

## North Korea's Controversial Satellite Launch

Greg Roberts

*After several previous unsuccessful launch attempts, a new country just joined the ranks of the elite few that have managed to launch and orbit their own satellites. North Korea's recent launch caused some mild hysteria and is quite controversial, even deemed illegal under international law! The launch itself was quite tricky, requiring some complicated maneuverers, to avoid flying over populated landmass. Space authorities and amateur satellite trackers have been following the satellite with great interest, trying to establish if the payload is operational or not, since it may be spinning out of control. As usual, Greg Roberts was well equipped and strategically situated to get the best data to unravel this puzzle.*



### Earlier N. Korean Launches

North Korea has been pursuing a program of developing and launching their own satellites for at least fourteen years, despite intense opposition from other countries such as South Korea, Japan and the United States who considered this a veiled attempt at developing long range ballistic missiles capable of carrying a nuclear warhead.

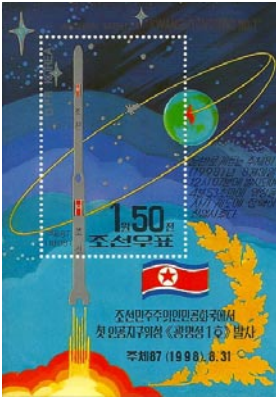
North Korea calls their satellites KWANGMYONGSONG (KMS), meaning "Bright Star" and regards it as an experimental satellite. KMS-1's launch took place on 31 August 1998.

It was hailed as a success by North Korea despite there being no evidence of any object actually achieving orbit. A special commemorative stamp was even issued.

The KMS- 2 launch attempt took place in April 2009 and again was hailed as a success. But once again no object entered orbit despite North Korea playing recordings of signals received from the "satellite" and again issuing a special commemorative stamp.

Their third attempt (KMS 3-1), on 13 April 2012, was an obvious failure when the first and second stages did not

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Commemorative stamps for North Korea's launches of KMS-1 on 31 August 1998 (left) and KMS-2 in April 2009 (above).

simply exercising its rights to the peaceful exploration of outer space according to Article I of the 1967 Outer Space Treaty to which North Korea is a party. The important part of this document is

separate cleanly. Due to the strict control of news, the North Korean public believe that they have satellites in orbit but no western tracking system could detect anything in orbit. It was all a figment of imagination by the North Korean government.

### Strong Opposition

North Korea faces intense opposition to their space program although they insist it is for peaceful exploration. Two resolutions adapted by the United Nations Security Council (UNSC) demanded that North Korea refrain from further launches using ballistic missiles. Resolution 1718 of 14 October 2006,

levied sanctions against North Korea as a result of their test of a nuclear weapon earlier that month and demanded that they cease testing and development of its ballistic missile program. The second resolution – UNSC Resolution 1874 of 12 June 2009 – implemented further sanctions after North Korea's second test of a nuclear weapon in May 2009 and repeated the same restrictions as Resolution 1718, including a demand for North Korea not to conduct any launch using ballistic missile technology.

The position adopted by North Korea is that it is

the clause “in accordance with international law”. This then means North Korea is in contravention since UNSC resolutions are considered binding international law on countries that are members of the United Nations – which includes North Korea.

Since a rocket is a rocket, these resolutions effectively mean that North Korea cannot launch anything. The distinction between a satellite launching rocket and a purely ballistic missile comes into effect once the rocket leaves the launch pad and is decided by the trajectory followed by the rocket.

### Surveillance Decoys

In mid-November 2012 US reconnaissance satellites spotted rocket components being transported from the North Korea missile production plant to the launch site. It thus came as no real surprise when on 1 December 2012, North Korea announced it would make a second attempt to launch its KMS 3-2 satellite into a polar orbit from its Sohae Launch Centre in Cholsan province using its UNHA-3 ("Milky Way 3") carrier rocket sometime in the period 10 December to 22 December. There was again intense foreign opposition.

Western and South Korean intelligence sources now concentrated on the launch site to see what would happen. It would appear that North Korea led them on a "merry chase" with disinformation. On 8 December a train was observed carrying what appeared to be missile components to the launch site. Then on 9 December North Korea announced that due to a technical glitch the

launch window was being extended. Satellite images showed part of the rocket being dismantled and this convinced western observers that the launch had been scrapped. Subsequent satellite spy photos however showed all parts assembled on the launch pad and eighteen hours later the launch took place. Apparently the rocket was in the process of being disassembled during a US spy satellite overfly and then being re-assembled when no satellites were around.

