# NASA SDS Orbit Ephemeris Product Software Interface Specification

Rev B

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The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

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# DOCUMENT CHANGE LOG

| Revision | Cover Date | Sections Changed | ECR # | Reason, ECR Title, LRS #* |
|---|---|---|---|---|
| Initial | 09/12/2019 | All | N/A | Modified to serve as SDS orbit ephemeris product SIS. Iterated with Nav and GPS on content.<br>LRR 044686 for NISAR JPL Sharma<br>LRR 044687 for NISAR ISRO |
| Rev A | | 1, 2, 3, 5 | | S1: Update figure 1-1. S2: Update Product latency.<br>S3: Update quality tags, Table 5-3: remove “no scientific notation” for xyz and covariance values in the format |
| RevB | 06/24/2024 | 1.3, 3, 4, 5, 6 | | S1.3: Add Navigation Plan<br>S1.4: Figure 1-1 deleted<br>S2: update table 2-1 and clarify latency and frequency. Add off-nominal statements.<br>S3: Clarified state vector time step value<br>S4: Add missing T to Example filename<br>S5: Fix discrepancies in fileClass, filetype, add empty maneuverList, remove row from covariance fields names, add gpsTimeEpoch, add clarifications, delete absoluteOrbitNumber field. Update manueverList fidelity expectations<br>S6: Add missing Acronyms |
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* *Include the JPL Limited Release System (LRS) clearance number for each revision to be shared with foreign partners.*



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# 1 Introduction

## 1.1 Purpose of Specification

This document serves as the NASA-ISRO Synthetic Aperture Radar (NISAR) L-SAR orbit ephemeris software interface specification (SIS) between the Navigation Team and the SDS. The orbit ephemeris products defined by this SIS will be used by the SDS for science processing and delivered from the SDS to the Distributed Active Archive Center (DAAC) for distribution the science community.

## 1.2 Scope of Specification

This product specification defines the NASA SDS orbit ephemeris products and their subsequent data layers. This includes an overview of time span coverage of various ephemeris products and expected delivery latency.

## 1.3 Applicable and Reference Documents

Applicable documents levy requirements on areas addressed in this document. Reference documents are cited to provide additional information to readers. In case of conflict between the applicable documents and this document, the Project shall review the conflict to find the most effective resolution.

Applicable Documents

- NISAR NASA Science Algorithm Software Design Document (JPL D-102254)

Reference Documents

- NISAR Mission Plan (JPL D-80830)
- NISAR Mission Operations Concept Document (JPL D-80832)
- NISAR Mission System Level 3 Requirements (JPL D 76366)
- NISAR SDS Orbit Ephemeris Product Functional Design Document and Operations Concept (JPL D-95657)
- GPS Directorate (2019) "NAVSTAR GPS Space Segment/Navigation User Segment Interfaces, Rev. K" IS-GPS-200, p.36 https://www.gps.gov/technical/icwg/IS-GPS-200K.pdf
- NISAR Navigation Plan (D-76341)



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## 1.4 SDS Orbit Ephemeris Product Background

The NASA SDS will receive four ancillary orbit ephemeris products on an operational basis:

1. Forecast Orbit Ephemeris (FOE)
2. Near real-time Orbit Ephemeris (NOE)
3. Medium-fidelity Orbit Ephemeris (MOE)
4. Precise Orbit Ephemeris (POE)

This document describes the salient features of each of the orbit ephemeris products and then defines the common format in which these will be received by SDS and delivered to the DAAC. **Error! Reference source not found.** shows the temporal relationship between the acquired SAR data and the orbit ephemeris products that could be used to process the SAR data.

## 1.5 Organization of this Document

Section 2 provides a description of the qualitative difference between different NISAR SDS Orbit Ephemeris products. Section 3 describes the various conventions used to describe the position and velocity of the imaging platform. Section 4 provides the orbit ephemeris product file naming convention. Finally, Section 5 describes the orbit ephemeris file format in detail.

# 2 SDS ORBIT EPHEMERIS PRODUCT CHARACTERISTICS

Table 2-1 shows the salient features of orbit ephemeris products that will be received by the SDS via the GDS and delivered to the DAAC for archiving. Latency and frequency in Table 2-1 are the Current Best Estimates (CBE) . Agreed upon latencies and frequencies are captured in the Mission Systems Operation Interface Agreements (OIA). The orbit ephemeris data is publicly available via the DAAC within 24 hours.



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Table 2-1. Salient characteristics of orbit ephemeris products

| Product | CBE Latency | CBE Delivery frequency | Time coverage | Sampling |
|---|---|---|---|---|
| Forecast Orbit Ephemeris (FOE) | forecast | daily | One week into the future | Every 30 sec |
| Near real-time Orbit Ephemeris (NOE) | hours | Sub-daily | One product file released every hour containing up to 30 hours of reconstructed orbits. May be a few hours less depending on downlink schedule | Every 10 sec |
| Medium Precision Orbit Ephemeris (MOE) | days | daily | One product file per day, including 3 hours of orbits from previous and subsequent day | Every 10 sec |
| Precise Orbit Ephemeris (POE) | weeks | daily | One product file per day including 3 hours of orbits from previous and subsequent day | Every 10 sec |

The table above provides CBEs for the latency and frequency of XML orbit ephemeris products in order to provide an approximate guide under nominal operations. For full details and the most up-to-date values of the expected latency and delivery frequencies, please see associated OIAs (e.g. JPL-NAV-017, JPL-NAV-019). The CBEs above should not be relied upon during off-nominal operations (e.g. GPS safing, spacecraft safing).

