Global Missile Launch Surveillance for Increasing Nuclear Stability*

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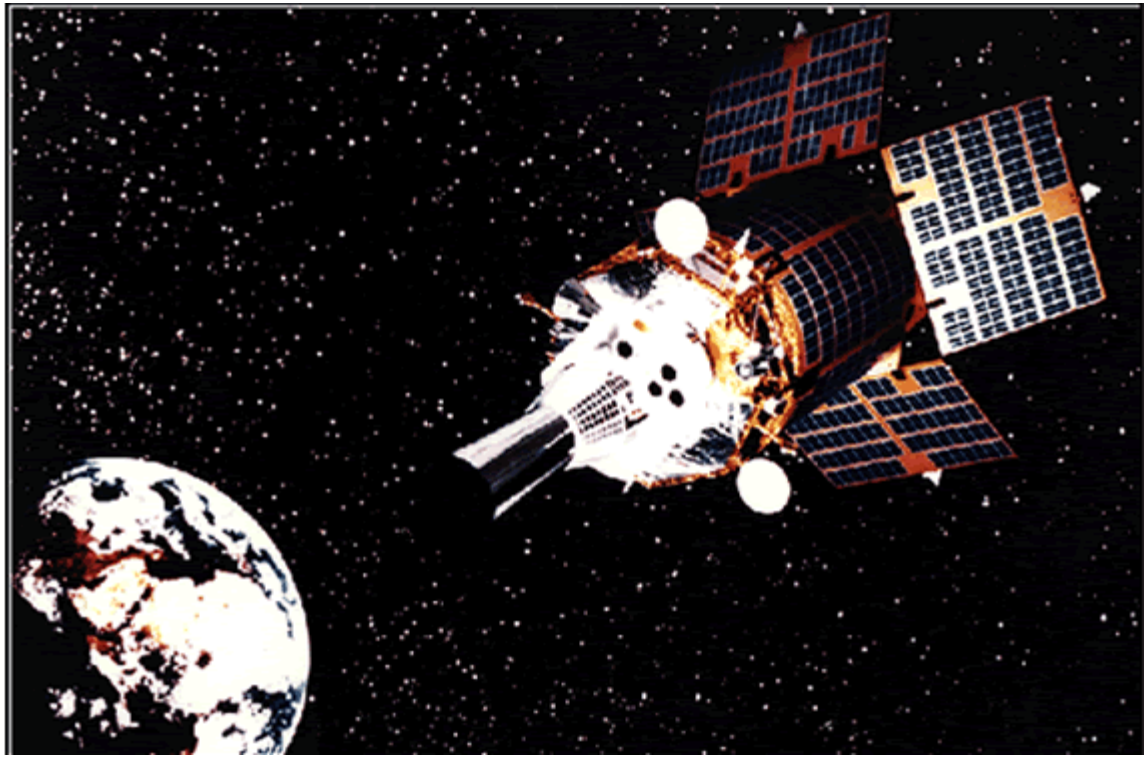
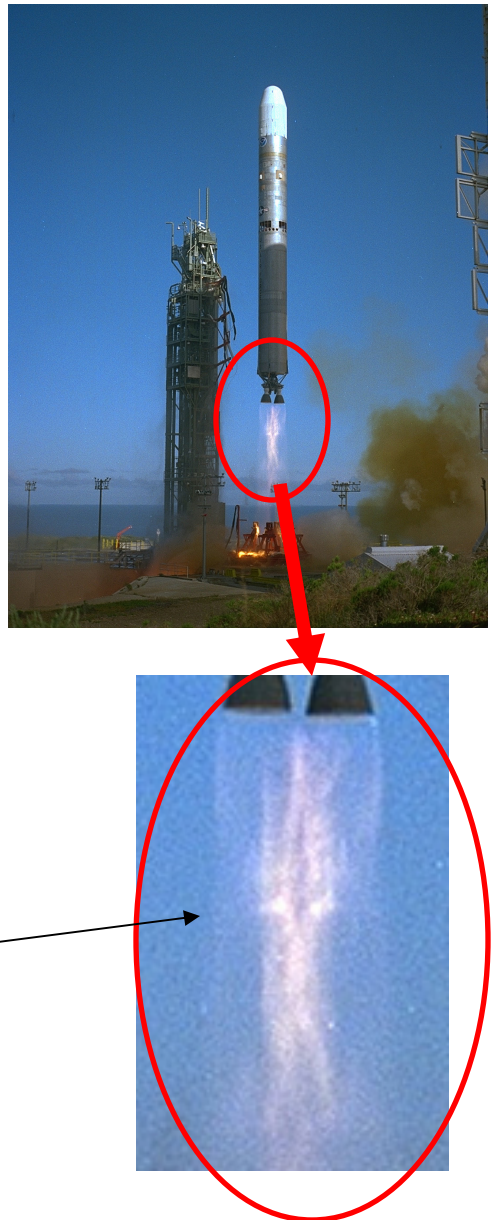
MIT

1. Detecting Missile Launches from Space
2. The Proposed Missile Launch Surveillance System
3. Increasing nuclear stability in India and Pakistan (and China)
4. Providing Russia with assurances it had not been attacked.
5. Increasing transparency of missile proliferation worldwide.

*Part of MIT Science, Technology and Global Security Working Group's South Asia Project

The United States and Russia/Soviet Union have used space-based missile launch sensors for over 25 years.





Visible light,

infrared is much brighter**!**

Most of the light from missile plumes comes from vibrational sates of the combustion products

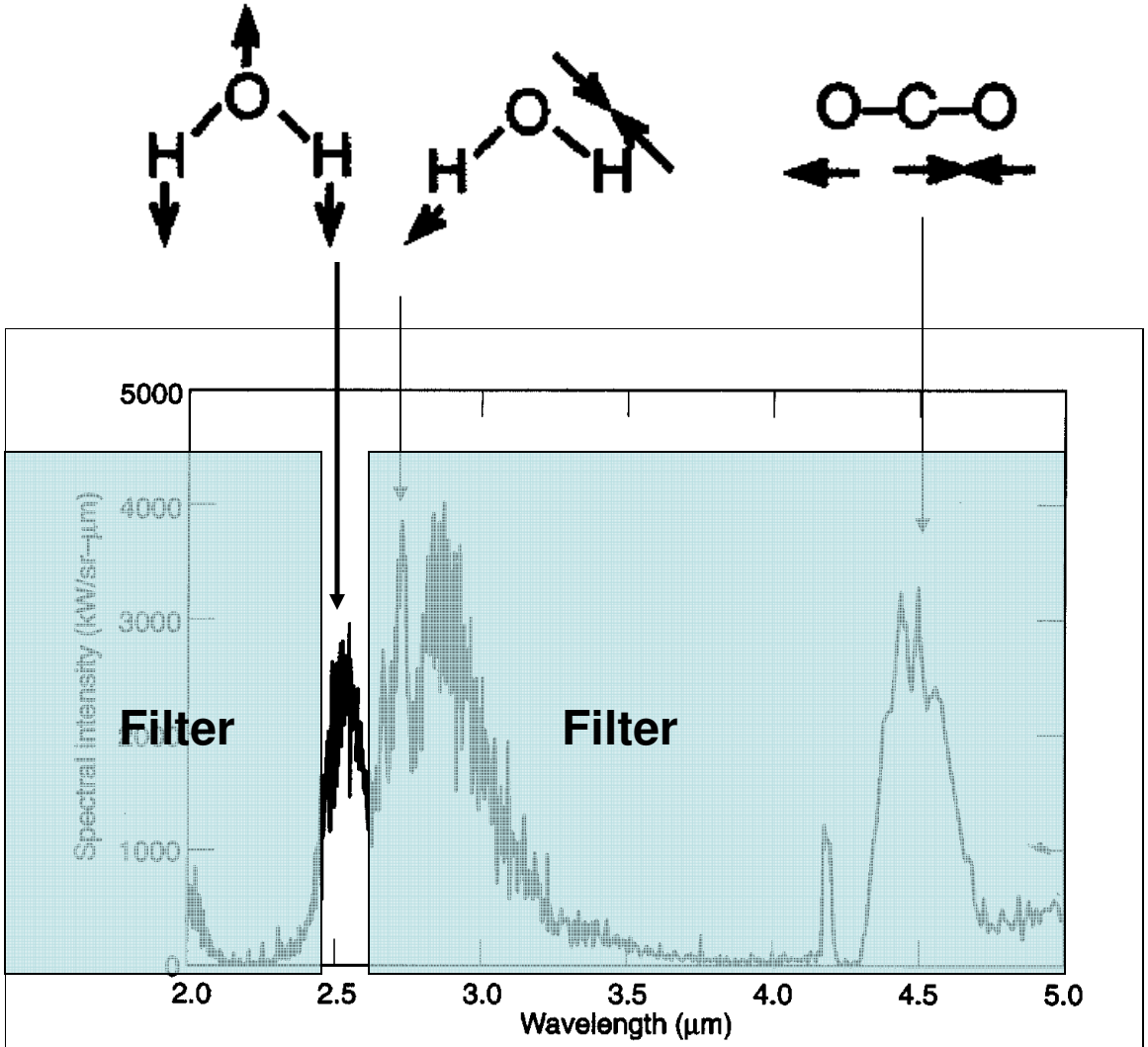
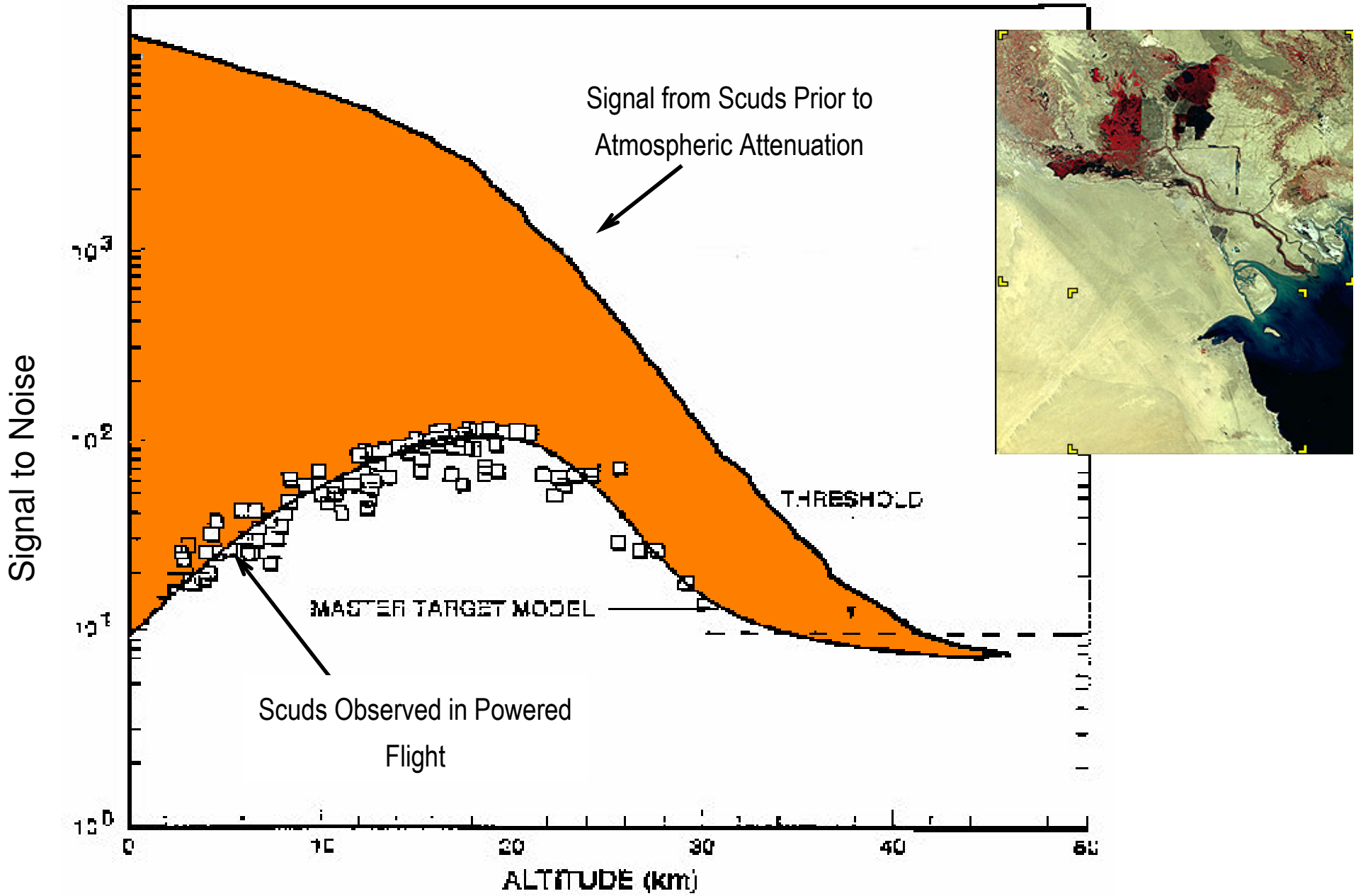
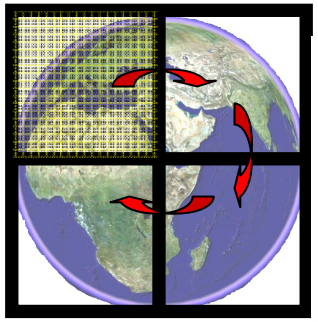


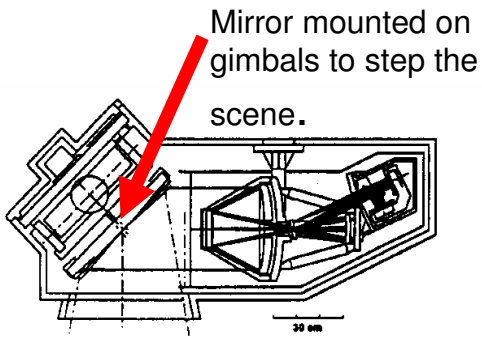
Fig. 5.3. Spectra of Titan IIIB at 18 km and viewing aspect of 48 deg.

