MIT
Science, Technology,
and Global Security Working Group

A Route to Armageddon: Technical Shortfalls in Russia's Nuclear Early Warning Systems

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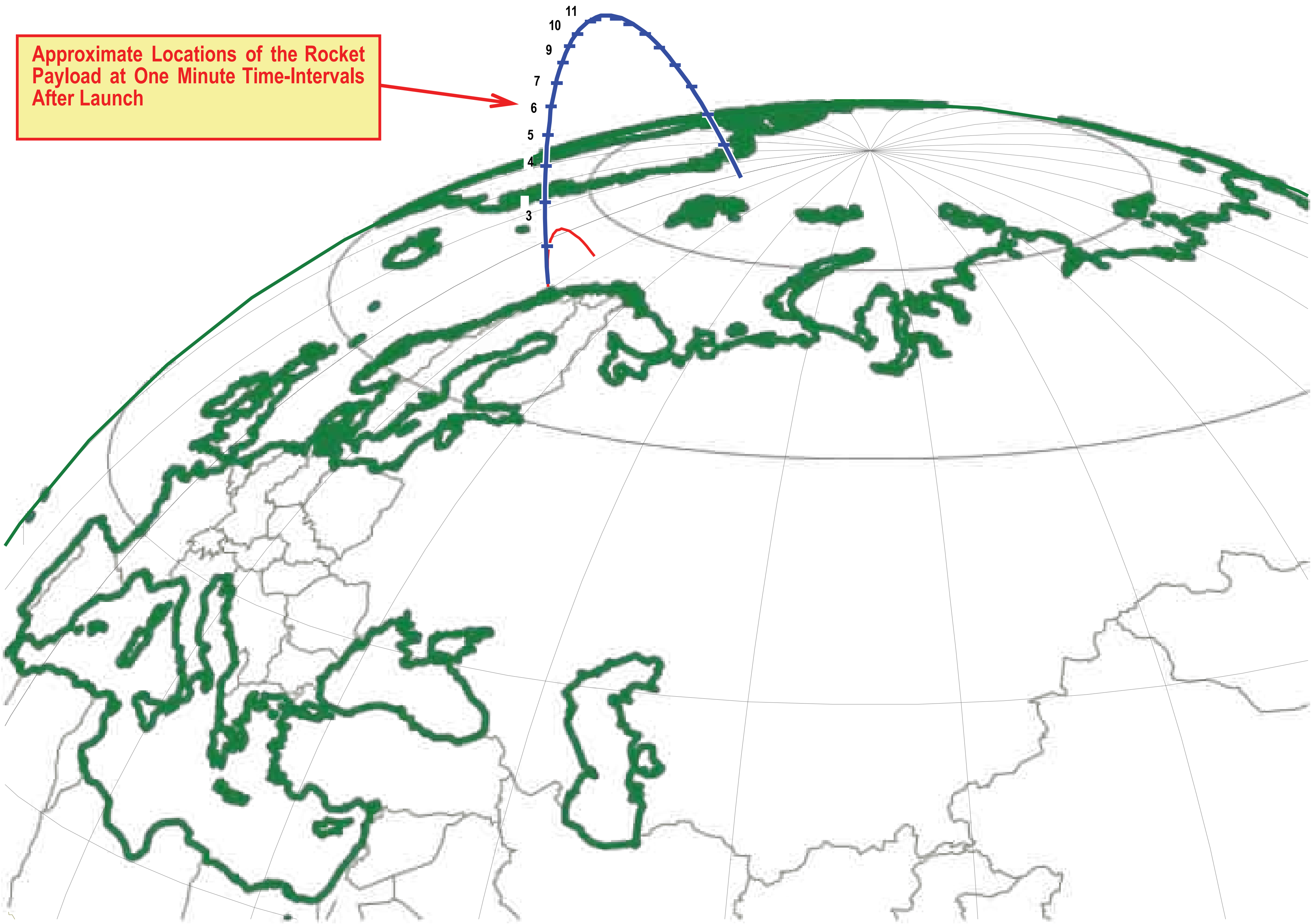
Because of the Ever-Increasing Firepower of US Nuclear Forces, and the Severe Technical Shortfalls in Russian Space-Based Sensing Technologies, Russia Has Been Forced Into a Doomsday Posture Where Under Certain Conditions Its Nuclear Forces Will Be Launched Automatically

The Russian Experience With the False Alert of January 25, 1995

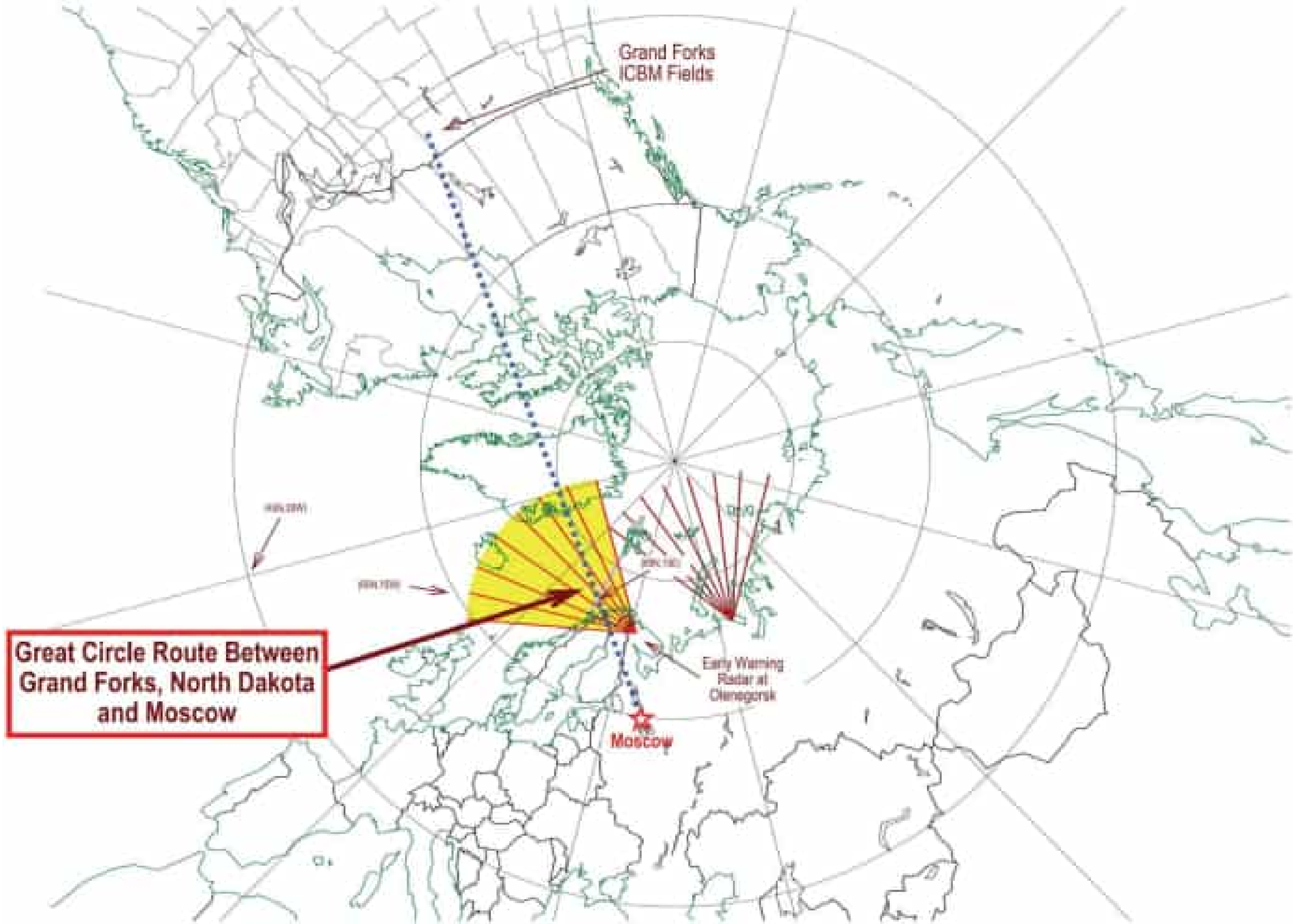
The Dog that Didn't Bark

The Russian False Alert of January 1995 What happened?

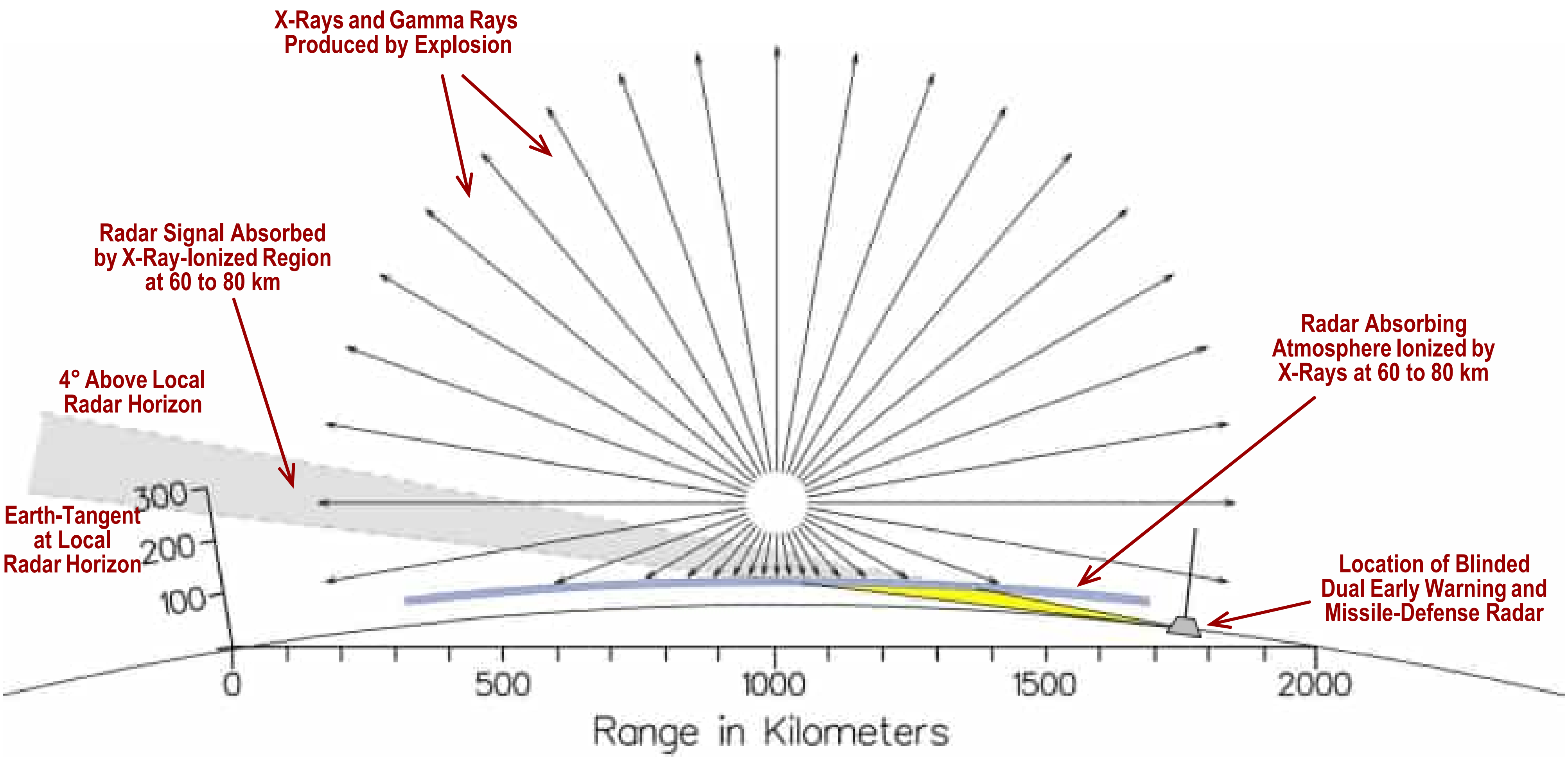
Trajectory of the Black Brant XII Sounding Rocket



ROCKET REACHED APOGEE WHEN IT WAS IN THE MIDDLE OF THE MAJOR US-ICBM ATTACK-CORRIDOR BETWEEN GRAND FORKS, NORTH DAKOTA AND MALMSTROM, MONTANA!



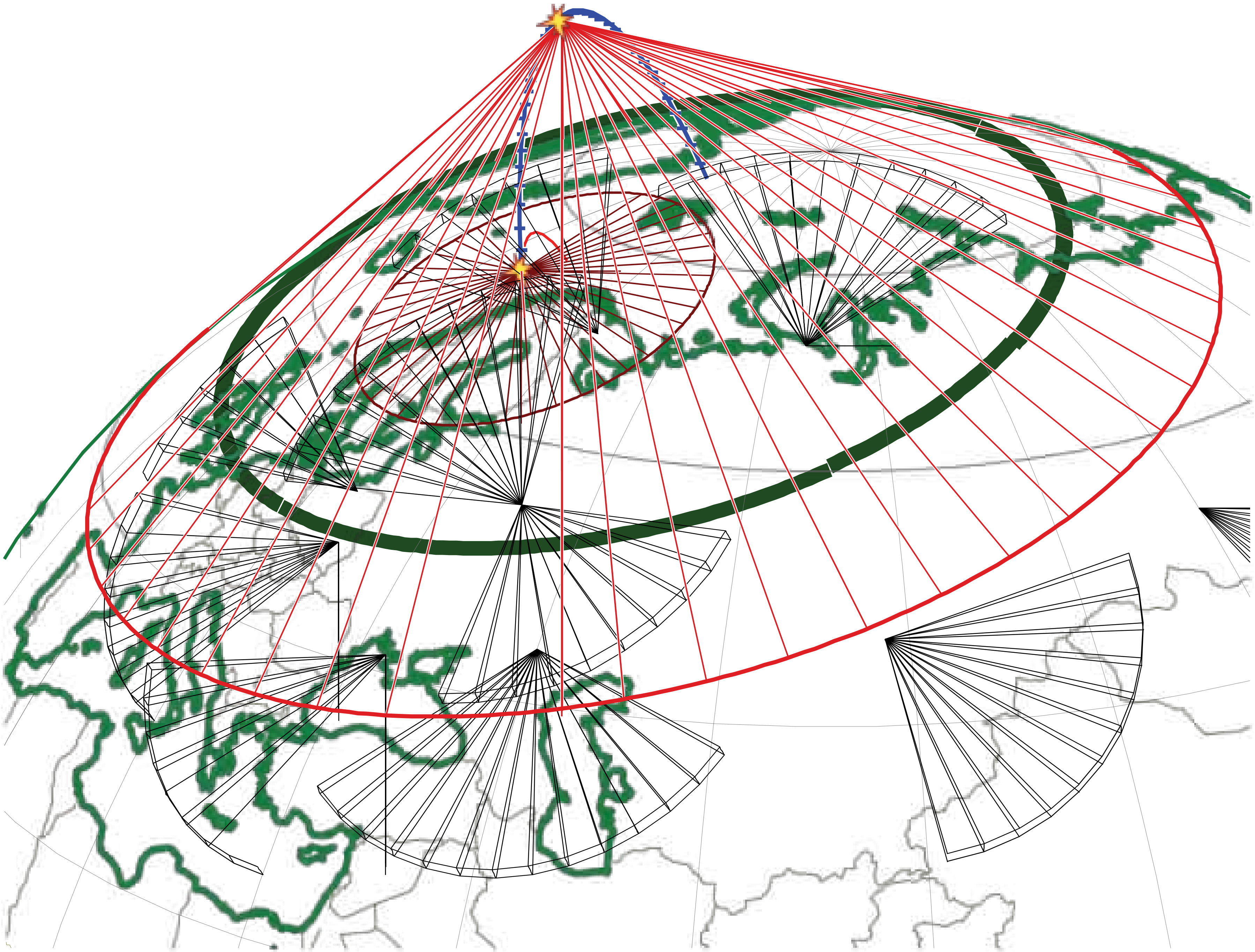
High-Altitude Nuclear Explosion to BLIND Russian Dual-Purpose Missile Defense and Early Warning Radars



How an Attack Aimed at Blinding the Dual Missile Defense and Early Warning Radars in Russia Might Be Seen If the Attack Occurs During the Night in St. Petersburg, Russia

The upper left photo is the skyline of Honolulu moments before the Starfish high altitude nuclear explosion occurred near 11 p.m. on 9 July 1962. The 1.4 megaton explosion occurred at about 400 km altitude over Johnston Island nearly 800 miles away. Within a second the sky was lit to daylight conditions, and it stayed lit for many minutes thereafter. At electromagnetic frequencies a radar like the one at Cape Cod attempting to search through the area of sky behind the explosion would be unable to do so for tens of minutes. Thus, such an explosion could be used to effectively "screen" an incoming attack from an early warning radar.

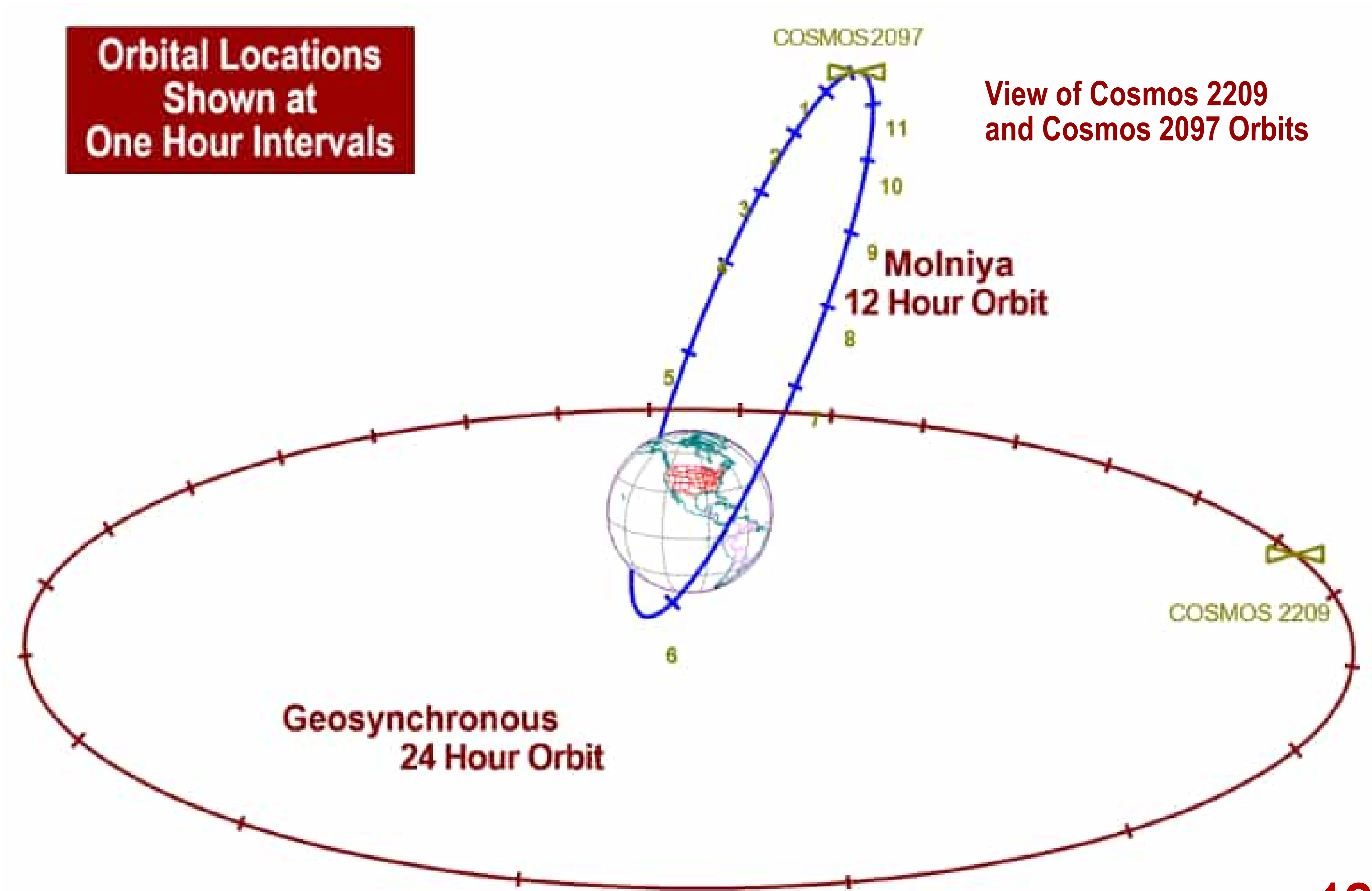
Area of Radar-Blackout from a One Megaton Nuclear Explosion at 1350 Kilometers Altitude



Sequence of Events Associated with a High-Altitude Nuclear Explosion and its Effects on the Olenegorsk Early Warning Radars

Current Russian Early Warning Predicament

Russia Has Space-Based Early Warning Satellites in Two Distinctly Different Orbits – Geosynchronous and Molniya



Russia Has Space-Based Early Warning Satellites in Two Distinctly Different Orbits – Geosynchronous and Molniya

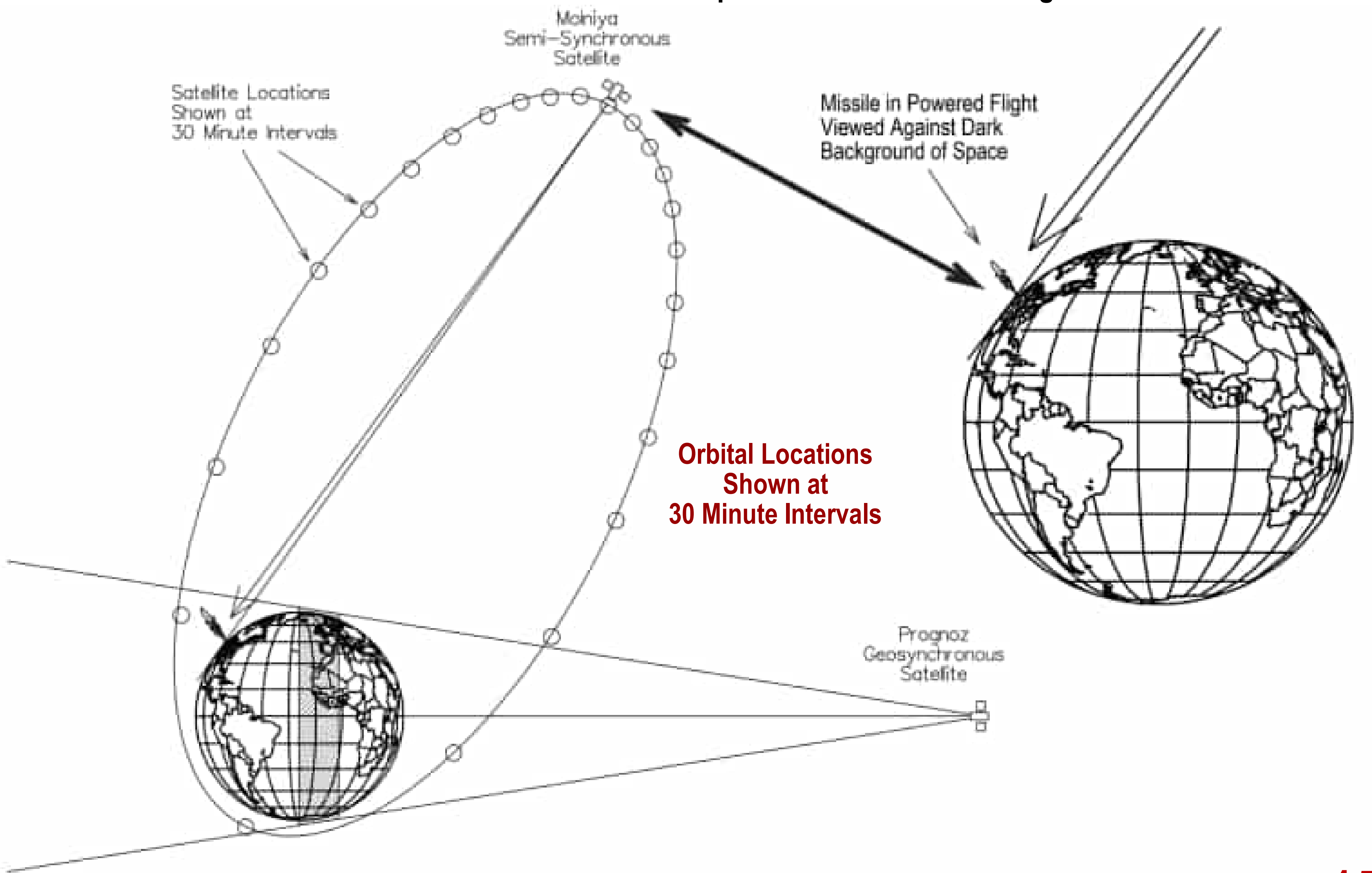
Oko Satellite 1 or 2?

