Subject: Orbit tracking programs
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The person who asked about orbit tracking programs for the shuttle (cobb@nbs-vms) hit one of my favorite topics. You asked for it!

I have been working off and on with various orbit tracking programs for several years, primarily to track the amateur radio satellites built by the Radio Amateur Satellite Corporation (AMSAT) and the USSR radio clubs.

The best general purpose orbit tracking program available for free public use was originally written in BASIC by Dr. Thomas A. Clark, W3IWI, president of AMSAT. A listing of his program appears in the AMSAT publication ORBIT magazine issue #6. You can get a copy of this issue by sending $2 to

AMSAT
PO Box 27
Washington, DC 20044

(This address is also good for general inquiries about AMSAT and its programs)

Tom's program has been translated into a number of dialects of BASIC, PL/1, HP-41C, etc, and are available from

Amsat Software Exchange (ASE)
Box 338
Ashmore, IL 61912

for small donations ($5-$15) to cover costs.

One of the guys running the ASE, Bob Diersing, N5AHD, runs a CBBS on (512) 852-8194 where you can read some info about the available programs and get Keplerian elements for a number of satellites.

Tom's article includes a very good discussion of the theory behind his program, which is a general one handling elliptical orbits as well as circular ones. It uses the "Keplerian Element" sets derived by the North American Air Defense Command (NORAD) that are available free from NASA. These numbers describe the size and shape of the orbit and the orientation of the orbit plane at a specified time (the epoch), as determined from optical and radar observations.

There is another satellite tracking program available, more comprehensive than the Clark program, in that it has a solar ephemeris for checking observer and satellite illumination. This is very useful for finding passes in which the satellite is illuminated and the observer is in darkness; under these conditions even a small (2 foot) amateur radio satellite can be spotted with a pair of binoculars. Something as large as Skylab or the Shuttle is very easy to spot if you know when and where to look.

It was written and is being sold by Sat Trak International in Colorado Springs for about $80. I have taken their software (originally in FORTRASH), and am converting it to a set of modular subroutines in C for use both in tracking and for orbit determination (deriving the Keplerian elements from transponder ranging measurements, which AMSAT will need to do for Phase III-B). Since these program cost money and belong to someone else, I can't place my versions in the public domain, but it might be alright to give them to persons who have already purchased the SatTrak software. (Sort of like paying your dues to AT&T to get a Berkeley Unix tape).

During the last shuttle mission, I tracked down a set of elements by phone (mail would have been too slow) through a public relations person at Johnson Space Flight Center. He had some trouble obtaining them, mentioning that I was the only person to ask for them, but he was quite helpful. I later posted them to net.columbia after verifying that they were reasonably accurate. By looking up the locations of the NASA tracking stations and running the tracking program with the Keplerian elements, I could verify its accuracy with the 900 410-6272 number. I found it very convenient to know when the shuttle was in range before calling the Dial-It number.

I suspect that if there is enough demand for them during future flights, they would be more readily available.

Unfortunately, the shuttle performs many maneuvering burns during a flight. For example, STS-4 increased its orbital altitude and eccentricity 2 days after I got the Keplerian elements, throwing off my predictions.

For those of you without computers (are there such people here?), approximate predictions can be made with a Mercator map and an acetate overlay. The overlay must contain a sine wave with an amplitude equal to the orbital inclination (28.5 degrees for STS-4, larger for the earlier flights). The trace period is such that equator crossings occur at the correct spacings, remembering that the earth is rotating under the orbit, so that each equator crossing occurs farther to the west. On the Mercator map, draw "range circles" around each tracking station, with the radius being given by

r * acos(r/r+h)

where r = radius of the earth
h = height of the satellite above earth surface (same units)

When the spacecraft enters a range circle, it is above that station's horizon.

Note that the map methods for tracking satellites are workable only when the orbits are reasonably circular. Satellites in elliptical orbits (e.g., the new Phase-IIIB spacecraft that will be launched in January) follow weird S-shaped ground tracks; for these, a computer is really the only practical answer.

On the topic of listening in, NASA uses a domestic satellite to distribute a service called "NASCOM", which is how the networks get their feeds. I called the public relations departments at both the Johnson and Goddard space flight centers and got two different answers as to which satellite and transponder is used. Since I am not rich enough to have a home satellite TV receiver (spending my money instead on ham satellite gear), I could not verify which is correct (I was trying to get the info to get my local CATV company to carry it). Anyway, maybe somebody with a dish can check these out:

Satcom I, Transponder 9 (JSC answer)
Satcom II, Transponder 13 (Goddard answer)

Rumor has it that unmanned launches (e.g., Delta) are also covered on NASCOM. Neither of these was on Satcom III-R, so my local CATV company couldn't carry it.

Hope this info helps.

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