An in-depth analysis by Marco Langbroek – a Dutch hobbyist satellite observer – clearly showed that launch occurred at the end of a one-hour gap during which there was no coverage by any known American, Japanese, or commercial imaging satellites in low earth orbit. A US military source is reported to have said that the US relied too heavily on overhead satellite imagery for warnings about the launch. However the United States does have satellites in

high orbit and amateur satellite observers have pinpointed the locations of these satellites, some of which are over Asia. These satellites would have been able to monitor the launch site. The important issue in the case of North Korea is that the existence of these satellites is highly classified and very few people have access to the information from them. So when the press clawed for information on this launch, one got the impression that North Korea had fooled everyone.

### Dodgy manoeuvres

Most countries try to avoid flying launches over populated areas and other nations. This obviously limits what orbits one can achieve from a particular launch site. The original launch site used by North Korea on its east coast overflew Japan. This created a lot of political problems, so a new site was set up on the west coast to avoid flying over Japan. However North Korea was still blocked by China, Taiwan or the Philippines from direct access to a

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sun-synchronous orbit, requiring an inclination of about  $97.4^\circ$  for the planned 500 km altitude.

Despite this, launch took place on 12 December at 00:49 UTC, heading southward.

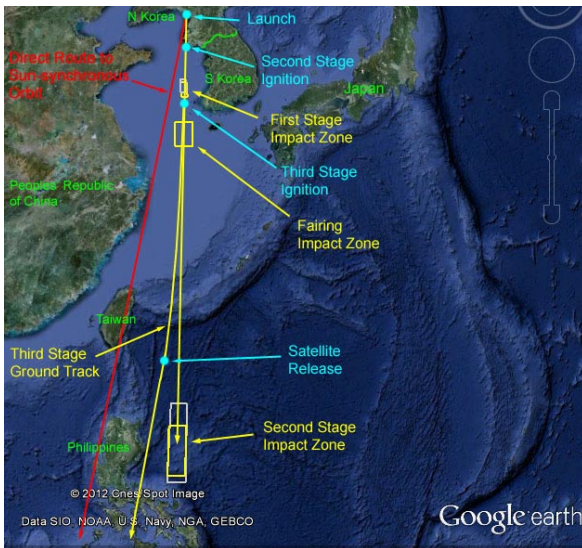
Bob Christy, a highly skilled hobbyist space analyst, provided extensive analysis of North Korea satellite activity on his excellent website. He clearly showed that in order to avoid flying over the Philippines, North

Korea solved the problem by launching the rocket in a direction that kept it away from other countries during the most dangerous part of the launch phase. After separation of the second stage, the third stage was turned before igniting. This led to a new trajectory that placed the satellite in the correct orbital inclination to achieve a sun-synchronous orbit.

There is no doubt that this is quite an achievement

for a country that has never had a successful space launch before. Jonathan McDowell pointed out that yawing the third stage required something like a change of  $50^\circ$  in flight direction before ignition of the third stage. Without this, the predicted impact zones indicated the satellite would have gone into a  $90^\circ$  inclination orbit.

The objects from the launch then flew on a trajectory that took them south past the Philippines, Western Australia and the South Pole before moving northwards along the east coast of South America, over the eastern United States and over the North Pole before heading southwards again. It was observed by North American Aerospace Defence Command (NORAD), which maintains 24/7/365 surveillance of space. They used radar as there was no optical visibility due to the objects being in Earth's shadow for most of its orbit. NORAD stated that its missile warning systems had



This diagram by Bob Christy shows how North Korea satellite did a “dog-leg” around the Philippines and avoided passing over China and Taiwan (the red trajectory).

## satellite tracking

detected a launch and that the rocket had apparently placed an object in orbit. Less than three hours after launch, four objects were catalogued from the launch. What is somewhat surprising is that initially the rocket was mistaken for the actual satellite. This is difficult to understand as the rocket is considerably larger and would have given a much larger radar reflection.