“Tundra”Satellite?

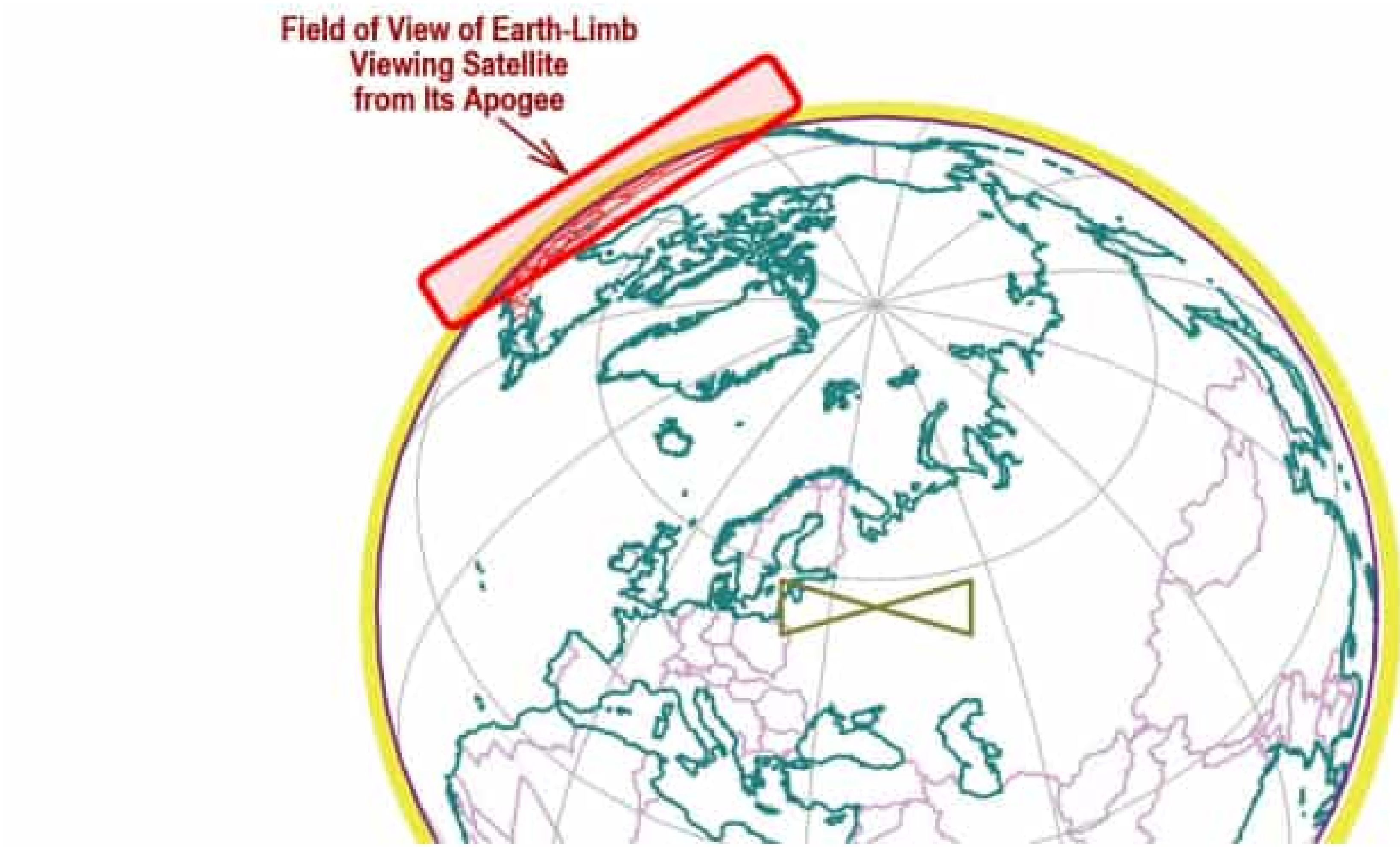
Russian Molniya Infrared Satellite Constellation

Russian Molniya Infrared Satellite Constellation

This Constellation Was Fully Populated during the False Alert of 1995
Nine Oko-1 or Oko-2 Satellites Required for 24-Hour Coverage



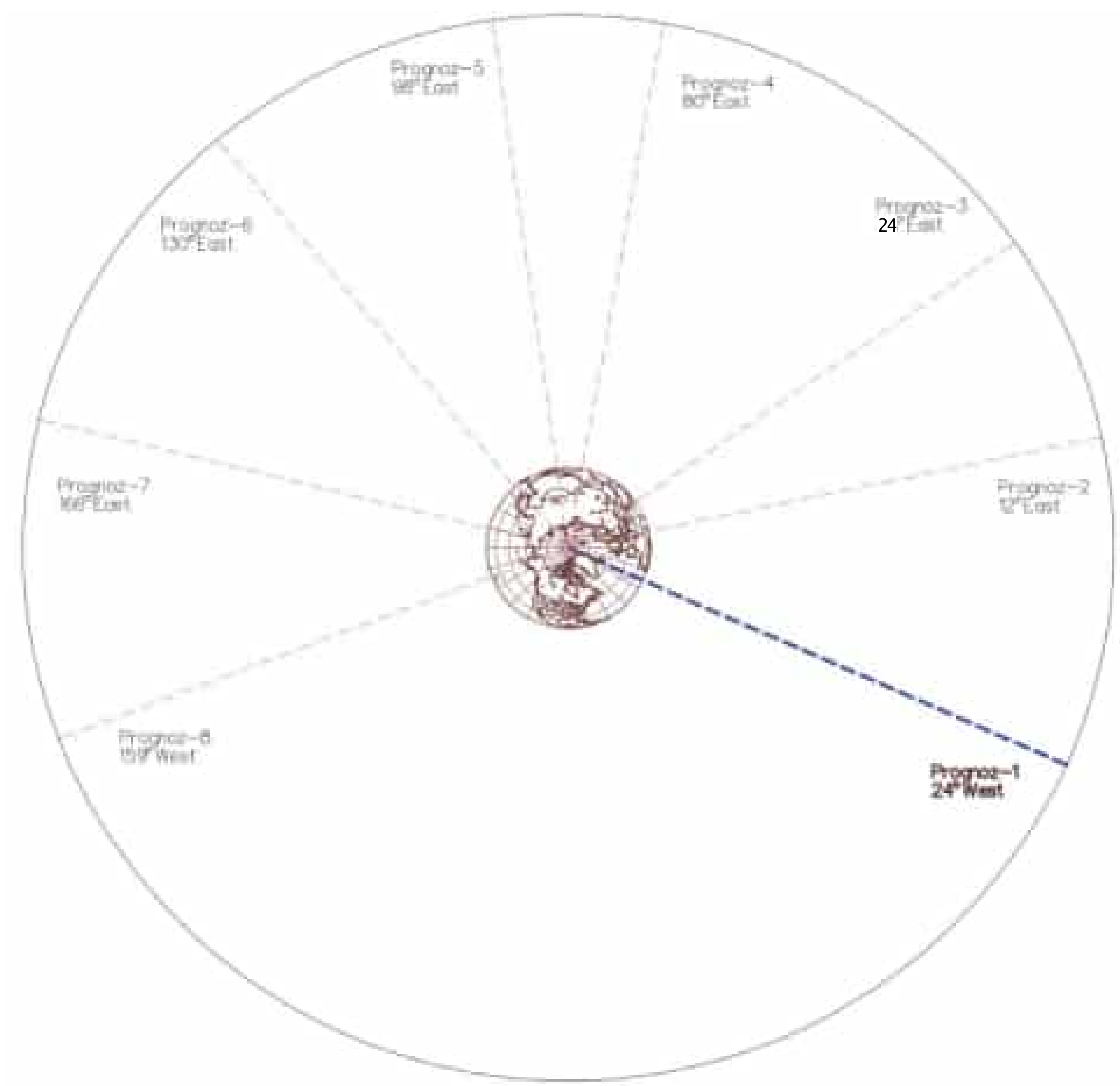
View of Earth-Limb from Apogee of Cosmos 2510



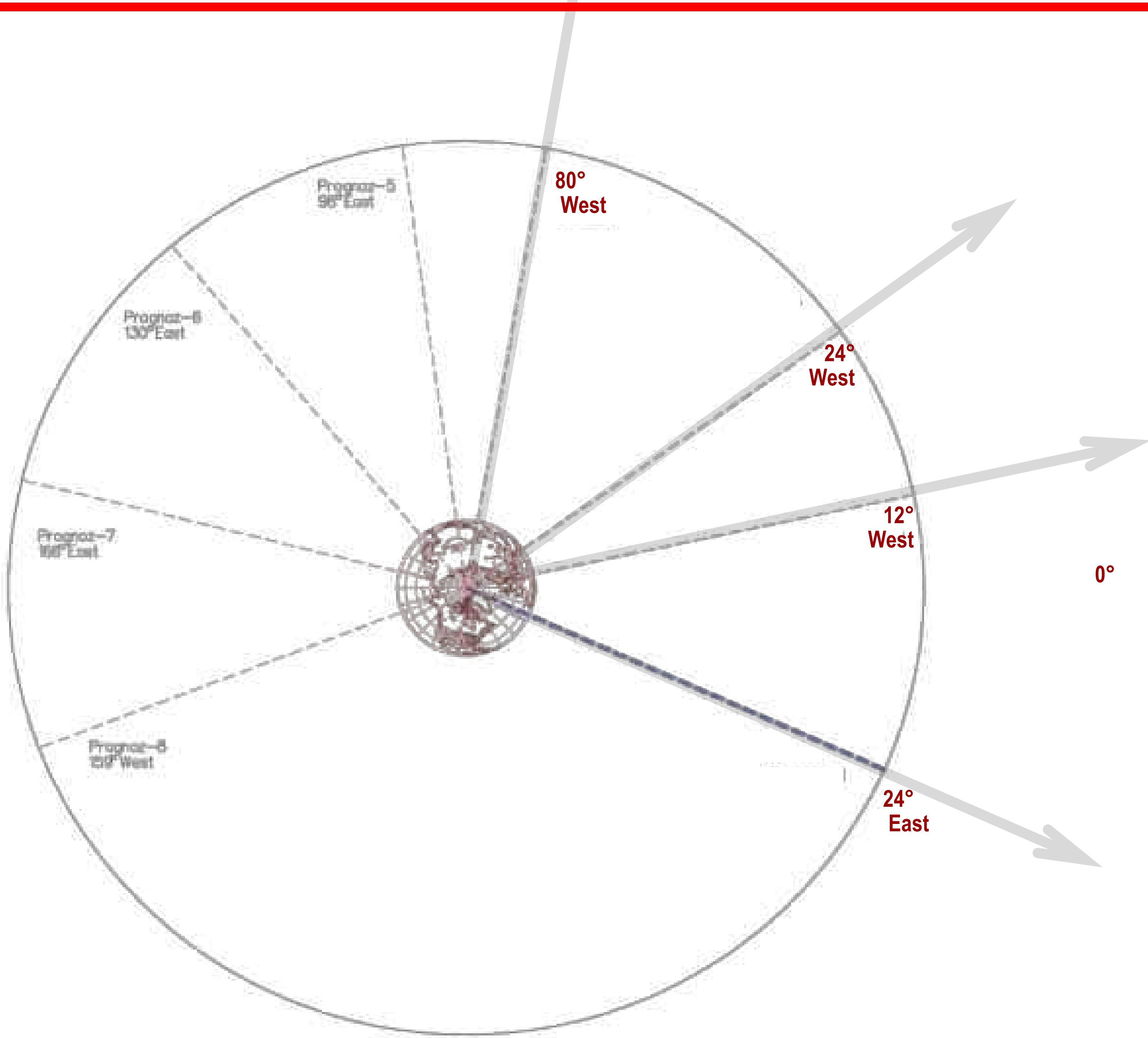
Russian Prognoz Infrared Satellite Constellation

(Geosynchronous Constellation)

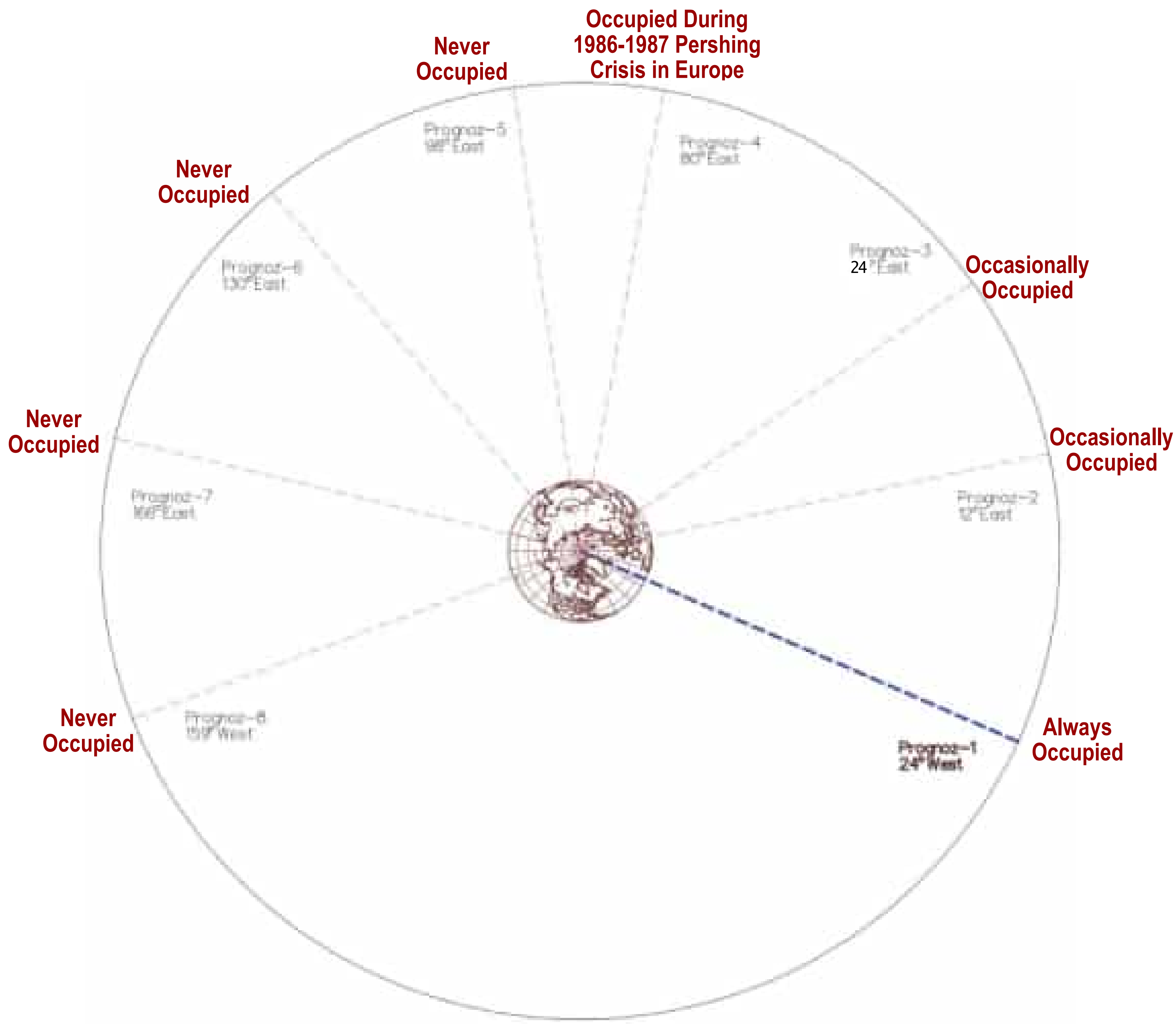
View of Internationally Registered Geosynchronous Slots for Prognoz System



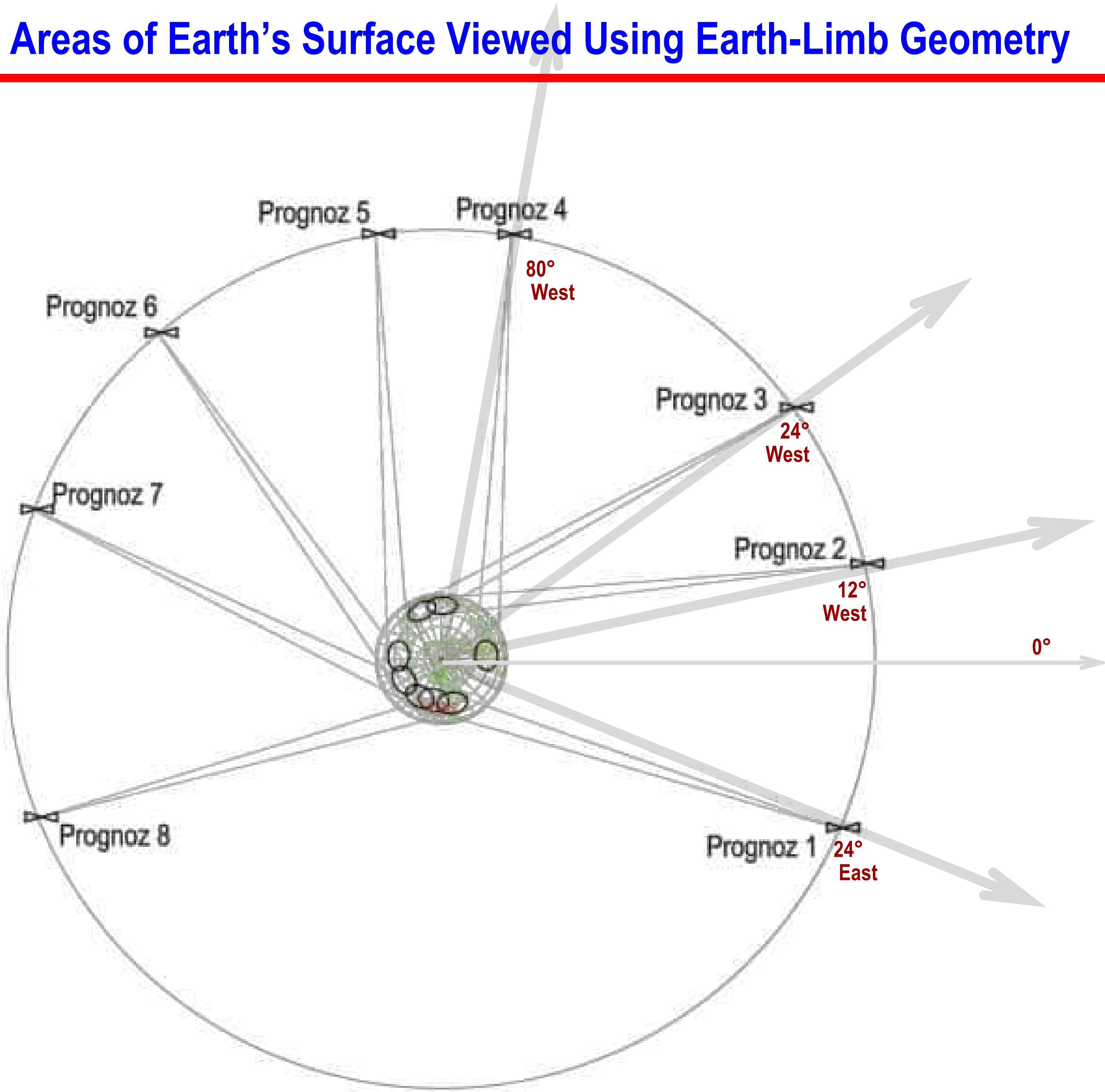
View of Internationally Registered Geosynchronous Slots for Prognoz System