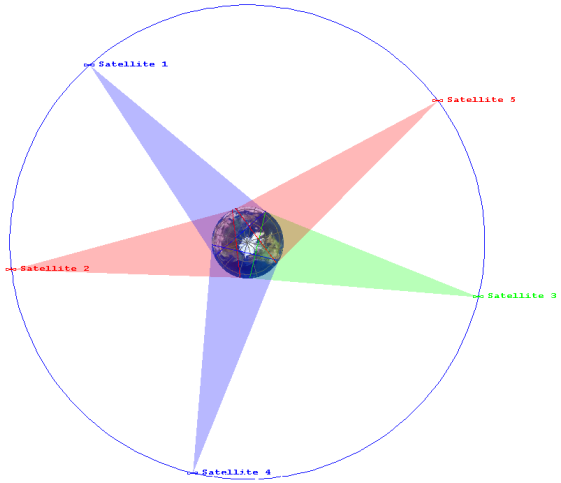
Improvements in technology will need to be made

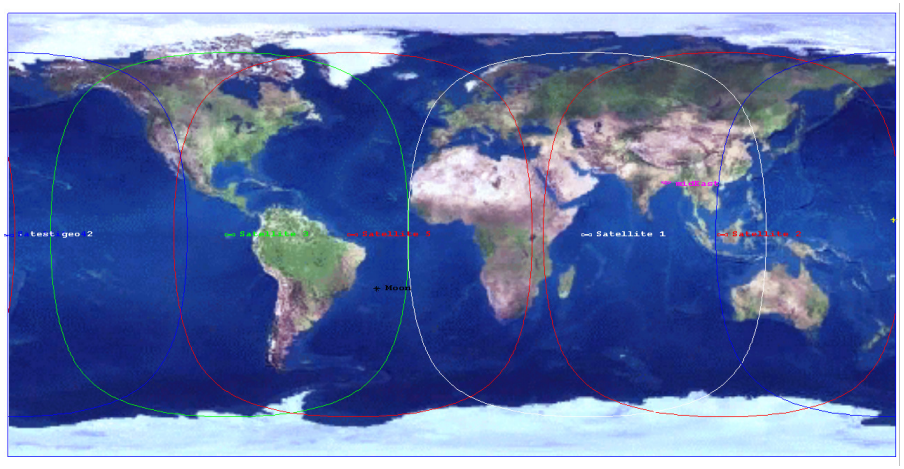


A globally shared, five satellite constellation capable of observing missile launches from geostationary orbit.

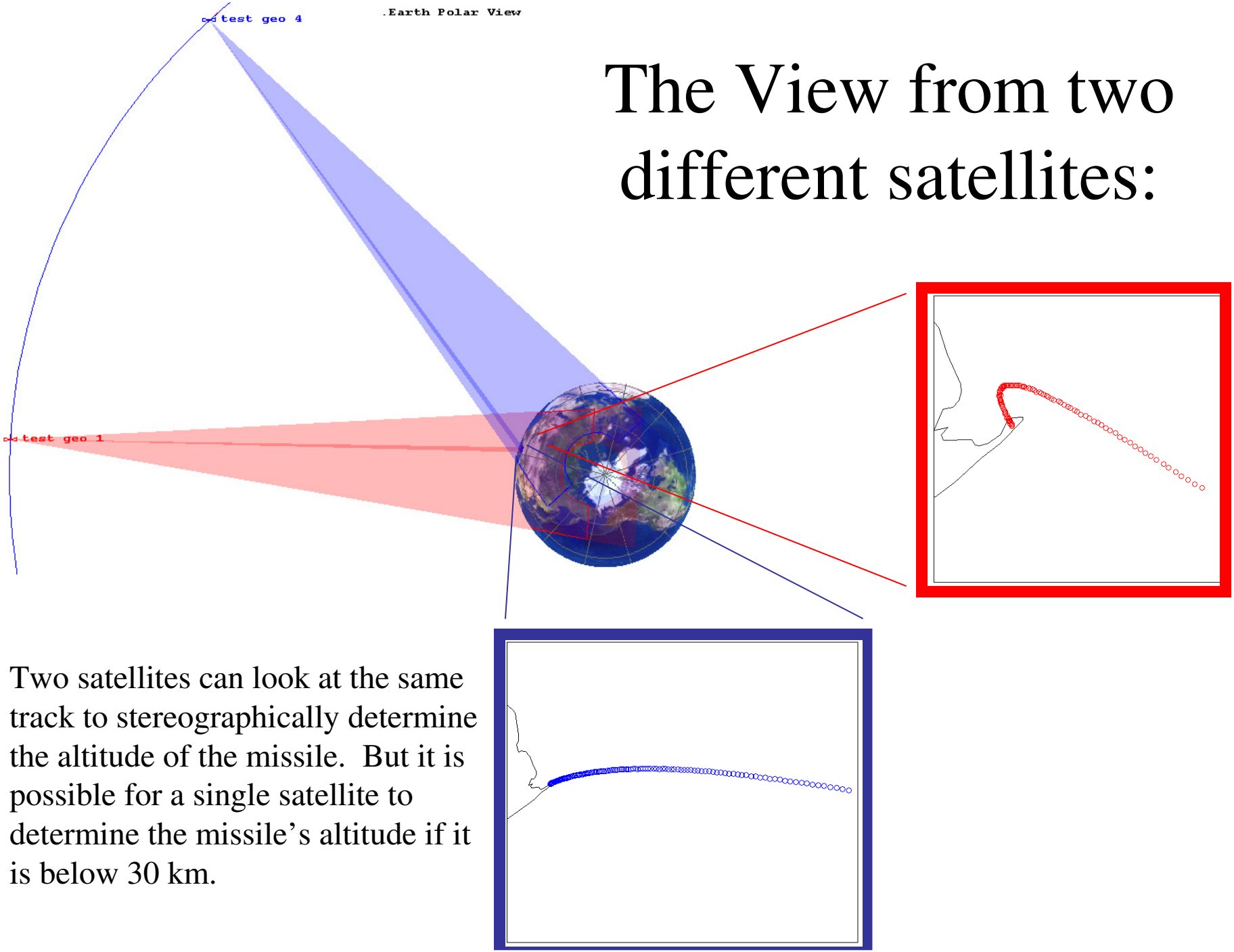








The View from two different satellites:



Two satellites can look at the same track to stereographically determine the altitude of the missile. But it is possible for a single satellite to determine the missile's altitude if it is below 30 km.

We can take advantage of the revolution in “chip” technology

Hawaii-2RG

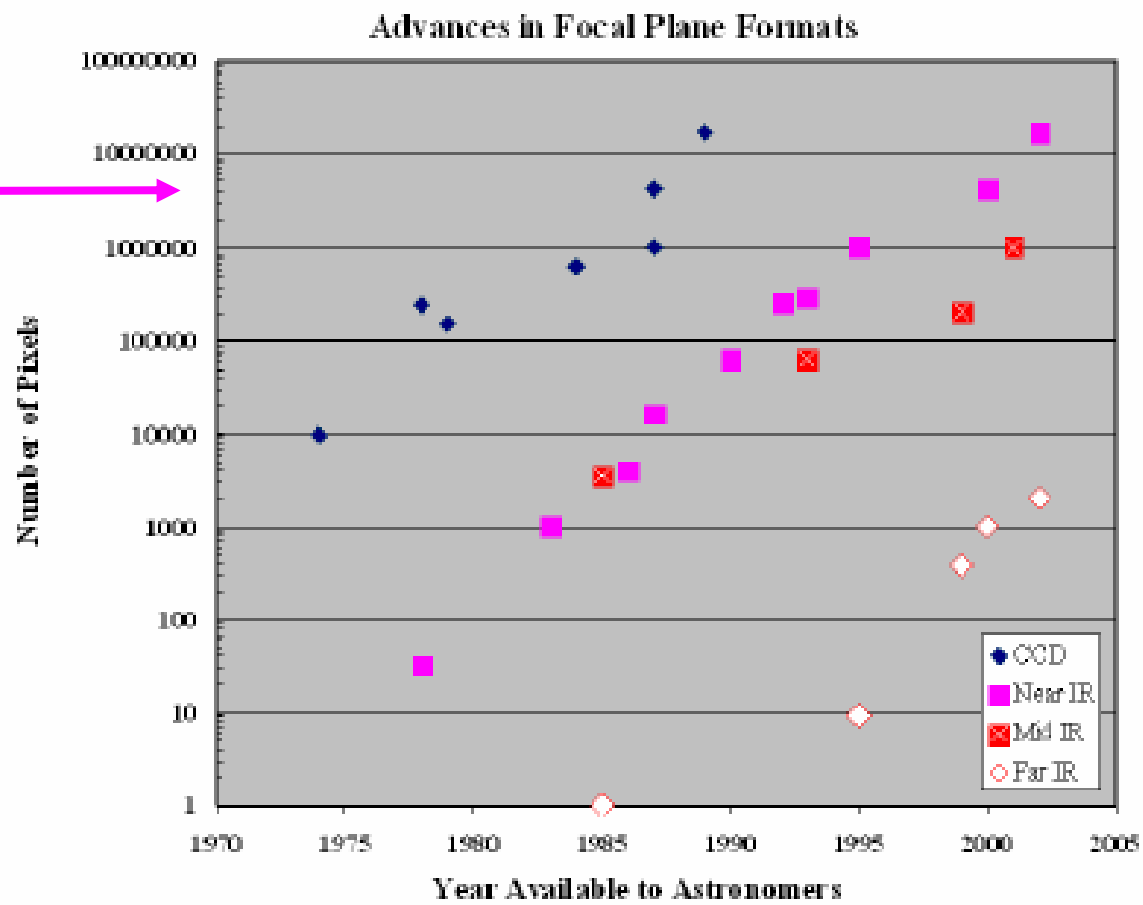
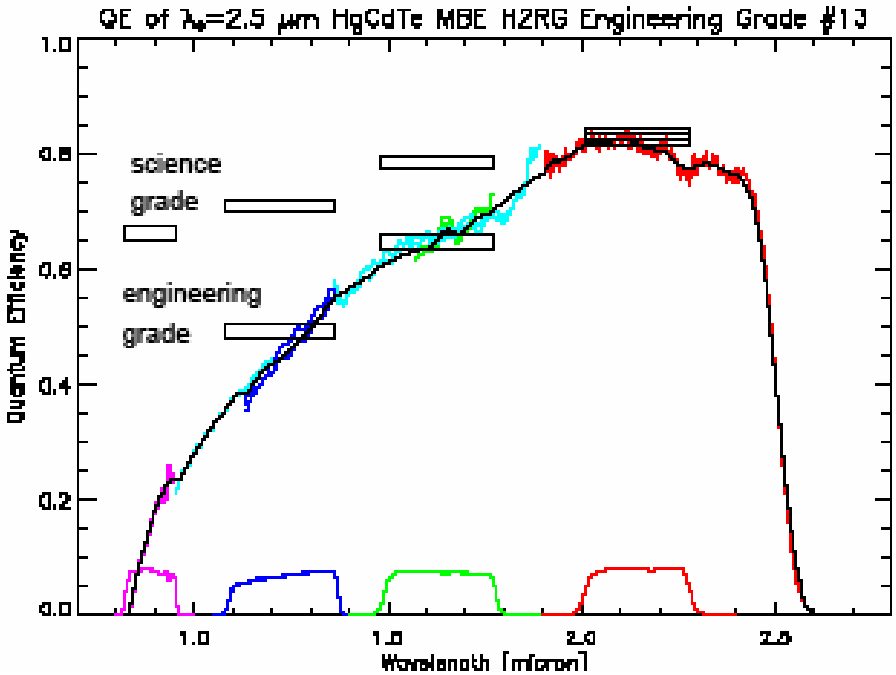


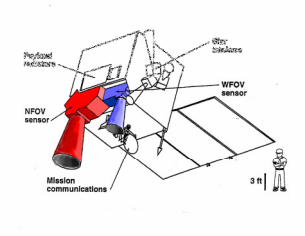
Figure 2. The Advancement of Array Formats with Time.

The HAWAII-2RG Focal Plane Array



Estimated cost of FPA = $350 K

Satellite Cost Estimates



(Assuming Russian launch services)

Unit satellite costs = $250 M

Launch service cost per satellite = $75 M

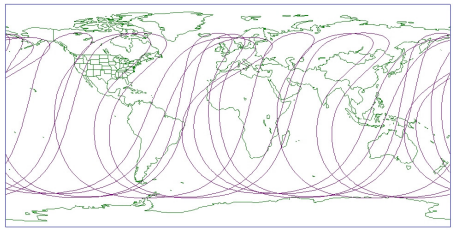
x5

Development costs = $400 M

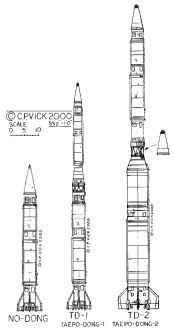
Total cost for system = $2,025 M

Possible uses of the system:

Increasing nuclear stability in India and Pakistan (and China)



Providing Russia with assurances it had not been attacked.

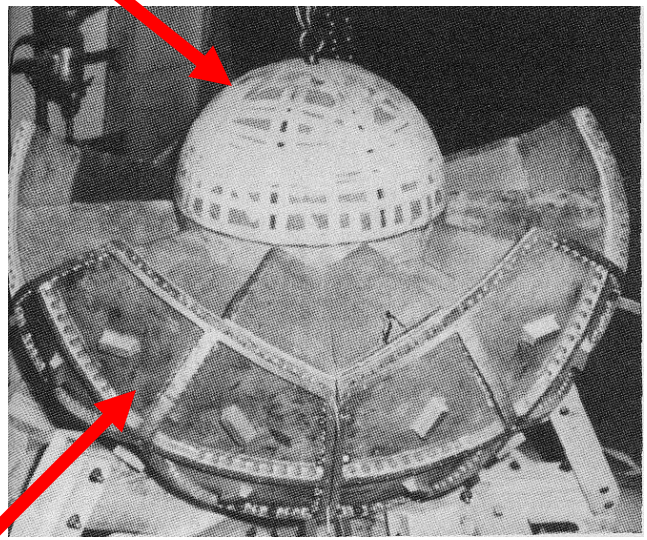


Increasing transparency of missile proliferation worldwide.

Increasing Nuclear Stability in India and Pakistan (and China)

Currently, both India and Pakistan are believed to stockpile their nuclear weapons as separate pieces:

Plutonium pit

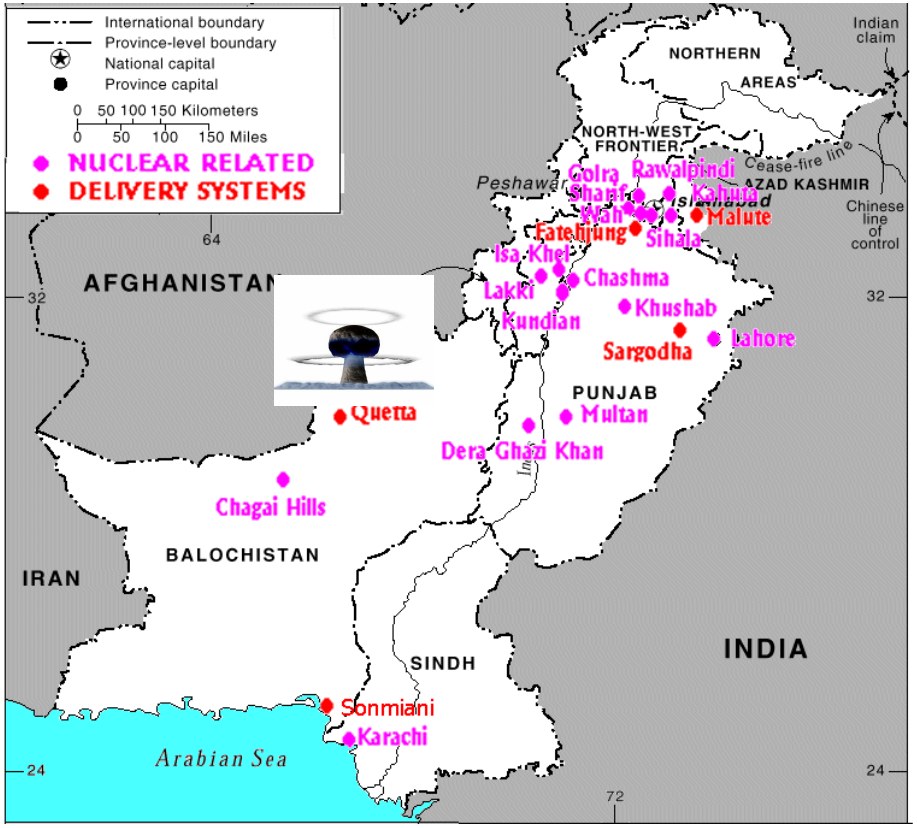


Without the surrounding conventional explosives, the pit cannot be compressed to cause a nuclear explosion.