Initially there was very little information available and some of the popular press articles were highly sceptical/critical of what had been done. Statements such that the satellite was tumbling wildly out of control, presented a hazard to other satellites, was a box wrapped in tin foil, launched by a rickety rocket, etc. were made. However, I felt that these did injustice to what I considered was a major achievement. Not only had North Korea executed a complicated “dog leg” manoeuvre, but it had also placed the satellite in a near circular orbit.

### Mild Hysteria

Reading some of the press articles written, it would appear there was a case of mild hysteria. It reminded of the film *The Right Stuff* where government officials were frantically dashing down corridors and waving papers after the launch of Sputnik 1. There was strong condemnation that it was a ballistic missile test and statements that the US was under threat of nuclear attack. But was this a ballistic missile test? The arguments against this are adequately covered in some of the references given, concluding that it was certainly a space launch and NOT a ballistic missile test.

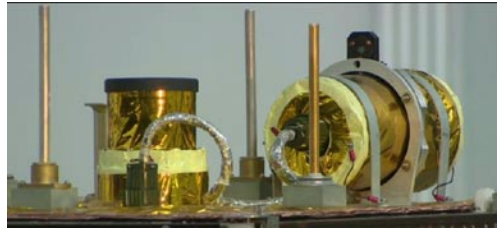
According to international law and the UNSC resolutions, the launch was illegal. North Korea however did everything “by the book” in announcing beforehand the splashdown zones for the first two stages and the payload shroud which corresponded to

a space launch trajectory and not a ballistic missile trajectory. The first stage was indeed recovered in the pre-announced splash zone by the South Korean Navy.

### What was put in orbit?

North Korea has not said much about this so there is little concrete evidence as to what the satellite is. In April 2012, prior to the failed launch of KMS 3-1, western journalists were shown a model (?) of the KMS satellite. Since North Korea referred to the new launch as KMS 3-2, it is logical to think that what was shown may have been the same satellite. If this is the case, the satellite is a cube with 0.65m square sides and about 1m long, weighing about 100 kg. The three sides shown to journalists were covered in solar cells (the fourth side was never shown but probably identical to the three visible). They appeared to be hinged, which some think might indicate that the solar panels could be extended in flight, but more likely

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(above) Close-up of top of the model shown in April 2012. Note the use of “duct tape” and the red electrical connectors!

(left) A “model” of the KMS satellite shown to western press in April 2012.

are purely there to allow the solar panels to be moved out the way to allow technicians access into the spacecraft body.

The bottom of the cube had a circular adapter plate which was probably used for attaching to the launch vehicle. There is some speculation that it may also have carried two antennae at the bottom. The more interesting bits are on top of the cube and is presumably the side that would point earthward, once in orbit. This side carried sensors, cameras and perhaps as many as six antennae and it is possible to make reasonably intelligent guesses as to what is what.

First there were four rods vertical to the base plate, consisting of two pairs of differing lengths. The longer pair is apparently used for up-linking commands on around 400 MHz, whilst the shorter pair are probably for transmission at around 470 MHz. There is also a cylindrical housing which may be the X-band downlink (around 9 GHz) for image transmission. The final antenna is a small disk on a stalk which may be a GPS receiver. There also appears to be two sensors: One, about 10 cm wide, protruding upwards from the base plate, which may be a wide field video camera with about 100 m resolution. The other,

lying horizontal on the top base plate, could be a horizon/sun or star sensor, so that the orientation of the space craft could be maintained to ensure that the camera points correctly.

### Dead or Alive?

Despite much monitoring of the frequency region around 470 MHz by many amateurs, in particular Bob Christy in the UK and Robert Oler of Texas, no positive transmissions have yet been received. This raises the question as to whether the satellite is a dummy, or the transmitter(s) have failed ... or activity has still to come. Presumably intelligence organisations and amateur

## satellite tracking

satellite trackers in the vicinity of North Korea would have looked for transmissions on any of the anticipated frequencies (up or downlinks) but so far indications are that none have been received. The general consensus is that the satellite has failed, probably during launch.

However it is not unusual for satellite activity to only occur some time after launch, especially if the satellite is spinning or possibly tumbling which prevents communication taking place.