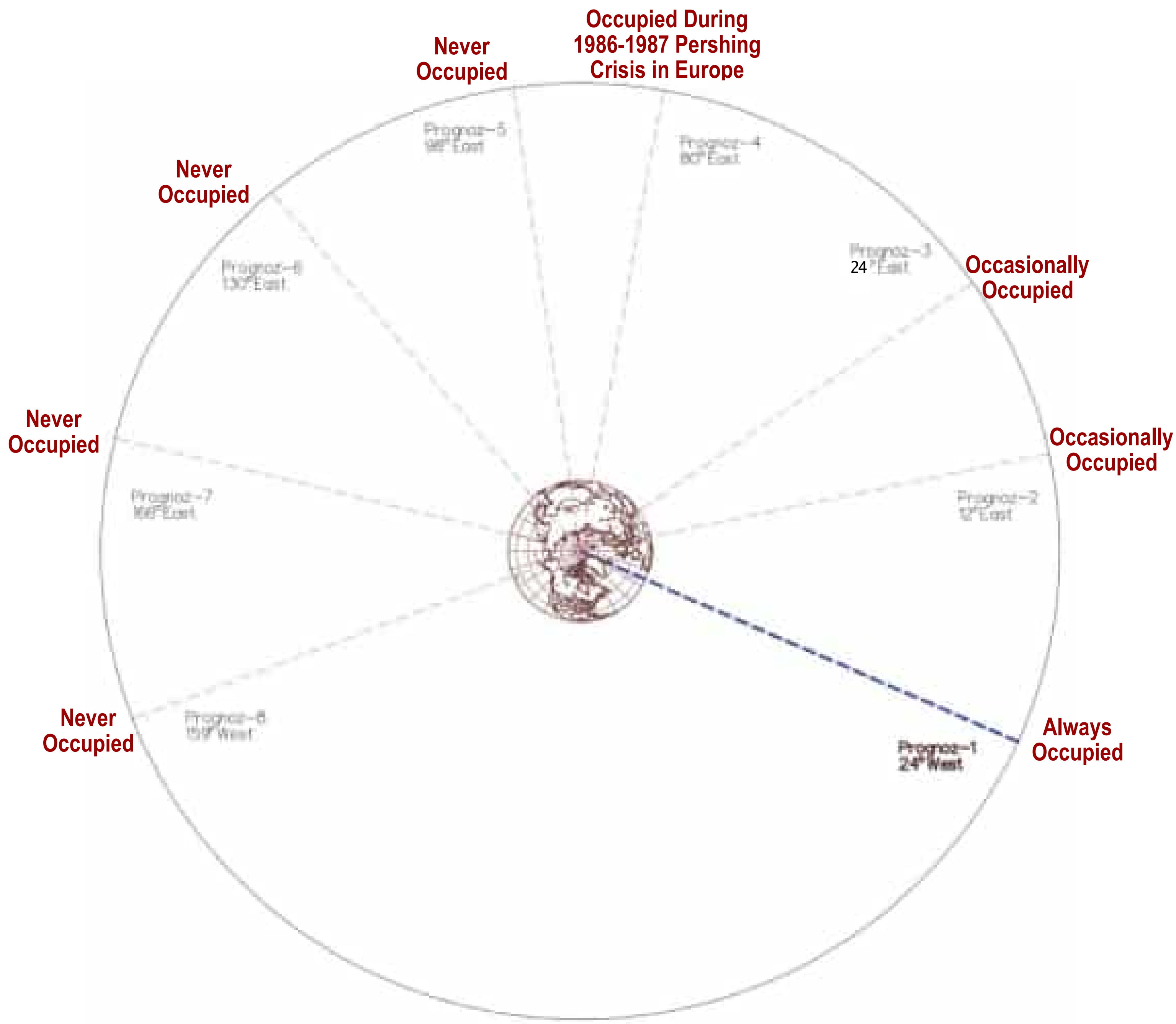
View of Internationally Registered Geosynchronous Slots for Prognoz System



Possible Areas of Earth's Surface Viewed Using Earth-Limb Geometry



View of Internationally Registered Geosynchronous Slots for Prognoz System



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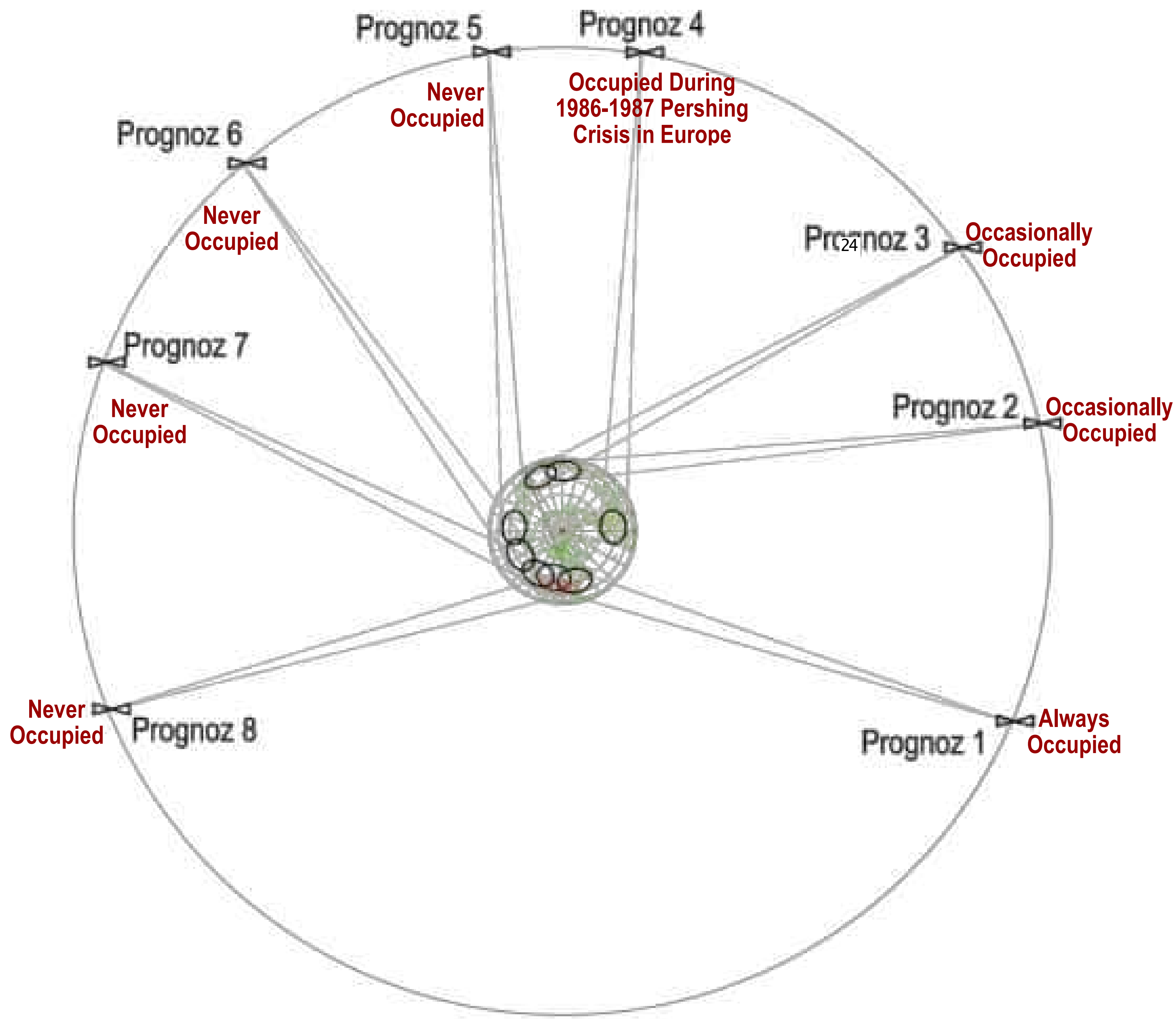
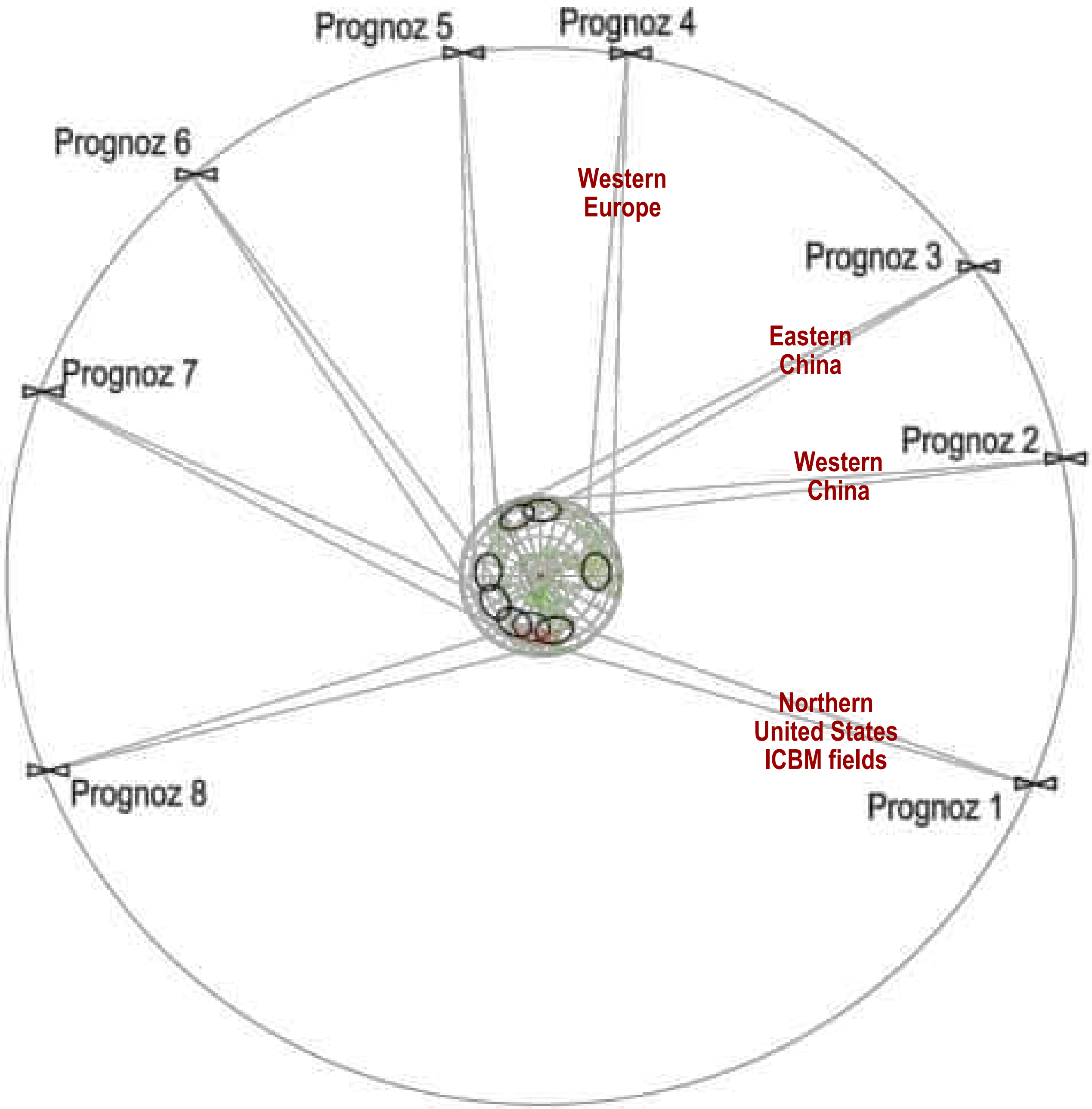
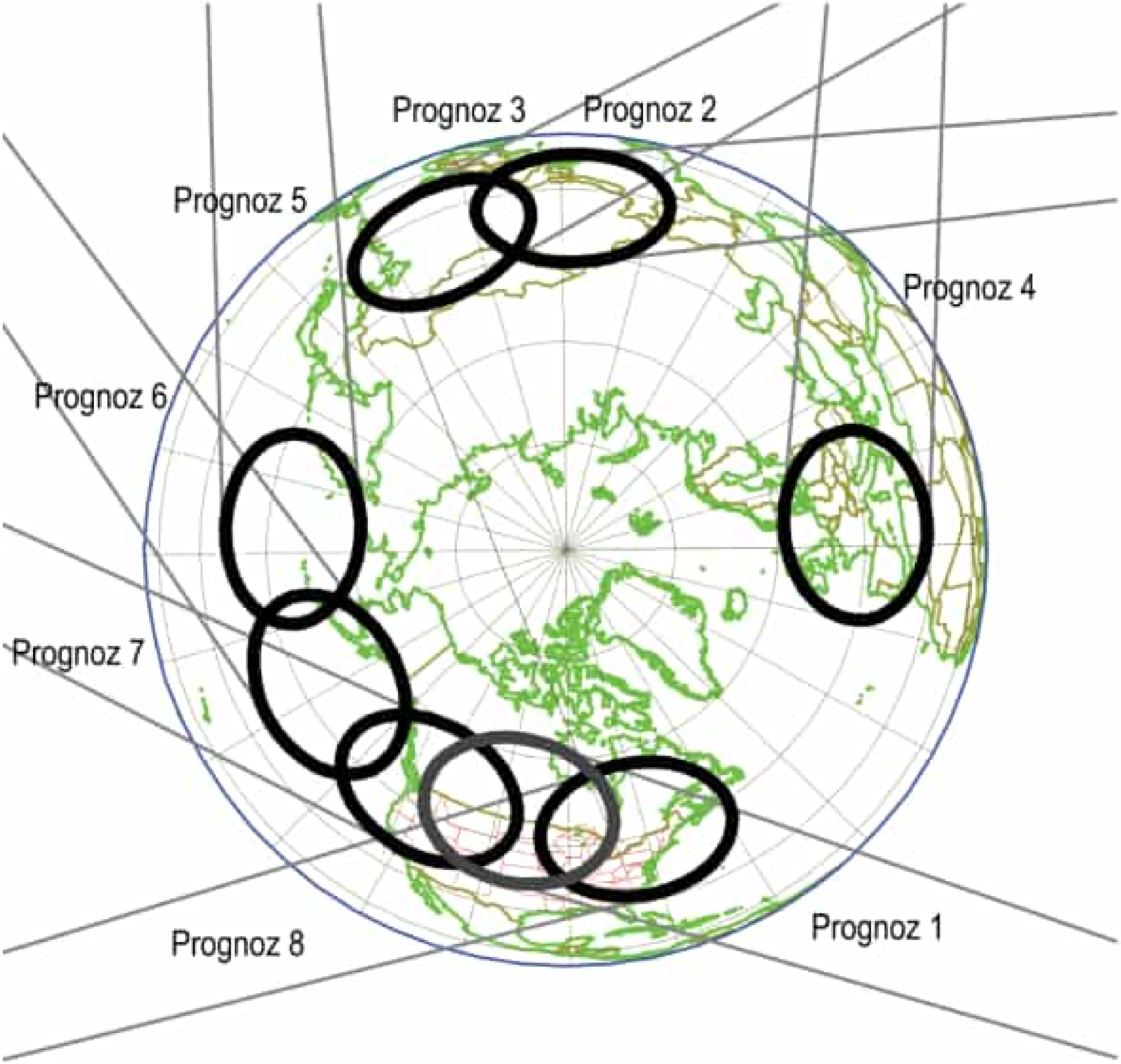
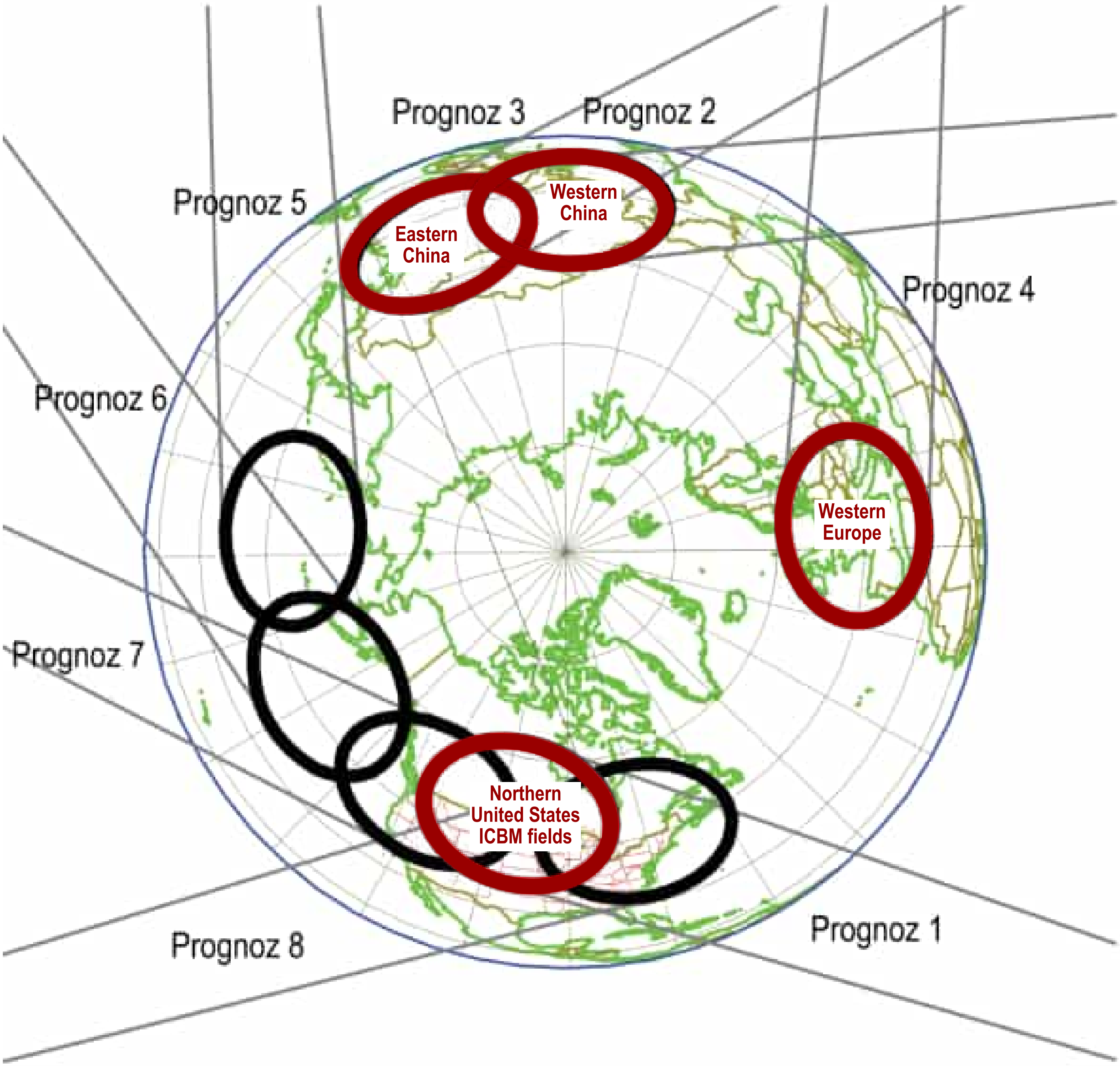


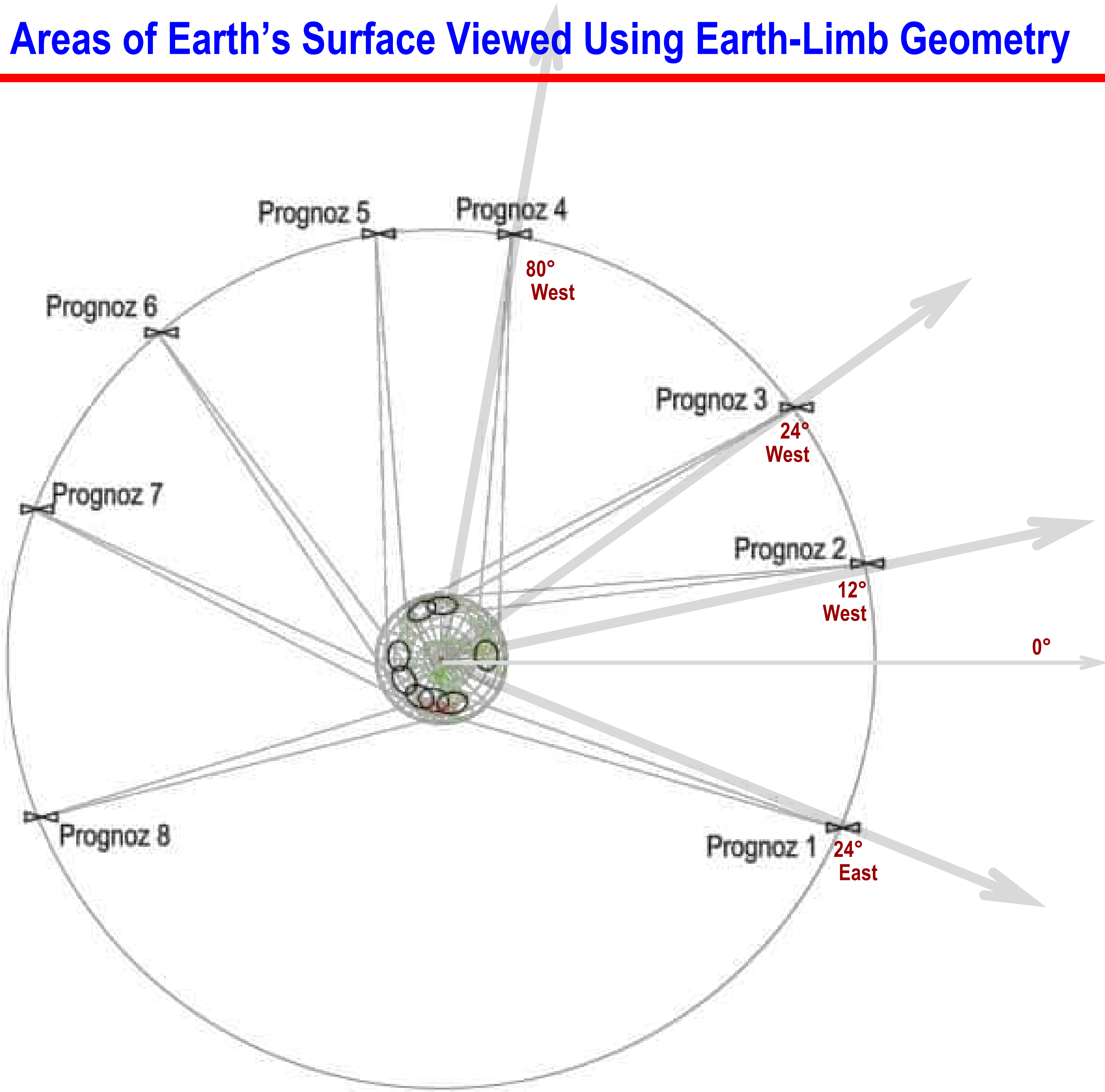
Possible Areas of Earth's Surface Viewed Using Earth-Limb Geometry



