



# Tracking Satellites

Why and How

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# Why Track Satellites

Dive Right In To The Details Then Zoom Out Some

When the US Government knows that a satellite has a good chance of hitting the ground, it should alert the public

- On Nov 3, 2015 – the people of Spain saw a fireball in the sky which turned out to be a satellite reentry
- It was a US government-launched Centaur upper stage, these are easily tracked by radars and optical systems
- <http://satobs.org/reentry/2008-010B/2008-010B.html>
- People checked the standard reentry warning pages and there was no object that correlated (see later)

# Parts of the Centaur upper stage



Significant pieces hit the ground,  
pieces that could have injured  
people

The items that were recovered  
were definitely from a Centaur  
upper stage



# Satellite Catalog

Let's back up – who warns the world of predicted reentries?

The US Air Force maintains a satellite catalog which has become (by default) the world's official record. Yet there are many blanks in this catalog.

The catalog documents the orbital parameters for most satellites which can be tracked but has LOTS of blanks for “off the books” satellites – many are “USA” or similar satellites

This is available at [Space-Track.org](http://Space-Track.org) Note: Off-the-books satellites reenter!

SATNAME	INTLDES	TYPE	COUNTRY	LAUNCH	SITE	DECAY	PERIOD	INCL	APOGEE	PERIGEE
USA 144	1999-028A	PAYLOAD	US	1999-05-22	AFWTR					
TITAN 4 R/B	1999-028B	ROCKET BODY	US	1999-05-22	AFWTR	1999-06-02	87.54	63.39	165	141
USA 144 DEB	1999-028C	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028D	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028E	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028F	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028G	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028H	DEBRIS	US	1999-05-22	AFWTR	2000-02-20				
USA 144 DEB	1999-028J	DEBRIS	US	1999-05-22	AFWTR					
USA 144 DEB	1999-028K	DEBRIS	US	1999-05-22	AFWTR					

## Default world official satellite catalog and reentry notification

- Aerospace Corporation has a major notification site
  - <https://aerospace.org/cords>
- Space-Track.org also has reentry predictions
  - mostly useful for objects that are not predicted to survive to strike the ground
- Other groups (see next page) maintain satellite catalogs and analyze what those off the books satellites are doing

# Tracking The “Off The Books” Satellites

- There is an international group of visual and RF astronomers that track satellites, there is little need to track the ones in the Satellite Catalog
  - [www.satobs.org](http://www.satobs.org)
- Many people track the “Off The Books” satellites since it is a fun challenge
  - It’s hard to optically track satellites in our area (winter is better)!
- Photographs are run through astrometry software and then another application to produce observations
- Mike McCants in Austin generates orbital parameters and maintains a web page where you can get them
- We track both “near Earth” satellites such as NOSS and “deep space” such as geosynch satellites (Magnum, Jumpseat, etc)
  - People track them and speculate about what is a likely mission
- Various people (Ted Molczan, Cees Bassa, Greg Roberts, etc) analyze orbits mainly to help the initial acquisition of new launches
  - Cees, Greg, and I helped Marcelo Zurita recover SensorSat – very low inclination low altitude
- A few of us are “analytical astronomers” that take the data from other people and extract information

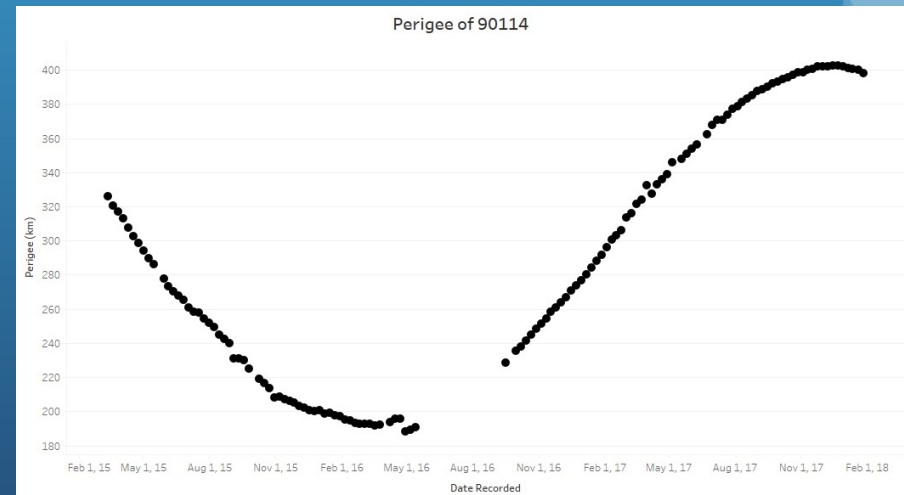
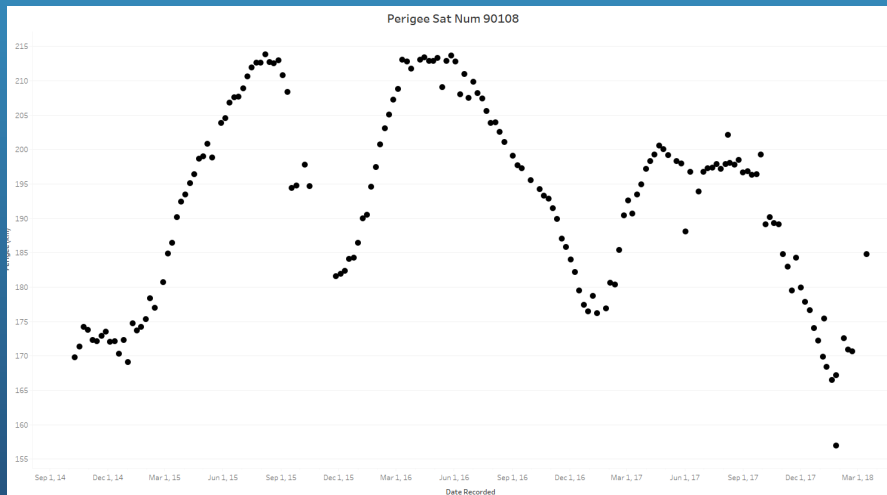
# Analytical Astronomers

