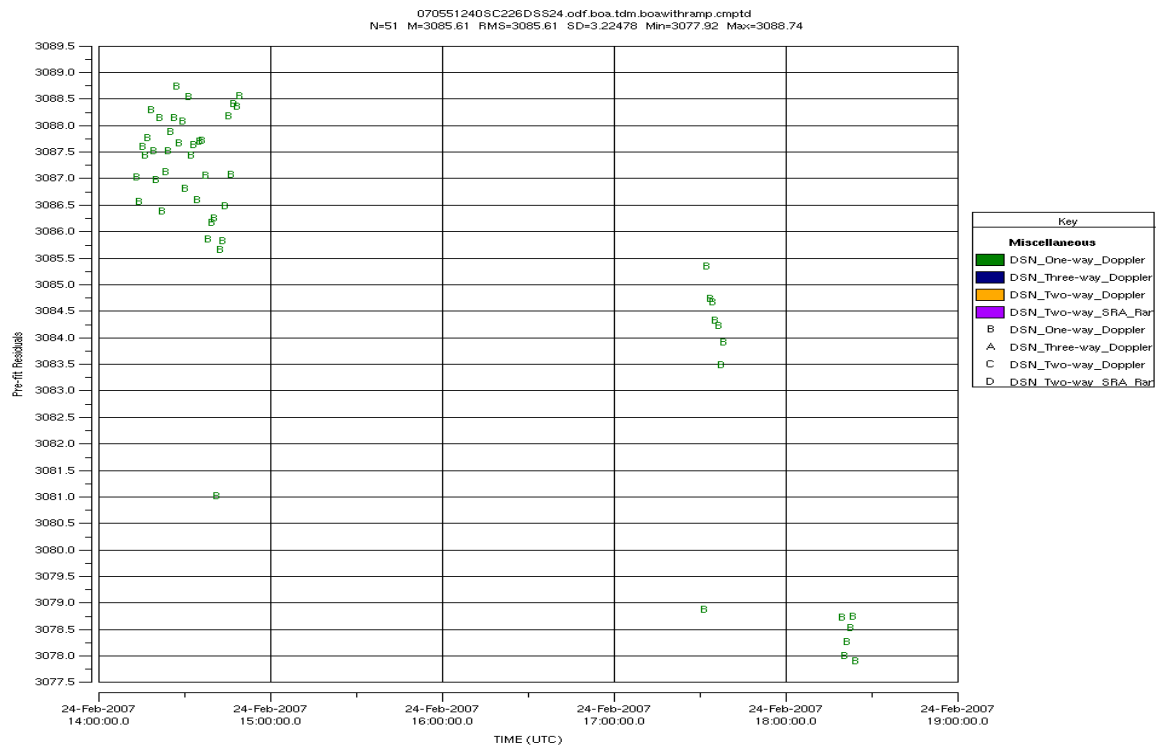


**Figure 6:  1W Residuals from TDM**
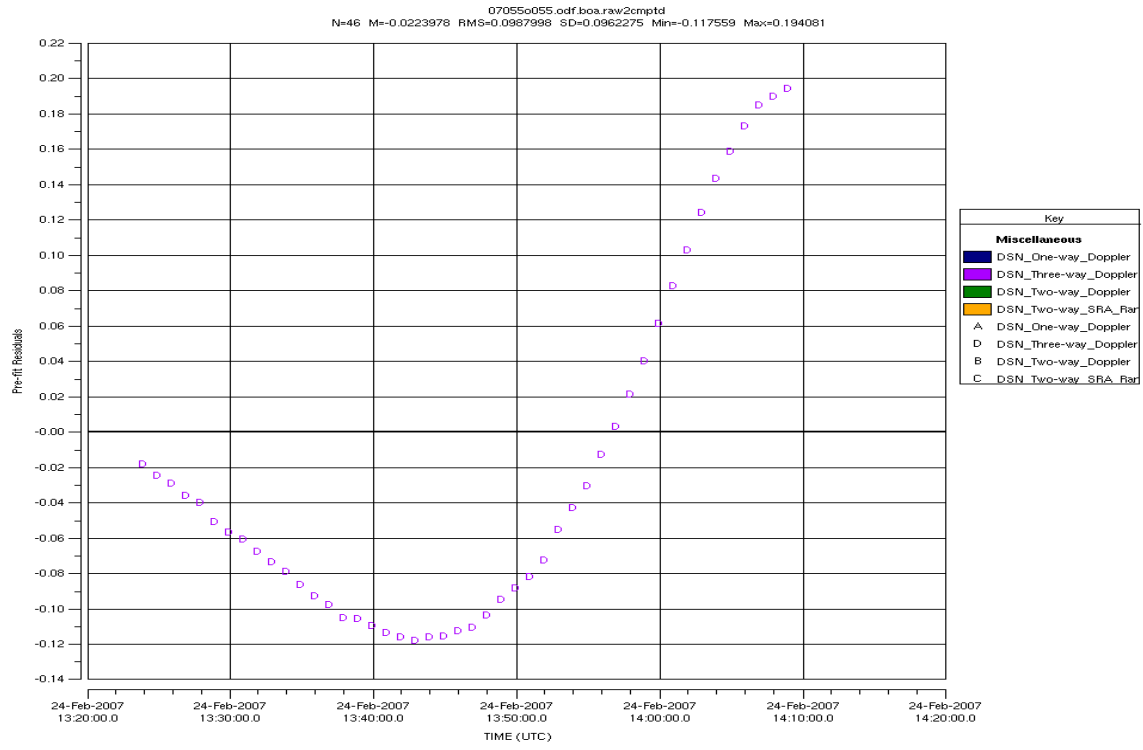
**Figure 7:  3W Residuals from TRK-2-18 ODF**
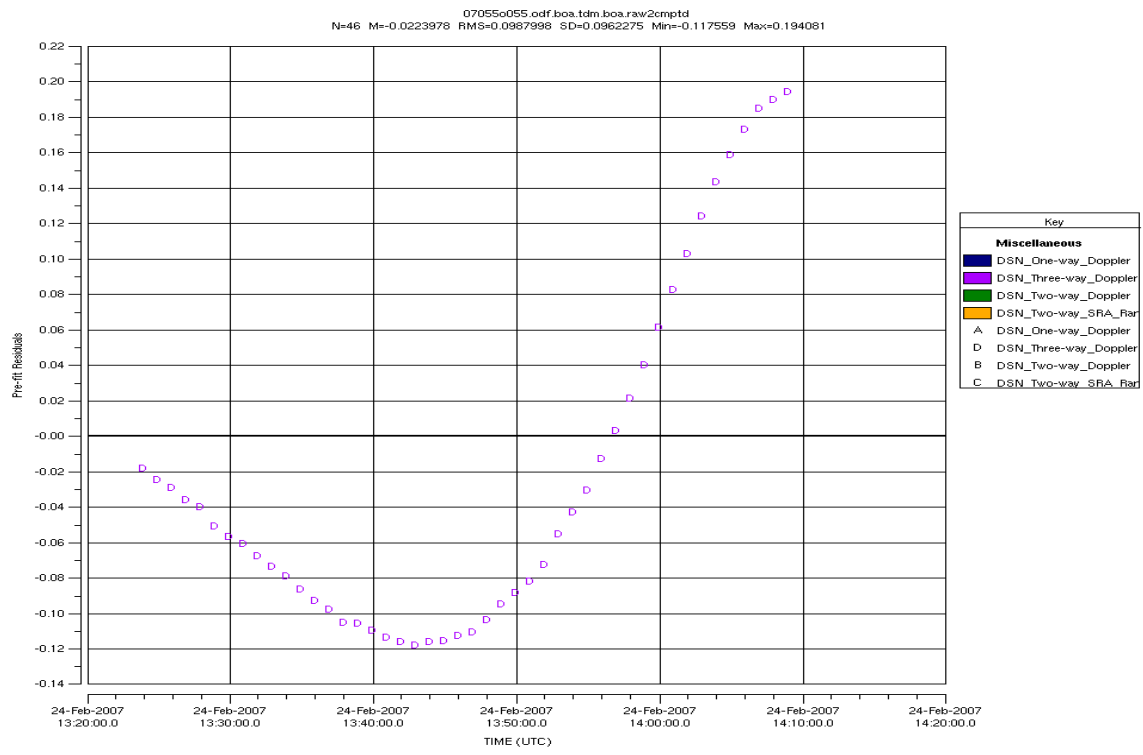


