North Korea Satellite Launch

Let us apply

ASTE-520

North Korea Satellite Launch

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2013

Mike Gruntman, Spacecraft Design, 2013.
Special Section: Let us apply ASTE 520 Spacecraft Design – North Korea Satellite Launch in December 2012

North Korea (DPRK) Satellite Launch

December 12, 2012

Democratic People's Republic of Korea (DPRK) (North Korea) successfully launched its first satellite into orbit

Launcher: Unha-3 rocket

Satellite:
KwangMyongSong 3 (**KMS-3-2**)
(apparently failed after deployment)

It was the 5th attempt to launch a satellite.

North Korea had succeeded **before** launch of a satellite by the **Republic of Korea (ROK)** (South Korea) on January 30, 2013

Satellite KMS-3-2
Credit: Nick Hansen
38north.org

Launch site: Sohae Satellite Launching Station, Cholsan County

Launch of Unha-3 rocket with satellite KMS-3-2
Credit: Associated Press

North Korea (DPRK) Satellite Launch

Many "talking heads" in the media and self-described "pundits" (not all) dismissively jeered at the successful launch by North Korea and played down its impact

Similar reactions often greeted previous unsuccessful launches and ballistic missile tests by North Korea

Examples (Associated Press):

(story title): *N[orth] Korea is still years away form reliable missiles*

... [successful launch] doesn't mean Pyongyang is close to having an intercontinental ballistic missile...

Let us leave it to others to decide whether some pundits are uninformed or simply pursue an agenda (belonging to an appeasement wing of political and diplomatic establishment)

Miscalculation is dangerous and consequential

We concentrate on technical aspects.

Let us apply what students learn in a graduate course, *ASTE-520 Spacecraft Systems Design*, to this North Korean launch

Almost 1100 graduate students took the ASTE-520 course during the last 10 years

Get orbit two-line-elements (TLE) from *Space Track*

Satellite KMS-3-2 TLE on December 14, 2012 (2 days after launch)