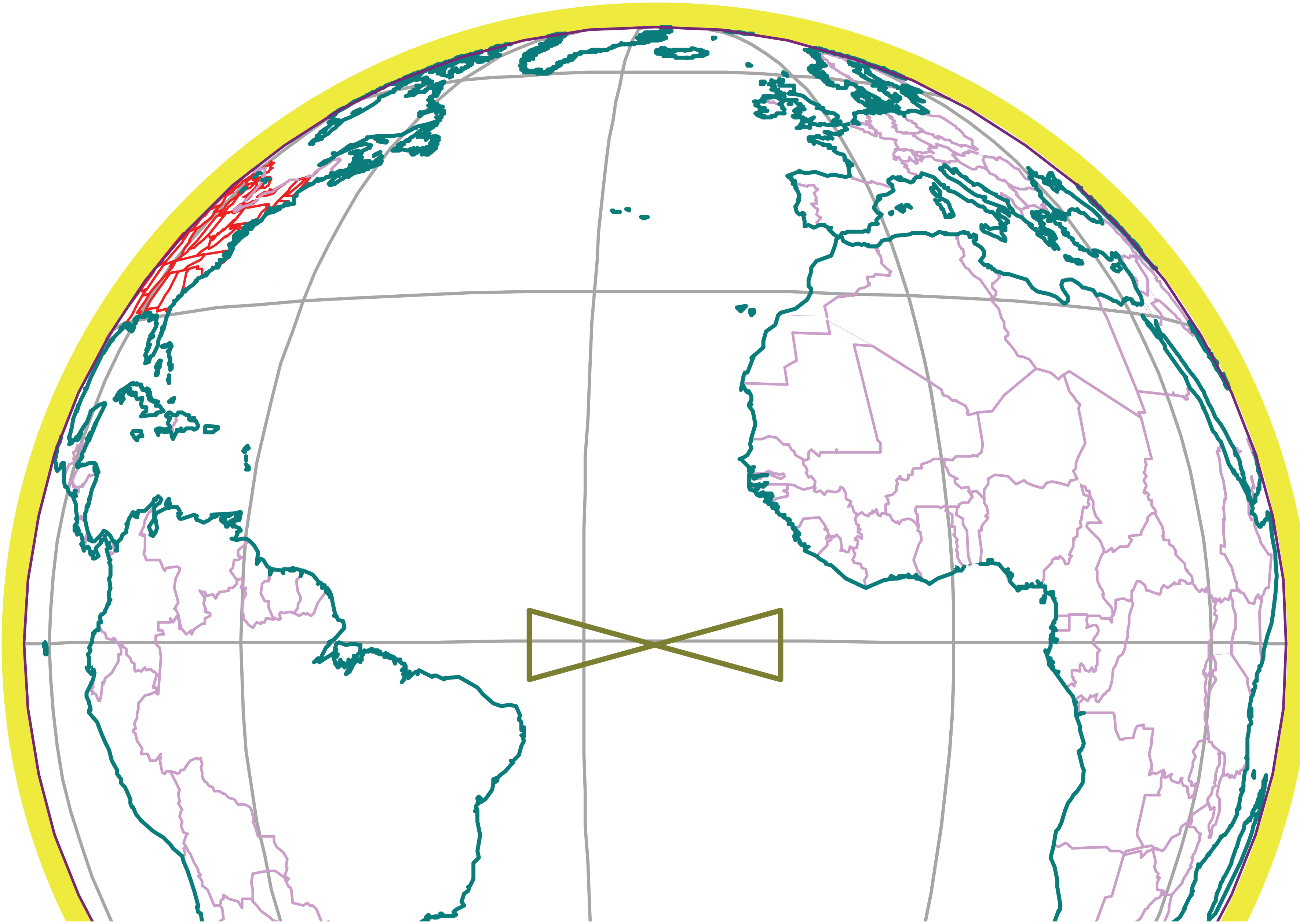

Prognoz 3
Prognoz 2
Prognoz 5
Prognoz 4
Prognoz 6
Prognoz 7
Prognoz 8
Prognoz 1


Prognoz 3
Prognoz 2
Prognoz 5
Western
China
Eastern
China
Prognoz 4
Prognoz 6
Western
Europe
Prognoz 7
Northern
United States
ICBM fields
Prognoz 8
Prognoz 1

Possible Areas of Earth's Surface Viewed Using Earth-Limb Geometry



View of Earth from Cosmos 2297 at Apogee



Rough Estimate of Current State of Russia's Early Warning Satellite Systems

(Geosynchronous and Molniya Systems)

Russia Has Been Launching New Class of Satellites Called "Tundra"

The orbital parameters of the four Tundra satellites that have so far been launched:

1. Cosmos 2510 (EX1) (Tundra 11L),Int'l Code 2015-066A
   NORAD catalog no.: 41032; Lightning[25] 38552 x 1626 km, 63.37° November 17, 2015, Active

2. Cosmos 2518 (EKS 2) (Tundra 12l), Int'l Code 2017-027A
   NORAD catalog no.: 42719 Lightning[26] 38552 x 1626 km, 63.37° May 25, 2017, Active[27]

3. Cosmos 2541 (EKS 3) (Tundra 13l), Int'l Code 2019-065A
   NORAD catalog no.: 44552 Lightning[28] 38537 x 1646 km, 63.83° September 26, 2019. Active

4. Cosmos 2546 (EKS 4) (Tundra 14l), Int'l Code 2020-031A
   NORAD catalog no.: 45608 Lightning[6] 35807 x 1654 km, 63.83° May 22, 2020, Active

All satellites have been launched into Molniya orbits
This means that the newest Russian satellites are still using earth-limb viewing

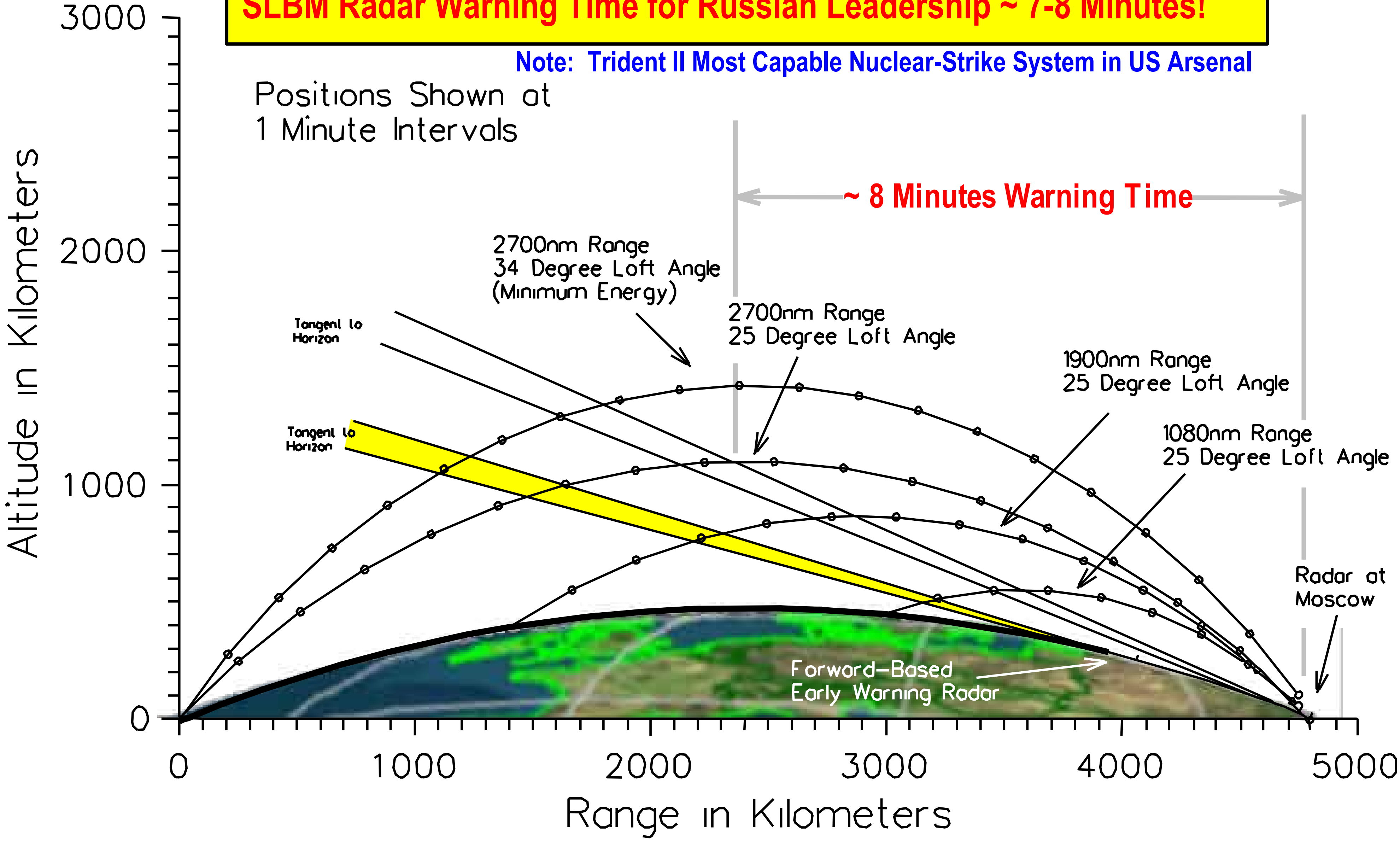
There are now no (or possibly only one) prognosis satellite in orbit
this indicates that the Russians have given up on using Earth-limb viewing satellites for more general global launch-surveillance.

Russian early warning is now essentially limited to UHF and VHF line-of-sight radars and Over-the-Horizon radars – which can be easily jammed and are highly dependent on the stability of the ionosphere at the northern latitudes where they operate.

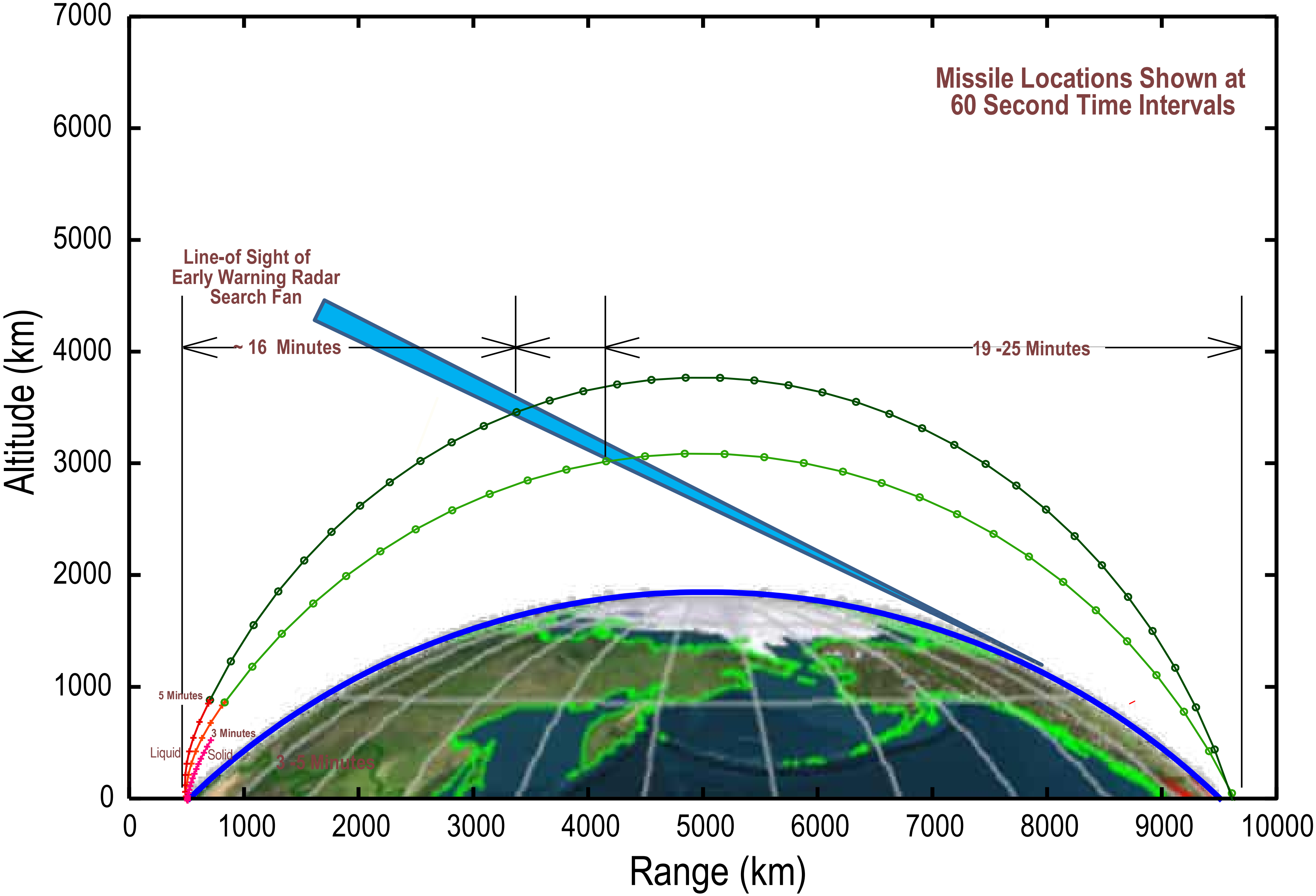
Russian Leadership Has 1/3 to 1/4 the Warning Time Compared to That of US Leaders

SLBM Radar Warning Time for Russian Leadership ~ 7-8 Minutes!

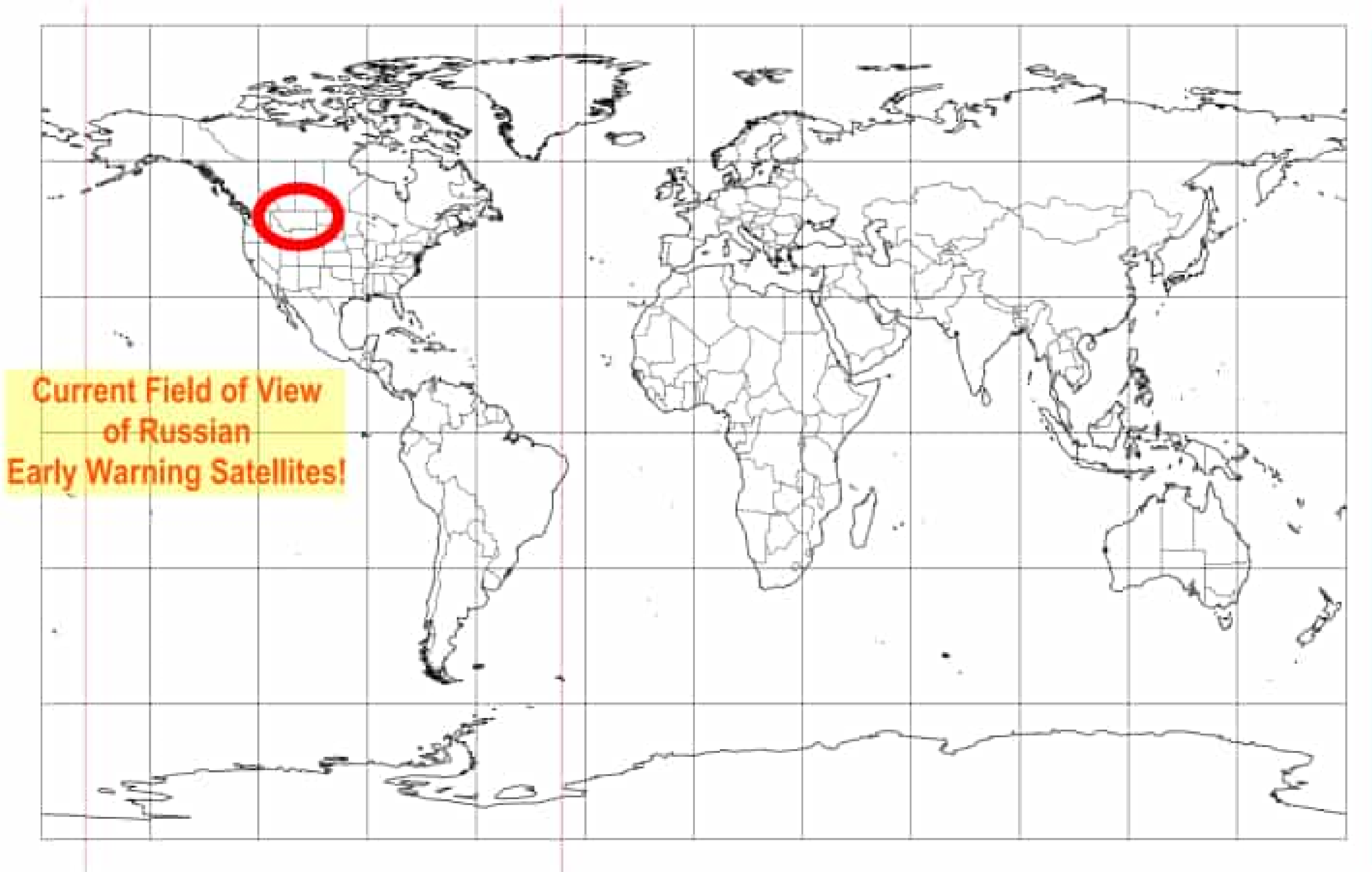
Note: Trident II Most Capable Nuclear-Strike System in US Arsenal



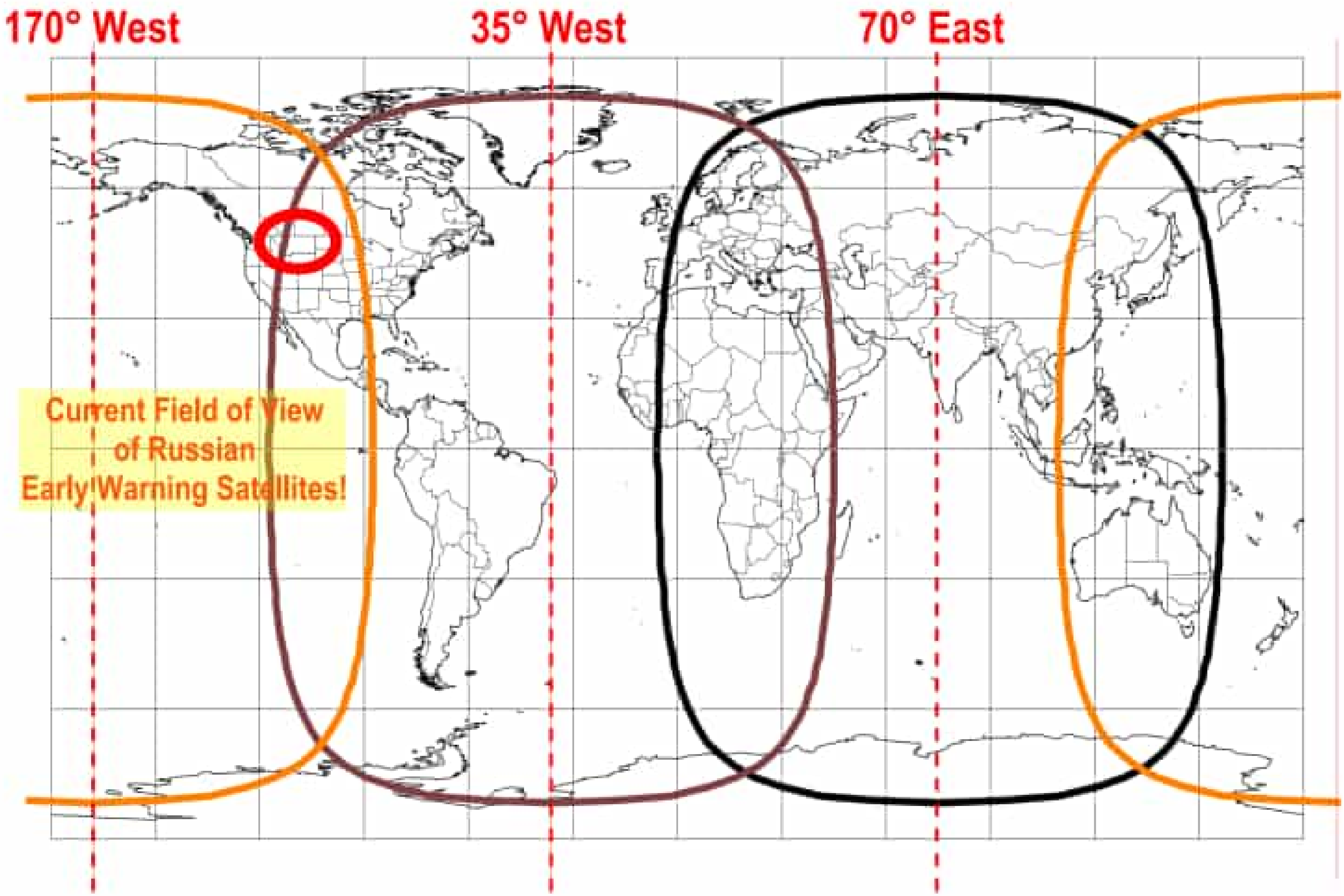
Warning Times Associated with a Russian Strategic Nuclear Attack with Land-Based ICBMs



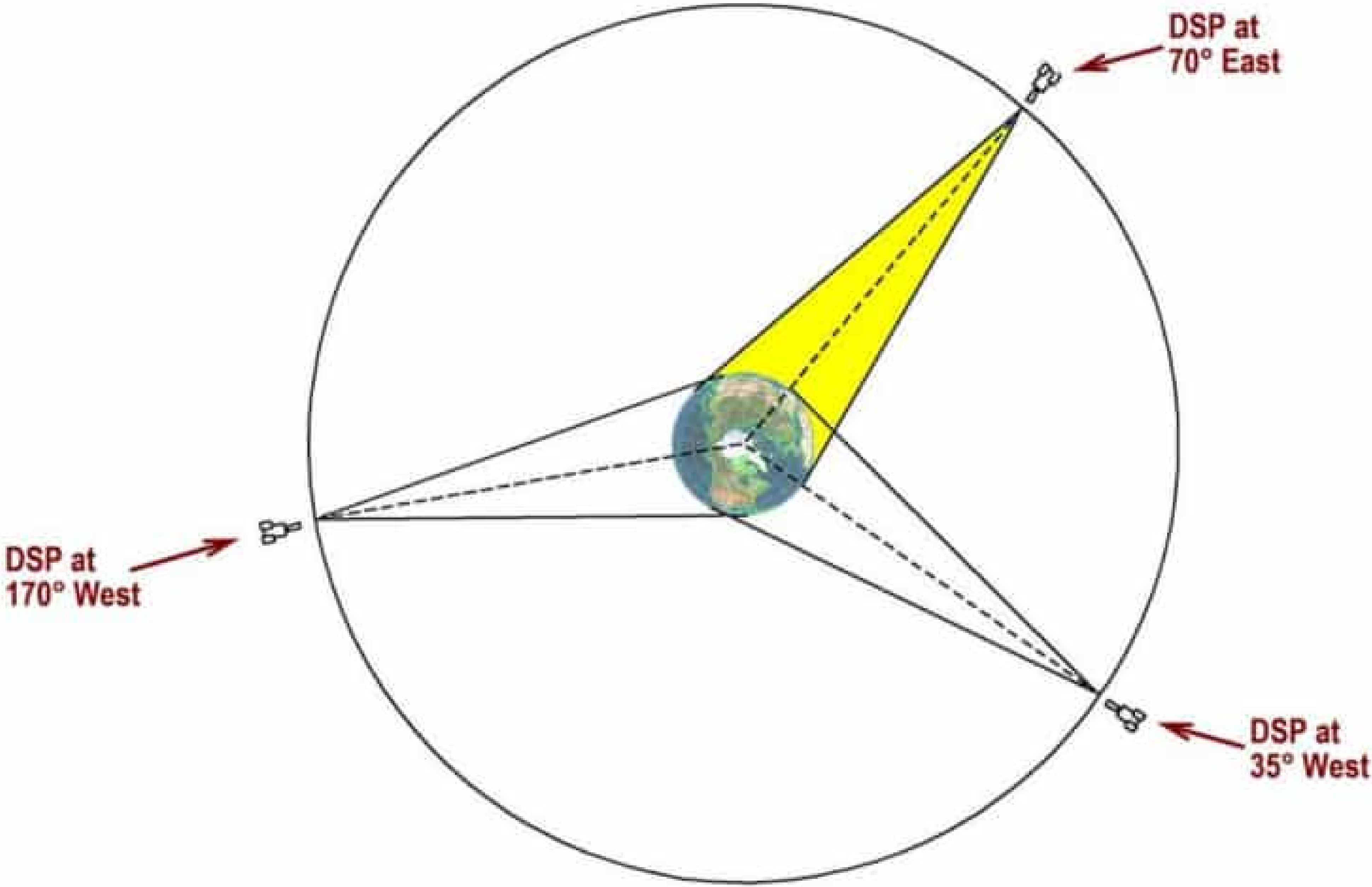
Current Field of View of Russian Molniya AND Prognoz Early Warning Satellite Constellations