# 3 SDS ORBIT EPHEMERIS PRODUCT CONVENTION

The orbit ephemeris products will use the following conventions:

1. A single state vector of the imaging platform will include Universal Time Coordinated (UTC) time tag, position vector (x, y, z), velocity vector (vx, vy, vz), and acceleration vector (ax, ay, az).
2. The position, velocity and acceleration will be provided in Earth-Centered, Earth-Fixed coordinate system with respect to the WGS84 G1762 system.
3. All information will be provided in SI units, i.e., position in meters (m), velocity in meters per second (m/s), and acceleration in meters per second squared ($m/s^2$).
4. The position, velocity, and acceleration state vectors will correspond to the L-SAR antenna phase center.
5. It is assumed that the ISRO S-SAR antenna phase center and L-SAR antenna phase centers coincide.



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6. State vectors in FOE will be output in time steps no greater than 30 seconds, and state vectors in NOE, MOE, and POE will be output in time steps no greater than 10 seconds.
7. A 6x6 error covariance matrix will be included with every state vector to allow for propagation of orbit uncertainties. The order of the entries in the covariance matrix are x, y, z, vx, vy, and vz.
8. Each state vector will be accompanied by a quality classification. The following quality tags are proposed:
    a. NOMINAL
    b. MANEUVER
    c. LARGE FORMAL ERRORS
    d. NO DATA (no GPS data for at least 300s)
    e. PREDICT.

# 4 SDS ORBIT EPHEMERIS PRODUCT FILE NAMING CONVENTION

Syntax:

NISAR_PID_P_PT_PRD_CreationDateTime_ValidityStartDateTime_ValidityEndDataTime.xml

where

- NISAR – 5 char for mission: NISAR
- PID – 3 character for Product Interface Definition Type: ANC for Ancillary
- P – 1 character for applicability to different instruments:
    - L (L-SAR only)
    - S (S-SAR only)
    - J (both L-SAR and S-SAR)
- PT – 2 chars for Processing Type and producer:
    - PR – Production JPL
    - UR – Urgent Response JPL
- PRD – 3 characters for the Product Type: FOE, NOE, MOE, POE
- CreationDateTime – 15 chars, UTC time tag of the product creation time in YYYYMMDDTHHMMSS format
- ValidityStartDateTime – 15 chars, time tag of the first orbit state vector in product in YYYYMMDDTHHMMSS format
- ValidityEndDateTime – 15 chars, time tag of the last orbit state vector in product in YYYYMMDDTHHMMSS format



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Example:
NISAR_ANC_J_PR_POE_20190904T145019_20180603T225942_20180605T005942.xml

# 5 SDS ORBIT EPHEMERIS PRODUCT INTERFACE DEFINITION

This section describes the XML format of an orbit ephemeris product. Each ephemeris product file consists of three primary collections: *productInformation, maneuverList,* and *orbitStateVectorList*. An orbit ephemeris product file is organized as follows:

```
<orbitEphemeris>
    <productInformation>
      ….
    </productInformation>
    <maneuverList>
    …..
    </maneuverList>
    <orbitStateVectorList count=”****”>
     ….
    </orbitStateVectorList>
</orbitEphemeris>
```

## 5.1 *productInformation* collection

The *productInformation* collection captures information regarding the product, such as product name, validity time period, input files, and file versions. This collection does not contain any orbit ephemeris information. The *productInformation* collection is organized as follows:

```
<productInformation>
   <productName>…</productName>
   <mission>…</mission>
```




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<validityStartDateTime>…</validityStartDateTime>
<validityEndDateTime>…</validityEndDateTime>
<fileClass>…</fileClass>
<fileType>…</fileType>
<productVersion>…</productVersion>
<creator>…</creator>
<creationDateTime>…</creationDateTime>
<gpsReferenceEpoch>….</gpsReferenceEpoch>
</productInformation>

Table 5-1 provides the characteristics of each of the *productInformation* tags.

