CASTOR'S "SPUTNIK 50TH ANNIVERSARY SATELLITE TRACKING BONANZA"

by Michael A. Earl

On December 27, 2006, an interesting question popped into my head. I asked myself, "How many artificial satellites can one person detect with modest astronomical equipment in one single year?" This question turned out to be the answer to another question I asked myself several days earlier, "How can I celebrate Sputnik's 50th anniversary in 2007?"

Sputnik 1, the first artificial satellite of the Earth, was launched by the Soviet Union on October 4, 1957. I wanted to celebrate the 50th anniversary of this monumental achievement with a monumental event of my own.

I had originally thought of detecting and tracking 1,000 individual satellites in 2007. This is far more satellites than I had ever detected in one single year. I eventually decided on a very unique target number; 1,957 individual satellites to celebrate the actual year of Sputnik's launch.

This "campaign" as I like to call it, would not only be about determining how many satellites I could detect. I would also be simultaneously collecting useful data on the photometric and orbital properties of the satellites detected. Tracking data (times and positions of the satellites) would be carefully recorded in order to use this data to research orbit determination techniques that might prove useful in the future. The data would also be used with my own orbital mechanics equations I had been developing since 1991.

Not all of the satellites would be active. In fact, most of them would be seen to tumble in space and therefore a separate side-project would inevitably be a tumble period survey.

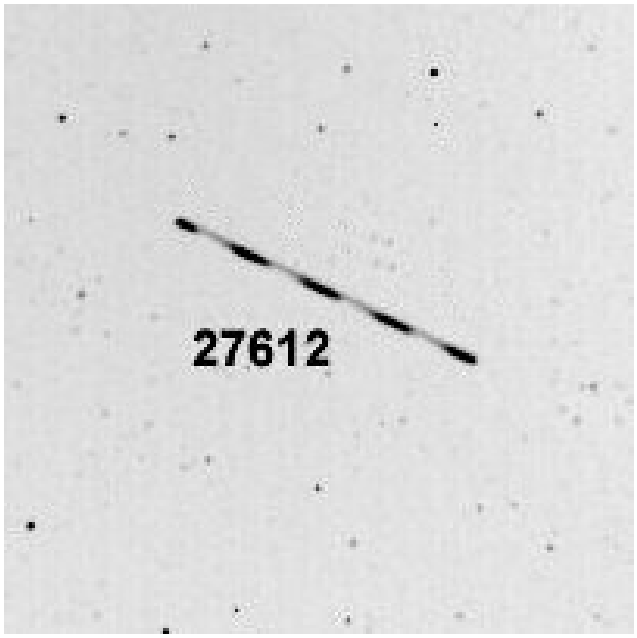

Figure 1: The LatinSat satellite (#27612). This is an excellent example of a tumbling satellite. Note how the brightness of the satellite changes as it travels through the field of view. The measured tumble period of this object was 1.21 seconds. This is a cropped negative image taken from the original CASTOR image originally taken on 09:48:06 UTC October 5, 2007.

The campaign would involve satellites of every orbit type, with distances of 200 kilometres to 200,000 kilometres from my vantage point in Brockville. If CASTOR could detect them, I would study them.

The campaign officially began on January 1, 2007, but since New Year's Day was clouded out, I could not collect any useful data until the evening of January 2, 2007. Using my SBIG ST-9XE CCD camera fitted with a 50mm wide field lens, I succeeded in capturing 25 low-altitude satellites in two hours on that first night. A very fun aspect of this project was catching satellites as they passed by and trying to identify them afterward. January would see a total of 198 low altitude satellites detected by CASTOR, including the International Space Station (ISS), weather satellites, communications satellites and "lots and lots" of old Russian rocket debris.