Comparison of Russian and US Early Warning Satellite Fields of View

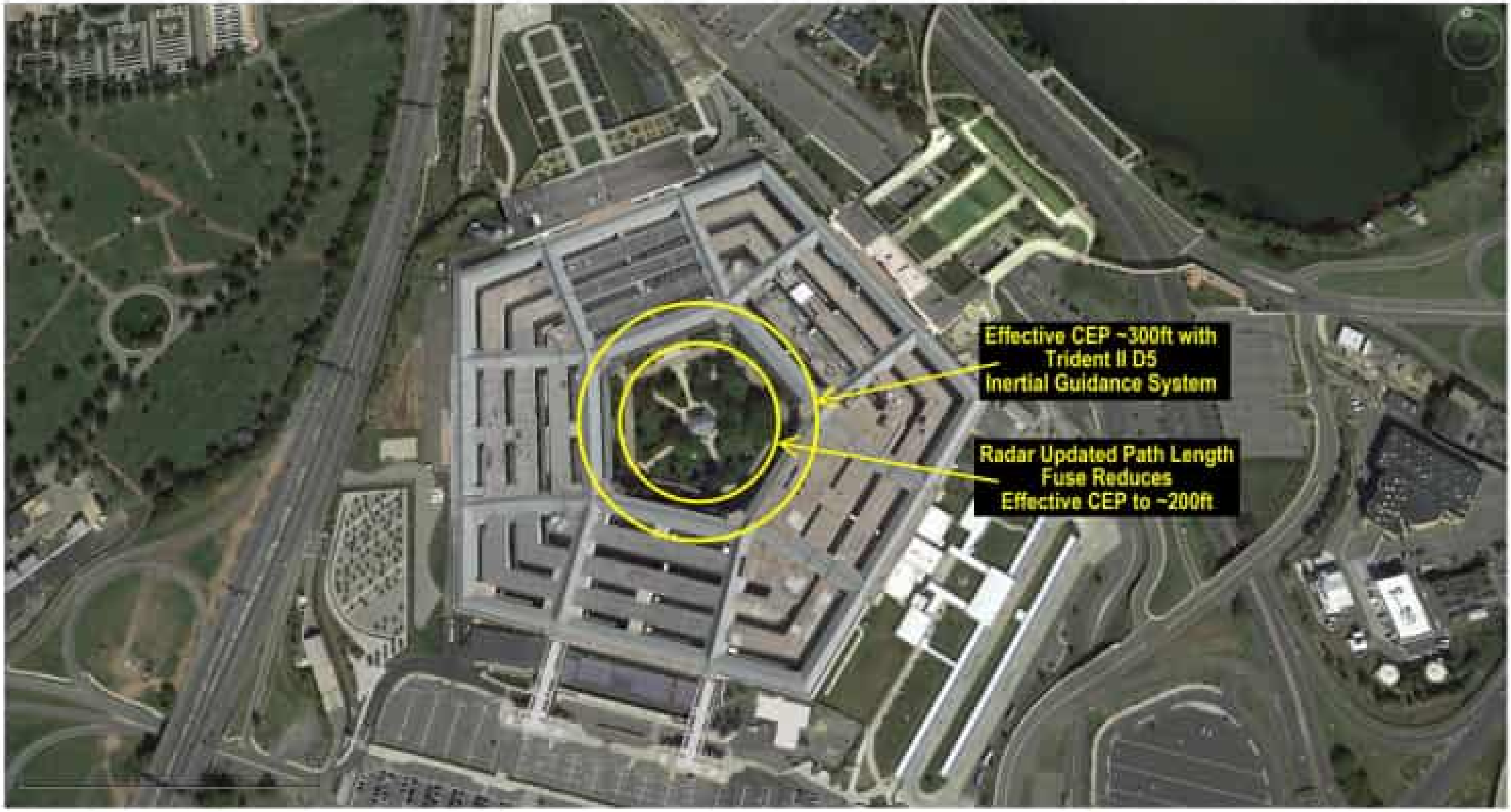


Rough Locations of US **LOOK-DOWN** Early Warning Satellites



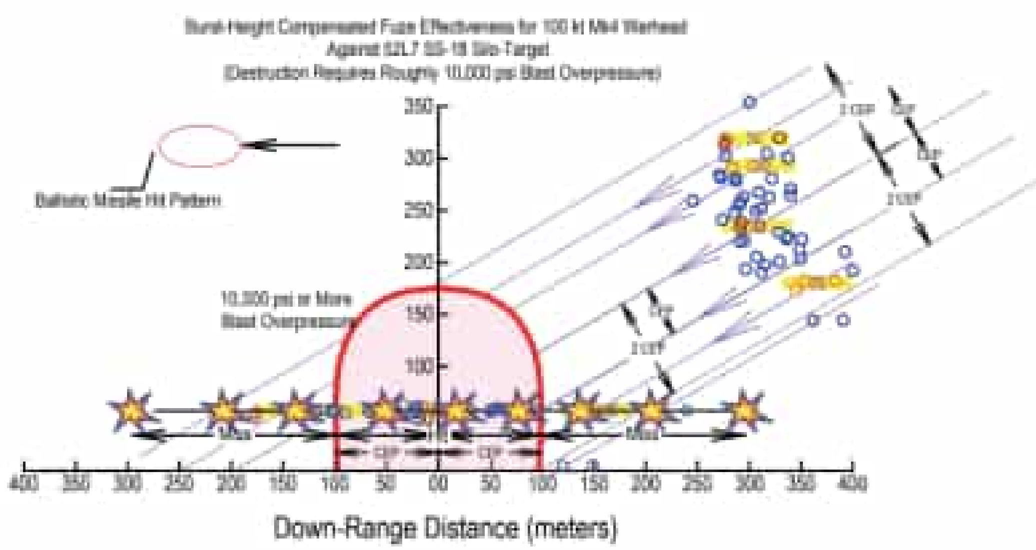
POINT OF INSTABILITY
US is Dramatically Increasing Its Hard Target Capabilities

Ballistic Missile Accuracy Improvements Currently in Progress in the US Nuclear Force Modernization Program is Drastically Increasing the Killing Power of Each US Warhead

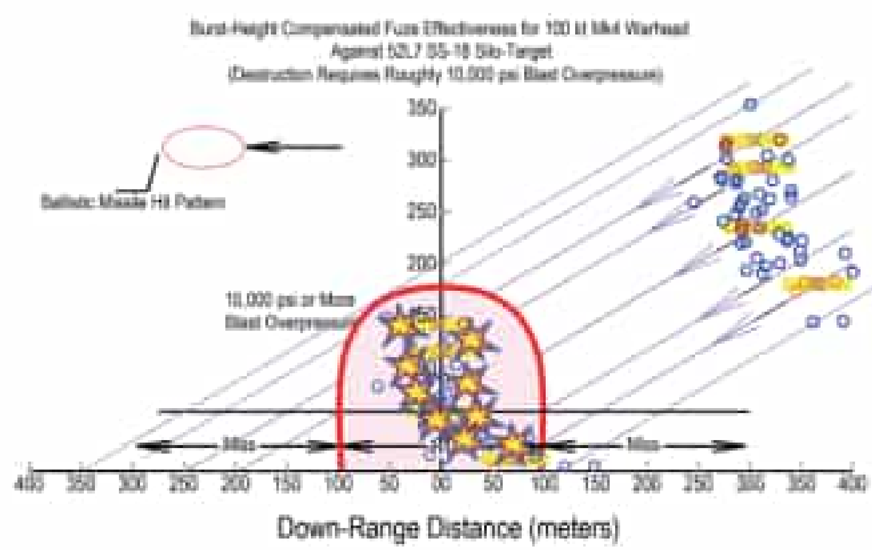


Comparison of the Effects of "*Constant* Burst Height" and "*Variable* Burst-Height" Fuses for 100 kt Mk4 Warhead Against 52L7 (10,000 psi) SS18 Silo-Targets

HOW THE TRIDENT ADVANCED FUSE INCREASES THE KILLING POWER OF THE MK4A WARHEAD

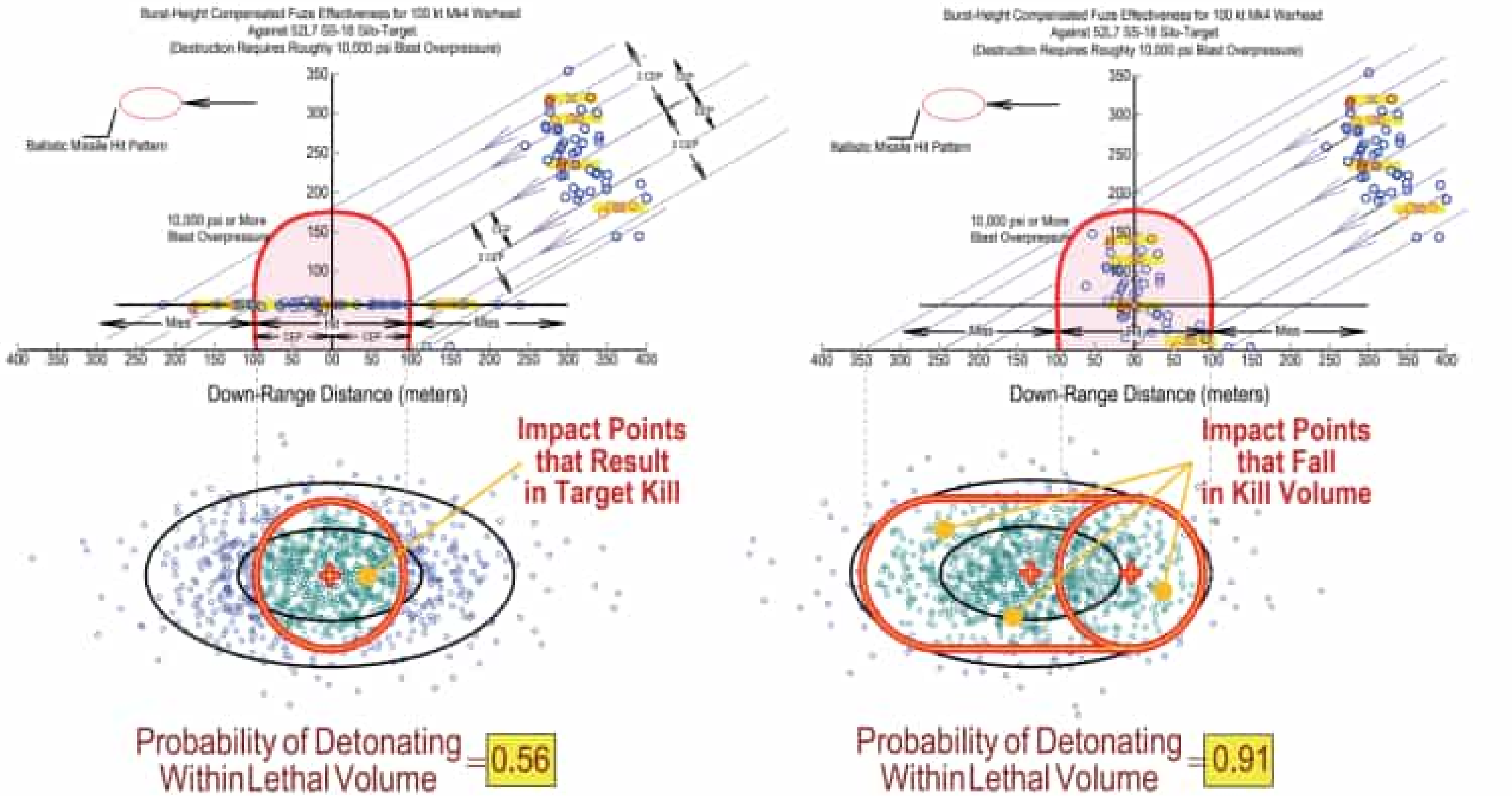


Warheads All Detonate at the Same Altitude



Warheads Detonate Within Lethal Volume

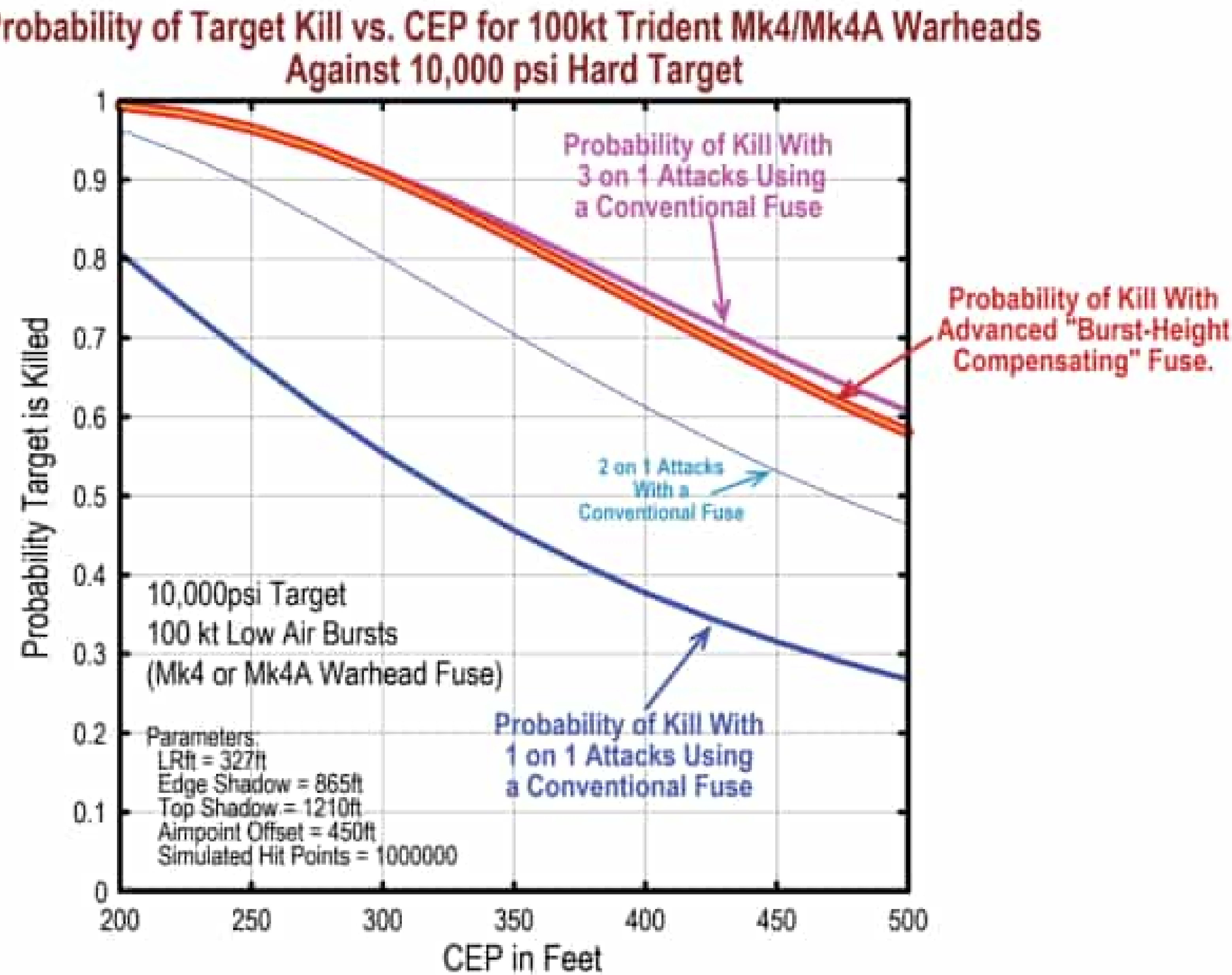
Comparison of the Effects of "*Constant* Burst Height" and "*Variable* Burst-Height" Fuses for 100 kt Mk4 Warhead Against 52L7 (10,000 psi) SS18 Silo-Targets



POINT OF INSTABILITY

Essentially All US SLBM Warheads Will Have a Very High Probability of Kill Against the Hardest Russian Silo-Based ICBMs

Probability of Target Kill vs. CEP for 100kt Trident Mk4/Mk4A Warheads Against 10,000 psi Hard Target

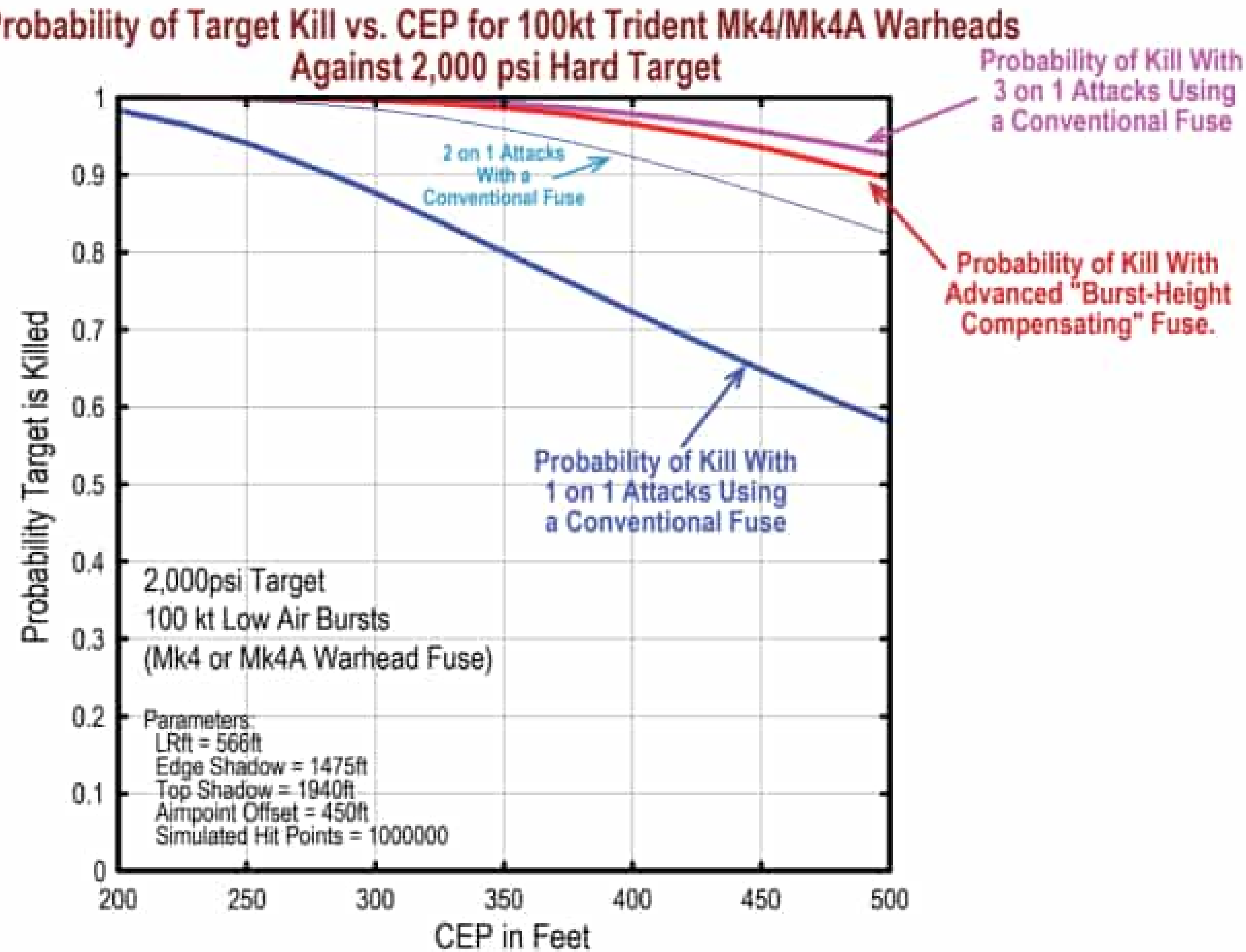


POINT OF INSTABILITY

The US Treats the Hardest Russian ICBMs as Hard to the Effects of a 10,000 psi Blast

