TRACKING SPACE DEBRIS including SPY SATELLITES

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ASSA SYMPOSIUM
October 2012

Doing rocket science:

Very limited budget

Almost worst possible observing location - light pollution/freeways/seeing

Utilizing as much as possible whats in the "junkbox"- this means having to be a junk collector!

Overcome being naturally lazy and not having much patience

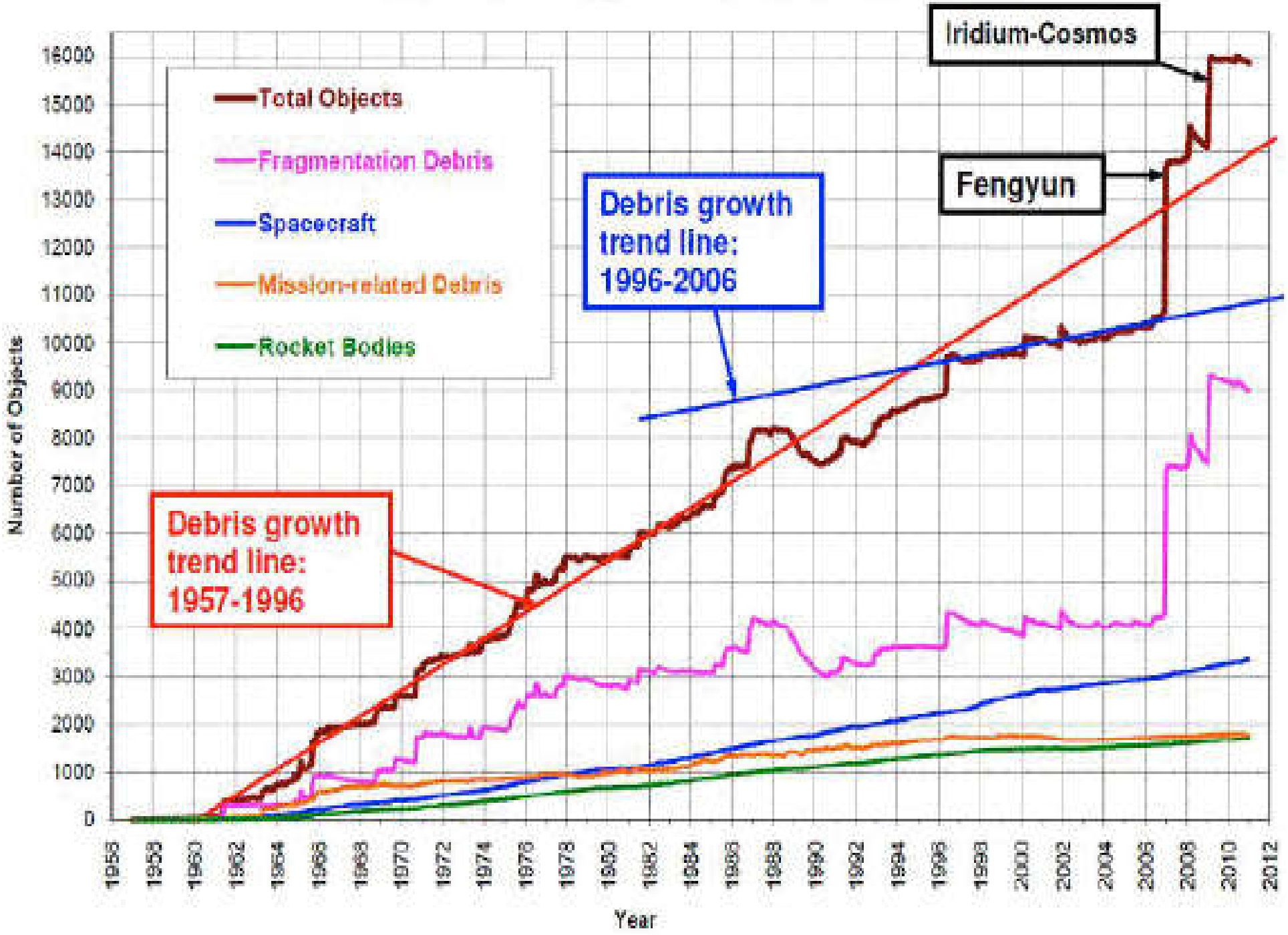
Am I sane ? Why do I subject myself to spending a fair portion of my remaining life watching clouds?