One fun project - we can plot perigee vs time to get an idea of when a satellite is likely to reenter (perigee at about 85 km)

I look at the off-the-books satellites to look for ones with low perigees

<https://sites.google.com/site/spaceflightresearchprojects/perigee>

The interesting ones are high eccentricity (mostly medium inclination)  
But we always need more observations!



# Decay Predictions

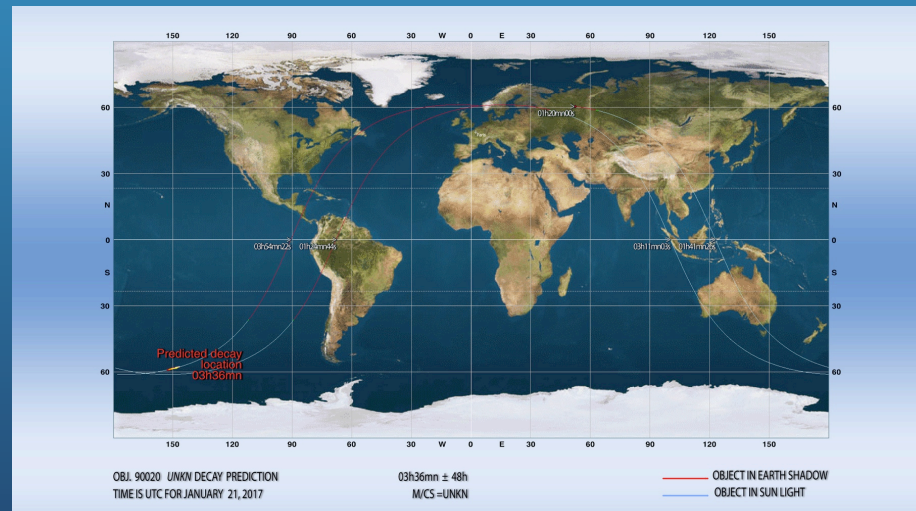
One useful contribution is to predict reentries for off-the-books satellites

I do the analysis and Joseph Remis in France has helped with graphics  
I have written some software to allow me to graph perigee

Greg Roberts in South Africa has helped with historical orbital information

Most of them have perigee in the Southern Hemisphere and impact in the water

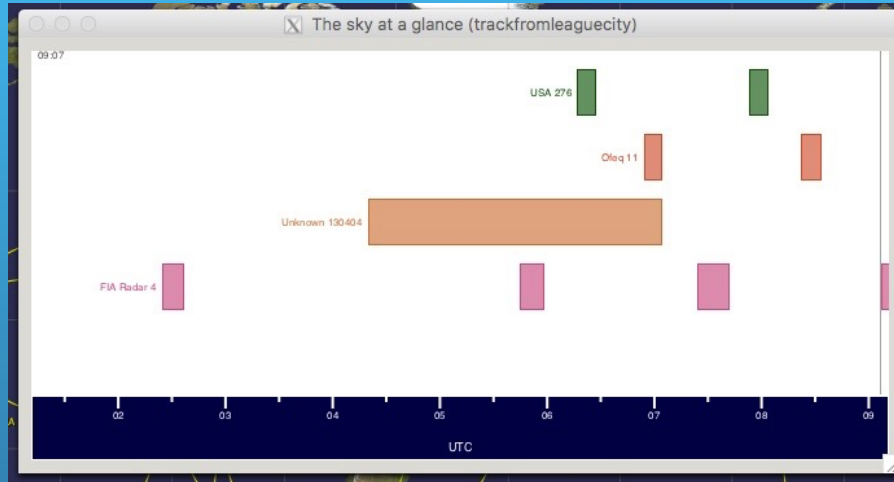
Stories I have written have appeared in The Space Review





# Software/Hardware I Use

- Gpredict (and JSatTrak)
  - Gives me “The Sky At A Glance” for observational planning



- Sony Nikon D200 camera, tripod, iPhone, laptop
  - This gets usable satellite tracks
- Set camera time from my iPhone, use Orbitrack to point camera
- <https://sites.google.com/site/opticalsatellitetracking/>

# Procedures

Wait for a cold front to come through and track after that

- Point camera toward track of satellite and use 15 sec exposure – point at known star that is along the path of satellite
- Start taking photos 30 seconds before satellite is in field of view, 15 second exposures
- Photos “resolve” in Astrometry.net and produce a file, that goes into SAO Image DS 9 to produce RA and Dec angles
- There are a number of steps required to get “observations”

PS in Dec 2018 the Air Force started releasing orbital information on a set of geosynch comm payloads – may release more orbits?

# USA 281



## Chinese Upper Stage



# Orbital Parameters

Inclination  
 Eccentricity  
 Mean Anomaly  
 Mean Motion (or Semi-major Axis)

Right Ascension of Ascending Node  
 Argument of Perigee

Epoch time