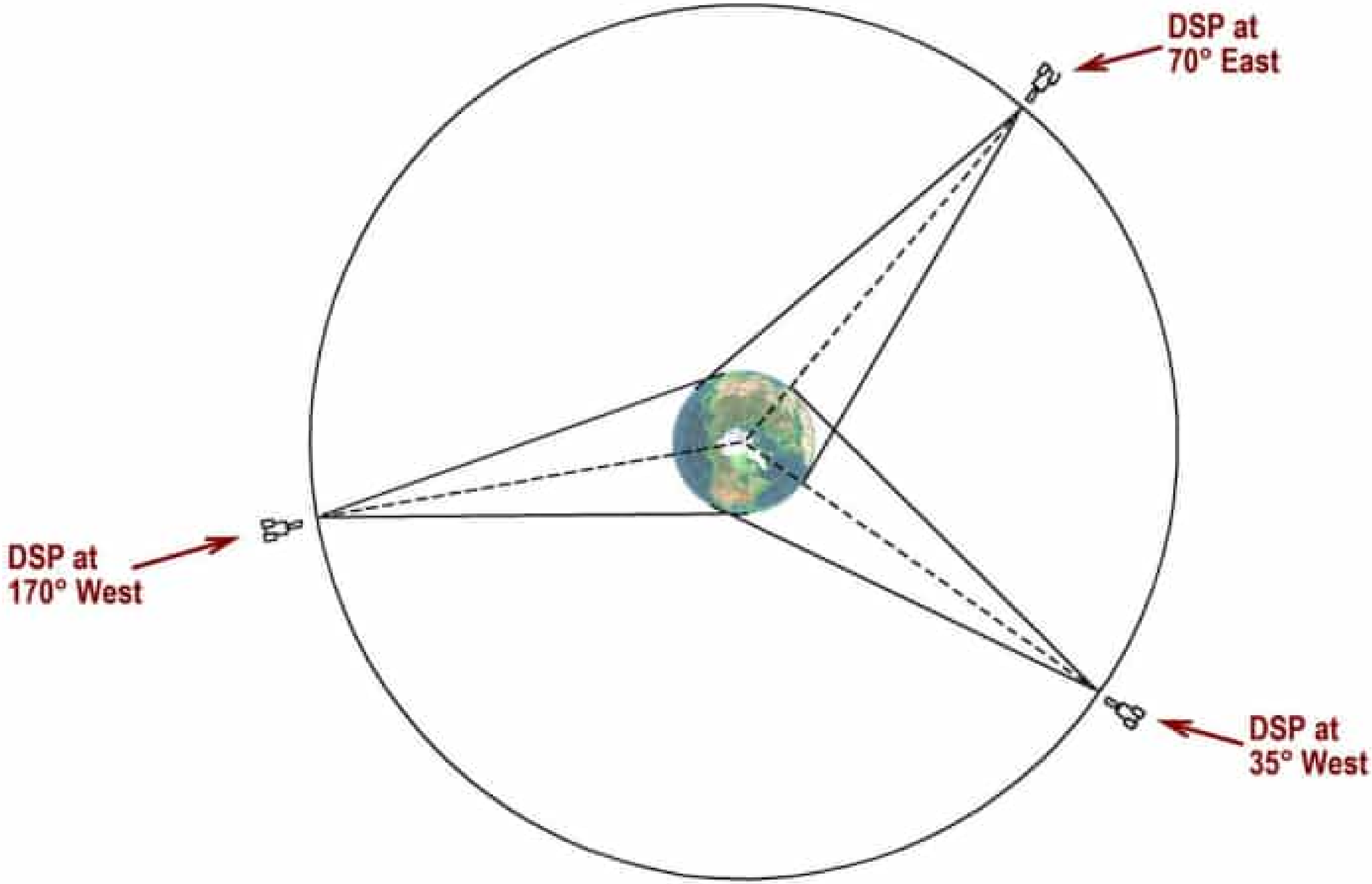
The Russians Assess The Hardness of Their ICBMs to be Less Than 2,000 psi Blast

Probability of Target Kill vs. CEP for 100kt Trident Mk4/Mk4A Warheads Against 2,000 psi Hard Target

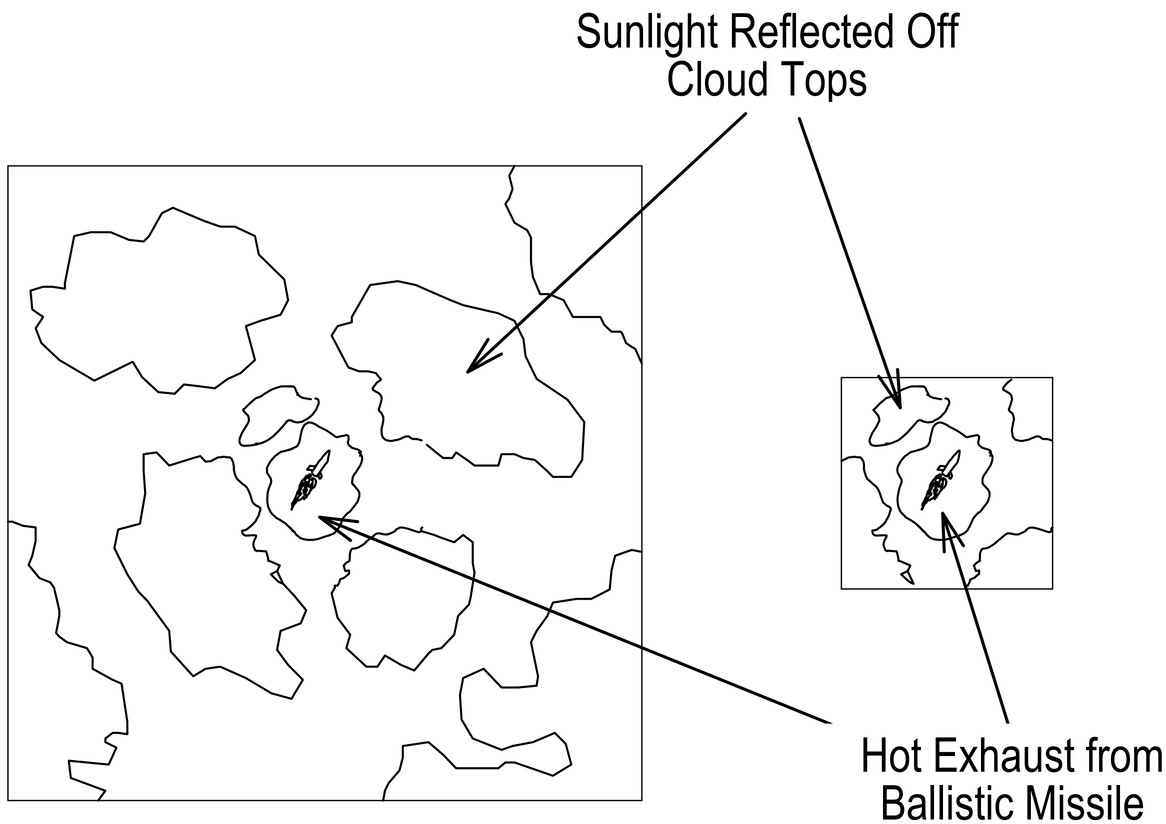


US Satellites Look STRAIGHT DOWN at the Earth

Rough Locations of US **LOOK-DOWN** Early Warning Satellites



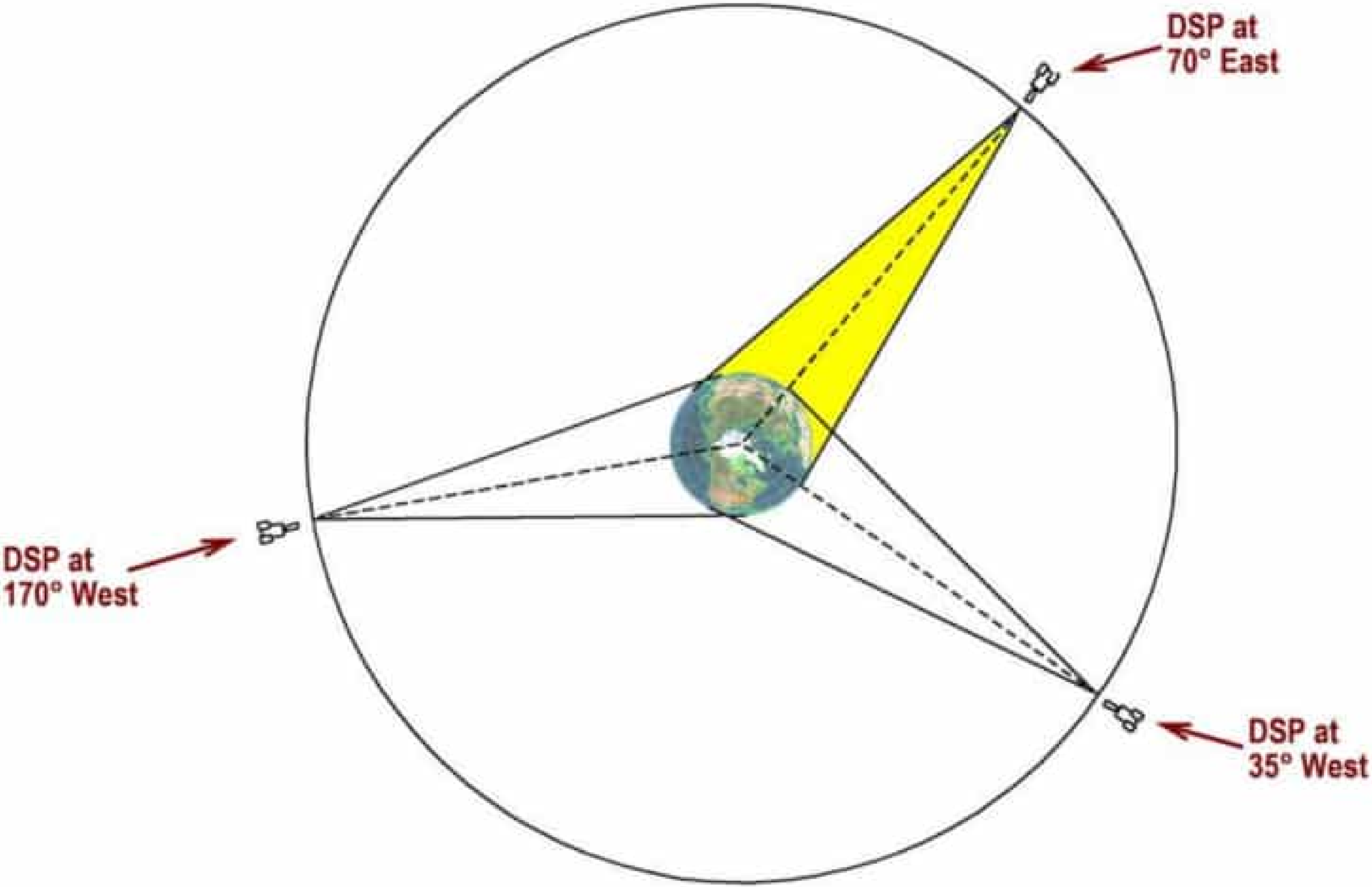
DSP Resolution and the Observation of Signals from Ballistic Missiles Against the Bright Background of Sunlight Reflected Off Cloud Tops



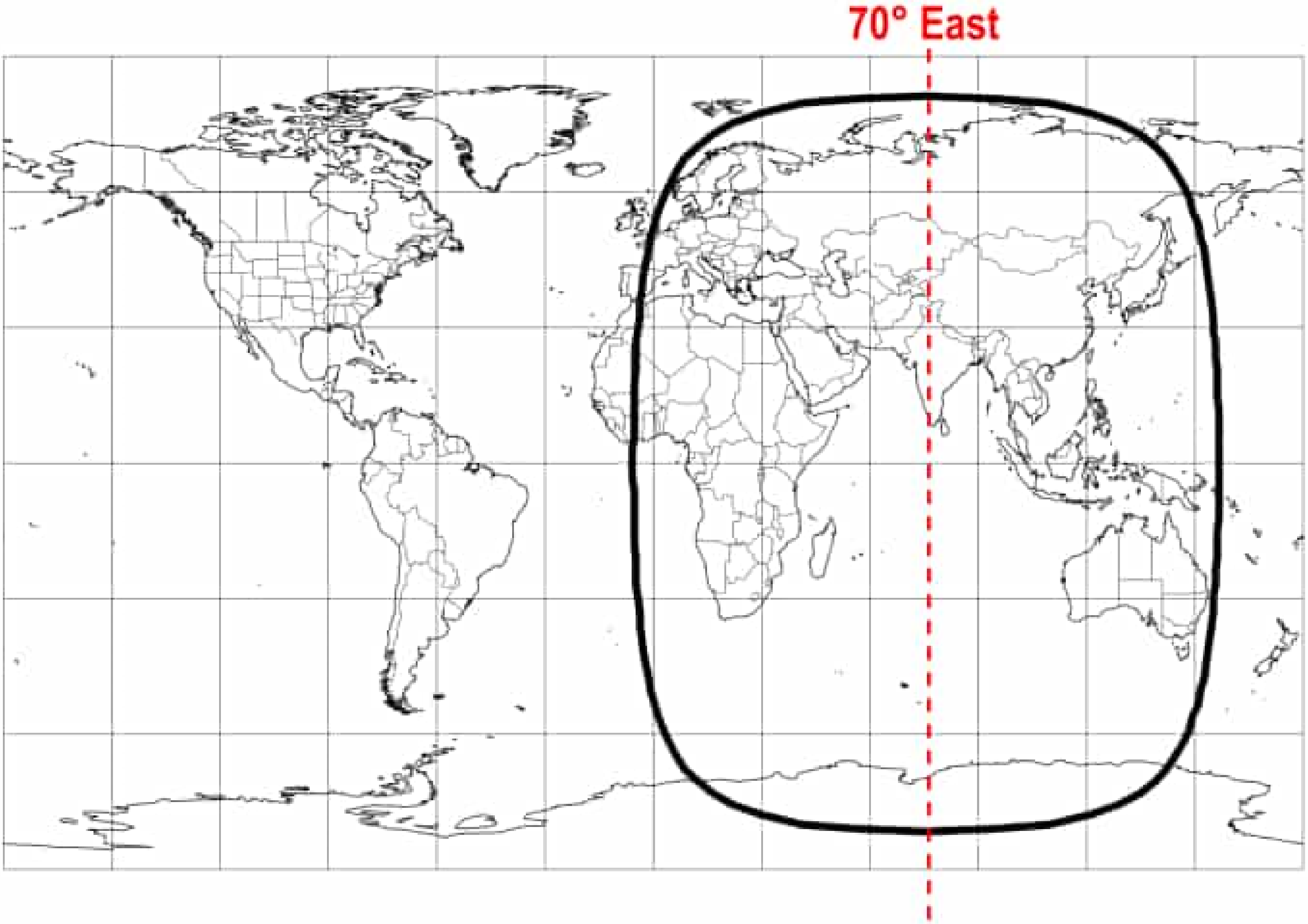
The number of separate sensors in the line array is an important factor that determines whether the satellite can detect ballistic missiles against the bright background created by the reflection of sunlight off moving cloud tops. A large number of sensors allows the satellite to observe many small areas above the earth. If the observed areas are sufficiently small, then the interfering signal from reflected sunlight will be small enough that the relatively weak signal from a missile can be observed. For this reason, infrared line arrays with 2000 to 6000 elements are critical components of a look-down space-based infrared early warning system.

Areas of US Global Monitoring of Missile Launch

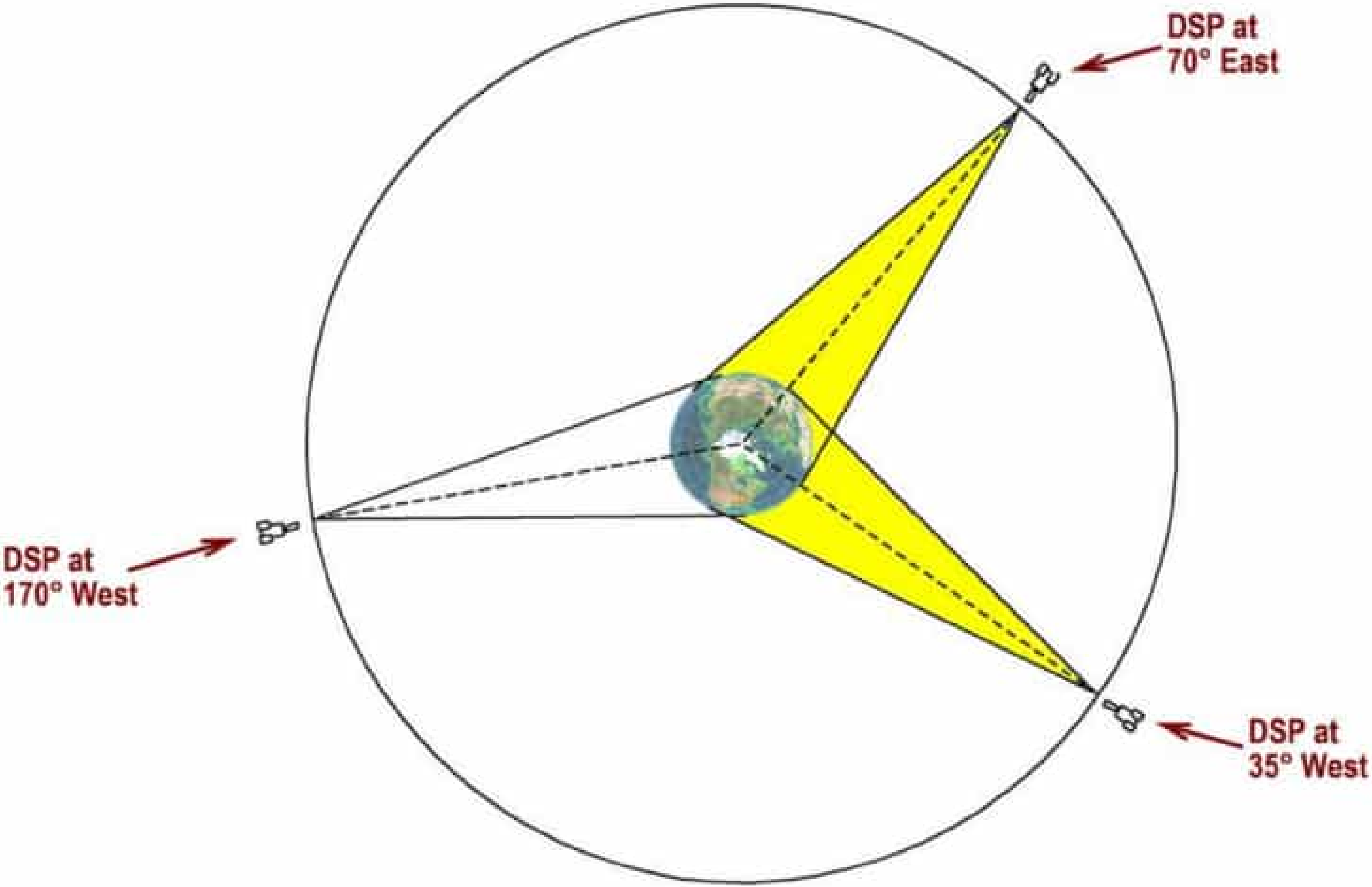
Rough Locations of US **LOOK-DOWN** Early Warning Satellites



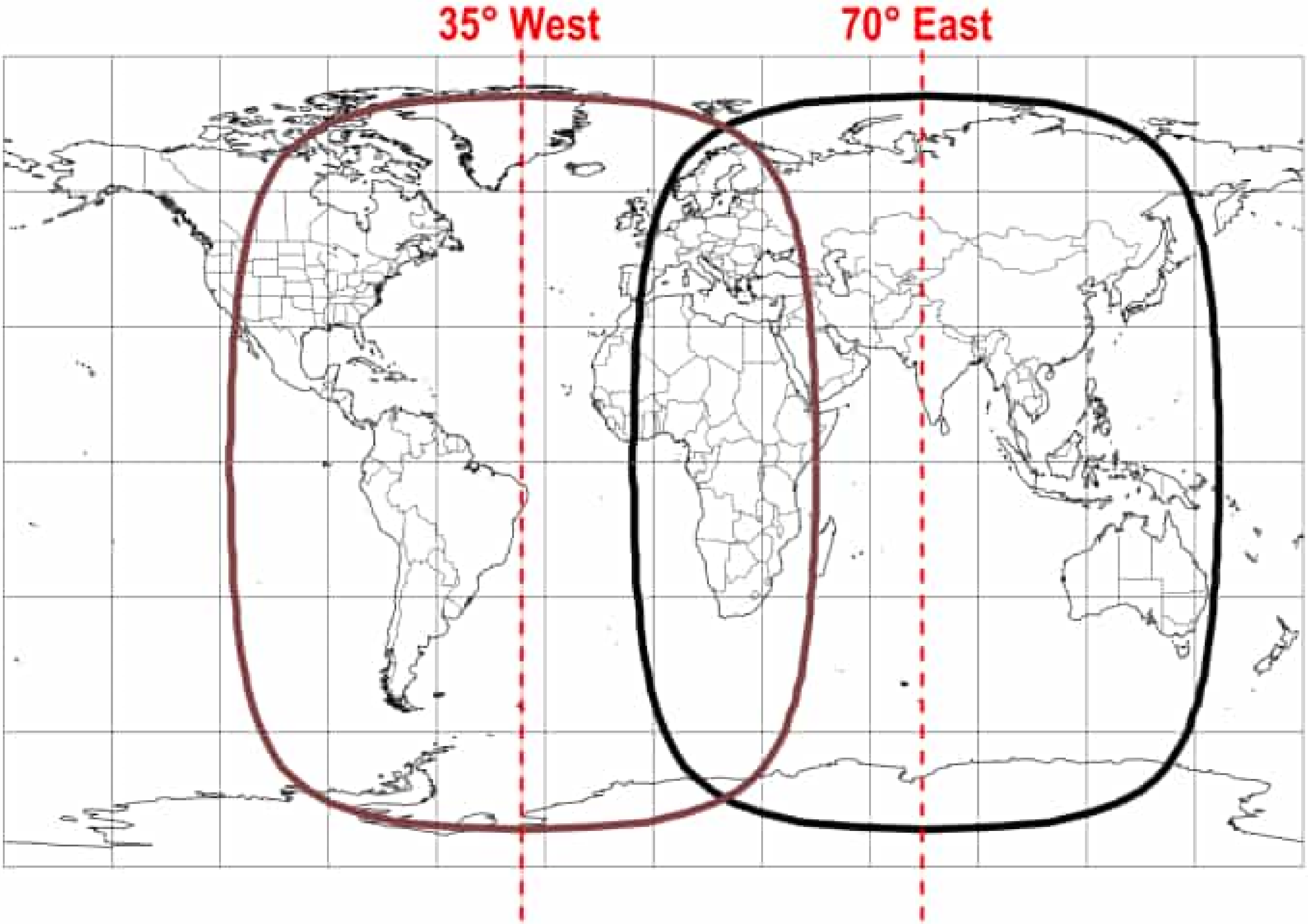
Field of View **LOOK-DOWN** of US Geosynchronous Early Warning Satellite at 70° West



