The UCS Satellite Database

The UCS Satellite Database is a listing of active satellites currently in orbit around the Earth. It is available as both a downloadable Excel file and in a tab-delimited text format, and in a version (tab-delimited text) in which the "Name" column contains only the official name of the satellite in the case of government and military satellites, and the most commonly used name in the case of commercial and civil satellites. The database is updated roughly quarterly.

Our intent in producing the Database is to create a research tool by collecting open-source information on active satellites and presenting it in a format that can be easily manipulated for research and analysis. The Database includes basic information about the satellites and their orbits, but does not contain the detailed information necessary to locate individual satellites. The UCS Satellite Database can be accessed at www.ucsusa.org/satellite_database.

Using the Database

The Database is free and its use is unrestricted. We request that its use be acknowledged and referenced in written materials. References should include the version of the Database that was used, which is indicated by the name of the Excel file, and a link to or URL for the webpage www.ucsusa.org/satellite_database.

We welcome corrections, additions, and suggestions. These can be emailed to the Database manager at SatelliteData@ucsusa.org

If you would like to be notified when updated versions of the Database are completed, please send an email request to this address.

Caveats

We have attempted to include all currently active satellites. However, because satellites are constantly being launched, decommissioned, or simply abandoned, the list may inadvertently contain some satellites that are no longer active but for which we have not yet received information. In cases where the available information is incomplete or inconsistent, the entries reflect our judgments based on the best information publicly available. The information in the Database, especially the orbit and parameters of the satellite, should be regarded as approximate and used as a guide to further investigation.

The official names of the U.S. military optical imaging satellites are not publicly known and there is no consensus on naming among public sources. As a result, we designate these satellites by "Keyhole" in the database, but list as well the alternate designations we have found in the sources.

Definition of Active Satellites

The database includes only "active" satellites: satellites that are currently maneuvering and/or communicating. This excludes satellites still orbiting but now no longer in use, though some of these may be still occasionally used for training operators or other secondary purposes. This also excludes passive satellites used, for example, for laser ranging and radar calibration, such as LAGEOS 1 and LAGEOS 2 and the CALSPHERE satellites.

Note on Sources

The information included in the Database is publicly accessible and free and was collected from corporate, scientific, government, military, non-governmental, and academic websites available to the public. No copyrighted material was used, nor did we subscribe to any commercial databases for information. Information from the Orbital Information Group (OIG) of NASA, which obtains its information from Air Force Space Command (AFSPC), was not used. Much of the information on classified satellites was obtained from magazine and newspaper articles and non-governmental organizations. Orbital data were obtained from Dr. Jonathan McDowell's SATCAT and GEO catalogues at his website, http://www.planet4589.org/space/, from the Office of Outer Space Affairs of the United Nations**,** and occasionally from other website sources**.** Orbital data for a few of the military satellites is estimated or obtained from http://www.globalsecurity.org. We encourage users with a broader interest in satellite catalogues to seek out Dr. McDowell's website and the AGI Satellite Database http://www.stk.com/resources/satdb/satdb1.cfm.

Acknowledgements

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User's Guide to the UCS Satellite Database

The following is a description of the information contained in the Database columns.

A: Name of Satellite, Alternate Names

The current or most popularly used name is listed first, with alternate or previously used names given in parentheses. A satellite can have several names during its operational lifetime, especially commercial satellites that are sold, leased, transferred as assets in business transactions, or simply used by more than one user. U.S. government intelligence satellites may be known by several names at the same time. A search of this column using the name familiar to you should locate the satellite.

In the files called "UCS_Satellite_Database_officialname_*date*.xls" and "UCS_Satellite_Database_officialname_*date*.txt", this column contains only the official name of the satellite in the case of government and military satellites, and the most commonly used name in the case of commercial and civil satellites.

B. Country of Operator/Owner

The home country identified with the operator/owner given in column C, i.e., the country that operates or owns the satellite or the home country of the business entity that does so. If this includes three or fewer countries, each is listed; otherwise the project is simply designated as Multinational. An exception to this is projects of the European Space Agency (ESA), which represent the joint efforts of its 15 member states and are designated as ESA.

C: Operator/Owner

The satellite's current operational controller. The operator is not necessarily the satellite's owner, as is the case for leased satellites.

D: Users

The affiliation of the primary users of the satellite is described with one or more of the keywords: *civil* (academic, amateur), *commercial*, *government* (meteorological, scientific, etc.), *military*. Satellites can be multi-use, hosting, for example, dedicated transponders for both commercial and military applications.

E: Purpose

The discipline in which the satellite is used. The purposes listed are those self-reported by the satellite's operator. A slash between terms indicates the satellite is used for multiple purposes. Terms in parentheses give more detail on the primary purpose.