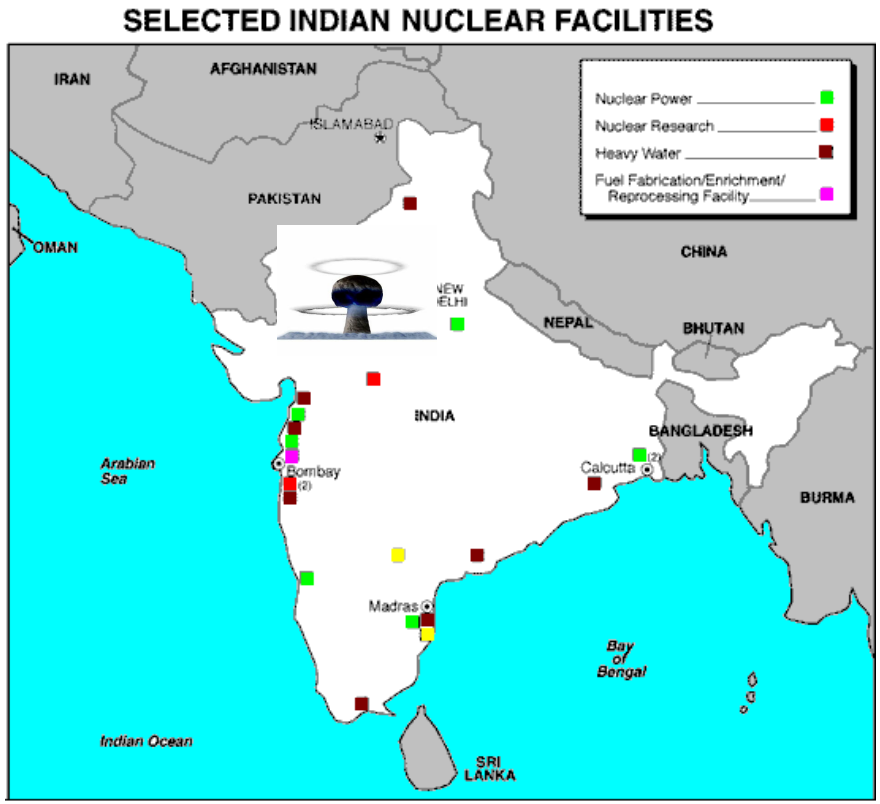
Conventional high explosives

However, both will presumably assemble their nuclear weapons in times of political tension!

What would **Pakistan** think/do if one of **its own** nuclear delivery sites was destroyed by a nuclear explosion?



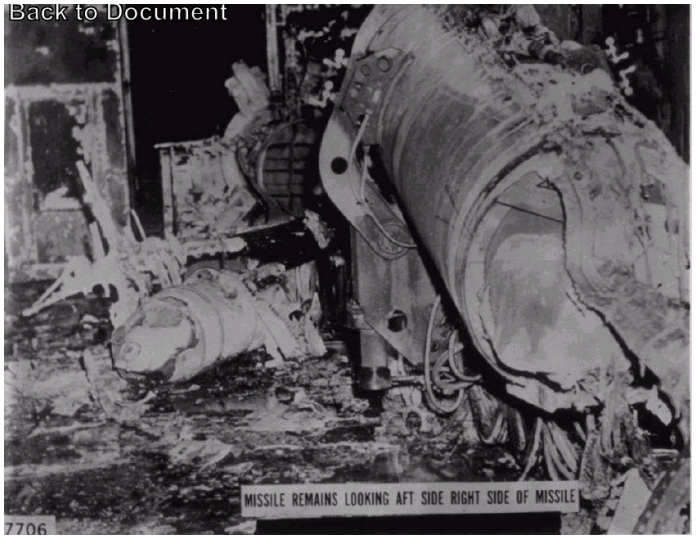
What would **India** think/do if one of **its own** nuclear delivery sites was destroyed by a nuclear explosion?



What if the explosion was caused by the country's own nuclear weapon detonating?

The Problem: Accidental nuclear detonations.

June 7, 1960, a on-alert BOMARC nuclear-tipped air defense missile burned, **melting the plutonium pit in the warhead.**



January 16, 1961, A US fighter on quick reaction alert was accidentally burned while loaded with a nuclear weapon. **The Genie (1.7 Kt) nuclear warhead was scorched and blistered**.

And many, many more!

Unfortunately, there are all too many other examples of accidents involving nuclear weapons!

27 July 1956—RAF Base Lakenheath. A B-47 practicing touch-and-go landings, slid off the runway and crashed into a nuclear weapons storage igloo spilling jet fuel from the bomber. Fire engulfed the storage igloo and the nuclear weapons inside.

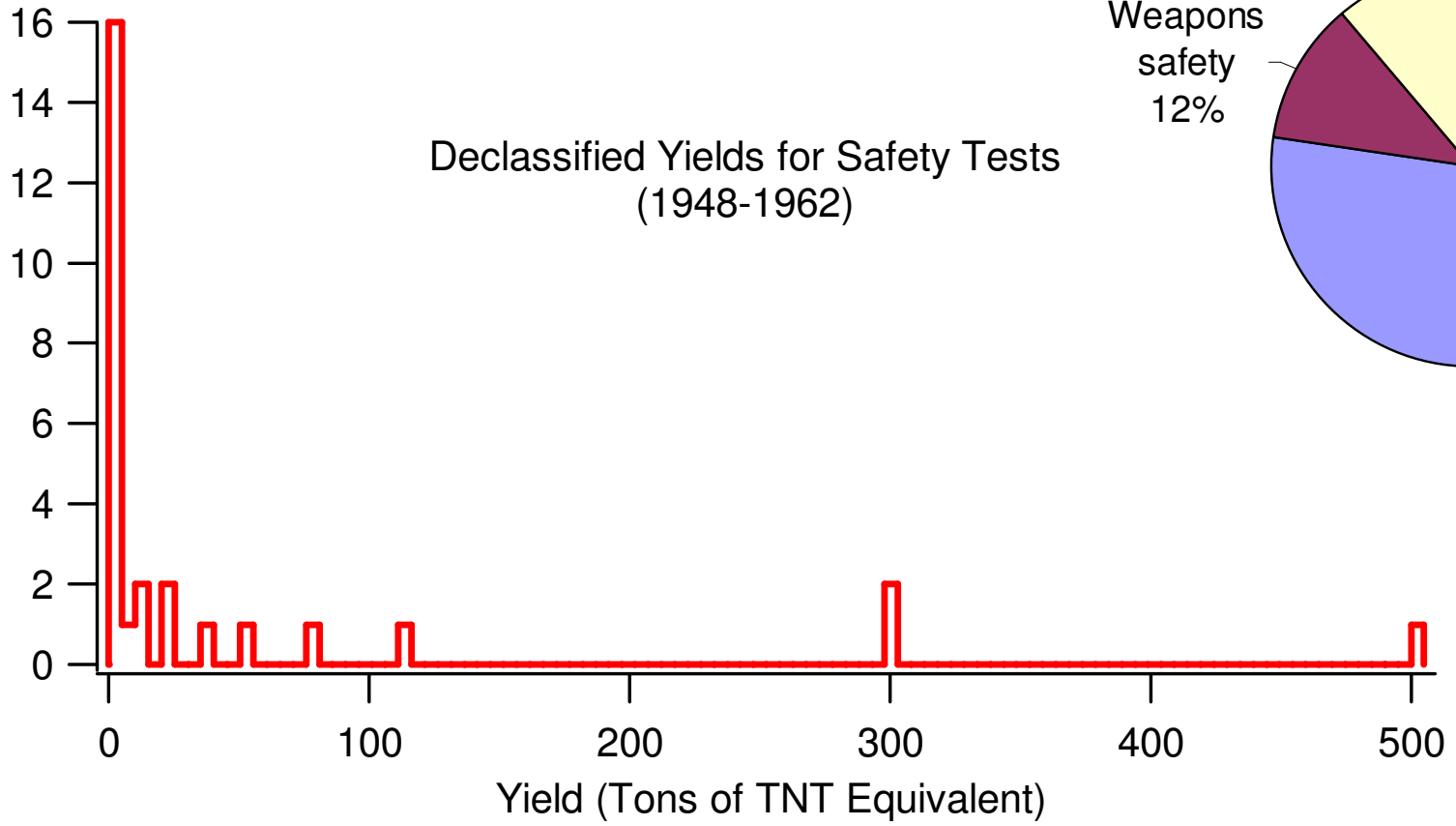
31 January 1958—SAC Base Reflex, French Morocoo. A B-47 with one nuclear weapon in full strike mode, skidded off the end of the runway, rupturing its fuel tanks and spilling jet fuel over the weapon. The base was evacuated fearing a nuclear explosion.

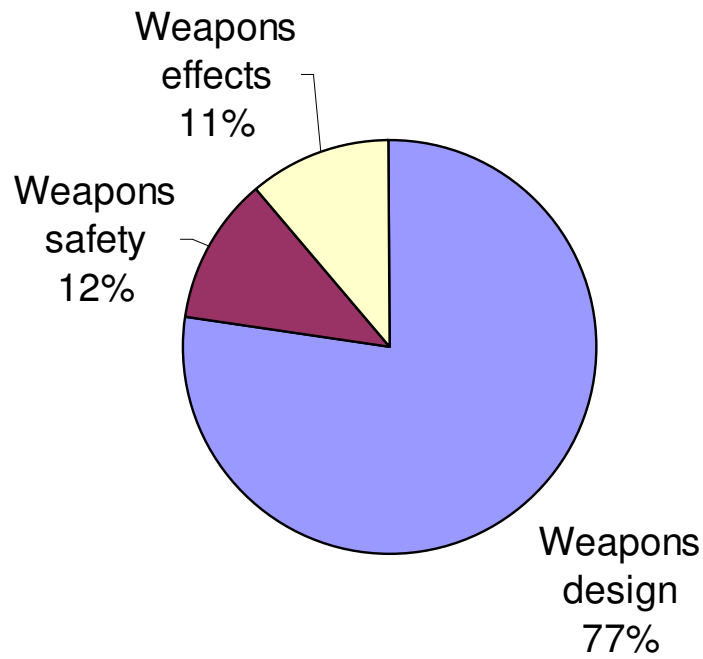
11 March 1958—Florence, South Carolina. During a SAC exercise, a B-47 accidentally released a nuclear weapon over a sparsely populated area near Florence. The high explosive in the weapon exploded on impact but there was no nuclear detonation.

4 November 1958, Dyess AFB, Abilene, Texas—A B-47 caught fire on takeoff with one nuclear weapon onboard. The weapon's high explosive detonated (causing a crater 35 feet in diameter and six feet deep) but did not cause a nuclear explosion.

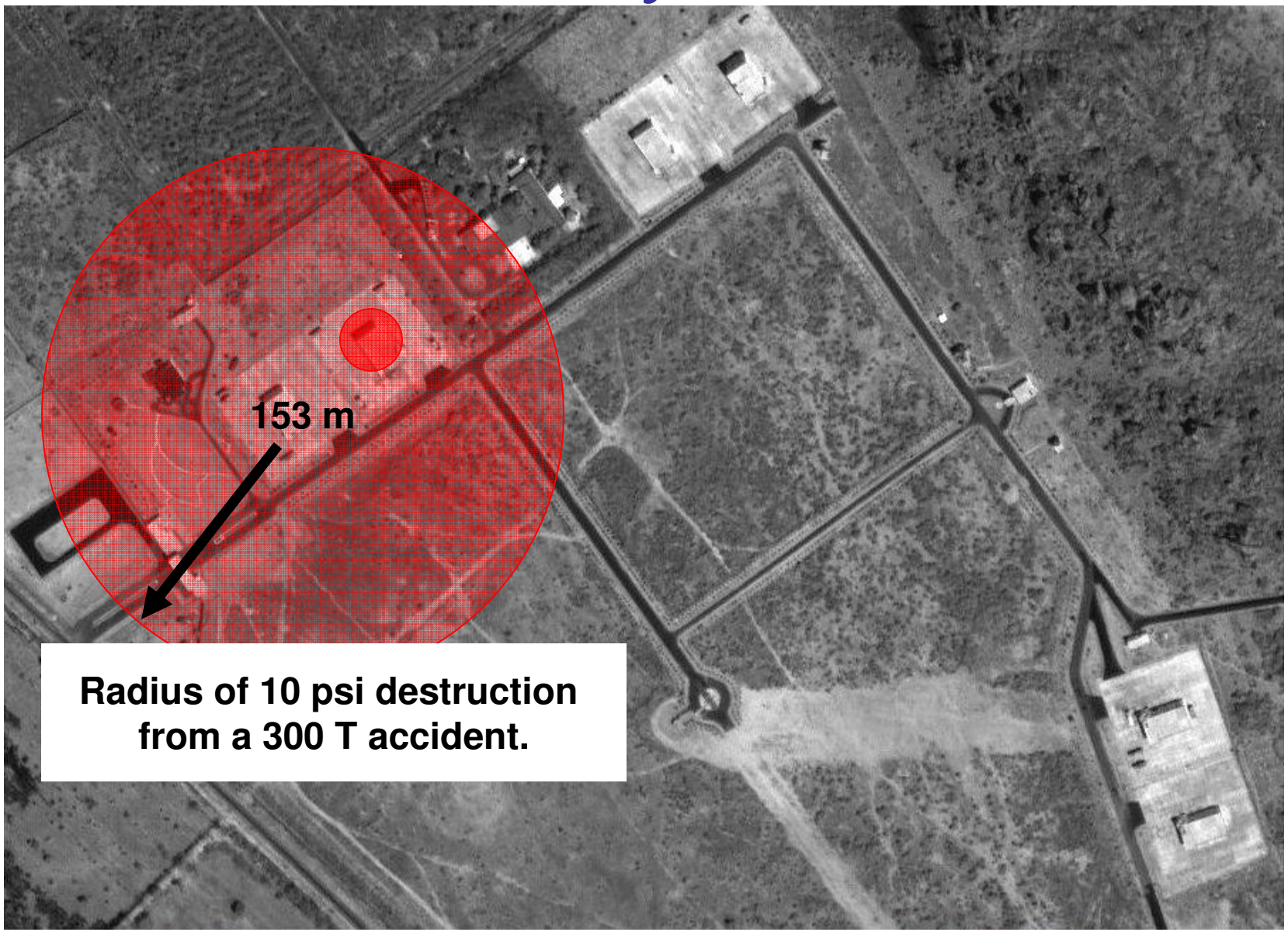
…and many, many more!