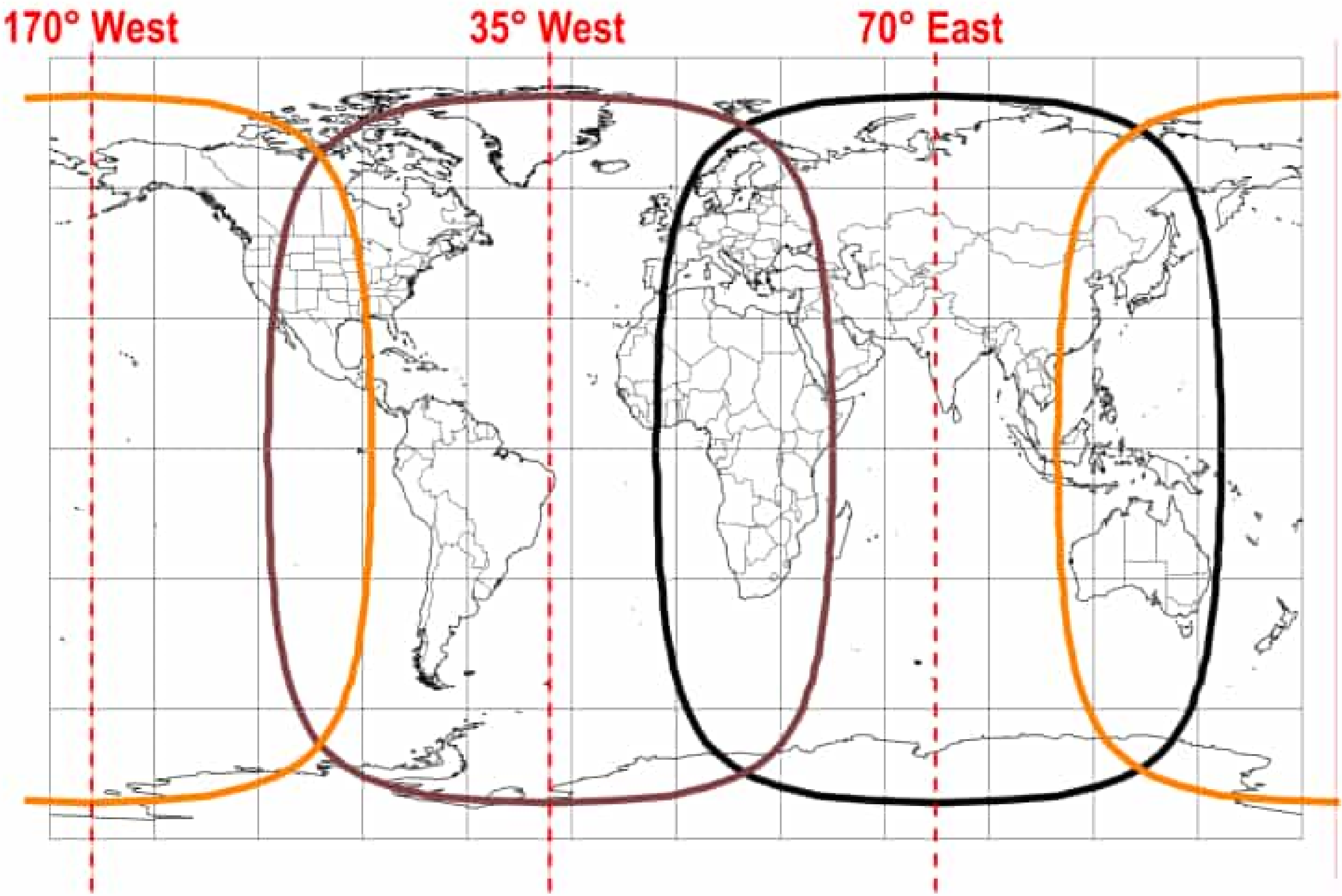
Rough Locations of US **LOOK-DOWN** Early Warning Satellites



Fields of View of US Geosynchronous Early Warning Satellite at 70° West and 35° East

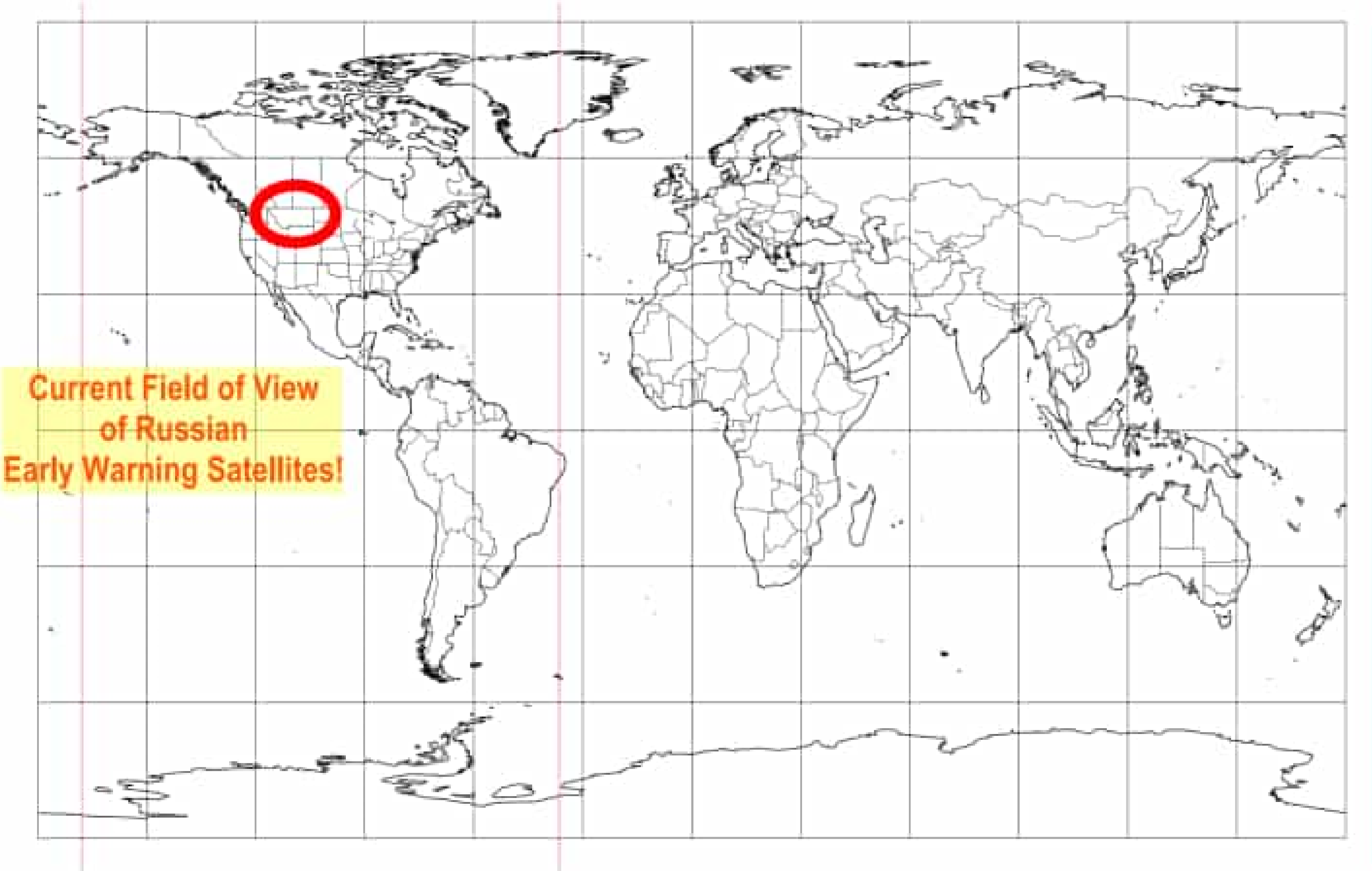


Fields of View of US Early Warning Satellite at 70° West, 35° East, and 170° East



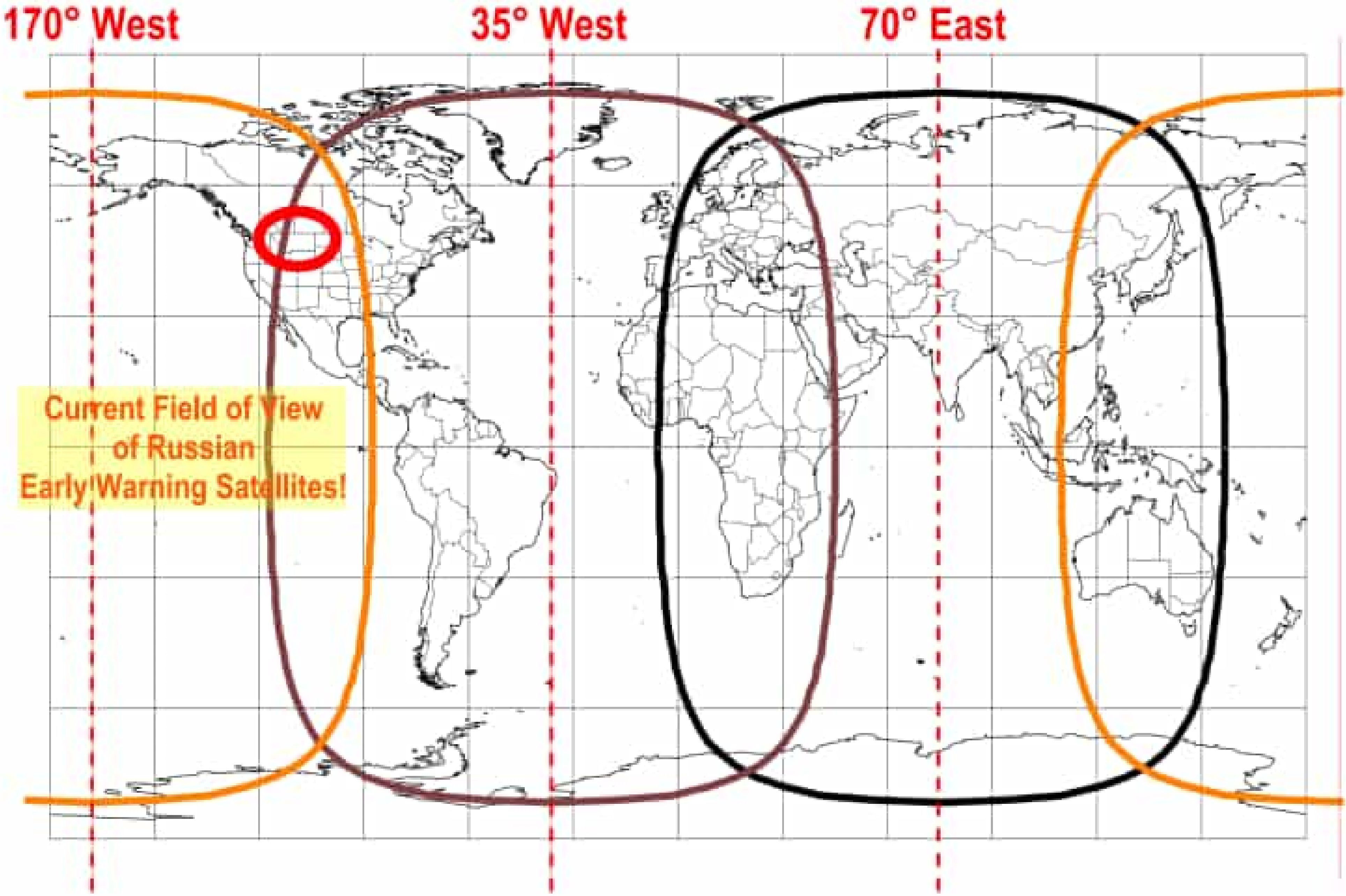
Areas of US Russian Monitoring of Missile Launch

Current Field of View of Russian Molniya AND Prognoz Early Warning Satellite Constellations



Comparison of Russian and US Areas of Missile Launch Monitoring

Comparison of Russian and US Early Warning Satellite Fields of View



Russian Response to Published Analyses of Russian Satellite Shortfalls

https://russiancouncil.ru/analytics-and-comments/analytics/opasnaya-modernizatsiya-amerikanskikh-yadernykh-boegolovok/

What measures should the Russian Federation take?

Alexei Arbatov, Head of the Centre for International Security IMEMO RAN, RIAC member

Vladimir Dvorkin, Principal Researcher, Political Military Analysis and Research Projects Sector, International Security Center IMEMO RAN, Major General, RIAC expert

Victor Yesin, retired colonel-general, RIAC expert

The information from American experts that Americans are conducting a deep modernization of their nuclear warheads to improve their qualitative characteristics is not new to Russian military and political leadership. This fact is **taken into account** during the development and implementation of the country's defense plan.

To maintain a nuclear missile balance with the United States, Russia is taking effective measures … to build up the capabilities of its missile …missile warning systems.

Deployment of a new unified space-based detection and command and control system has begun, with an expected completion of a new constellation of spacecraft in near-Earth orbits by 2020.

With this in mind, it can be argued that Russia is capable of timely detection of a nuclear missile attack and an adequate response to it. The missiles in service with the strategic nuclear forces, as has been repeatedly asserted at the highest military and political levels, can overcome the missile defenses of any adversary that it could create in the

Russian and US Decision-Making Timelines

Estimated Time Needed to Carry Out Nuclear Launch-Operations No Matter What Response Is Chosen

Time Needed to Carry Out Basic Nuclear Weapons Launch-Operations

Time for attacking missiles to rise over the horizon into the line-of-sight of early warning radars	1 minute
Time for radars to detect, track, and characterize detected targets, and to estimate the size and direction of motion of targets	1 minute
Military and civil command conference to determine response	1 to 3 minutes
Time for command and unit elements of silo-based forces to encode, transmit, receive, decode, and authenticate a launch order	2 to 4 minute
Time for missile crews to go through full launch procedures	1 to 3 minutes
Time for launched missile to reach a safe distance from its launch-silo	1 minute
Total time consumed in unavoidable and essential operations	**7 to 13 minutes**

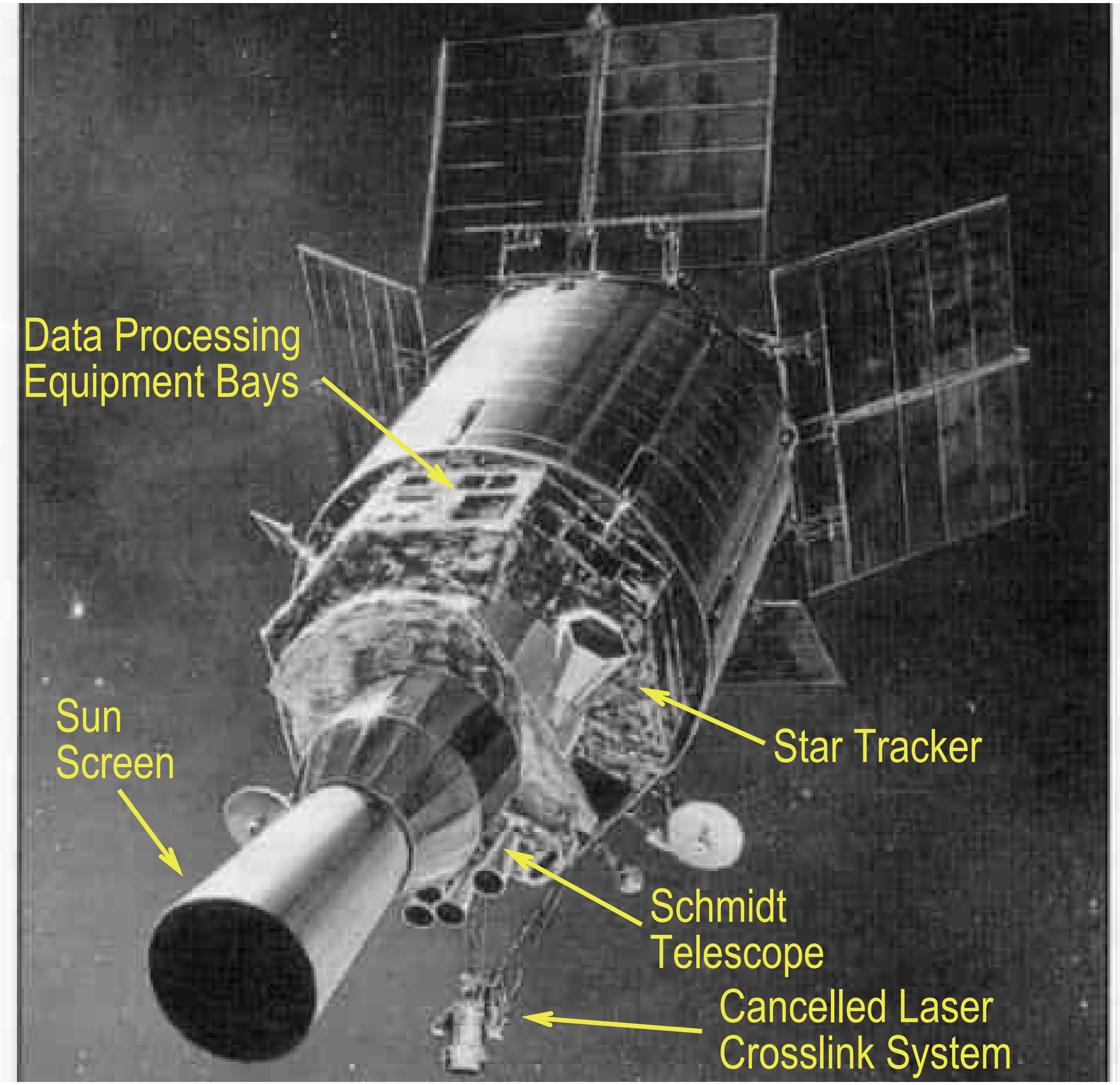
NOTES:

If a short time-line attack is attempted against Russia, a Russian response aimed at launching silo-based missiles before nuclear weapons detonate on them would require time for several technical operations. Time would also be needed by political leadership to assess the situation and decide whether or not to launch the silo-based missile force. The amount of time available for decision-makers to assess the situation and decide whether or not to launch silo-based nuclear forces is the difference between the time it takes for warheads to arrive at targets and the time needed to carry out operations no matter what response is chosen.