ITS FUN and REWARDING !!!!

WHY DO IT

- The Earth is in the middle of a huge rubbish dump made by mankind as a result of 55 years of launching satellites into space.
- Currently approximately 17000 objects 10cm or larger BUT 150 million larger than 0.1 cm in orbit.
- 30000 objects per day come within 10 km of one another .
- Change of collision is 1/250, so if 1000 operational satellites chances are that 4 or 5 will be damaged by these objects.


What goes
up ----
does not
always
come down!


Iridium-Cosmos
Fengyun
Total Objects
Fragmentation Debris
Spacecraft
Mission-related Debris
Rocket Bodies
Debris growth trend line: 1996-2006
Debris growth trend line: 1957-1996
Number of Objects
Year
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
1956
1958
1960
1962
1964
1966
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2002
2004
2006
2008
2010
2012

THE KESSLER SYNDROME

In a paper written as early as 1978 NASA scientist Donald J.Kessler wrote

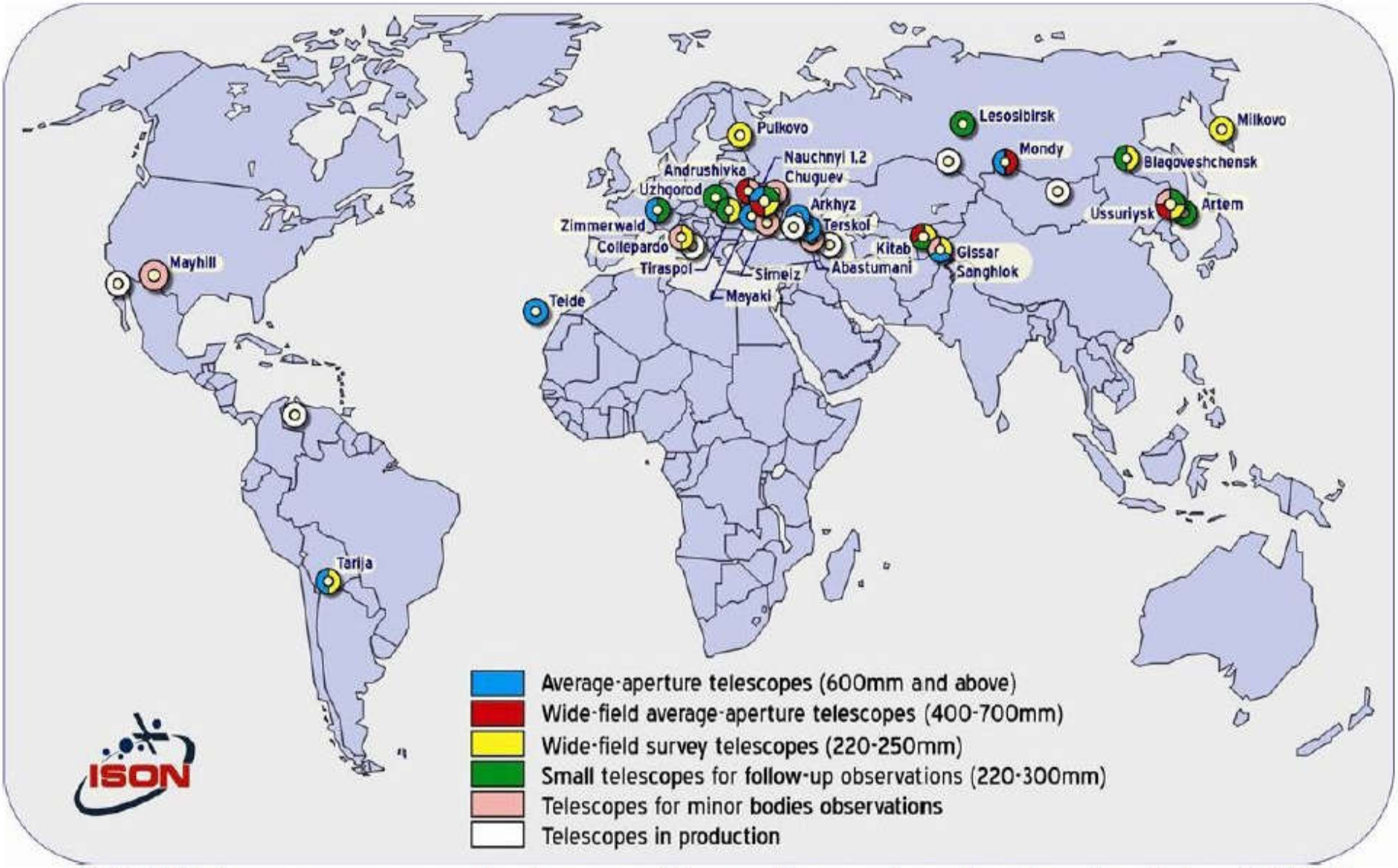
“debrii flux will increase exponentially with time EVEN if zero net input rate may be maintained”