The US has experienced a number of failures of one-point safety designs

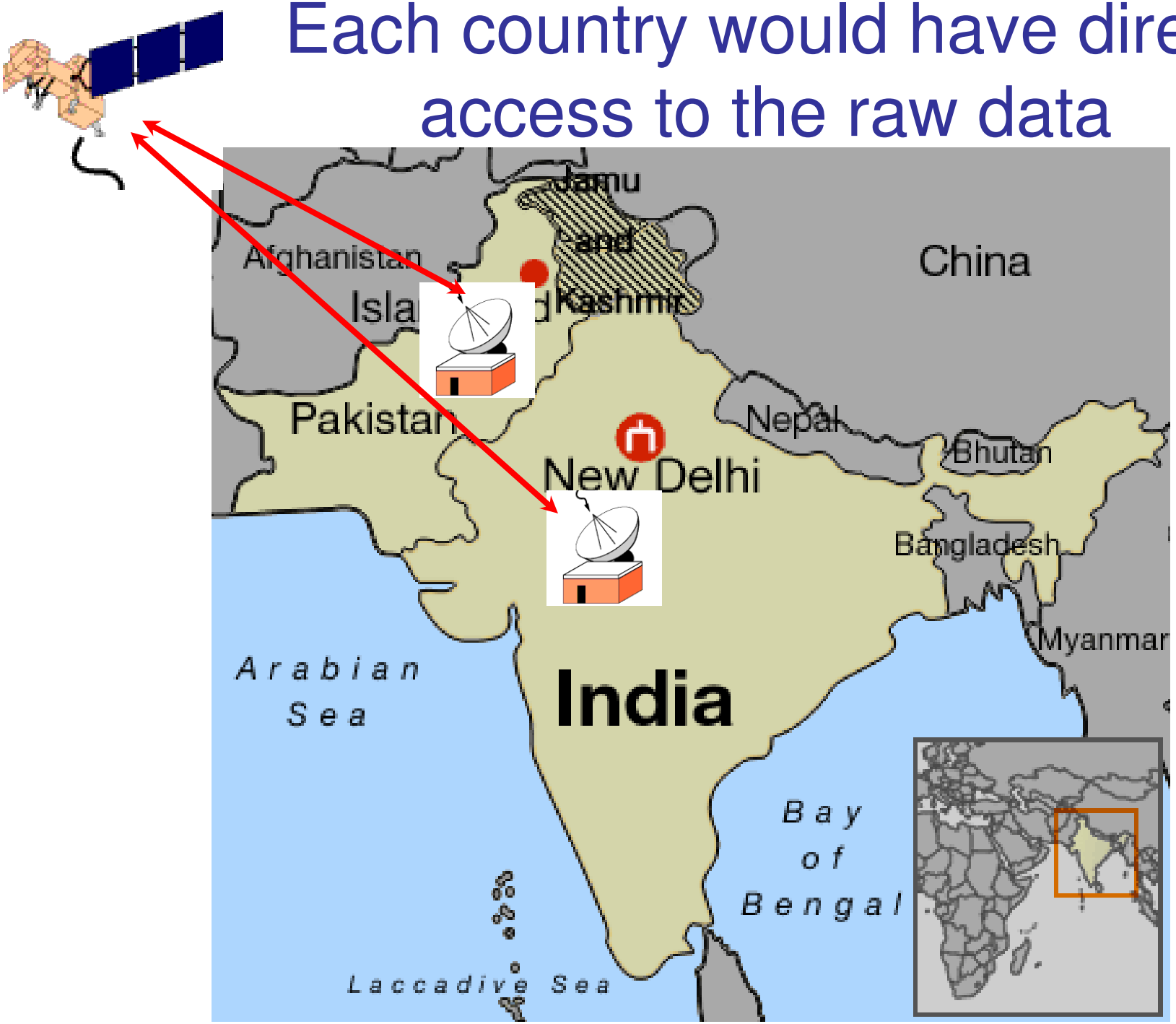




Probable Prithvi TEL Garages, outside Hyderabad, India

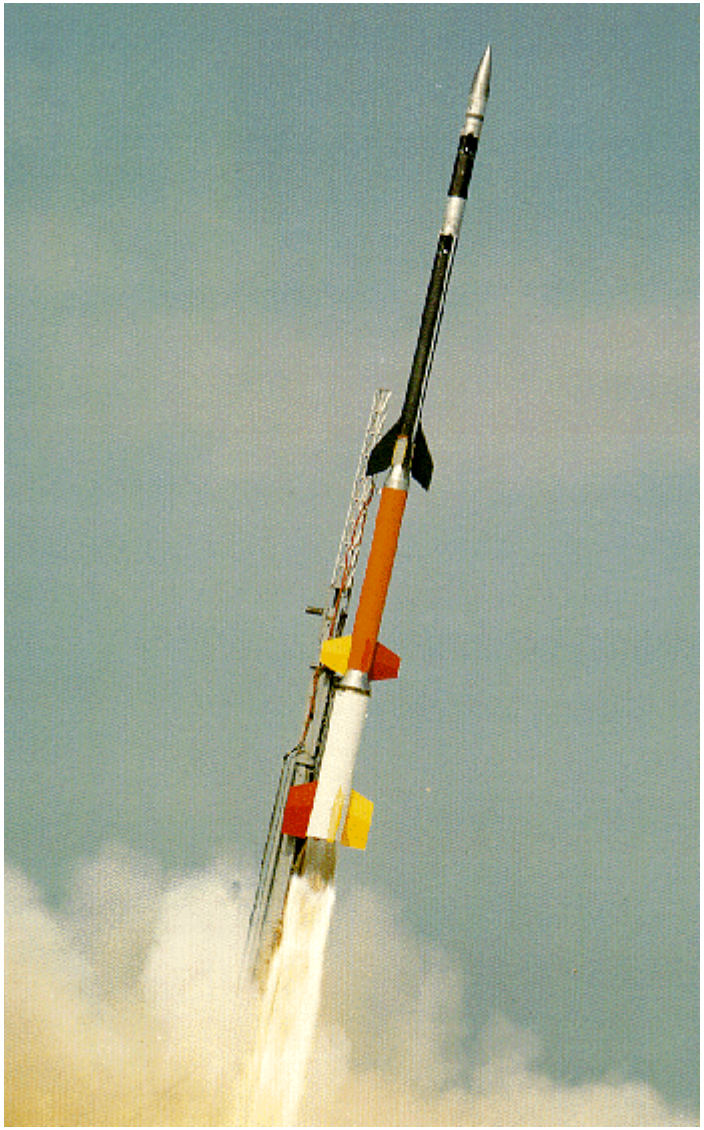


Each country would have direct access to the raw data

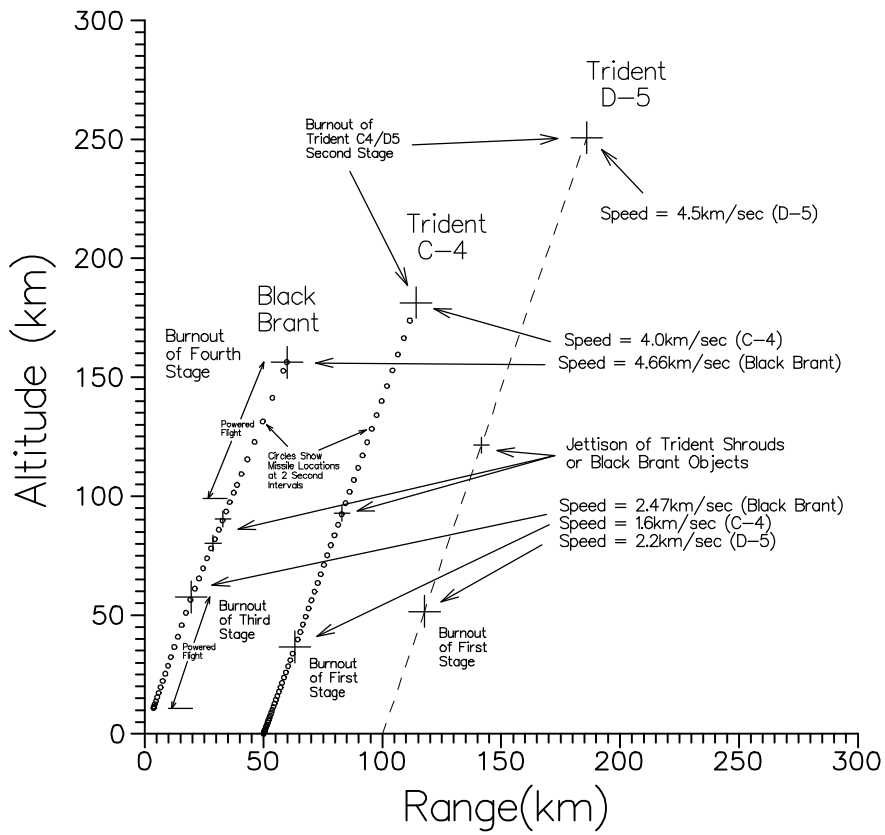


Providing Russia with Assurance

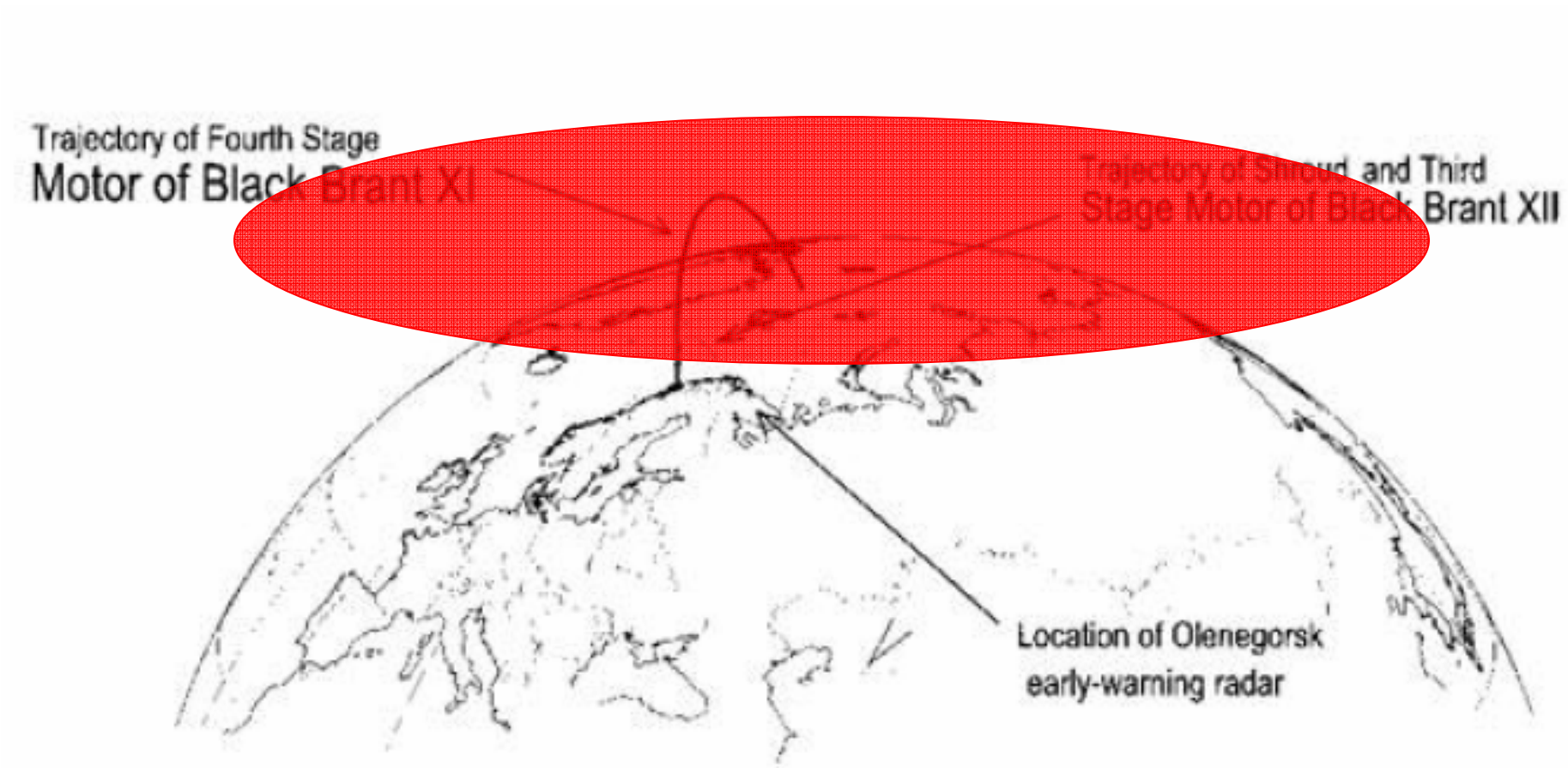
A January 26, 1995 sounding rocket launch triggered an increased Russian alert level

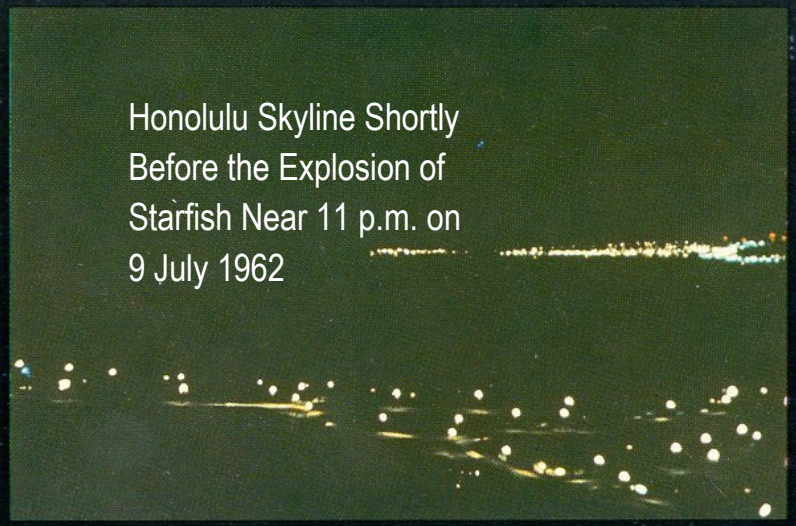


Many of the Black Brant XII's characteristics appeared similar to a Trident's.

