AFSPC Astrodynamic Standard Software

Last Revision: 29-March-2012

AFSPC/A9AC maintains and distributes, for AFSPC, the following Astrodynamic Standard Software. All software listed here contains these markings: **U.S. Only, Unclassified, Export Controlled**. Due to the sensitive nature of these products, access to these programs is tightly controlled. All requests for this software must be approved in writing by **HQ AFSPC/A3C.**

(To request the Astrodynamic Standards software, see the section titled "Obtaining the Astrodynamic Standards Software Products" below.)

Available Software

Key to Table Entries: *(next two tables)*

Y - Listed program/version IS available for operating system/platform.

• - Listed program/version is NOT available for operating system/platform.

Officially Released Astrodynamic Standards Software

SOFTWARE	VERSION	Linux 32-bit	Linux 64-bit	SGI	SunSolaris Sparc	SunSolaris x86_64	Windows 32-bit	Windows 64-bit
AOF	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
BatchDC	**V5.4.1c**	•	•	Y	•	Y	•	•
BatchDC	**V5.4.1d**	Y	•	•	•	•	Y	•
COMBO	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
FOV	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
IOMOD	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
LAMOD	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
ROTAS	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
SATRAK	**V6.0**	•	•	•	•	•	Y	•
SeqDC	**V5.2**	Y	•	•	•	•	Y	•
SGP4	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y
SPEPH	**V5.4.2**	Y	Y	Y	Y	Y	Y	Y

Pre-Release (BETA) Software *(not for use in operational systems)*

SOFTWARE	VERSION *(family)*	Linux 32-bit	Linux 64-bit	SGI	SunSolaris Sparc	SunSolaris x86_64	Windows 32-bit	Windows 64-bit
COMBO	**V7.beta**	•	•	•	•	•	Y	•
JAFSPCAS-SGP4 **	**V1 (beta)**	•	•	•	•	•	Y	•
LAMOD	**V7.beta**	•	•	•	•	•	Y	•
SATRAK	**V7.beta**	•	•	•	•	•	Y	•
SGP4	**V7.beta**	Y	Y	•	•	•	Y	Y
SP *	**V7.beta**	Y	Y	•	•	•	Y	Y

Notes:

1) For Pre-Release software: version family shown. Actual version currently available may include minor version designators not listed here.

2) * The V7.beta SP program is the follow-on product to the V5.4.2 SPEPH program. Previous versions of the SPEPH program had SGP4 functionality embedded in it. The new SP program no longer contains this functionality. (Note: The SGP4 functionality is available in the SGP4 program - a separate software product available from HQ AFSPC/A9).

   What this means from a user perspective...

   The older SPEPH program would accept either VCMs or TLEs as input for ephemeris generation calculations. The new SP program will only accept VCMs as input for ephemeris generation calculations. If you need to generate ephemeris data from TLE input data, you'll need to use the SGP4 program.

3) ** JAFSPCAS-SGP4 is the java implementation of the SGP4 product. It also contains the following propagators: SGP, Two-Body, and GPJ2. An example Graphical User Interface is included.

Astrodynamic Standards Software Products - Program File Types

The Astrodynamic Standard programs are available in the following formats:

- BatchDC, SeqDC, and SATRAK 6.0 are only available as standalone executable programs.
- SATRAK V7 (Beta) is available in an install package format. It relies on a .msi *(Windows Install file)* to install the software and modify the Windows registry.
- JAFSPCAS-SGP4(Beta) is only available as java compiled bytecode *(class files).*
- All other programs are delivered as either Dynamic Link Library (dll) files *(MS Windows operating systems)* or Shared Object (so) files *(Linux/Unix operating systems)*. These programs cannot be run standalone. A separate driver program is required to access the Astrodynamic Standards functionality. An example driver program (including source and build file) is included in all deliveries of this type.

Software Descriptions

Abbreviations used in this section:	
ASTAT - Association STATus	JSpOC - Joint Space Operations Center
TLE - Two Line Element set	VCM - Vector Covariance Message

PROPAGATORS:

SGP4 - (Simplified General Perturbations #4) Is an analytic method based on a general perturbation theory for generating ephemerides for satellites in earth-centered orbits. It is the proper means for correctly propagating a JSpOC TLE

SP and **SPEPH** - (Special Perturbations) Is a high accuracy special perturbations theory which uses numerical integration to calculate ephemerides for satellites in earth-centered orbits. It is the proper means for correctly propagating a JSpOC VCM.

APPLICATIONS:

AOF - (Area Over flight) - AOF computes when overhead satellites have potential visibility to a geographic location or area on the surface of the earth. Visibility is defined as a nominal FOV (user specified angle half-angle) around the satellite's subpoint intersecting the defined points or areas on the surface. Supported geometries include either a point, a circular area about a point, or a regular trapezoidal area based on two geodetic coordinates. The satellite's input orbit description may be either a SGP4 TLE or a SP VCM.