### Spinning out of Control?

Shortly after launch I was requested to try and observe the four objects identified from the launch in an attempt to determine what the objects were and whether they had been correctly identified. In addition it was thought important to determine the spin rate which might indicate whether the satellite was in a stable attitude and also possibly whether the satellite was under control. Due to the geometry of the satellites

orbit and its proximity to Earth's shadow there was only a narrow strip in latitude in the southern hemisphere from which the satellite could be optically observed. I happened to be the only recognised optical tracker, either amateur or otherwise, that could possibly obtain observations.

Before launch North Korea stated that the satellite was to be three axis stabilized, meaning it would not have significant rotation in any of the three axes of movement relative to the earth. This is typical of what is required for a satellite that needs to keep

a camera pointing at the Earth and away from the Sun. This can be achieved in several ways ranging from gyroscopes, reaction wheels to simpler ways such as gravity gradient booms that use Earth's gravity to orientate a satellite towards Earth.

### Visual Tracking

My first task was to observe the four objects. This established that the objects were correctly identified. The rocket was easily the brightest object and relatively stable, rotating/tumbling very slowly which is quite normal so not much attention has been paid



Image of KMS 3-2 satellite being tracked, extracted from video taken 20 December 2012 at 19h 50m 25.1s UT.

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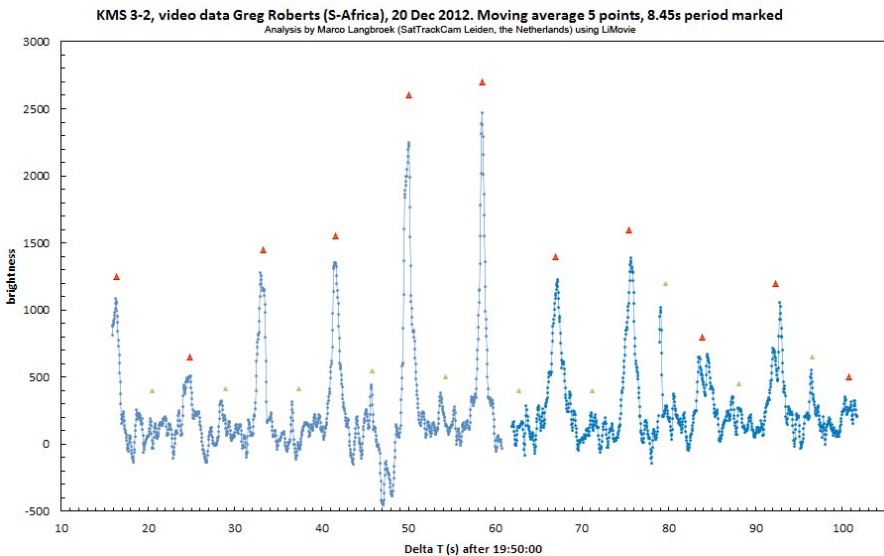
to it since the initial observations. Two of the objects are small but quite dense. I was only able to briefly observe one of them when it produced a few faint flashes—probably part of the separation mechanism. The other small object was not seen in three attempts so is obviously small, probably identical to the other small object.

The satellite is of course of main interest. Initial observations showed it was tumbling/rotating at about four revolutions per

minute - this was based on a brightish flash being produced roughly every 17 seconds, initially to about magnitude +5 or +6. However as the satellite got higher in elevation, it became possible to see smaller fluctuations about every 8 seconds or so with the flashes now about magnitude +7. As the satellite passed culmination (thus at minimum distance from the observer), it was possible to see small variations roughly every 4 seconds or so, but magnitude now around +7.5 or +8.

### Analysing the Data

This raised the question; which is the true period of the satellite? I interpreted what I saw as a bright flash every 17 seconds, to be coming from the same item that produced the ~8 second flash. So the spin period was ~17 seconds. When I observed the ~4 second period, I suspect I was seeing a reflection from each of the four surfaces of the cube. Marco Langbroek did a careful analysis of one of the earlier video recordings and derived a period of about 4.23 seconds. This



Light curve of KMS 3-2 obtained by Marco Langbroek on 20 December 2012.



## satellite tracking

has served as the baseline for any further changes. It would therefore appear that the satellite is tumbling/rotating at about four rotations per minute. This is quite normal for a satellite and it could take many weeks for the stabilization system to slow the satellite spin rate enough to acquire gravity lock and maintain a constant orientation such as is required for the camera to operate.