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KMS 3-2
1 39026U 12072A 12349.53278831 .00003698 00000-0 22989-3 0 189
2 39026 097.4069 038.3900 0060101 164.1189 196.1944 15.08739244 386
         inclin    RAAN   eccentr  argperi  meanan  rev per day
```

inclination	i	=	97.4069 deg
right ascension of ascending node	Ω	=	38.3900 deg
eccentricity	e	=	0.0060101
argument of perigee	ω	=	164.1189 deg
rev per day		=	15.0873924 rev/day

Orbital period = (24 hr) / (rev per day) = 5726.6 sec = 1 hr 35 min 26.6 sec

Orbit – nearly circular and retrograde

KMS-3-2 Orbit

Semimajor axis $P_0 = 2\pi \sqrt{\frac{a^3}{\mu_E}} \Rightarrow a = \left(\mu_E \frac{P_0^2}{4\pi^2}\right)^{1/3} = 6918.189 \text{ km}$

Perigee: radius $R_p = a(1-e) = 6876.610 \text{ km}$ — **altitude of perigee** $h_p = 498.470$ **km**

Apogee: radius $R_a = a(1+e) = 6959.768 \text{ km}$ — **altitude of apogee** $h_a = 581.628$ **km**

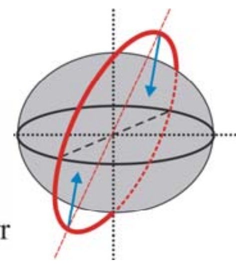
Solar activity is unusually low during this 11-year solar cycle, reducing upper atmosphere density and satellite drag. A satellite in a KMS-2-3 orbit will only slowly loose its altitude.

Regression of nodes due to Earth oblateness

$$\dot{\Omega}_{LN} = \frac{d\Omega}{dt} = -\frac{3nJ_2 R_E^2 \cos i}{2a^2(1-e^2)^2} =$$

$$1.9525 \text{ rad/sec} = 0.9666 \text{ deg/day} \approx 353 \text{ deg/yr}$$

Moon and Sun: **< 0.02 deg/yr**



KMS-3-2 Orbit – Sun-Synchronous Orbit?

For sun-synchronous orbits: regression of nodes $\dot{\Omega} = 0.9856 \text{ deg/day}$

Such orbits favored for reconnaissance and remote sensing satellites

Consider KSM-3-2 orbit with a = 6918.189 km and eccentricity e = 0.0060101

At what inclination i would such an orbit be sun-synchronous?

$$\cos i = -\frac{2\dot{\Omega}_{LN}\, a^2 (1-e^2)^2}{3nJ_2 R_E^2} = -0.13146 \Rightarrow i = 97.55°$$

Moon and Sun: **Δi < 0.001º**

KMS-3-2 inclination: 97.41º ⇒ Δi = 0.14º from sun-synchronous

North Korea likely tried to launch this satellite into sun-synchronous orbit

KMS-3-2 Orbit – Repeating Orbit?

Repeating orbit? – Favored for reconnaissance and remote sensing satellites

Repeating orbit: a satellite completes N_2 orbits during N_1 sidereal days
N_1 and N_2 are integers

orbital period P_0 = 5726.6 sec

Earth rotation angular rate $\dot{\Omega}_E$ = $2\pi/T_{SD}$ (T_{SD} = 1 sidereal day)

regression of nodes rate $\dot{\Omega}_{LN}$ = 1.9525 rad/sec

$$2\pi N_1 = P_0\left(\dot{\Omega}_E - \dot{\Omega}_{LN}\right)N_2 \quad \Rightarrow \quad \frac{N_1}{N_2} = \frac{P_0\left(\dot{\Omega}_E - \dot{\Omega}_{LN}\right)}{2\pi} = 0.066284$$

If N_1 = 1 and N_2 =15

$$\frac{N_1}{N_2} = \frac{1}{15} = 0.066667$$

It seems that North Korea tried to deploy a satellite into a sun-synchronous repeating orbit with daily revisits. It would be a logical orbit for a reconnaissance satellite covering their archenemy South Korea.

Launch of Satellite KMS-3-2

Launch site:
Sohae Satellite Launching Station
in western North Korea

Launcher: Unha-3

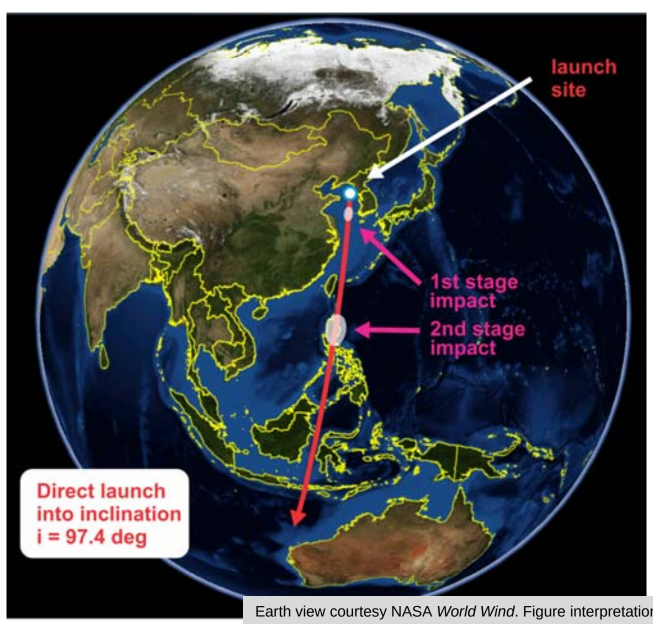
three-stage rocket

1st stage engines:
red-fuming nitric acid (RFNA) and kerosene (heritage: Soviet R-17 Scud)

Direct launch into orbit with inclination i = 97.4º