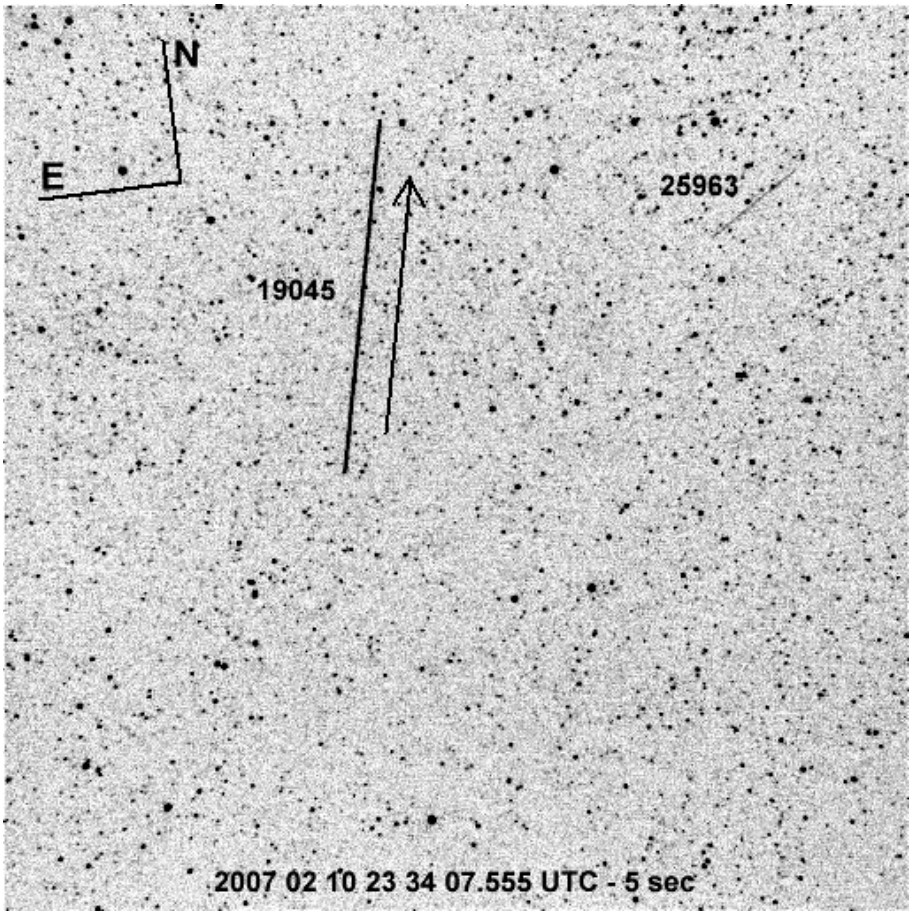

Figure 2: A typical CASTOR image of two Low Earth Orbit (LEO) satellites. The featured satellite (longer streak) is the Russian Cosmos 1939 (NORAD #19045) environmental monitoring satellite. The arrow indicates the satellite's direction of travel. The compass direction indicates the Alt-Az orientation of the image. The second satellite (at top right) is the telecommunications satellite GlobalStar M029 (NORAD #25963). This is a negative of the original CASTOR image originally taken at 23:34:08 UTC February 10, 2007.

February was much the same as January in the sense that CASTOR detected only low altitude satellites. CASTOR bagged 124 new satellites in February, including more communications satellites and more Russian rocket debris.

March began with more low-altitude satellites, including more communications satellites and even more Russian rocket debris.

March 30, 2007 was the date of the second of a ten class course that I was instructing at the Mill of Kintail. After the class had concluded, I decided to use my Celestron NexStar 8i SE telescope with the ST-9XE CCD camera as a test case for

future tracking. Only three satellites were detected on that trial night, but one of them was the first trans-Atlantic live television broadcasting satellite, Telstar 1. Telstar is still orbiting the Earth, but has been dead since 1963. Another of these three satellites was the first GPS (Galileo Positioning System) satellite launched by the European Space agency (ESA), Giove-A (Jupiter-A). By the end of March, CASTOR had detected 159 new satellites, with a total of 481 since January 2nd.