- some fear we have already passed the point of no return

Professional Tracking

- United States Space Surveillance network- SPACETRACK – ONLY non-classified objects. Data available to anyone after registering. Military
- Russian Space Surveillance System – military - 75% complete – not in public domain.
- ISON – International Scientific Optical Network- Keldysh Institute of Applied Mathematics,Russian Academy of Sciences in Moscow only tracks objects in geosynchronous orbit – data not in public domain – ESA publication CLASSIFICATION OF GEOSYNCHRONOUS OBJECTS once a year

International scientific optical network



ISON is an open international project started in 2004 for regular monitoring of the near-Earth space

Search and survey subsystem for the GEO region: eleven *22-25 cm telescopes with FOV of 3.5- 5.5 degree*

OTHER COUNTRIES

Several countries operate tracking radars and include the United Kingdom,France, Germany and Norway, whilst several utilize telescopes but none of this data is in the public domain.

AMATEUR – EARLY DAYS

The amateur tracking of artificial earth satellites began in 1957 with the MOONWATCH tracking program and continued until closed down in 1975 but several of the more active amateurs still continued tracking satellites purely for pleasure.

In the mid 80's the United States ceasing issuing orbital data on sensitive satellites – this was a challenge the amateur trackers could not ignore – we had to find those satellites and generate our own orbital data from our observations!

In a fact sheet on SSA issued by Brian Weeden of the Secure World Foundation had this to say

- "Although they are only loosely organized through the Internet the amateur observing community represents a non-trivial SSA Capability. Some have the capability to image satellites or detect radio frequency transmissions. In particular they have demonstrated the ability to routinely track classified national security payloads from several countries."

ISON and AMATEURS

- “ISON is a non-government organization , and they come up with some of the most interesting stuff. ISON does not, as far as anyone knows, withhold data because of any national security concerns. This is fairly certain because ISON work is monitored, and complimented by the efforts of amateur astronomers and orbital addicts who connect via the Internet, and constantly scour the sky for new objects, and movements of existing ones.
- The Internet based amateurs are often the first to spot new activity,mainly because they have more eyeballs, and in some cases, impressive optical equipment, searching the skies”

- Quote www.strategypage.com - DEAD MAN FLOATING

Satellite Scorecard

- As of 26 September, 2012 approx 38780 objects had been catalogued by SPACETRACK of which 16761 appear in their “public” catalog, the remainder either having decayed or been “classified”.
- After removing obvious debris one ends with 6615 objects of reasonable size. This does not include classified objects.
- The amateur network tracks 350 objects NOT found in the SPACETRACK catalog so the catalog is missing at least 20% of the objects large enough to cause serious damage. For satellite operators this is a major concern.
- The amateur network is the only organization that makes these elements freely available to ANYONE throughout the year, so being called a “non-trivial SSA capability” is justified.