1st stage impact area:
Yellow Sea west of Korea

2nd stage impact area:
Philippines (Luzon)
unacceptable



Earth view courtesy NASA *World Wind*. Figure interpretation, processing, and augmentation by Mike Gruntman

Launch of Satellite KMS-3-2

Direct launch due south
with orbit inclination i = 90º

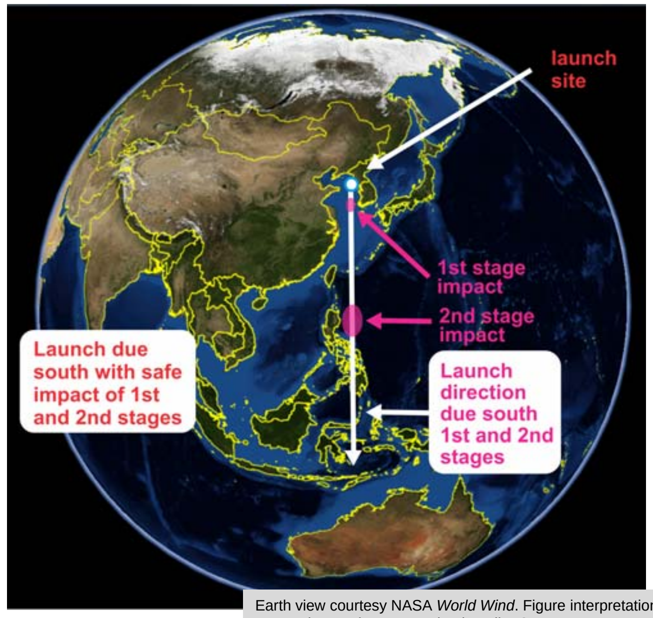
1st stage impact area:
Yellow Sea west of Korea
(not far from launch site)

2nd stage impact area:
~300 km east of Luzon
(Philippines)

Safe launch

Problem:
"wrong" inclination (i = 90º)

not sun-synchronous orbit



Earth view courtesy NASA *World Wind*. Figure interpretation, processing, and augmentation by Mike Gruntman

Launch of Satellite KMS-3-2

Direct launch due south

1st stage impact area:
Yellow Sea west of Korea

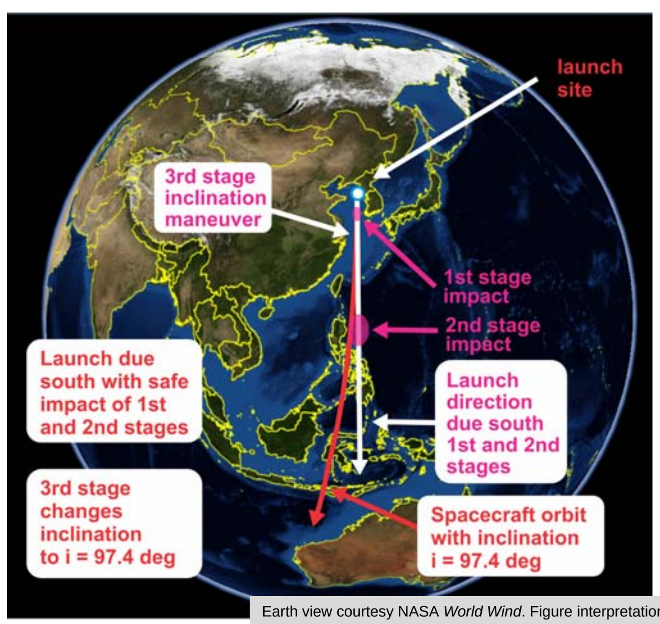
2nd stage impact area:
~300 km east of Luzon

3rd stage accelerates the satellite and turns the trajectory to achieve inclination i = 97.4º

Safe launch

Challenge: precise guidance and attitude control of launch vehicle

Almost successful, with inclination error only ~0.1º



Earth view courtesy NASA *World Wind*. Figure interpretation, processing, and augmentation by Mike Gruntman

North Korea (DPRK) Satellite Launch – Conclusions

North Korea shows continuous improvements in and mastering of long-range ballistic-missile and related space-launch technologies.

Given North Korea's size, isolation and international sanctions, it is a truly remarkable achievement.

It is only a question of time when North Korea achieves indigenous intercontinental ballistic missile capability and deploy operational satellites.

Two months after this satellite launch, North Korea conducted its 3rd nuclear test in February 2013.

Dismissing, denigrating, and jeering at North Korean real achievements is **irresponsible, unfair, and consequential**. It may lead to **dangerous miscalculation** by policy makers.

One does not need technology of 2010s to place a nuclear warhead half a world away. The 50-year old rocket technology from 1960 would suffice.

One does not have to be a rocket scientist to understand this. But some of us are.

Our students learn science and engineering which helps to deal with real problems with solid knowledge.

About the author:

Dr. Mike Gruntman is Professor of Astronautics in the USC Viterbi School of Engineering. He is the founder of the *USC Astronautics Program* and served, from 2004-2007, as the founding chairman of the *Department of Astronautical Engineering* at USC.

Dr. Gruntman is a specialist in astronautics, space science, space technology, space instrumentation and sensors, space education, and rocket history. He authored and co-authored more than 200 publications. His book "*Blazing the Trail. The Early History of Spacecraft and Rocketry*," AIAA, Reston, Va., 2004, received an award from the International Academy of Astronautics.

Professor Gruntman teaches a course, *ASTE-520 Spacecraft Systems Design*, that is among largest of this kind in the country. Almost 1100 graduate students took his course during the last 10 years.

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