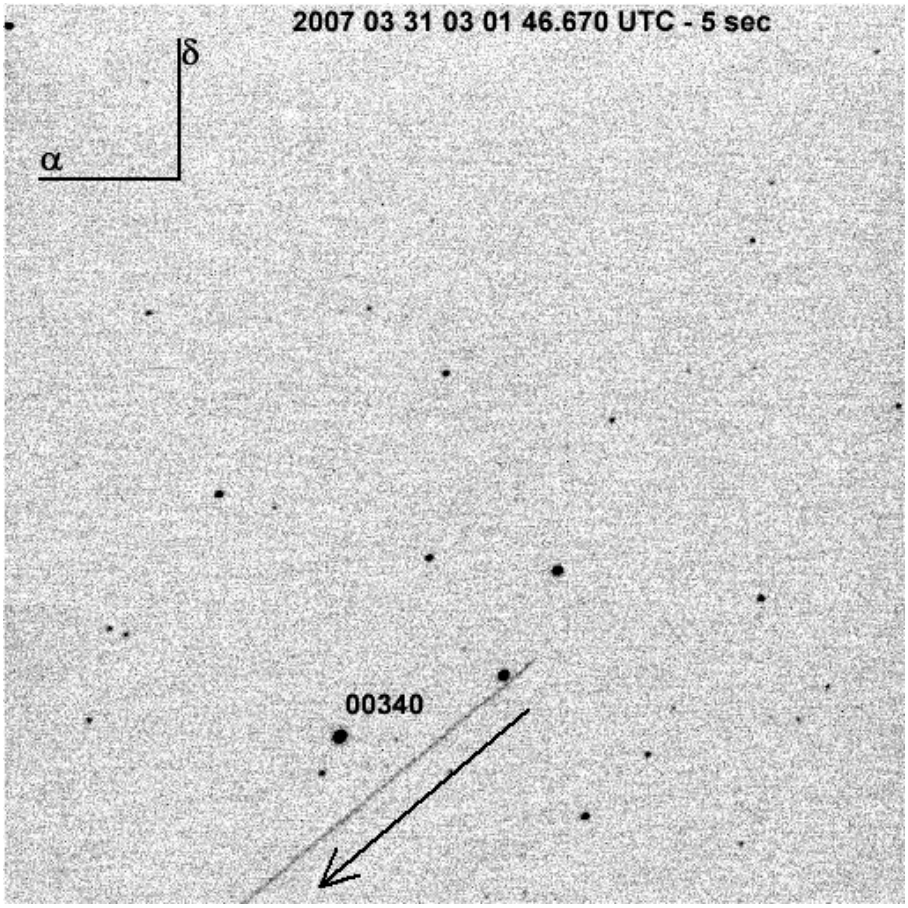

Figure 3: The original Telstar 1 satellite (NORAD #00340) moved so quickly in the 5-second exposure that it exited the field of view before the shutter closed. The arrow indicates the satellite's direction of travel. The compass direction at the upper left indicates the equatorial (2000.0 R.A. and Dec.) orientation of the image. This is a negative of the original CASTOR image taken at 03:01:47 UTC March 31, 2007 at the Mill of Kintail Conservation Area Gatehouse in Almonte.

The first week of April was unfavourable, mainly because of the rain and snow. However, the remainder of the month was very good with 10 clear nights for tracking. April saw higher altitude satellites being detected with the Celestron NexStar 8i telescope. On April 30th, CASTOR detected Telstar 2 and the Canadian satellite ISIS-1. April saw another 126 satellites, mainly low-altitude, but some mid-altitude satellites, such as several of the American and Russian GPS satellites at 20,000 kilometres. The total at the end of April was 609, a mere third of the total number CASTOR had set out to detect!

I switched to using my Celestron NexStar GPS 11-inch telescope at the beginning of May. I couldn't have picked a better time to do this. May's weather was outstanding! Clear skies prevailed straight through from April 30th to May 9th! This is the longest continuous string of clear skies I had ever witnessed in southern Ontario! In May, CASTOR switched to exclusively detecting mid-altitude satellites (2,000 to 40,000 kilometres in altitude). In those nine days of May, CASTOR picked up an astounding 202 new satellites, bringing the total to 811.

On the morning of May 5th, I decided to honour the 10th anniversary of my first day of work at the Royal Military College (RMC) in Kingston (May 5, 1997). I detected and tracked the Molniya 1-75 satellite, the first satellite I had detected (through the eyepiece) at RMC. Molniya 1-75 has held a special fascination for me, because it had a very long tumble period and very bright and gold flashes when lit favourably by the Sun.

After the sky clouded over on May 10, I decided to take a well-earned break for the rest of May, having reached the month's quota very early.

I resumed the campaign in June using the 11-inch telescope and ST-9XE CCD. I switched to tracking geosynchronous satellites for the summer months. Geosynchronous satellites are the ones you point your satellite dishes to! They also deliver your satellite radio. I succeeded in detecting most of the Telesat (Canadian) geosynchronous satellites, such as Anik F1, Anik F1-R, Anik F2, Anik F3, Nimiq 1 and Nimiq 2 (for the Bell ExpressVu and Star Choice users). June also saw the detection of all three Sirius Satellite Radio satellites (Sirius 1, 2 and 3), which are the only satellites placed in what's called a "Tundra" orbit. I also detected its direct competitor's (geostationary) satellites (XM 1, 2, 3 and 4). The weather satellites GOES 10, 11 and 12, responsible for your Environment Canada satellite maps, were also detected and tracked.