THE AMATEUR NETWORK

- Optical observers = 22, radio observers =8
- UNITED STATES - 7 (5 optical , 3 radio)
- CANADA - 3 (3 optical, 1 radio)
- UK – 6 (4 optical, 2 radio)
- FRANCE – 2 (2 optical, no radio)
- NETHERLANDS - 2 (2 optical, no radio)
- ITALY – 1 (1 optical, no radio)
- RUSSIA – 2 (2 optical, no radio)
- SWEDEN – 2 (1 optical, 1 radio)
- SOUTH AFRICA – 1 (1 optical, 1 radio)
- AUSTRALIA – 1 (1 optical, no radio)
- Some members have both optical and radio capability

CLASSIFIED.TLE

This file contains orbital elements for about 350 objects not found in the SPACETRACK public catalog. It is made up of about 200 objects in high earth orbit, some as high as 50000 kms, and at least 60 of these satellites are still operational. In addition it includes 85 rocket casings and 25 objects that have not yet been identified with a particular launch.

The remaining 150 satellites are in relatively low orbits and include all manner of objects. It is not known how many are still operational, apart from those that change their orbits from time to time. It is necessary to track all these satellites frequently in order to detect any orbit changes as early as possible.

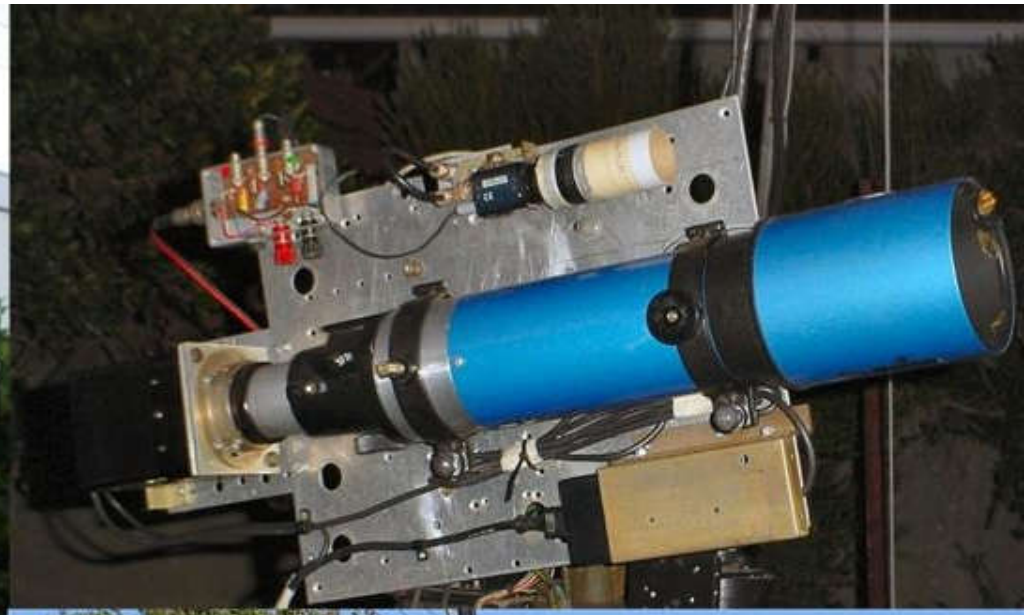

VLADIMIR
AGAPOV
TED
MOLCZAN


Igor Molotov and Vladimir Kouprianov
2011 10 4

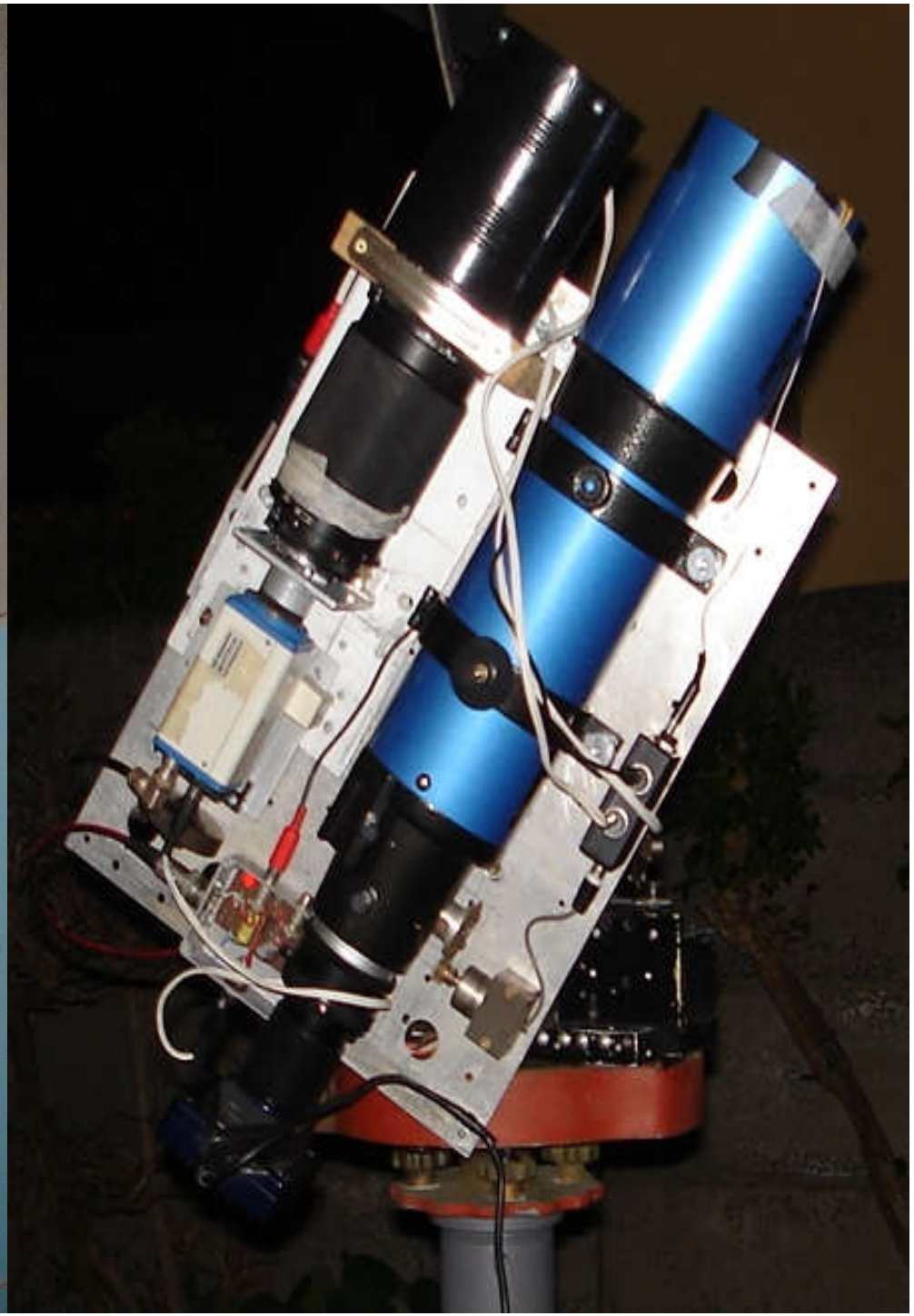

ORION
NASA


KEVIN FETTER


2008 12 3




CELESTRON




MINTRON
12V1-EX
MINTRON
VIDEO


MEADE
MEADE DSI PRO II
CCD


SAC 9
VIDEO CAM


WATEC 902H2 VIDEO
LEVEL
Watec
AUTO IRIS

MicroLine ML8300M

Quality. Cooled. Cameras.

3326 x 2504 Imaging Array Size
5.4 µm Pixel Size

At 3.7 x 3.7 x 5 inches the MicroLine is a small camera with big camera capabilities. Each component of the MicroLine camera is designed and manufactured for a long life in the most demanding conditions. MicroLine download speeds are fast yet maintain the 16-bit resolution necessary to produce high quality images. MicroLine achieves a minimum of 60° C sustainable cooling without water assist. Simply set the MicroLine cooling where you want it and the camera will do the rest, quickly and without worries.