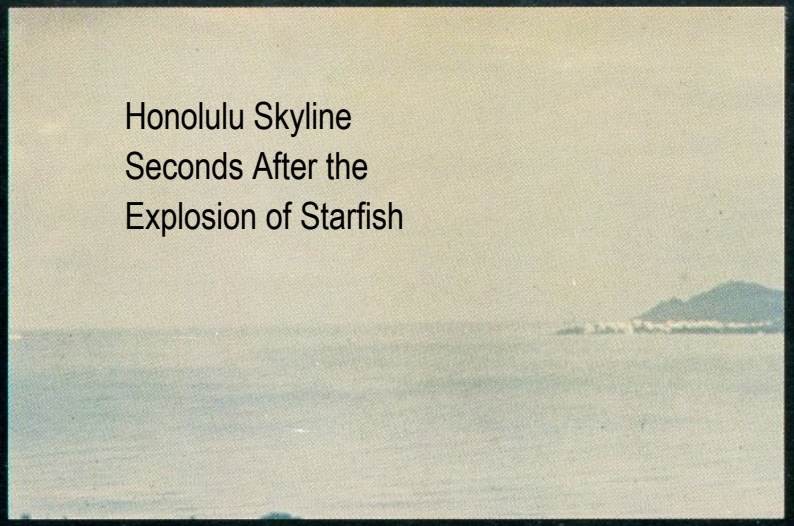


What Russia was afraid of:

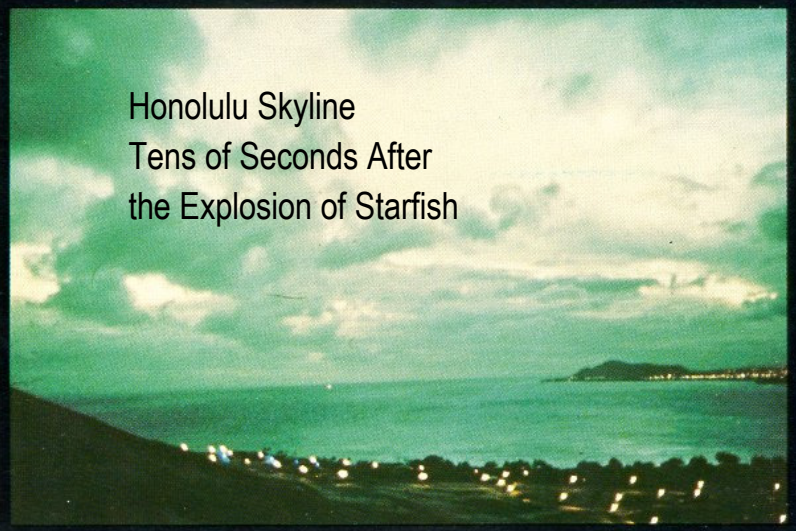




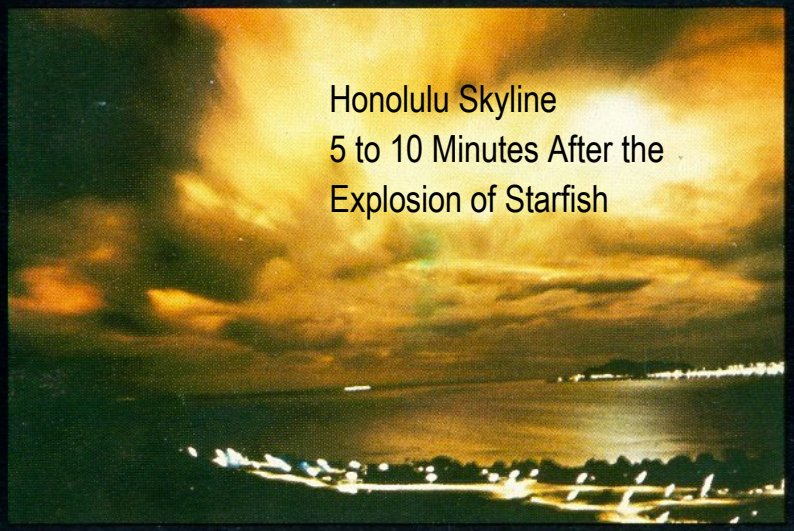
Honolulu Skyline Shortly Before the Explosion of Starfish Near 11 p.m. on 9 July 1962



Honolulu Skyline Seconds After the Explosion of Starfish

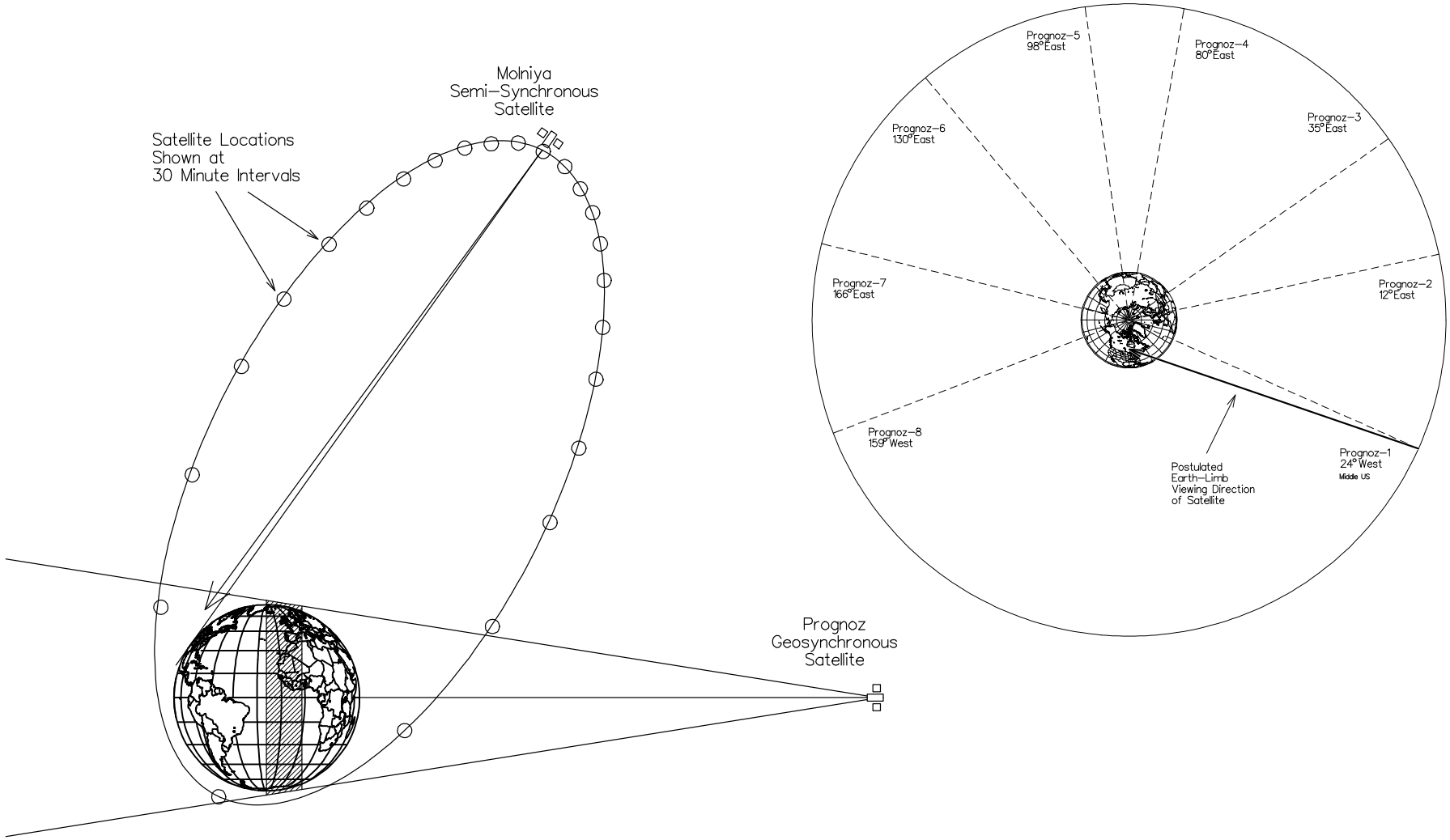


Honolulu Skyline Tens of Seconds After the Explosion of Starfish

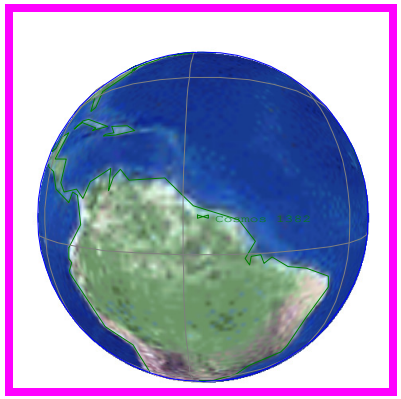


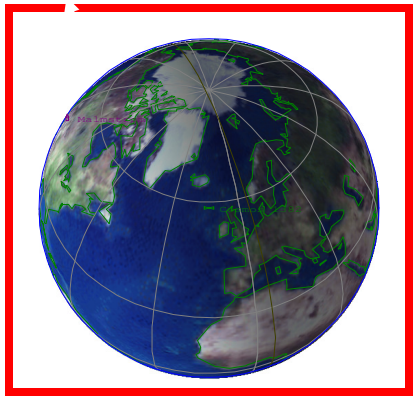
Honolulu Skyline 5 to 10 Minutes After the Explosion of Starfish

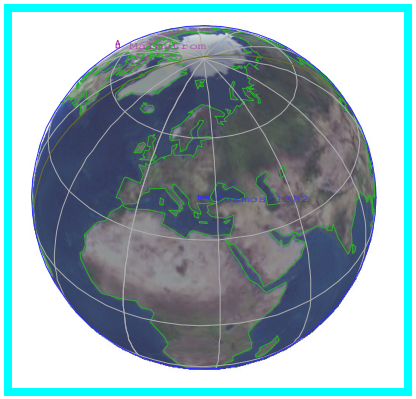
Russia has two different early-warning satellite systems.

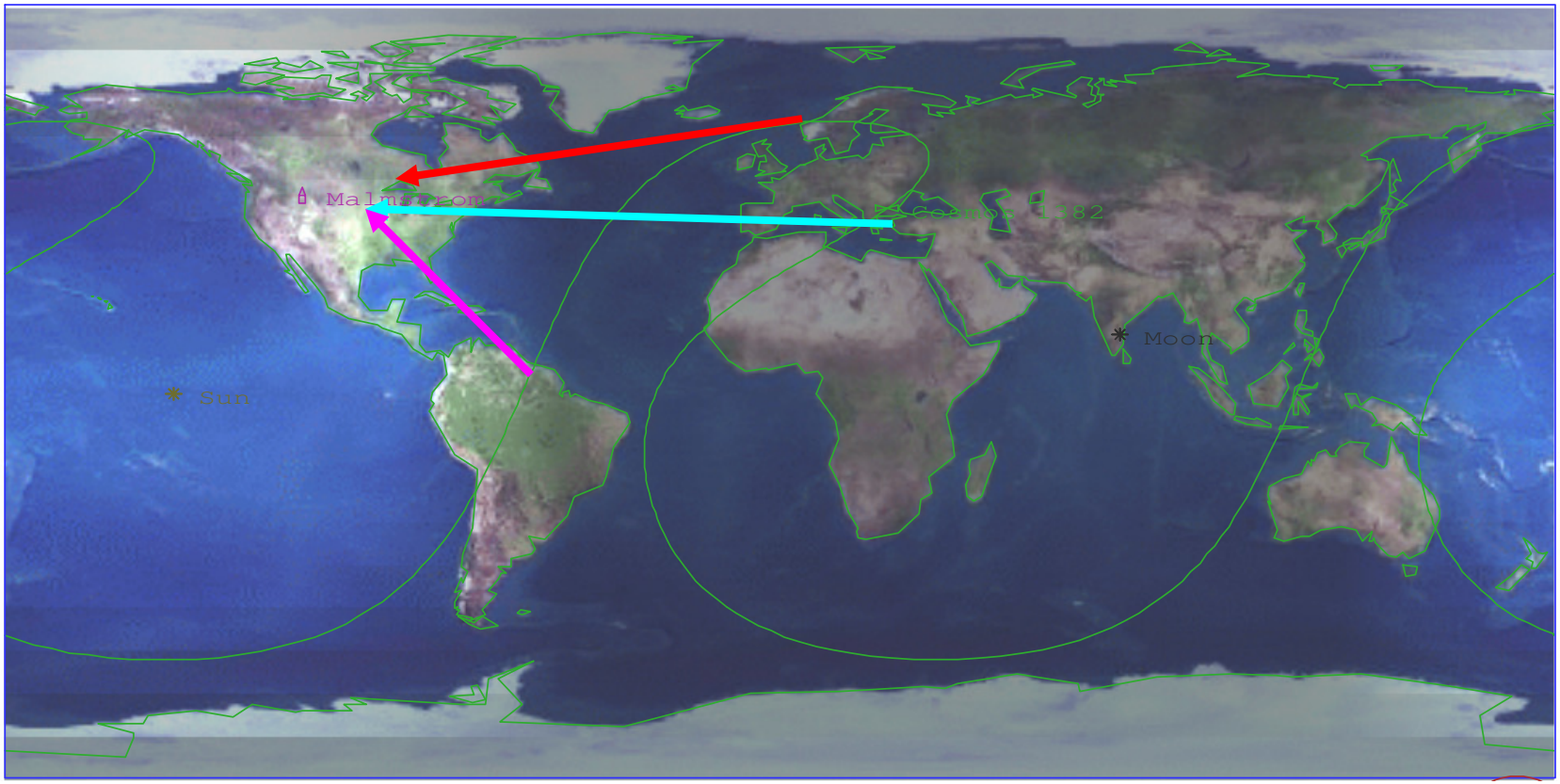


Russia's Early-warning system avoids the ground-induced background by viewing missiles on the edge of space.