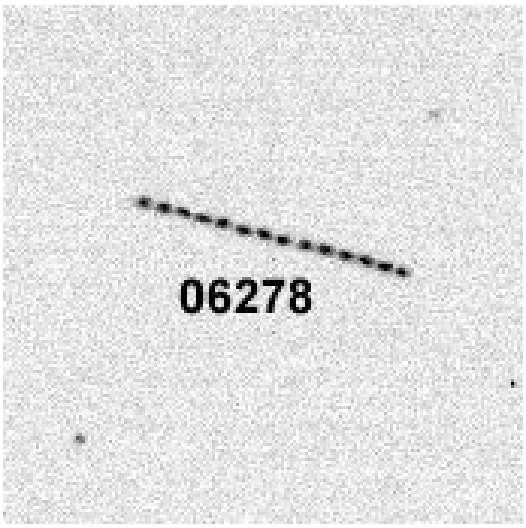

Figure 4: A CASTOR image of the first commercial geostationary communications satellite Anik A1 (Telesat 1) (NORAD #06278), launched in 1972. CASTOR would detect most of the Telesat fleet, past and present, in 2007. The object is tumbling, given its choppy light curve, indicating it is no longer active. Anik A1 was shut down in 1982. This is a negative cropped image of the original CASTOR image taken at 06:46:46 UTC July 16, 2007.

On June 11, I detected the “notorious” satellite Telstar 401. On January 11, 1997, this satellite lost all power in a solar storm, causing it to float aimlessly within the geostationary belt; a belt of satellites directly responsible for most of our satellite communications industry. Many satellites had to be manoeuvred out of the path of this rogue satellite to avoid possible catastrophic collisions. I detected the tumbling of this infamous satellite, proving that it was indeed inactive.

In June, I also began to tinker with high-altitude satellite detection. I had detected high-altitude satellites before, but not as seriously as I had in 2007. On June 12th, CASTOR broke its own distance record when it successfully detected a Russian rocket body 143,800 kilometres distant. The previous CASTOR record was 141,000 kilometres set just before I left my position (and the original CASTOR) at RMC in Kingston in March 2001.

The high distance record was broken again on the partly cloudy night of June 12-13th. CASTOR had just finished detecting the Chandra X-Ray Observatory at 113,780 kilometres distant, when I decided to try something very bold. The sky was clouding over and threatening rain, but the south-western sky had a 20 degree clear patch. I had discovered that within that patch of sky lay the first Soviet X-Ray observatory, named

Astron. My orbit propagator had indicated that this object was 195,600 kilometres distant at the time! Since the rest of the sky was clouded over, I decided to take a chance and attempt it.

Astron was not found in the first several images, which made me think that either the object was too far away for me to detect or the object's orbit elements were not perfectly accurate. I began a search for the object and found that the object had indeed been detected in the first attempts! The object had been moving so slowly that it appeared as another "star" in a standard 10-second exposure! After changing the exposure time to 30 seconds, I discovered a very small streak that moved with every subsequent image. This could only be the Astron satellite! I had completed obliterated any previous distance record set by CASTOR (past or present) with a range of 195,600 kilometres (half way to the Moon). That record stands to this day.

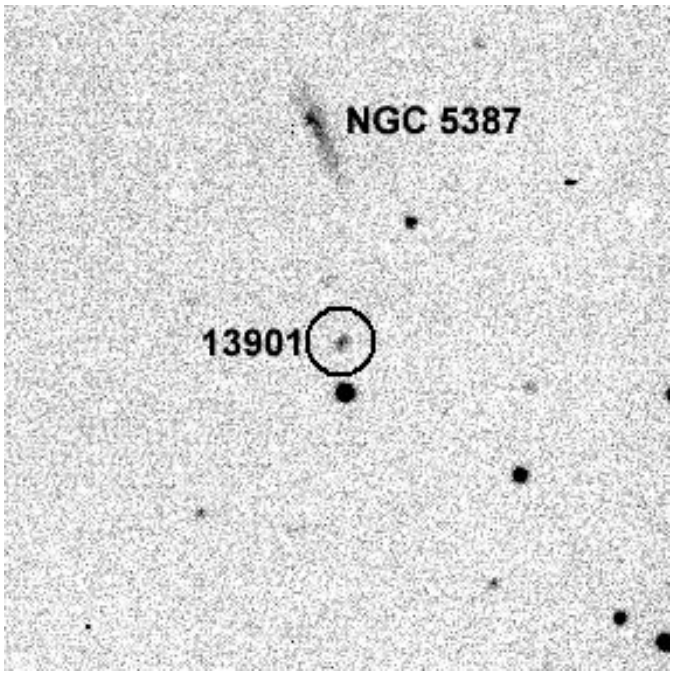

Figure 5: The Soviet Astron X-Ray observation satellite (NORAD #13901). In this 30-second exposure, the satellite (circled) travels only several arc-seconds, indicating its great distance from CASTOR at the time. The galaxy NGC 5387 can also be seen, one of the many galaxies CASTOR would accidentally detect over the 2007 year. This is a negative cropped image from the original CASTOR image taken at 04:37:26 UTC June 13, 2007.