F: Class of Orbit

We divide satellite orbits into two broad classes: (1) nearly circular orbits and (2) elliptical orbits. Satellites in elliptical orbits have apogees and perigees that differ significantly from each other and they spend time at many different altitudes above the earth's surface. We categorize satellite orbits with eccentricity less than 0.14 as nearly circular, and those with eccentricity 0.14 and higher as elliptical. The definition of eccentricity and the rationale for this division are included in the appendix.

Nearly Circular Orbits are further classified by their altitude:

Low Earth Orbit (LEO)[1] refers to orbits with altitudes between 80 km and roughly 1,700 km, where the upper altitude is chosen to correspond to an orbital period of 2 hours.

- **Medium Earth Orbit (MEO)** refers to orbits with altitudes greater than 1700 km and less than 35,700, corresponding to orbital periods between 2 and 24 hours. The most

[1] The upper altitude used to define LEO is somewhat arbitrary and different authors use different values. This value is chosen to be consistent with Jonathan McDowell's conventions (http://planet4589.org/space/log/orbits.html, accessed November 3, 2005). Similarly, the labeling of LEO orbits follows McDowell's.

important region of this band is near 20,000 km, which corresponds to semi-synchronous orbits (12-hour period).

- **Geosynchronous Orbit (GEO)** refers to orbits with altitudes of approximately 35,700 kilometers, which corresponds to an orbital period of approximately 24 hours, allowing these satellites to appear nearly stationary as viewed from the earth.

G: Type of Orbit

Nearly Circular Orbits are further classified by their altitude:

- **Low Earth Orbit (LEO)**[2] refers to orbits with altitudes between 80 km and roughly 1,700 km, where the upper altitude is chosen to correspond to an orbital period of 2 hours. In the database, LEO orbits are further labeled as:
  LEO/E—low earth equatorial orbit, with inclination between 0º and 20º
  LEO/I—low earth intermediate orbit, with inclination between 20º and 85º
  LEO/P—low earth polar orbit, with inclination between 85º and 95º
  LEO/R—low earth retrograde orbit, with inclination between 104º and 180º
  LEO/Sun-sync—low earth sun-synchronous orbit, with inclination between 95º and 104º

Elliptical Orbits are also further classified in the database:[3]

- **Elliptical/CLO** refers to cislunar orbits, which have an apogee greater than 318,200 km.

- **Elliptical/DHEO** refers to deep highly eccentric earth orbits, which have orbital period greater than 25 hours and eccentricity greater than 0.5.

- **Elliptical/Molniya** refers to orbits with period between 11.5 and 12.5 hours, eccentricity between 0.5 and 0.77, and inclination between 62º and 64º.

H: Longitude of position in GEO

For satellites that are in geosynchronous orbits, this is the earth longitude of the point over which the satellite sits, in degrees. A "+" indicates longitude east of 0º (Greenwich) and a "-" indicates longitude west.The column is blank for satellites in non-GEO orbits.

I: Perigee

The altitude above the Earth's surface of the satellite's perigee, which is the point of the orbit closest to the Earth's center of mass, given in kilometers.

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[3] These definitions also follow McDowell's conventions.

J: Apogee

The altitude above the Earth's surface of the satellite's apogee, which is the point of the orbit farthest from the Earth's center of mass, given in kilometers.

K: Eccentricity

The eccentricity, ε, of a satellite's orbit describes how strongly the orbit deviates from a circle.

It is calculated with the following relation: $\varepsilon = \dfrac{h_a - h_p}{h_a + h_p + 2R_e}$, where h_a is the altitude of the satellite above the earth at apogee, h_p is the altitude at perigee, and R_e is the earth's radius (we use the approximate value of the mean earth radius, R_e = 6370 km).
An orbit with eccentricity of zero is a circle. See Appendix for more information.

L: Inclination

The angle between the orbital plane of the satellite and equatorial plane of the Earth, measured in degrees.

M: Period

The time required for the satellite to complete one full orbit of the Earth, given in minutes.

N: Satellite Launch Mass

The mass of the satellite at the time of launch, including fuel, given in kilograms.

O: Satellite Dry Mass

The mass of the satellite without fuel, measured in kilograms. We have included this number when listed in one of the sources, but users should be aware that sources are often ambiguous about this term's definition, and it is possible the Database entries in this column may refer to quantities defined differently. In some cases the primary source indicates explicitly that this mass refers to the beginning of the satellite's life, after the satellite has been placed in its assigned orbit, and therefore apparently excludes kick motors, etc. These cases are indicated by "(BOL)" following the entry.

P: Power

The amount of useable electric power produced by the satellite, often by solar panels, given in watts. The power produced typically decreases over time; a number followed by "(BOL)" or "(EOL)" refers to the level of power generated near the beginning or end, respectively, of the satellite's planned lifetime.