Table 5-1. *productInformation* XML tags

| Field (XML Tag) | Description | Format |
|---|---|---|
| productName | Identifier for this specific ROP instance | Unique ID, also reflected in filename convention. |
| mission | Name of the mission | String<br>Valid Value: NISAR |
| validityStartDateTime | Time tag of first orbit state vector in product | Date and time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| validityEndDateTime | Time tag of last orbit state vector in product | Date and time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| fileClass | Indicate class of product. | String<br>Valid Values: Operational, Custom, Test |
| fileType | To indicate type of orbit product | String<br>Valid Value: FOE, NOE, MOE, POE |
| creator | Name of the creator. Indicate the agency or group generating the product | String<br>Valid Values: NASA JPL, ISRO |
| creationDateTime | Time tag associated with product creation | Date and Time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| gpsReferenceEpoch | The “zero” for the GPS time in the gps field. Matches the definition used in GipsyX software. | ISO format + reference system (UTC)<br>2000-01-01T11:59:47.000000 UTC |

## 5.2 *maneuverList* collection

The *maneuverList* collection captures any additional information that may impact the quality of the ephemeris solutions in the product. This collection includes time-span information and the nature of maneuvers. The FOE, MOE, NOE maneuvers are forecasted and may not actually be



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executed. The POE will only contain executed maneuvers. The *maneuverList* collection is organized as follows:

<maneuverList count=”3”>
<maneuver index=”1”>
….
</maneuver>
…..
<maneuver index=”3”>
….
</maneuver>
</maneuverList>

If the maneuverList is empty, the XML file will contain the following:

<maneuverList count=”0”/>

### 5.2.1 *maneuver* tag

A single maneuver entry is as follows:

<maneuver index=”**”>
<startDateTime>….</startDateTime>
<endDateTime>….</endDateTime>
<note>….</note>
</maneuver>

Table 5-2 provides the characteristics of each of the *maneuver* tags.

Table 5-2. *maneuver* XML tags

| Field (XML Tag) | Description | Format |
|---|---|---|
| startDateTime | Time tag of first orbit state vector in product | Date and Time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| endDateTime | Time tag of last orbit state vector in product | Date and Time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| note | Description of maneuver or relevant information | String |




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## 5.3 *orbitStateVectorList* collection

*orbitStateVectorList* encapsulates a collection of *orbitStateVector* tags. The total number of orbit state vectors is included as an attribute named *count* of the *orbitStateVectorList* tag. Each of the individual *orbitStateVector* tags are also tagged with an attribute named *index* to indicate their relative position in the collection. The *orbitStateVectorList* tag is organized as follows:

```
<orbitStateVectorList count=”8400”>
    <orbitStateVector index=”1”>
     ….
    </orbitStateVector>
    ….
    <orbitStateVector index=”8400”>
    ….
    </orbitStateVector>
</orbitStateVectorList>
```

### 5.3.1 *orbitStateVector* tag

A single state vector entry is as follows:

```
<orbitStateVector index=”****”>
   <utc>…</utc>
   <tai>…</tai>
   <gps>…<gps>
   <x>…</x>
   <y>…</y>
   <z>…</z>
   <vx>…</vx>
   <vy>…</vy>
   <vz>…</vz>
   <ax>…</ax>
   <ay>…</ay>
   <az>…</az>
   <quality> … </quality>
   <covariance>
      <x> … </x>
      <y> … </y>
```




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```
      <z> … </z>
      <vx> … </vx>
      <vy> … </vy>
      <vz> … </vz>
   </covariance>
</orbitStateVector>
```

Table 5-3 provides the characteristics of each of the *orbitStateVector* tags.

Table 5-3. *orbitStateVector* XML tags

| Field (XML Tag) | Description | Format |
|---|---|---|
| utc | Time tag of state vector in Coordinated Universal Time | Date and time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| tai | Time tag of state vector in International Atomic Time | Date and time in ISO-8601 format (YYYY-MM-DDThh:mm:ss.uuuuuu) |
| gps | GPS time in seconds | Quad precision number |
| x | X-coordinate in meters | Double precision number |
| y | Y-coordinate in meters | Double precision number |
| z | Z-coordinate in meters | Double precision number |
| vx | Velocity in X in meters per sec | Double precision number |
| vy | Velocity in Y in meters per sec | Double precision number |
| vz | Velocity in Z in meters per sec | Double precision number |
| ax | Acceleration in X in meters per sec^2 | Double precision number |
| ay | Acceleration in Y in meters per sec^2 | Double precision number |
| az | Acceleration in Z in meters per sec^2 | Double precision number |
| quality | String indicating quality of state vector. One of few pre-determined values. See section 3 for valid values. | String |
| Covariance/row | Represents rows of covariance matrix associated with the state vector | List of space separated 6 double precision numbers |



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# 6 ACRONYMS

| | |
|---|---|
| ADT | Algorithm Development Team |
| CBE | Current Best Estimate |
| DAAC | Distributed Active Archive Center |
| FOE | Forecast Orbit Ephemeris |
| GDS | Ground Data System |
| GPS | Global Positioning System |
| InSAR | Interferometric Synthetic Aperture Radar |
| JPL | Jet Propultion Laboratory |
| MOE | Medium-fidelity Orbit Ephemeris |
| NASA | National Aeronautics and Space Administration |
| NISAR | NASA-ISRO Synthetic Aperture Radar |
| NOE | Near Real-time Orbit Ephemeris |
| OIA | Opeations Interface Agreement |
| POE | Precision Orbit Ephemeris |
| SAR | Synthetic Aperture Radar |
| Sec | seconds |
| SDS | Science Data System |
| SIS | Software Interface Specification |
| TAI | International Atomic Time |
| UR | Urgent Response |
| UTC | Coordinated Universal Time |
| XML | Extensible Markup Language |



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