MicroLine with a Fast 45mm Shutter

ML8300M Specifications	
Sensor	KAF-8300
Array Size	3326 x 2504
Pixel Size	5.4 µm
Typical Minimum Cooling	-60° C Below Ambient
Typical Download Speed @ 16-bit	8 MHz (other speeds available)
Typical System Noise	8 e- RMS @ 8 MHz
Nonlinearity	<1%
Temperature Stability	0.1° C
Operating Environment	-30° C - 45° C | 10% - 90% Relative Humidity
Sensor Manufacturer	Kodak
CCD Grades Available	Standard
CCD Type	Front Illuminated
Color/Monochrome	Monochrome
Mega Pixels	8.3
Sensor Diagonal	22.5 mm
Linear Full Well	25,500 e-
Typical Dark Current	<0.1 e-/pixel/sec. @ -35° C
Anti Blooming	1000x
Available Shutters (Optional)	42 mm, 45 mm
Shutter MTBF	1,000,000
Remote Triggering	Standard
Power	12v
Interface	USB 2.0
Dimensions	3.70 x 3.70 x 4.77 (94 x 94 x 121.3)

TYPICAL OBSERVING SESSION

- Switch on PC for GPS system to acquire lock
- Generate predictions for planned session – 10 mins-load data into CoSaTrak program - DOS
- Remove dust bin- attach required optical assembly .
- Connect power to mount and USB cable.
- Start camera control program and allow ccd camera to reach –30 deg C. Focus camera reasonably well
- Refer to prediction list-select target-set on target
- Take images – 1,2 or 4 bin, exposures 0.5 to 30 sec
- Good session 5-6 hours long subject to cloud/moon

PROCESSING 1

- Good session 1200-2000 fits images to mag +15
- Quick run through images–delete garbage ~ 20-30%
- Depending on what imaged decides how measured.
- If automatic processing all satellites in an image are marked – sometimes 20-30 satellites if heo –geo
- NO IMAGE PROCESSING of any kind done,although sometimes automatic dead pixel removal if using 6 inch Celestron.
- If automatic processing approx 8-10 seconds per image. Time accuracy 50 ms, position accuracy sub-pixel

PROCESSING cont

- Process remaining images manually.
- Put data into correct report format.
- Run report through program to compare position reported against predicted position to ensure correct object.
- Identify all objects in the field correctly-specifically note unidentified or moved.
- Post data to processing centers. Usually within a few hours the new updated elements based on these observations are posted on the Internet.
- 1 hr observation produces ~ 2-3 hours processing