Q: Date of Launch

R: Expected Lifetime

The planned operational lifetime of the satellite, given in years. This figure is reported by the satellite's operator and may be based on the expected failure rate for the hardware and software of the satellite, the fuel capacity of the satellite and the expected requirements for maneuvering and stationkeeping (many satellites run out of fuel long before their hardware and software wear out), the planned budget for operating the satellite, and the expected availability of improved future generation satellites. This figure can be misleading, especially in terms of scientific satellites. For example, the Akebono satellite, launched in 1989 with a design life of one year, is still functioning in 2009.

S: Contractor

The prime contractor for the satellite's construction. The construction of satellites generally involves a number of subcontractors as well. Frequent corporate mergers mean that the name listed as the prime contractor may not be the name of that corporation today. In creating the database, we listed what was shown on the company or agency's website at the time the database was originally constructed. (These will not necessarily be updated with each new version of the database).

T: Country of Contractor

The home nation of the corporation, institution, or governmental agency that was prime contractor (Column S) for the construction of the satellite.

U: Launch Site

The name and/or location of launch facility.

V: Launch Vehicle

The name and model of the launch vehicle used to lift the satellite into orbit. The launch is often contracted separately from the construction of the satellite, either by the prime contractor or the owner of the satellite.

W: COSPAR Number

The COSPAR number is the international designation assigned by the Committee on Space Research (COSPAR) to each object launched into space. Names of satellites often change, but this number remains constant. The number reflects the year of the launch and sequence of launch within that year. For example, a COSPAR number of 1998-063B would indicate that the satellite was launched in 1998, and that it was on the 63rd successful launch of that year. The "B" indicates that the given satellite was the second object catalogued from that launch.

X: NORAD Number

The NORAD number is the five-digit number assigned by the North American Aerospace Defense Command (NORAD) for each satellite in their catalogue. The number is assigned when an object is first observed, and remains with the object throughout its existence.

Y-Z: Comments

General description of satellite, special purposes, etc.

AA: Source used for orbital data

All sources for the information on each satellite are reflected in these columns (see **Note on Sources** above). Column **AA** indicates the source used for the orbital data (perigee, apogee, inclination, period). The abbreviations in Column **AA** are given below:

JMSatcat103, JMSatcat803, JMSatcat304, JMSatcat1104 – Jonathan McDowell's Satellite Catalogue, updated as of January 2003, August 2003, March 2004, and February 2006. These are no longer accessible, having been replaced by **JMSatcat206**, updated as of February 2006 (http://www.planet4589.org/space/jsr/jsr.html).

JM/103, JM/803, JM/304, JM/206 – Jonathan McDowell's Catalogue of items in geosynchronous orbit. The version currently accessible is **JM/206** (http://www.planet4589.org/space/jsr/jsr.html).

JMSR – Jonathan's Space Report: twice monthly report from Jonathan McDowell on launches, deorbits, etc. (http://www.planet4589.org/space/jsr/jsr.html).

oosa – Office of Outer Space Affairs, United Nations. All nations have agreed to inform the OOSA of any launches, and they are catalogued at this site. Unfortunately, many do not comply with this agreement or do so in an incomplete manner (http://www.oosa.unvienna.org/SORegister/regist.html).

SC-ASCR – An excellent database of orbital spacecraft is maintained on the website of the Academy of Sciences of the Czech Republic (http://www.lib.cas.cz/knav/space.40/INDEX1.HTM).

Heavens Above – (http://www.heavens-above.com)

GS – www.globalsecurity.org. Site created and maintained by John Pike, an expert on military space (http://globalsecurity.org/space/library/report/2005/satellitetables2004.htm).

AB-AG: Other sources

Appendix

In general, an orbit is not a circle, but an ellipse. A circle is the set of all points equidistant from a given point, which is the center of the circle. Instead of a center, an ellipse has two *foci*. The ellipse consists of those points with the property that the sum of the distance from each point to the two foci is constant. (So a circle is the special case in which the two foci merge to become a single point.) An elliptical satellite orbit has the Earth at one of the foci.