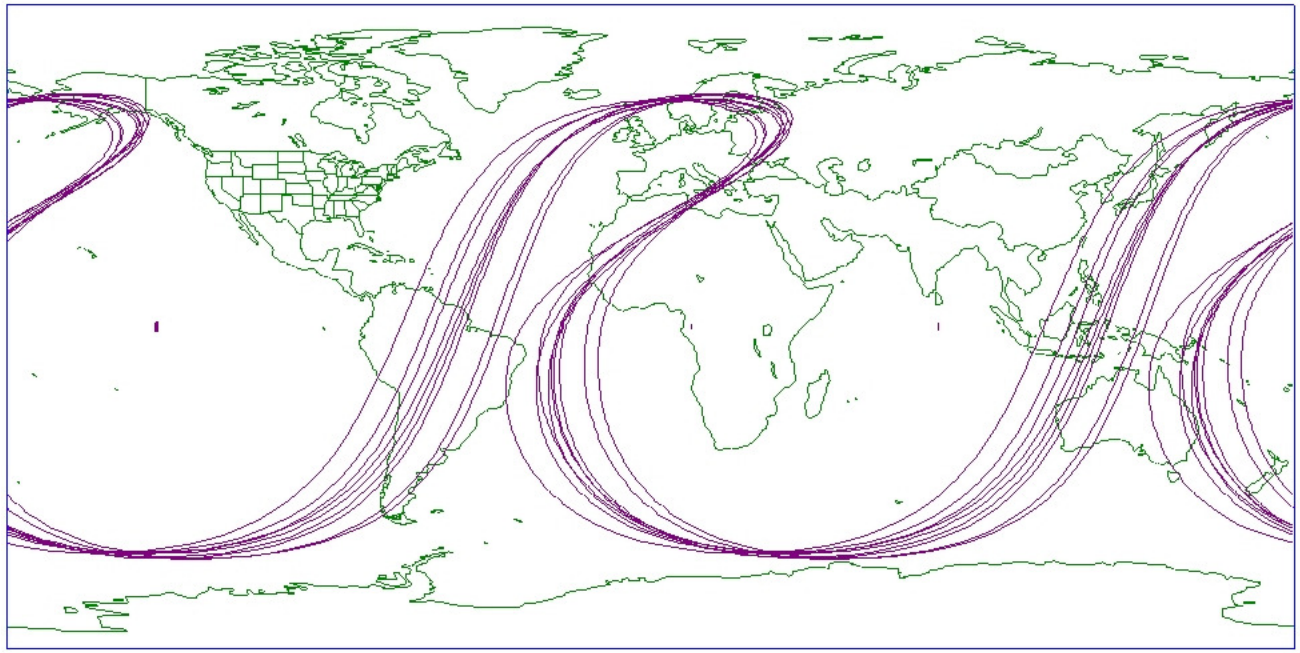




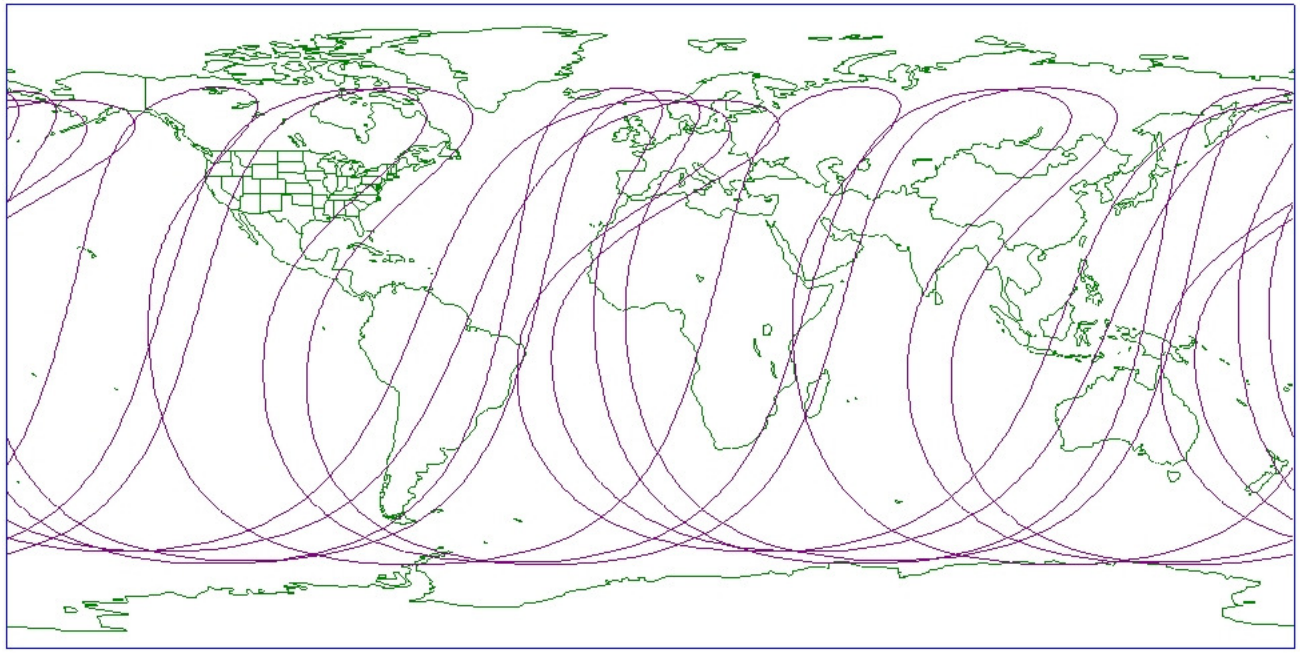


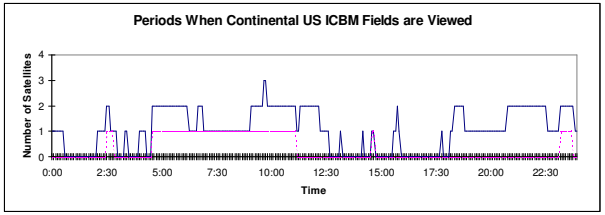
Finical difficulties have greatly curtailed Russia's ability to deploy Early-warning satellites.

1995



2001

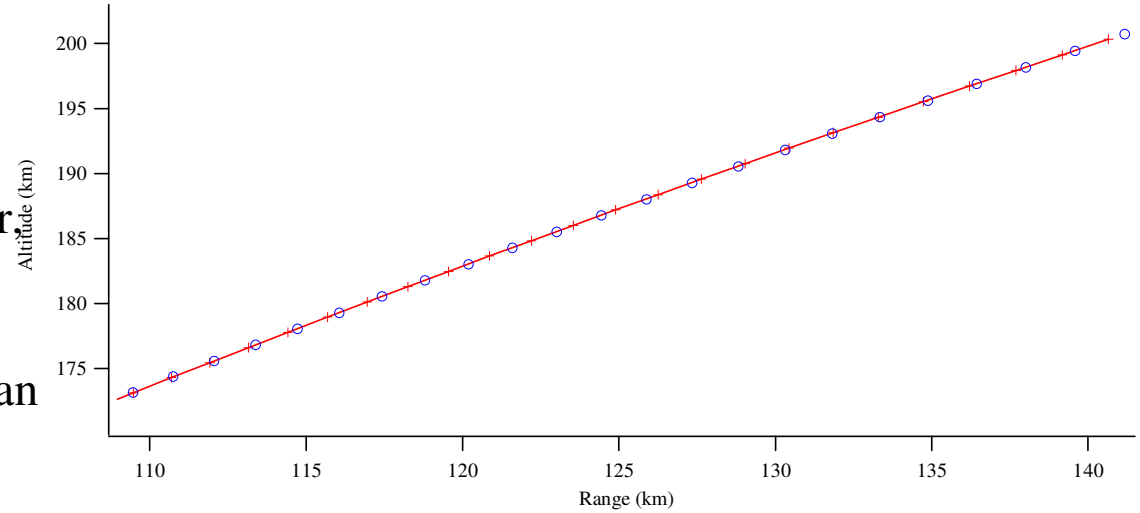




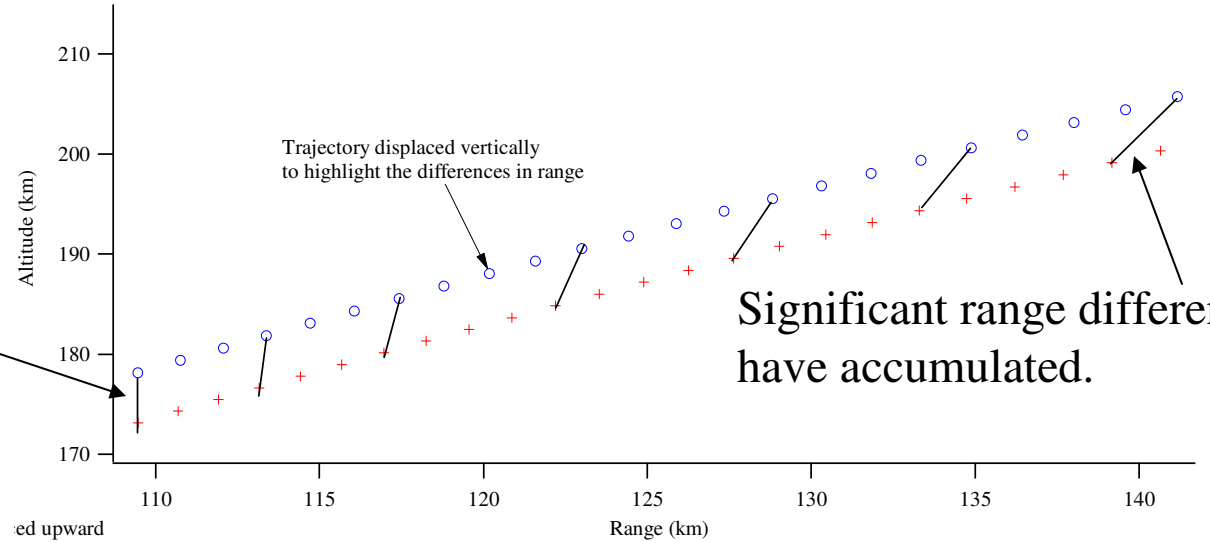
Increasing Transparency of Missile Proliferation Worldwide

Determining "end point" accelerations for Taepodong 1's that differ by ±6% in throw weight.

The trajectory profiles for a Taepodong 1 with 2 different throw weights are very similar, but the accelerations—as measured by distances flown over the same time period—can easily separate throw weights differing by ±6%.



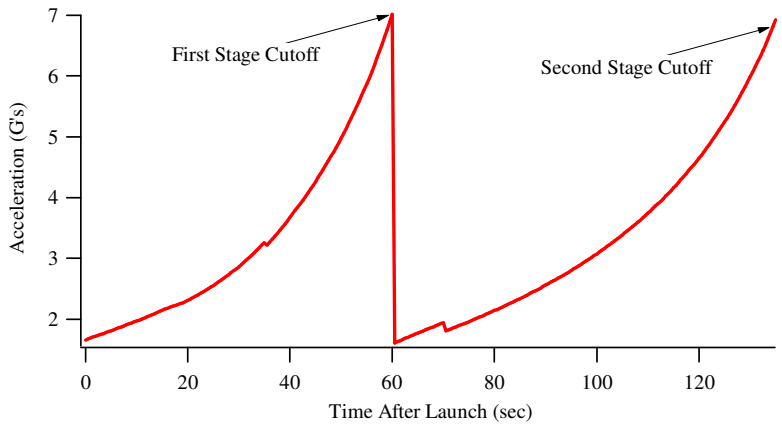
Start of observations for two different throw weights



Significant range differences have accumulated.

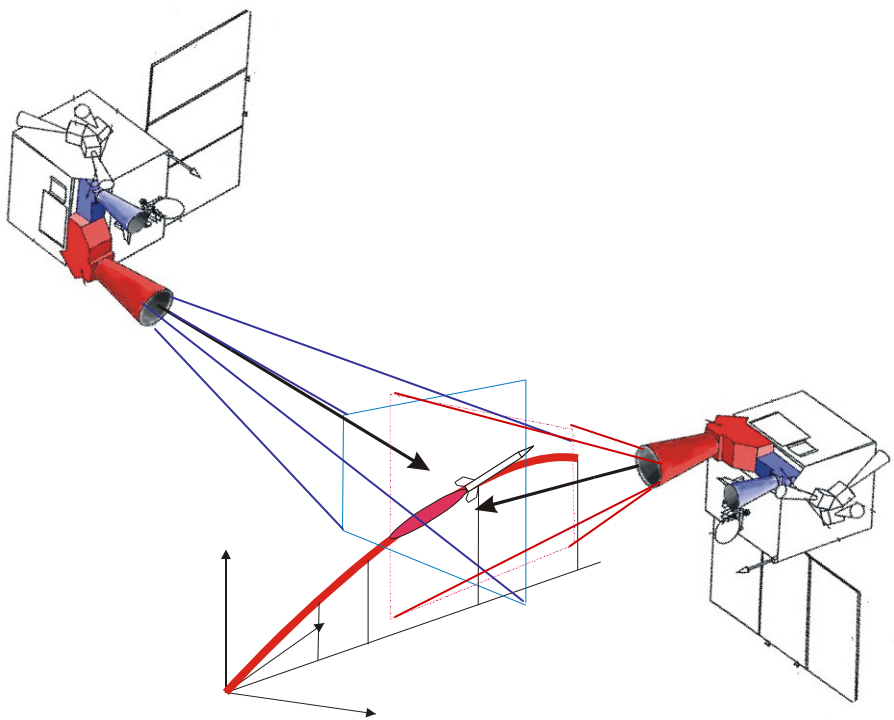
ed upward

Determining missile throw weight:

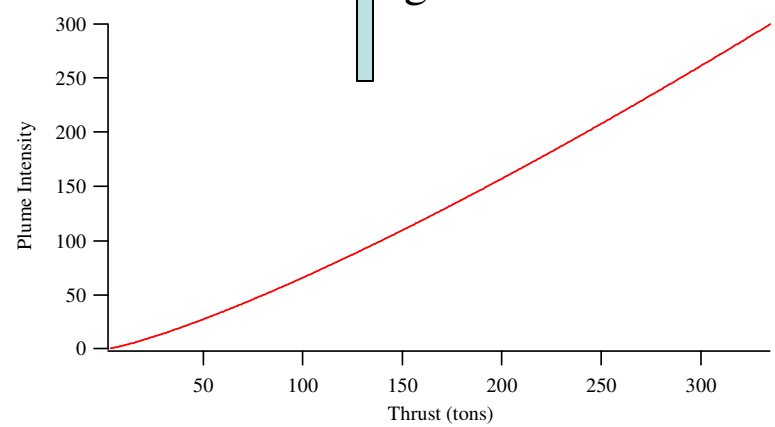


Measuring acceleration, a, from spatial coordinates and the thrust, T, from plume intensity gives:

$$m_{throw} = \frac{T}{a}$$

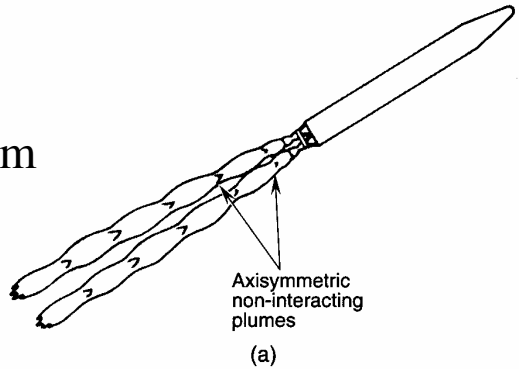


Plume intensity give the thrust

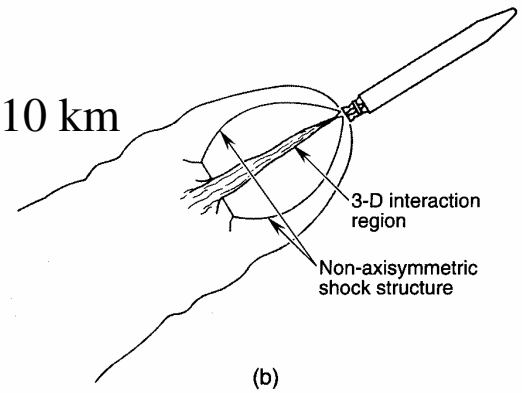


Determining the number of engines:

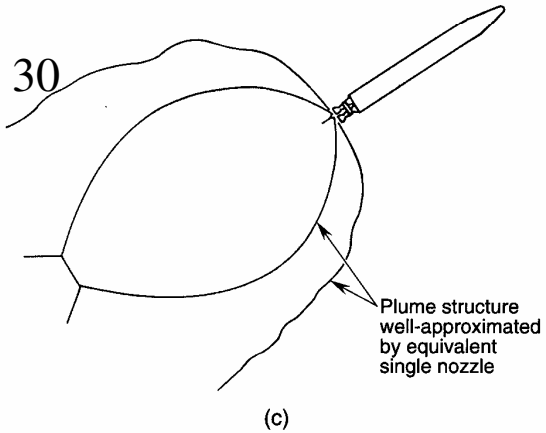
Less than 5 km altitude



Greater than 10 km



Greater than 30 km:

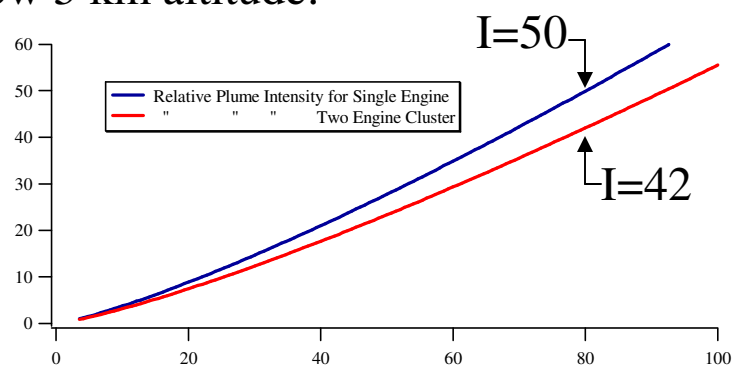


Total thrust = 80 tons (i.e. Taepodong 1)

Model 1: Single engine with total thrust = 80 tons

Model 2: Two engine cluster, each with 40 tons

Below 5 km altitude:



A single engine missile is 20% brighter than a two cluster engine!