### Spinning Down?

Consequently the satellite has been observed on a fairly regular basis and attempts made to determine whether the spin rate is changing. In the meantime, for some unknown reason, the flashing seems to have become less pronounced, usually around mag +7.5 to +8, which makes it more difficult to get an accurate spin rate. The data seems to indicate that the spin rate is decreasing very slowly. Whether this is due to a system "actively" decreasing the spin rate or just simply gravity is not known. Whilst mag +7.5

or so is bright in terms of satellite magnitudes, it is not that easy to get an accurate video record with exposures as short as possible - typically 1/50th or /160th sec. The shorter the exposure, the more accurate the period that can be determined.

Unfortunately suitable optical visibility ceased at the end of January 2013 as the satellite moved into Earth's shadow after which it is only perhaps optically trackable from very high northern latitudes. But there are no observers there which means the only other possible way to determine if the satellite is slowing down is maybe possible from the radar reflection. The last determined spin rate was about 4.6 seconds, possibly decreasing very slowly.

### Conclusion

The situation at the moment is that the satellite appears dead and there is no evidence that it was ever operational. It is tumbling but not at an excessive rate and this appears to be slowing down, but is going to take a LONG time, if ever,

to stop spinning.... so my guess is that the satellite is well and truly dead.

The United Nations Security Council unanimously adopted a resolution on 22 January 2013 condemning the rocket launch and expanded existing UN sanctions. They also threatened "significant action" if North Korea stages a nuclear test. North Korea replied by saying it planned to carry out a third nuclear test and more rocket launches aimed at its "arch enemy", the United States, stating that "settling accounts with the U.S needs to be done with force, not with words". No time frame for the nuclear test was given but it is believed that it could be soon.

### Acknowledgements

I would like to sincerely thank my colleagues for allowing me to freely use whatever material they had on their very informative websites or what they had published. I would highly recommend that people interested in more details visit the following websites:

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[www.wired.com/dangerroom/2012/12/launch/all](http://www.wired.com/dangerroom/2012/12/launch/all)

“Almost Everything You’ve Heard About the North Korean Space Launch is Wrong” - Brian Weeden - Technical Advisor to Secure World Foundation. A very comprehensive summary of the entire event.

<http://blogs.wsj.com/korearealtime/2012/12/19/a-week-after-launch-the-lowdown-on-north-koreas-satellite> where Bob Christy gives the lowdown on what had happened.

<http://sattrackcam.blogspot.nl>

Marco Langbroek details the absence of spy coverage and possible North Korean spooks on his weblog. He also gives a report on the optical behaviour of the satellite and rocket, complete with videos from The author and analysis of the light curves. There is also much other interesting material of interest to space enthusiasts.

[www.zarya.info](http://www.zarya.info)

Bob Christy's comprehensive outstanding site, full of information on ALL satellite related activity. To reach the material related to the North Korean launch go to [www.zarya.info/Diaries/NKorea/Kwangmyongsong32.php](http://www.zarya.info/Diaries/NKorea/Kwangmyongsong32.php)

Make sure to also check out the various links in blue on the left hand side of the page. This site is the best one that I know of and I cannot recommend it highly enough.

[www.northkoreatech.org/2012/03/19/stamps-of-previous-satellite-launches/](http://www.northkoreatech.org/2012/03/19/stamps-of-previous-satellite-launches/) shows pictures of stamps of previous (failed) orbiting missions

[www.northkoreatech.org/2012/12/25/caught-on-video-north-koreas-satellite/](http://www.northkoreatech.org/2012/12/25/caught-on-video-north-koreas-satellite/) shows several of the videos of the tracking of the satellite by the author

<http://38north.org/category/sat-analysis/>

Latest on activities in North Korea

[www.nytimes.com/2012/12/18/world/asia/north-korean-satellite.html?\\_r=0](http://www.nytimes.com/2012/12/18/world/asia/north-korean-satellite.html?_r=0)

“Astronomers say North Korean Satellite is most likely dead”

[www.planet4589.org/space/jsr/jsr.html](http://www.planet4589.org/space/jsr/jsr.html)

Jonathan McDowell's reports on current satellite activity. For back issues, go to [planet4589.org/space/jsr/back](http://planet4589.org/space/jsr/back) and for a report on the North Korean launch, download report No 672.