BATCHDC - (Batch Differential Correction) Performs a least squares batch differential correction of orbital elements using tracking data (sensor observations). It will properly update either SGP4 keplerian elements (JSpOC TLE) or SP state vectors (JSpOC VCM) using the appropriate propagator theory.

COMBO - (Computation of Miss Between Orbits) Computes close approaches between satellite orbits based on user specified criteria. The input orbit descriptions may be either a SGP4 TLE, a SP VCM, or an externally generated ephemeris file. In COMBO V7 probability of collision is calculated when SP VCMs are input.

FOV - (Field-of-View) FOV determines times in which orbiting satellites fly through a ground based observer's conical field of view. The field of view can be defined by a constant azimuth and elevation boresight, a constant right ascension and declination boresight, or as a line-of-site to an orbiting satellite. The input orbit descriptions may be either a SGP4 TLE, a SP VCM, or an externally generated ephemeris file.

IOMOD - (Initial Orbit Generation) Computes an initial set of orbital elements (JSpOC TLE) from three sensor observations.

LAMOD - (Look Angle Module) Computes sensor (ground based or space based) viewing opportunities (i.e., "look angles") for earth centered satellites. The input orbit description may be either a SGP4 TLE, a SP VCM, or an externally generated ephemeris file.

ROTAS - (Report/Observation Association) Associates sensor observations against satellite element sets using the same algorithms used by the JSpOC. It correctly determines the appropriate ASTAT association

status category (0, 1, 2, 3). The input orbit description may be either a SGP4 TLE, a SP VCM, or an externally generated ephemeris file.

SEQDC - Sequential Differential Correction Sequential Differential Correction performs a series of least-squares differential corrections (DC). These differential corrections are computed in a sequential mode, which uses one or more observations or tracks while retrieving former covariance information from a prior DC. SEQDC uses either the SGP4 or SP theory for ephemeris calculation.

TOOLS:

SATRAK - (Satellite Trajectory and Attitude Kinetics) SATRAK V7 replaces the legacy DOS-based SATRAK V6 with a modern and richly interactive user interface suited for current Windows operating systems. SATRAK allows analysts to generate SGP4 ephemeris, use LAMOD to determine satellite viewing opportunities, and analyze JSpOC TLE datasets. The results may be displayed on 2D and 3D maps/views, as plain text listings, and/or as tabular data. There is advanced sorting, filtering, and grouping capabilities for the tabular input and output data. Graphics options include the display of sensor coverage, color coding of various display elements, and various other enhancements/features that aid analysis.

In addition, some additional specialized functionality is also included:

- SimOrb - Create a TLE from launch related data (launch time, launch location, azimuth or inclination, period or altitude).
- Decay - Estimate when one or more satellites will decay using the King-Hele algorithm (TLE & solar flux inputs).
- BLUE - Update a nominal launch folder TLE to a "on-orbit" TLE based on launch time.
- MANAL - Given pre- and post- maneuver orbit descriptions (TLE), analyze a maneuver's parameters.

32-bit vs. 64-bit Operating System Considerations

The 32-bit Astrodynamic Standards programs will generally run on platforms running a 64-bit version of the same operating system. For standalone executables (such as BatchDC), there is rarely a problem. However for dll and so-based programs, care must be taken to insure that the program and all the necessary runtime components are of the same architecture. *Reminder: Be sure to use the correct 32 or 64-bit compiler option when compiling the driver programs.*

For example, if the 32-bit AOF program is planned to be run on a 64-bit system:

- the 32-bit AOF dlls (or shared objects) must be installed on the system,
- the associated driver program used to access the AOF functions must be present and compiled as a 32-bit executable, and
- any necessary “non-A9-developed” runtime libraries (e.g. FORTRAN Math Libraries), must be of the correct architecture to be called by the 32-bit AOF program and suitable for the operating system type.

Note that none of the 64-bit Astrodynamic Standards programs will run on a 32-bit operating system.

Astrodynamic Standards Software Technical Contacts

More information on the suitability of the software products for an intended purpose can be obtained from:

Dinh Nguyen, HQ AFSPC/A9AC, 719-556-3705, dinh.nguyen.1@us.af.mil

Stephen McCaughey, HQ AFSPC/A9AC, 719-5563708, mailto:stephen.mccaughey@us.af.mil

Tim Payne, HQ AFSPC/A9AC, 719-556-3706, tim.payne@us.af.mil

Note: The Space Innovation and Development Center (SIDC) **Integrated Space Situational Awareness (**ISSA 5.0 AV) (Formerly **SCOPES**) software product is not maintained or delivered by HQ AFSPC/A9AC.
For more info on this product, contact:

Mr. John Lundy, 719-721- 9787, john.lundy@us.af.mil

Mr. Marc Herklotz, 719-721-9247, marc.herklotz@us.af.mil

Ms. Robin Herklotz, 719- 721-9209, robin.herklotz.ctr@us.af.mil

Obtaining the Astrodynamic Standards Software Products

Astrodynamic Standards software will not be released without written approval from HQ AFSPC/A3C.