On June 20th, CASTOR detected the Space Shuttle Atlantis after it had undocked from the International Space Station. June saw another 199 satellites, bringing the total up to 1,020 satellites since January 2nd. I was past the half-way point! I took the rest of the month off, having reached my quota for June early.

July was as successful as June with very beautifully dry and clear skies. CASTOR detected and tracked another 267 satellites in July, bringing the total to 1,287. I finally began to feel the 1,957 goal in my grasp! I had 670 satellites left and 5 months left in which to accomplish it.

From August to December, I detected and tracked satellites from every orbit type in order to reach the 1,957 goal more quickly. I began to think that I could reach the 1,957 goal on or before Sputnik's October 4th anniversary and pulled out all the stops to reach that goal.

In August, CASTOR detected another 198 satellites, bringing the total to 1,485. Only 472 left to go!

September was another great month, but the heady days of finding famous satellites were ending. I was simply detecting a lot of space junk left over from past missions, mainly from the U.S. and the Soviet Union. I began wondering if I was reaching the end of the satellites that I could detect with my 11-inch telescope and ST-9XE CCD camera. I fondly referred to that point as "The Brick Wall". September saw another 165 new satellites (mainly space junk) bringing the total to 1,650. I began to doubt that I could reach the 1,957 goal by October 4th.

I put up a good fight on the night of October 4-5; the night of the Sputnik 50th anniversary. CASTOR detected and tracked 147 new satellites on that night; the largest amount I have ever detected in one single night. Another record broken! The total on October 5th was 1,746, just 211 satellites shy of the goal. The total at the end of October was 1,849, just 108 satellites to go before the goal was reached! However, November had arrived!

Most astronomers in southern Ontario know that November is typically the worst month to observe. The clouds are normally relentless and you are lucky to get 5 days of clear skies out the entire month. I was hoping that would not happen this time. The first half of November turned out to be uncharacteristically excellent with great skies and even better temperatures!

At 23:45:15.67 UTC November 13, 2007, CASTOR detected its 1,957th satellite for the 2007 year: an old Soviet SL-14 type rocket body, one of the last to be launched before the collapse of the Soviet Union. CASTOR had achieved the goal it had set on

December 27, 2006. It was a major accomplishment; one that had never before been single-handedly attempted or achieved by anyone in the world.

Throughout the remainder of November and December, CASTOR detected an additional 95 new satellites, but it was clear that the fortuitous weather that had blessed the campaign from January to mid-November was changing. The latter half of December was nearly a complete washout, thanks to relentless clouds and nasty snowstorms. December had a mere 4 nights of clear skies.

So, how many artificial satellites can one person single-handedly detect with modest equipment in one single year? Well, my current answer is approximately 2,052, nearly one fifth of the total number of artificial satellites orbiting the Earth right now. If it wasn't for the horrible weather in December, I am sure I would have had at least 2,200.

The "Sputnik 50th Anniversary Satellite Tracking Bonanza" was a campaign that had never been conceived or attempted by any other Canadian institution, large or small. The data collected by CASTOR over 2007 offers a unique insight into the vast satellite population that is orbiting us at this very moment; a satellite population that we take for granted every single day.

Figure 6: CKWS TV (CBC Kingston) conducted an interview with me to see CASTOR and to discover more about the campaign. I am in the center of the image “pretending” to use CASTOR (as it was daytime). The interview was aired on CKWS TV during their 6 p.m. “NewsWatch” broadcast on October 17, 2007.

CASTOR has shown that the technology of today can allow one single person to detect and track over 2,000 of our satellites in one year. The precise number of satellites within the present satellite population that can be detected by CASTOR’s equipment remains unknown, but the number detected over 2007 is a good cross-section of the capabilities of CASTOR; yet another reason to carry out this celebratory project.

Stay tuned for a much more detailed article that I am currently writing for the June issue of the JRASC and more many more articles in 2008-09.

CASTOR web site: www.castor2.ca

CASTOR Sputnik 50th Anniversary Data Page:
www.castor2.ca/13_Sputnik_50th/data_main.html