MIT's **Science, Technology, and Global Security Working Group's** Program on Increasing Nuclear Stability in South Asia

Previous activities:

1. **Meetings with Pakistani and Indian military officials**
2. **Separate conferences with Indian and Pakistani policy makers.**
3. **Meetings with Indian satellite and space experts**

Next activities:

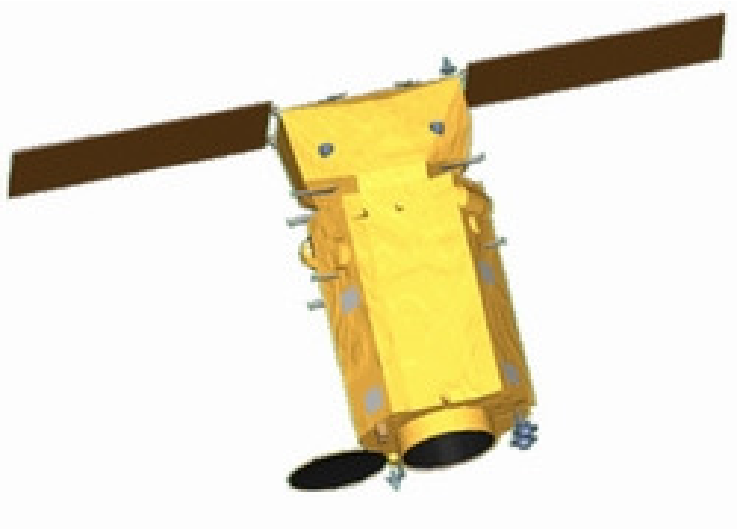
1. **Joint conference with Indian and Pakistani policy makers about the missile launch surveillance system. (Singapore 2007?)**
2. **Joint conference with Indian and Pakistani technical experts to design the system (Berlin 2008?)**

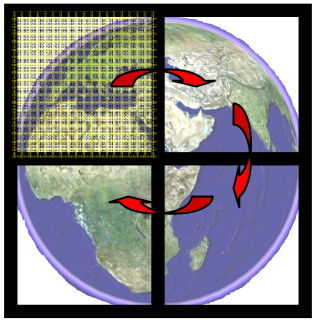
Political Choices will have Technical Implications (and vise versa)

1. **Dedicated, separate alert and tracking telescopes?**
2. **Delay between observation and data download?**
3. **See to the ground wavelengths vs. water absorption wavelengths?**
4. **Larger telescopes vs. longer revisit times?**

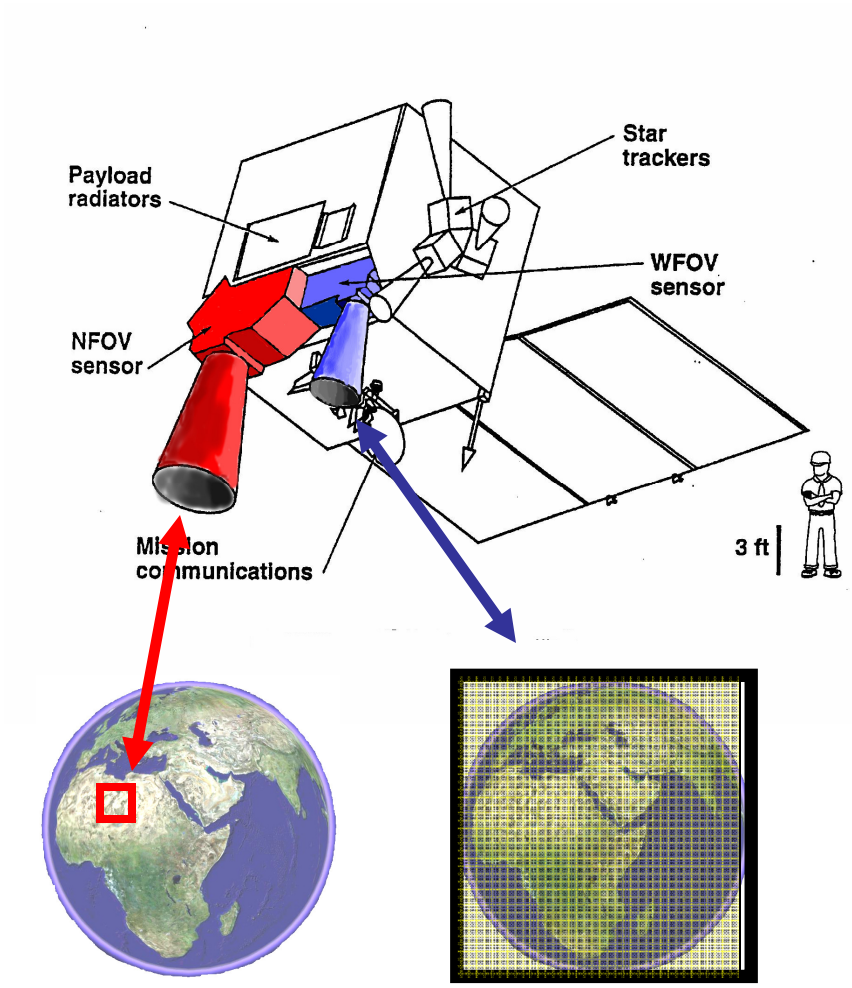
In Principle there are Two Options for Alerting and Tracking:

Single sensor



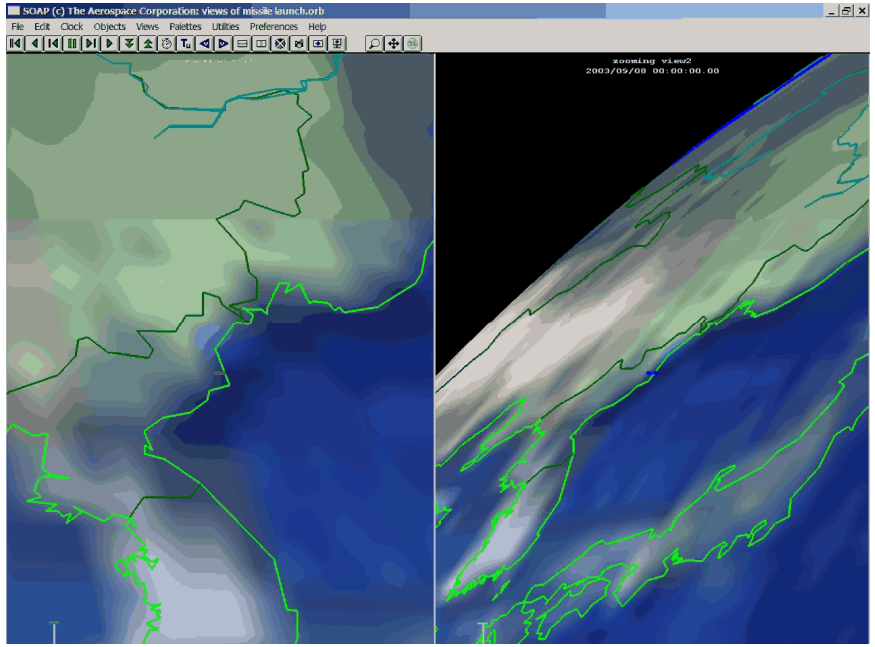


Two sensors

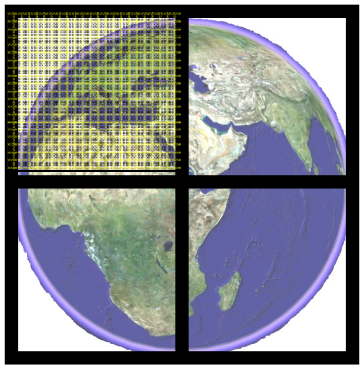


More information (including a paper detailing the system capabilities and a conceptual design) can be found on the web at:

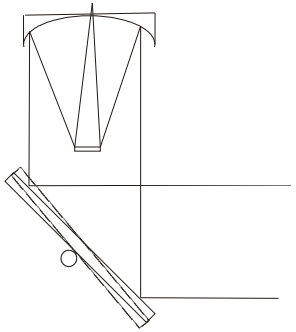
http://mit.edu/stgs/southasia.html



Design parameters for single 2048x2048 FPA



4 steps

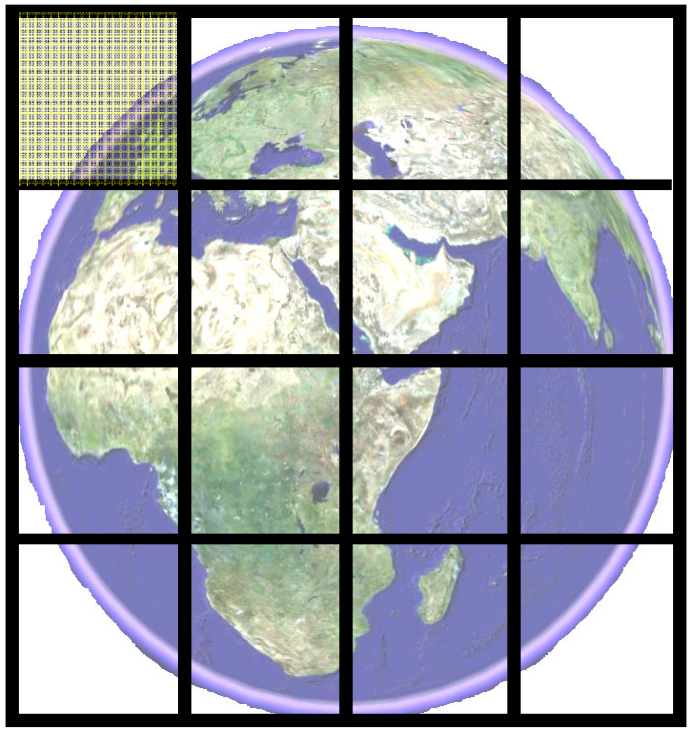


IFOV=3.11 km

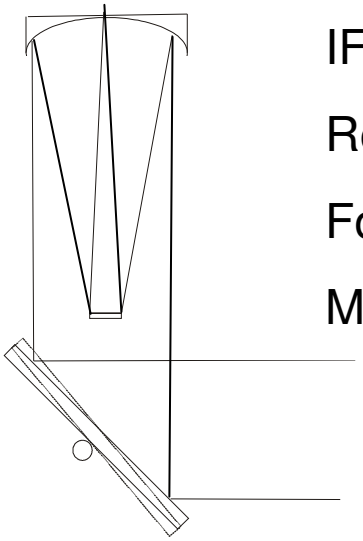
Revisit time = 1 sec.

Focal length = 0.5 m

Mirror diameter = 0.11 m



16 steps



IFOV=1.6 km

Revisit time = 4 sec.

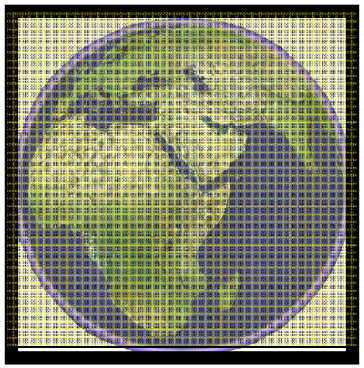
Focal length = 1 m

Mirror diameter = 0.11 m

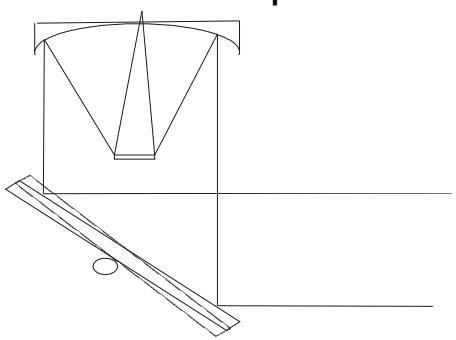
Determines Earth image size.

Determines size of FPA illuminated.

Design parameters for array of 4 2048x2048 FPAs



No steps

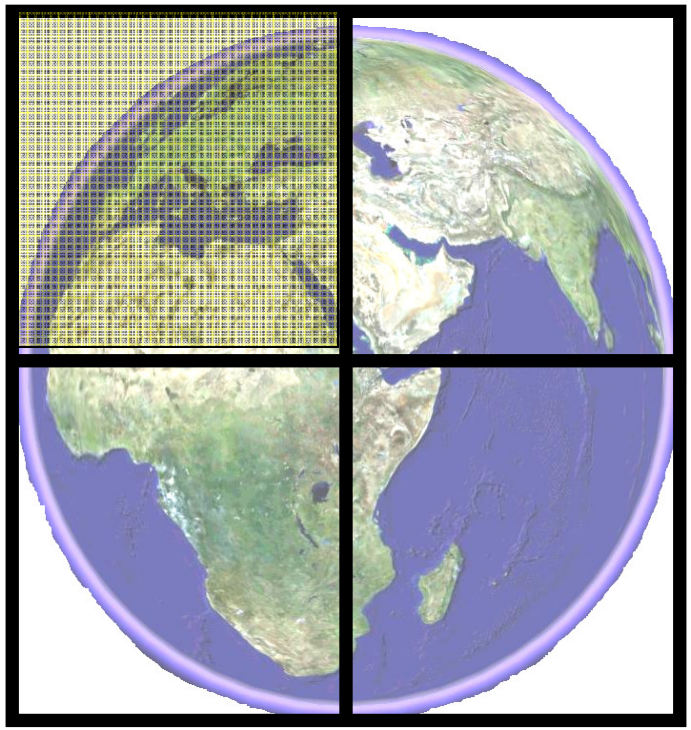


IFOV=3.11 km

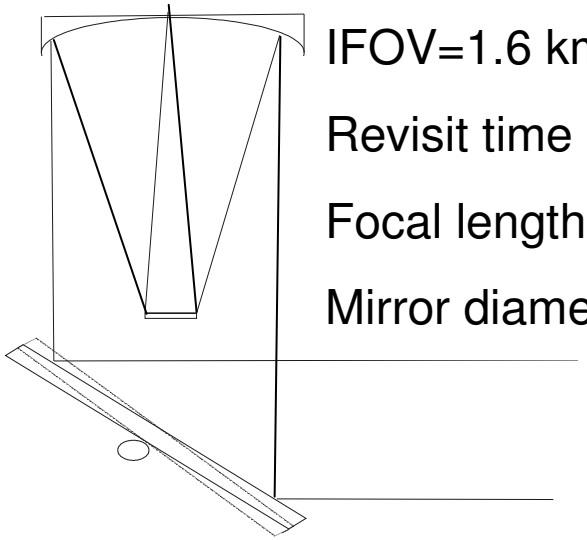
“Revisit time” =
integration time ~ millisec.