The following are the Government Points of Contact for Distribution of AFSPC Astrodynamic Standards:

Primary email contact:

Mr. Mark S. Riddle, HQ AFSPC/A3SC ,
mark.riddle.2@us.af.mil, 719-554-9582, DSN 692-9582

Include Courtesy Copy emails to:

Maj Nathaneal T White, HQ AFSPC AFSPC/A3SC,
nathanael.white@us.af.mil, 719-554-3770, DSN 692-3770

and

Lt Col Tyler M. Evans, Chief, Space Control Operations, HQ AFSPC/A3SC
tyler.evans@us.af.mil, 719-554-3606, DSN 692-3606

Requests for Astrodynamic Standards Software products must be made through HQ AFSPC/A3CN. Due to the sensitive nature of these products, access to these programs is tightly controlled. All applicants must be working on programs in support of or in partnership with the U.S. Government. These programs are not available for commercial use.

There are two methods currently available for requesting the Astrodynamic Standards software.

1. The "manual" method, where AFSPC/A3CN sends the applicant the request paperwork in MS Word format. (Contact the POCs listed above for more information).

2. The "SARP" method, where the request is submitted via the Space Analysis Resource Portal (SARP) website. (In order to navigate to the SARP website, https://halfway.peterson.af.mil/SARP, the requestor must have an U.S Govt issued CAC card and be logged into the NIPRnet or SIPRnet. This website cannot be accessed from the Internet). For more information on obtaining the Astrodynamic Standards software using the SARP method, refer to the document, "***Instructions for Requesting Astrodynamic Standards Software.pdf***" (available upon logging onto the SARP website or available upon request).

Astrodynamic Standards Release Package - Contents

Once the necessary request has been approved by HQ AFSPC/A3C, HQ AFSPC/A9AC be notified and will create an ***Astrodynamic Standards Release Package*** for the requesting entity. This delivery package will typically contain:

- The latest currently available documentation for the software product(s),
- The approved software product(s),
- Example driver files (including driver source), if applicable. For dll and shared object-based Astrodynamic Standard programs (see Program File Types), this will include an example driver program written in C for V5.4.2 products, and an example driver program written in C, C#, VB.NET, FORTRAN, Java (via provided JNIs), and Matlab for the V7.beta programs (when available).
- A working, standalone test environment, if available. Typically, all that is necessary to run the included test files is to copy the directory to the target machine (although some setup may be necessary for Unix/Linux machines). The test environment contains test cases, input and data files necessary to run the program. Output data from A9 runs is included, as well as a means to compare the output generated by the test cases to the output provided by A9,
- The newer products (generally V7.beta and some 64-bit programs) include VERDICT, a comparison program written by HQ AFSPC/A9AC's Dinh Nguyen. This program can compare selected results between two runs even if the formats of the files differ. The VERDICT program output describes the magnitude of the differences, so it is easier to tell whether the difference is significant or not.

The SATRAK and JAFSPCAS-SGP4 Release Packages do not contain the standalone test environment detailed in the previous paragraph. They do provide a graphical or form-based user interface.

Astrodynamic Standards Release Package – Delivery Method

Depending on the request method used, the software is delivered via the following means:

If the request was generated by the SARP method:

If all the requested software is available via the SARP website, the requestor will obtain the software via download from the website. Note that the requestor here is the person who actually submitted the request on the SARP website. This might be different than the POC identified in the approval paperwork.

If some software is not available on the SARP website, the missing software items will be sent via the "manual" method (below).

If the request was generated by the "manual" method, the software is typically sent to the POC on an optical disc (CD or DVD) sent via U.S. Mail, Certified Delivery. The POC can specify an alternate recipient or delivery address be used instead as long as the recipient is covered by the signed MOA/NDA legal agreements For example, the POC can direct that the delivery be sent to the Technical POC at the actual work location.

Other delivery methods are also possible (local delivery, overnight, etc), but require prior coordination.

Appendix A

Astrodynamic Standards – Grouped by Functionality

ORBITAL APPLICATIONS

- Look Angle Generation (LAMOD)
- Computation of Miss Between Orbits (COMBO)
- Overfly (AOF)
- Field of View (FOV)

EPHEMERIS GENERATION

- SGP4
- SPEPH and SP

ORBITAL CORRECTION

- BATCHDC (Provides orbital correction to both SGP4 and SP)
- SEQDC (Provides batch sequential DC capability for both SGP4 and SP)

OBSERVATION ASSOCIATION

- ROTAS

INITIAL ORBIT GENERATION

- IOMOD