MORE RECENT ACTIVITIES

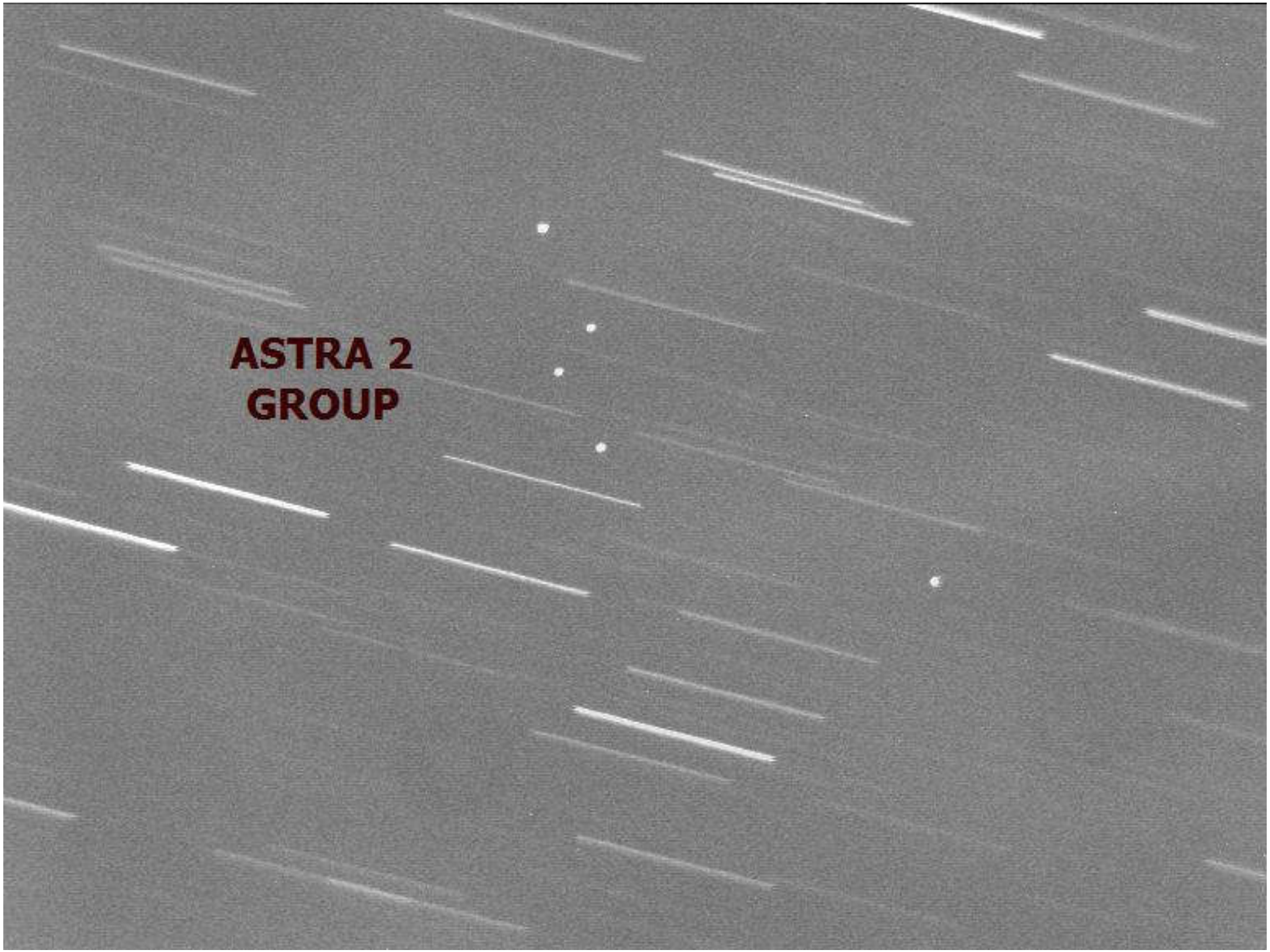
- IMAGE satellite-JPL
- STEREO mission - JPL
- USA 193 2008
- OMID (Hope)
- DMSP F18 – Oct 2009 –United Space Alliance
- PLANET C–JPL–Venus Climate Orbiter –May2010
- EGYPTSAT 1 –Swedish Space Corp – July 2010
- SUNSAT/SUMBANDILA optical – Nov 2010
- PHOBUS-GRUNT Mars mission Nov 2011
- ENVISAT –ESA May 2012

WHAT NEXT?

- The amateur network needs to be expanded, ESPECIALLY in the southern hemisphere. We cannot cope with the number of satellites on our list so many are observed infrequently and sometimes lost until found again which takes time – eg the OFEQ satellites.
- New good observers are RARE and some don't stay the course.
- All night automatic tracking- practical but how to cope with the increased amount of data.
- Increase interest by live streaming on say Google+. Not practical in my case as internet connection is far too slow and cannot handle data rate or amount of data.
- This is a hobby – no money/time especially if still earning a living.


7.6 x 5.7 degrees. 3 second exposure.Camera stationary.
135mm focal length f/2.8. Camera 3326 x 2504 pixels, 4 bin mode


INTELSAT
904
WGS 2
PAN
PAKSAT 1R
HELLASSAT
2


ASTRA 2
GROUP


USA 237


OTV3- X37B scheduled Oct 25.
Rockwell
X-33

The Satellite Tracking group received an invitation to present a paper describing "how we do it" to the Sept 2010 conference held in Hawaii. All members declined the invitation as we were not prepared to tell them how to put us out of "business" as the U.S.Military made up a large part of the audience.

The invite was repeated in 2011 with the same result.


THANK YOU FOR WATCHING

Some useful websites

- www.satobs.org/seesat/
- www.prismnet.com/~mmccants/
- www.Satelliteorbitdetermination.com/index.htm
- www.zarya.info/index.htm
- www.svengrahn.pp.se
- www.heavensat.ru/english/
- www.celestrak.com
- www.heavens-above.com
- www.spacetrack.org/perl/login.pl
- www.uhf-satcom.com
- www.n2yo.com