Focal length = 0.5 m

Mirror diameter = 0.22 m



4 steps



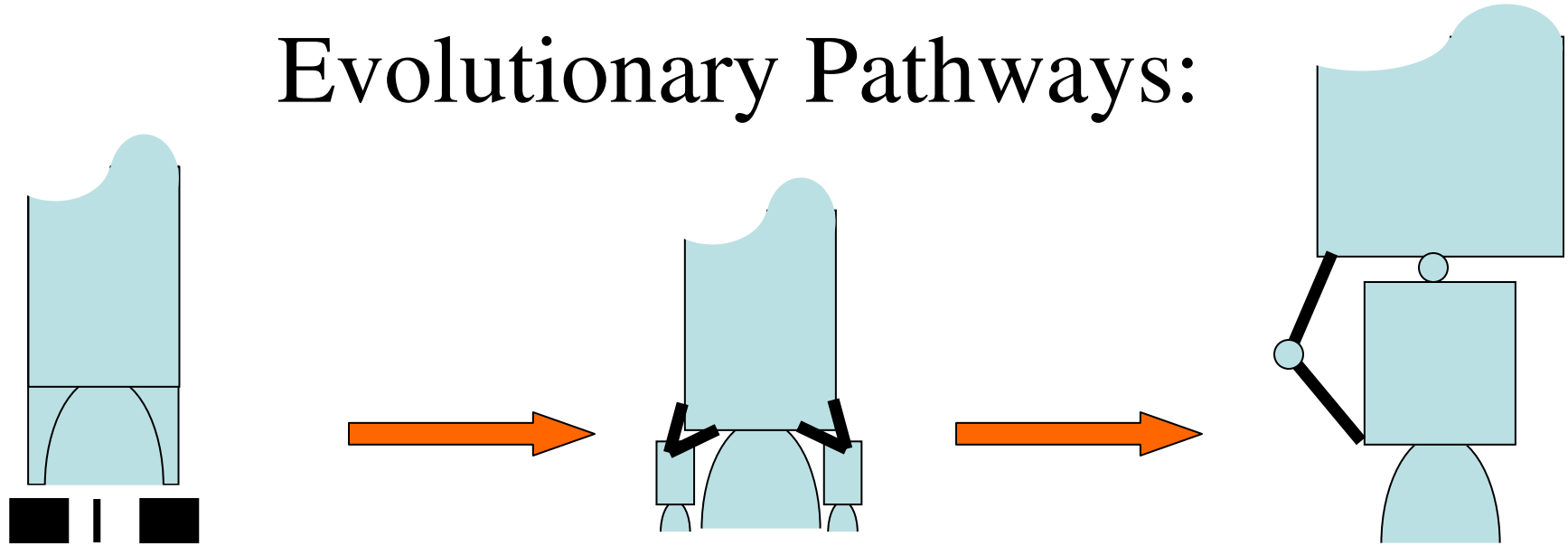
IFOV=1.6 km

Revisit time = 1 sec.

Focal length = 1 m

Mirror diameter = 0.22 m

Possible Thrust Vector Control Evolutionary Pathways:



Jet vanes

Vernier engines

Swiveled engine

•Obtainable from reverse engineering of SCUD engine

•Lose ~5% of thrust due to drag

•Difficult to indigenously produce graphite for vanes

•Eliminates drag of jet vanes

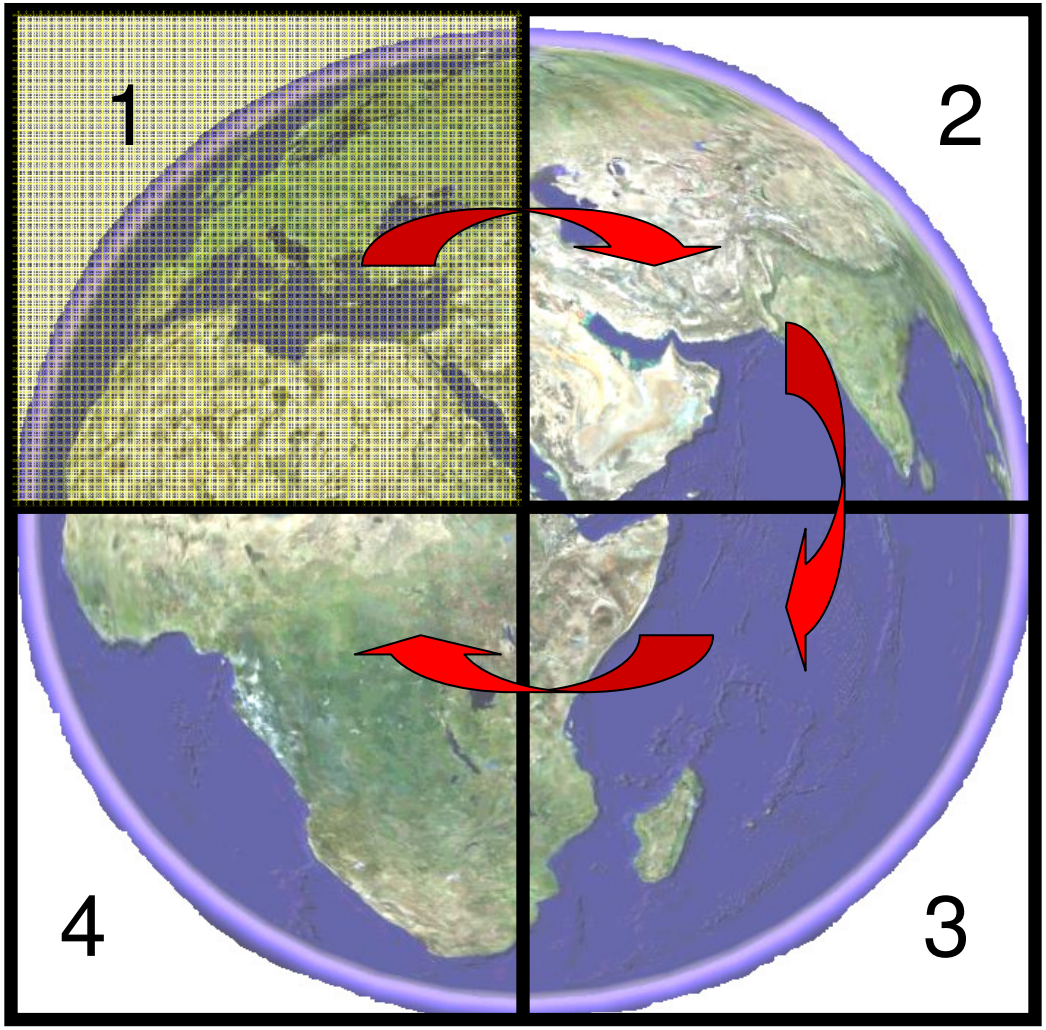
•Actuators of verniers can be less strong and less sophisticated than main engine actuators.

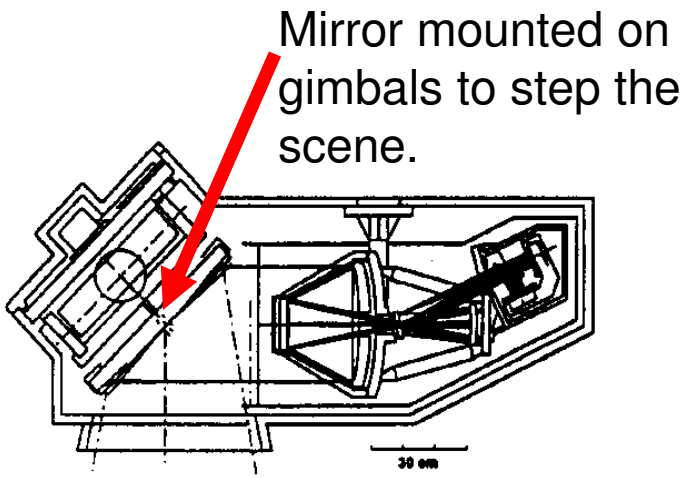
•Penalty in weight of small thrusters.

•Reduces weight penalty associated with vernier engines

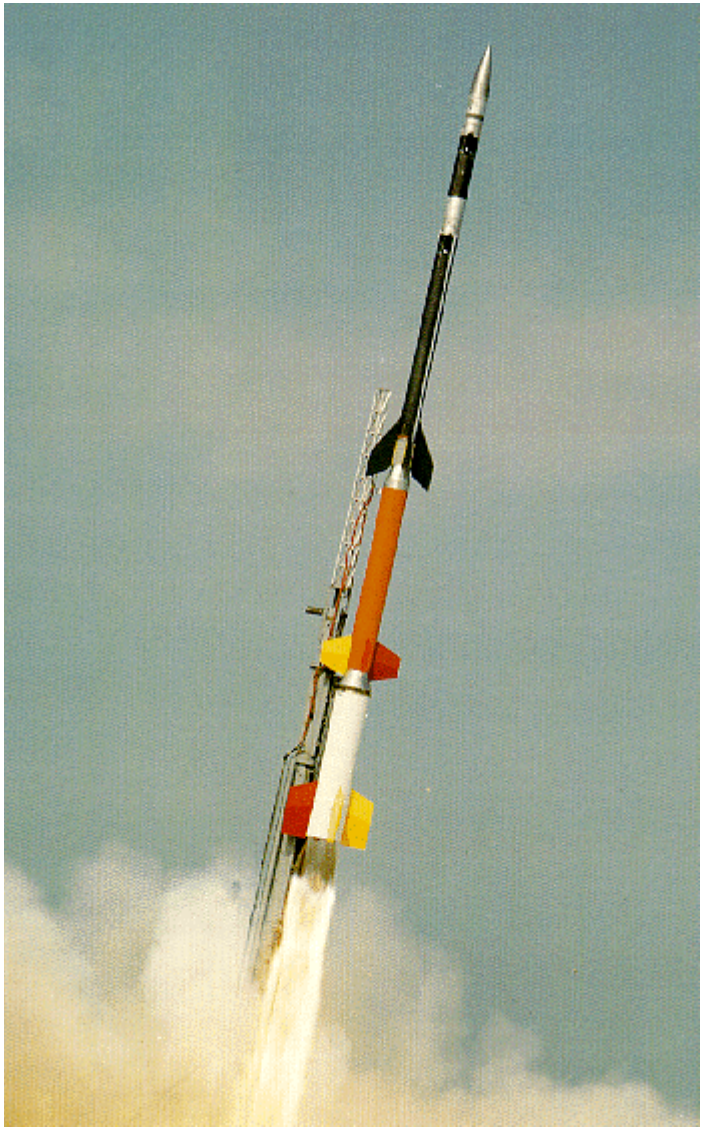
•Needs higher accuracy machining and stronger actuators than vernier engines.

Step-Stare Pattern

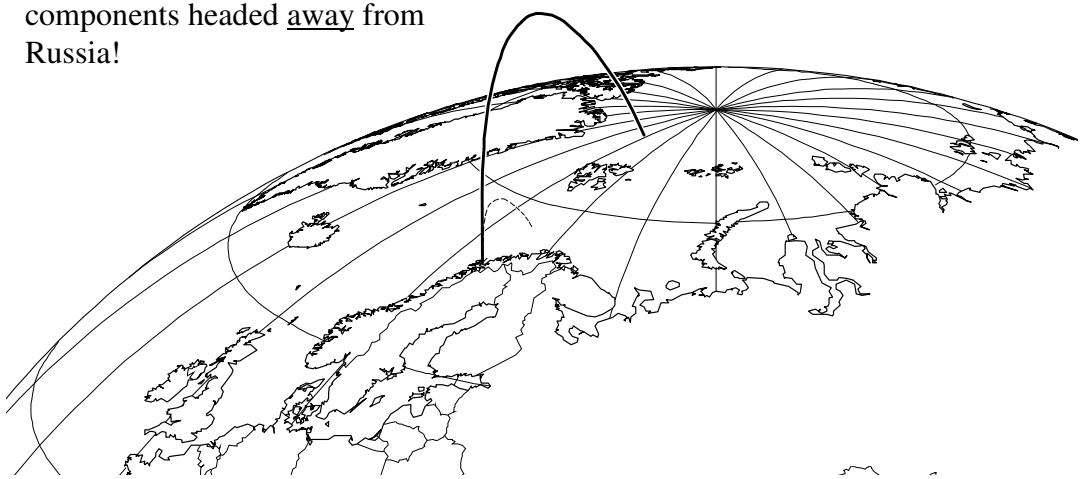
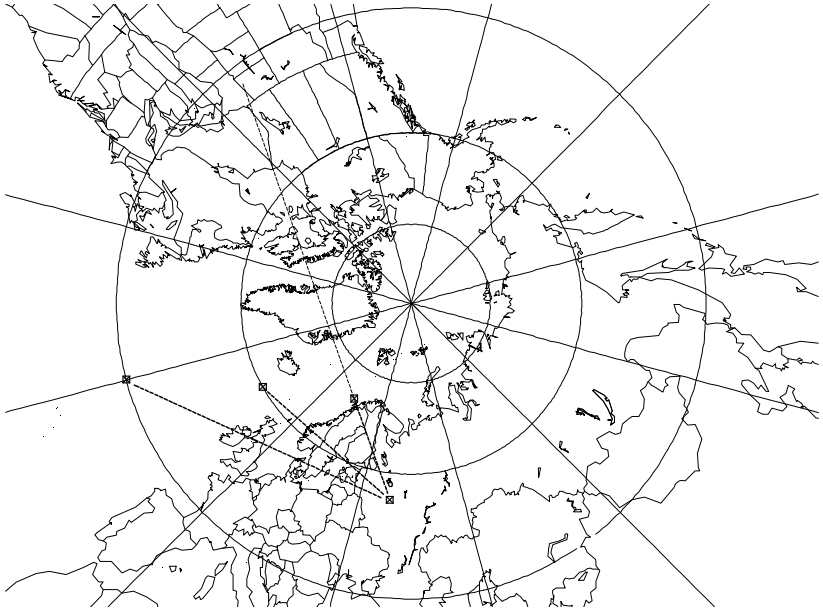




A January 26, 1995 sounding rocket launch triggered an increased Russian alert level



The rocket and all its discarded components headed away from Russia!



But they all headed along a path that would blind Russian Radars to US ICBM launches.