**Figure 8:  3W Residuals from TDM**

## 8.10 Test Case #10:  Meteorological / ESA => JPL
### Tracking Data Message Prototype Test Data Sheet
**Version 1.0**

| 1 | Report Date: | 31-Aug-2007 |
|---|---|---|
| 2 | Program Under Test: | Tracking Data Message (TDM) Prototype |
| 3 | Agency Responsible for Prototype: | ESA |
| 4 | Prototype Version # (if applicable): | N/A |
| 5 | Test Engineer: | David Berry |
| 6 | Agencies Participating in this Test Case: | ESA, NASA/JPL |
| 7 | Test Case Number: | 10 |
| 8 | Spacecraft: | N/A |
| 9 | Tracking Data Types: | Meteorological (temperature, pressure, relative humidity) |
| 10 | Tracking Data Date/Time Range: | 2007-03-07T19:37:50 to 2007-03-07T19:52:50 |
| 11 | Variances from Expected Results: | None. |
| 12 | Results (Pass, Partial Pass, Fail): | Pass |
| 13 | Results Reviewed / Approved By: | Tomas Martin-Mur |
| 14 | Comments: | The TDM also contained TROPO_DRY and TROPO_WET keywords.  These were not checked, as they were not germane to this test case.  Test Case 8 applies to these keywords, so the prototyping of these data types is covered by that test case. |

# 9.    References

[1] *Procedures Manual for the Consultative Committee for Space Data Systems*. CCSDS A00.0-Y-9. Yellow Book. Issue 9. Washington, D.C.: CCSDS, November 2003.

[2] Tracking Data Message, CCSDS 503.0-R-2, Red Book, December 2006.

[3] Tracking Data Message, CCSDS 503.0-R-2.7, Red Book, September 2007.

[4] 820-013, TRK-2-18, Tracking System Interfaces, Orbit Data File Interface, Revision D, 20-December-2006.

[5] IFMS-OCC Interface Control Document, Makalumedia/MR/IFMS/ICD/FTP-OCC, Issue 9.3.1, 09-April-2003.

[6] 820-013, TRK-2-23, Tracking System Interfaces, Media Calibration Interface, Revision A, 31-July-2006.

# 10.  Acronyms

| | |
|---|---|
| CCSDS | Consultative Committee for Space Data Systems |
| CESG | CCSDS Engineering Steering Group |
| CMC | CCSDS Management Council |
| CSP | Control Statement Processor |
| CWE | Common Working Environment |
| DLR | Deutsches Zentrum für Luft und Raumfahrt |
| DSN | Deep Space Network |
| ESA | European Space Agency |
| ESOC | European Space Operations Center |
| IFMS | Intermediate Frequency and Modem Systems |
| JPL | Jet Propulsion Laboratory |
| NASA | National Aeronautics and Space Administration |
| ODF | Orbit Data File (aka TRK-2-18 file) |
| RID | Review Item Discrepancy |
| TDM | Tracking Data Message |