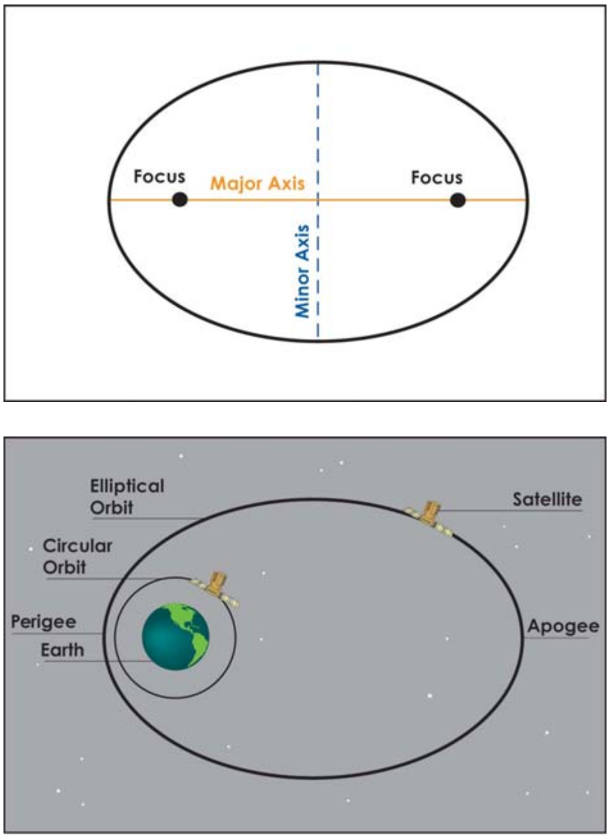

Figure 1. The top figure shows an ellipse, with the major and minor axes and the two foci marked. The lower figure shows satellites on circular and elliptical orbits, with the Earth at the center of the circular orbit and at one of the foci for the elliptical orbit.

The eccentricity ε of an orbit is given by:

$$\varepsilon = \frac{h_a - h_p}{h_a + h_p + 2R_e}$$

where h_a and h_p are the altitudes at apogee and perigee, respectively, and R_e is the earth's radius (the mean earth radius is approximately 6370 km).

We choose the value of $\varepsilon = 0.14$ to distinguish nearly circular from elliptical orbits for two reasons. Calculating values of eccentricity for the entries in the database shows only one significant gap in these values, which suggests a natural division between types of orbits. The gap lies between $\varepsilon = 0.06$ and 0.22 and is centered at $\varepsilon = 0.14$.

Moreover, $\varepsilon = 0.14$ is the value of eccentricity for which the major and minor axes of the ellipse differ in length by 1%.

Below are shown four ellipses with different eccentricities, all with the same major axis. In Figure 2, they all have one of their foci at the gray dot. In the Figure 3 the ellipses are shifted so their centers coincide (rather than one of their foci); the ellipse with $\varepsilon = 0.14$ is essentially indistinguishable from a circle ($\varepsilon = 0$).

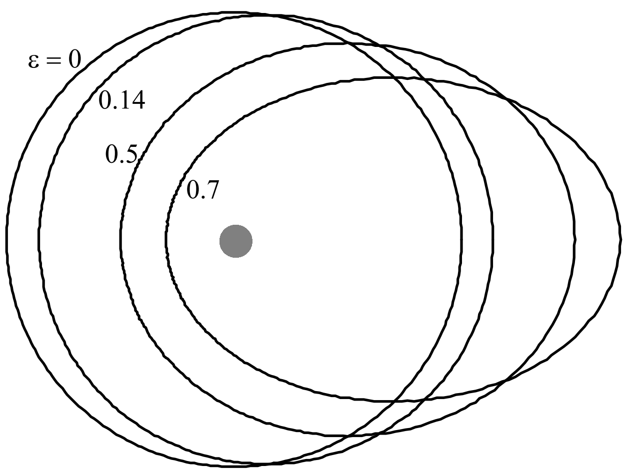

Figure 2

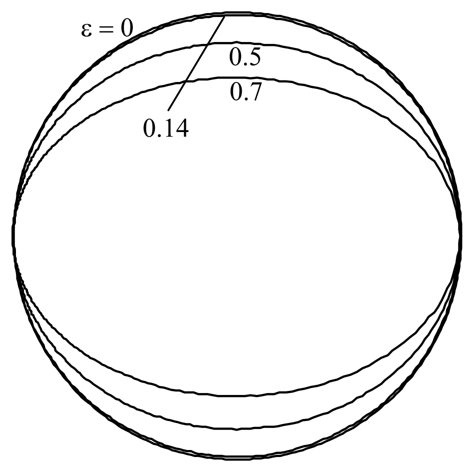

Figure 3

In Figure 2, even though the ellipses with $\varepsilon = 0$ and $\varepsilon = 0.14$ are essentially the same shape, they are distinguishable since the focus of the $\varepsilon = 0.14$ ellipse is different from its center, and the ellipse is shifted relative to its position in Figure 3. This shift is relatively large because, from the definition of eccentricity, the distance from the focus to the center of the ellipse goes linearly in ε, while the difference between the lengths of the major and minor axes goes as ε^2. The shifting of the focus will make the altitude at apogee differ from the altitude at perigee even though the orbit is essentially circular.

For comparison, these figures also show ellipses with $\varepsilon = 0.5$ and $\varepsilon = 0.7$, which are typical of highly elliptical orbits such as Molniya orbits.