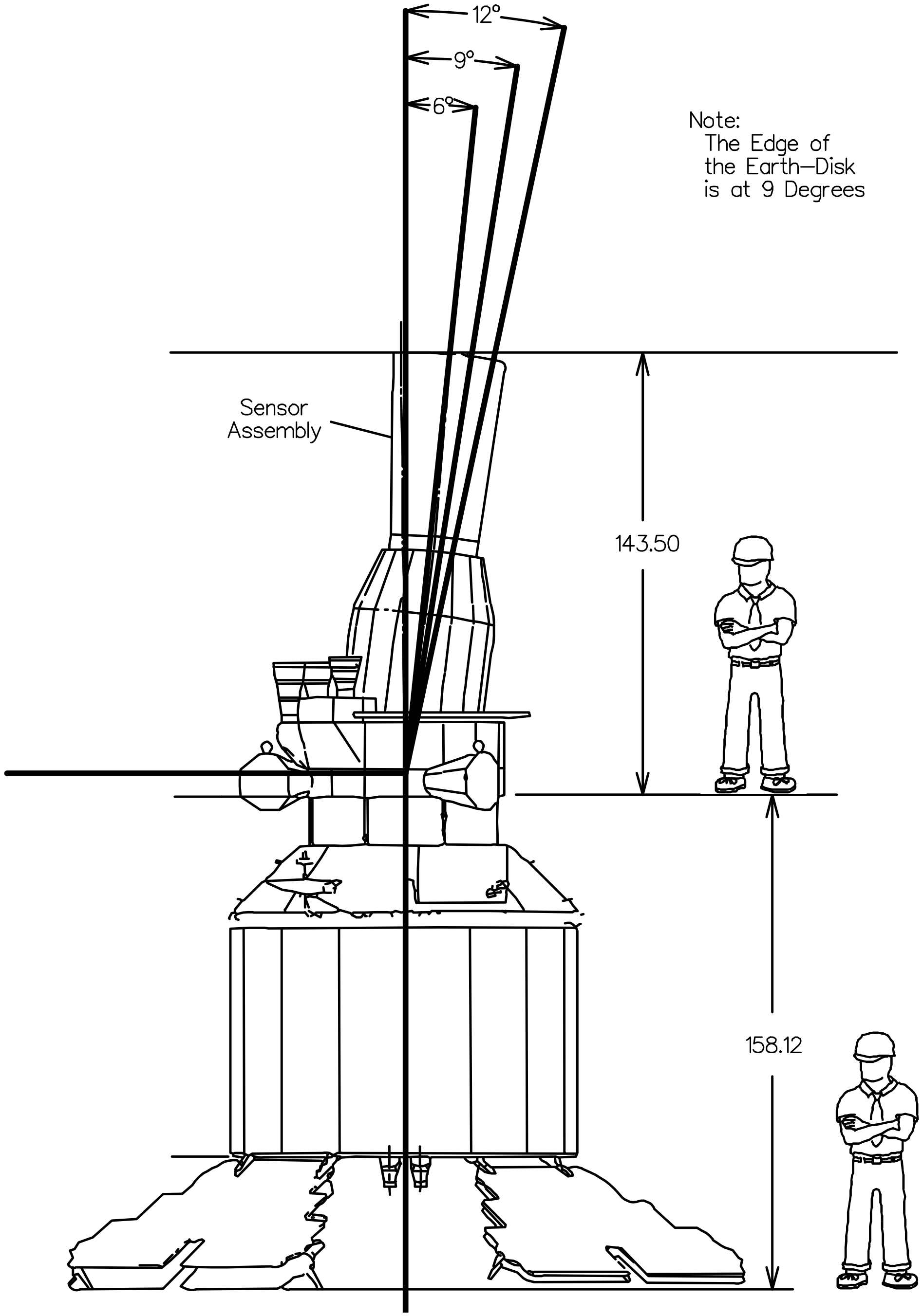
Thank You for Your Patience

Some General Information on the Defense Support Program Satellites

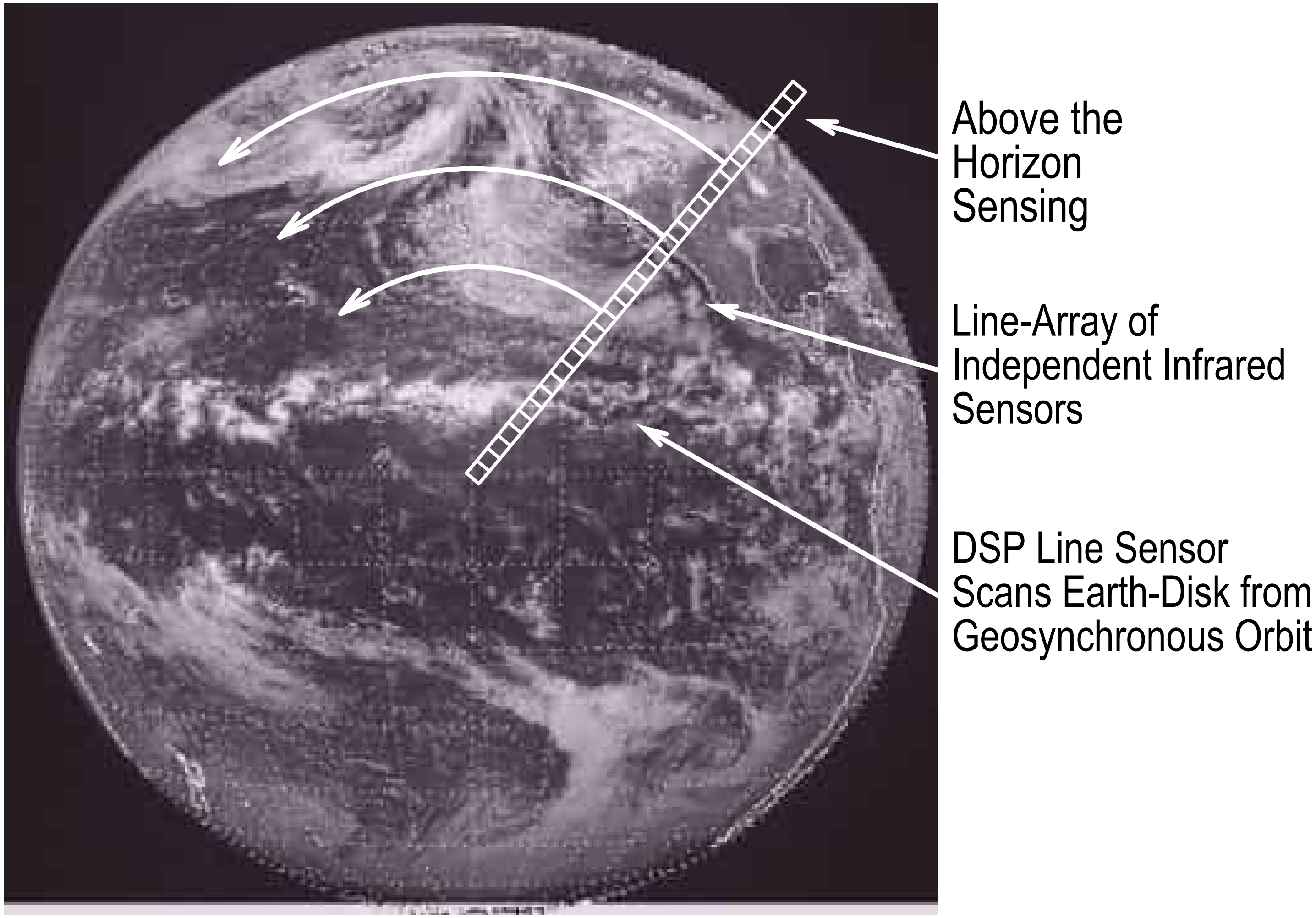
DSP-1 (Block 14) Satellite on Orbit



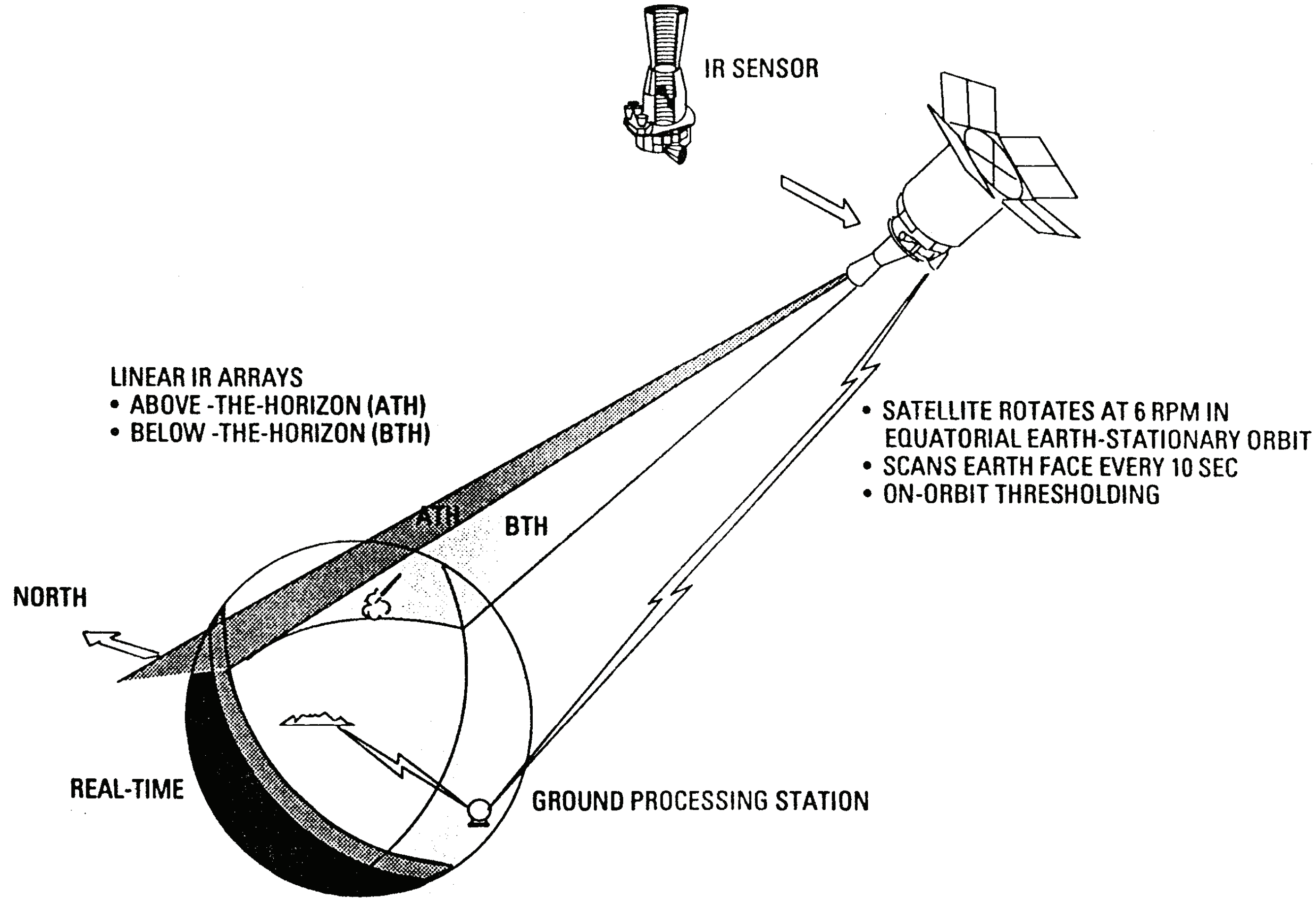
DSP Phase 2 Satellite –
First Launches
in Late 1975 and
Mid-1976



Subtraction of Sunlight Background Reflected From Cloud Tops
Ten Second DSP Revisit Time to Each Pixel



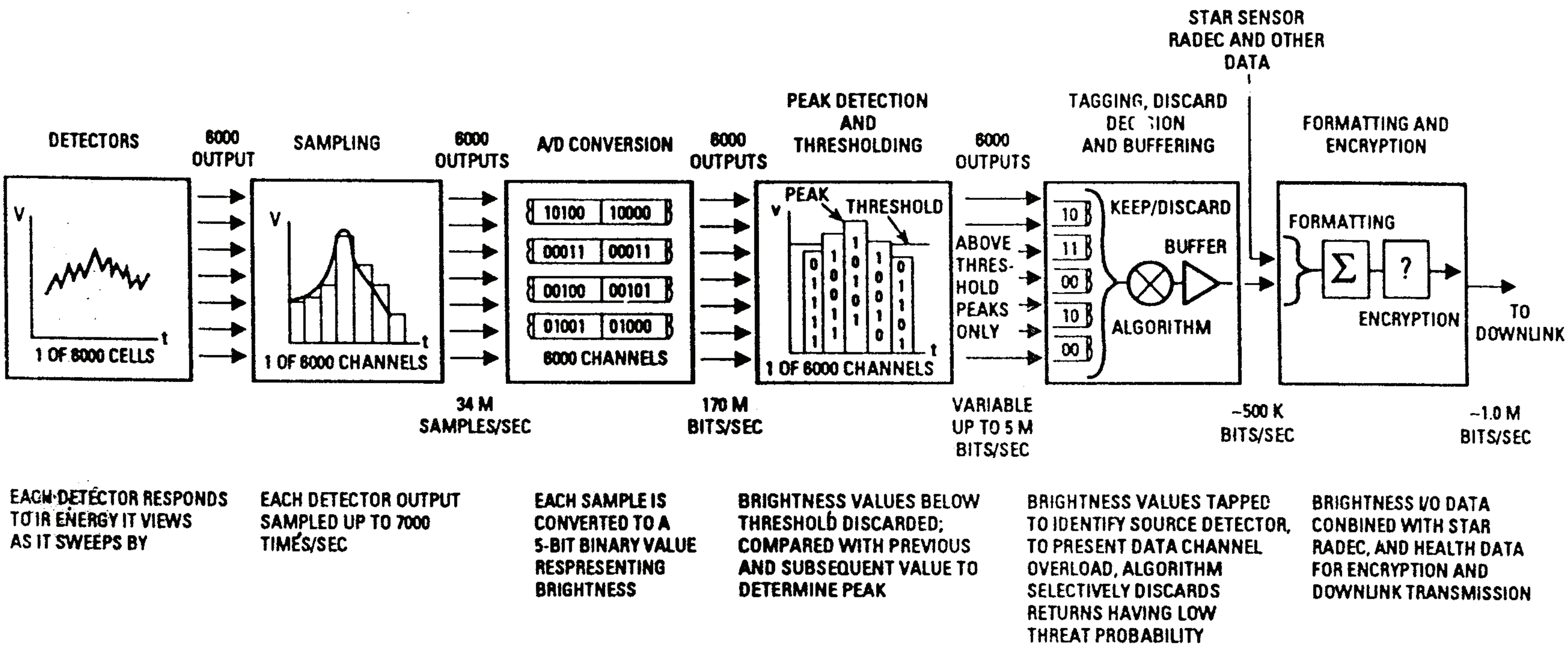
Some Characteristics of the DSP Infrared Surveillance System



The Defense Support Program satellite system was derived from Missile Defense Alarm System (MIDAS) Program, started in 1960. Current DSP satellites provide the US with global warning of missile attack by detecting the infrared emissions from the exhaust plumes of missiles in powered flight. Because these satellites can "look-down" and "see" missiles against the bright earth background, three satellites in geosynchronous orbit can cover almost the entire globe. Two additional satellites are planned in future versions of the system in highly eccentric Molniya semi –synchronous orbits to observe the region around the north pole that is not in view from geosynchronous orbit for the launch of SLBMs. The most recently built generation of satellites, the DSP-1, has 6000+ detectors. It can observe infrared signals at two wavelengths and has both Above-The-Horizon (ATH) and Below-The-Horizon (BTH) search capabilities. The DSP-1 uses both PbS (Lead Sulfide) and HgCdTe (Mercury Cadmium Telluride) focal plane detectors, giving it the ability to observe a second "color", probably at 4.5 microns. The two color capability incorporated in DSP-1 was originally tested on the *Phase II Upgrade* Satellites during the period from 1975 to 1985. The current DSP-1 has a five year design life. Major upgrades incorporated in the DSP-1 for survivability include the Laser Crosslink Subsystem (LCS), which allows for secure Satellite to Satellite Communication, and improved hardening to JCS Level-2. The DSP-1 weighs 5250 lbs.

The DSP Program also includes a series of ground stations deployed worldwide, which process and disseminate information from the satellites. Additional information follows in the next viewgraphs.

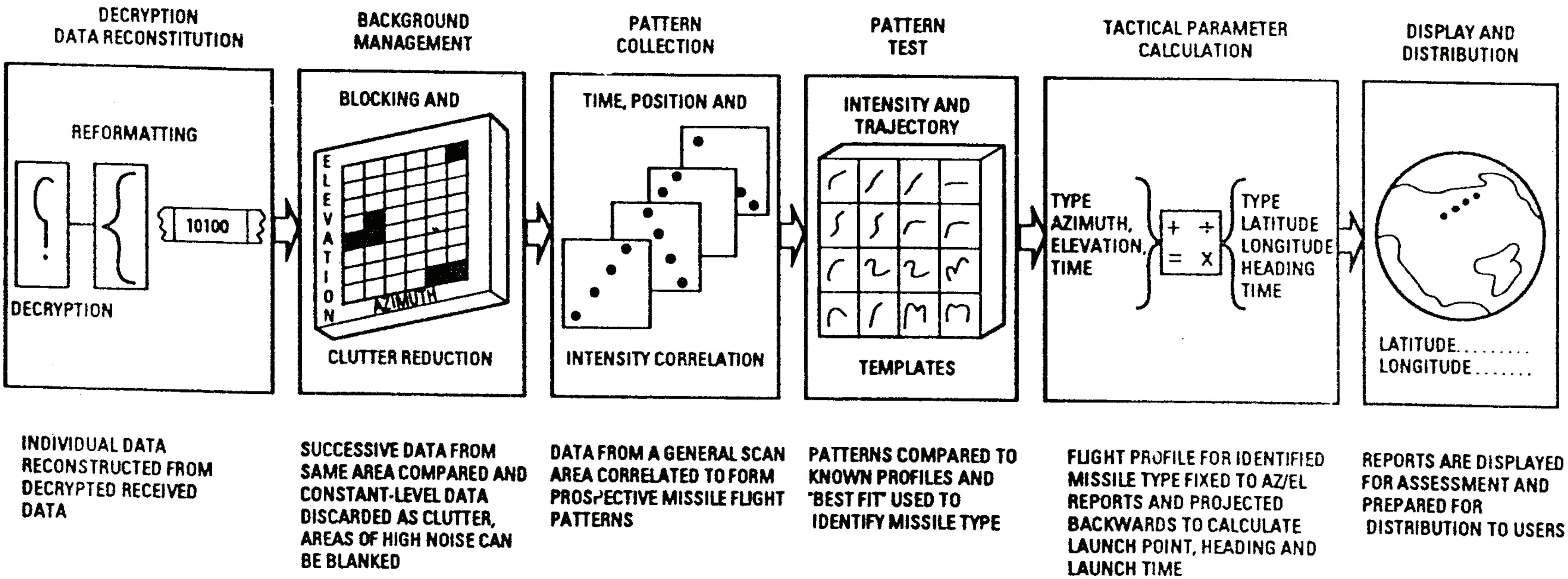
DSP On-Board Signal and Data Processing



ON-BOARD SIGNAL/DATA PROCESSING – ALLOWS SYSTEM TO OPERATE AT MAXIMUM POSSIBLE SENSITIVITY WITHOUT OVERLOADING THE DOWNLINK. PROCESSING IS AN INITIAL SORT, SELECTING RETURNS HAVING THE HIGHEST POTENTIAL OF BEING TARGETS

Each IR detector on the 6000+ detector focal plane responds to any IR energy source that is within its field-of-view. The analog signal generated by each detector is amplified and sampled at up to 7000 times/sec resulting in 34 million samples/sec data rate to the *Analog to Digital* (A/D) oonverter. Each sample is then converted to a 5-bit binary value representing brightness (32 levels of brightness), which is then passed to the peak detection and thresholding circuit in the *Infrared Processing Unit* (IRPU). The IRPU reduces the 34 million returns/sec of data to approximately 500,000 returns/sec by selectively discarding non peaks and lower level data. The *Central Control Unit* (CCU) polls the IR data from the IRPUs at a maximum rate of 526,000 returns/sec, selectively discarding less important data to reduce the data rate to approximately 22,000 returns/sec. The CCU then formats and tags the data, and sends it to the downlink for transmission to ground stations that will further process and analyze the data.

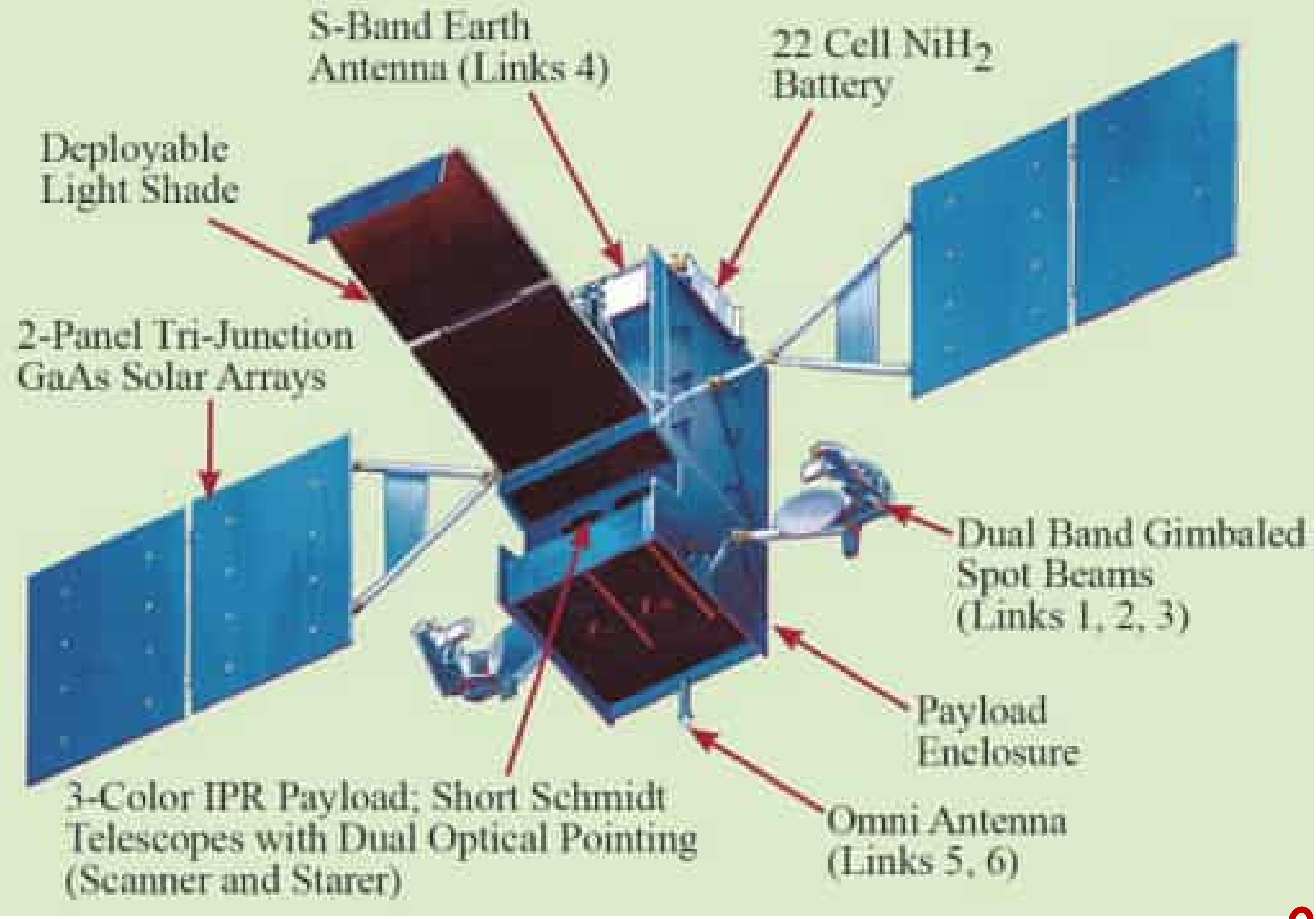
DSP Off-Board Data Processing



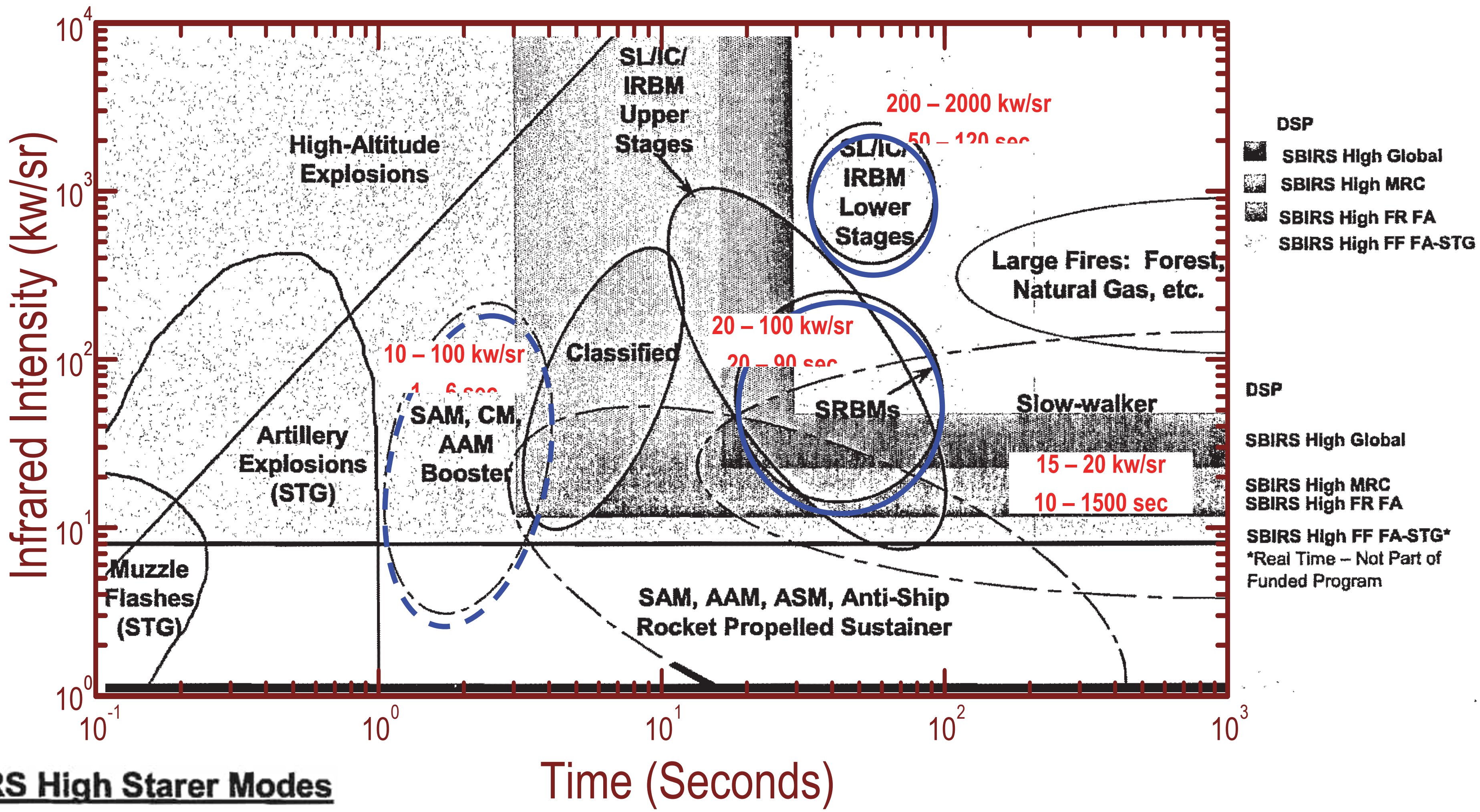
GROUND DATA PROCESSING – CONVERTS INDIVIDUAL DATA INTO LAUNCH WARNING INFORMATION FOR ASSESSMENT

When the encrypted data from the satellite is received at a ground station the Ground Receiver decodes and reconstructs the data transmitted from the satellite. Clutter rejection is accomplished by comparing successive samples of data in a background management program. This process filters out background clutter or noise making it possible to detect signals from real targets. The filtered data has many false signals in it so individual detections must then be checked to determine if they are arranged in space and time like the signal that is generated from a moving missile. This process is called "area correlation". The detected tracks found by correlation are then compared to signals from known targets using "best fit" algorithms. The comparison includes the brightness and position of detections on the estimated track as a function of time. The result of this process leads to an estimate of missile type, launch point, launch time, and heading.

The Space-Based Infrared Satellite (SBIRS) Geosynchronous Spacecraft



Representative SWIR & STG Intensity and Duration of IR Events



SBIRS High Starer Modes

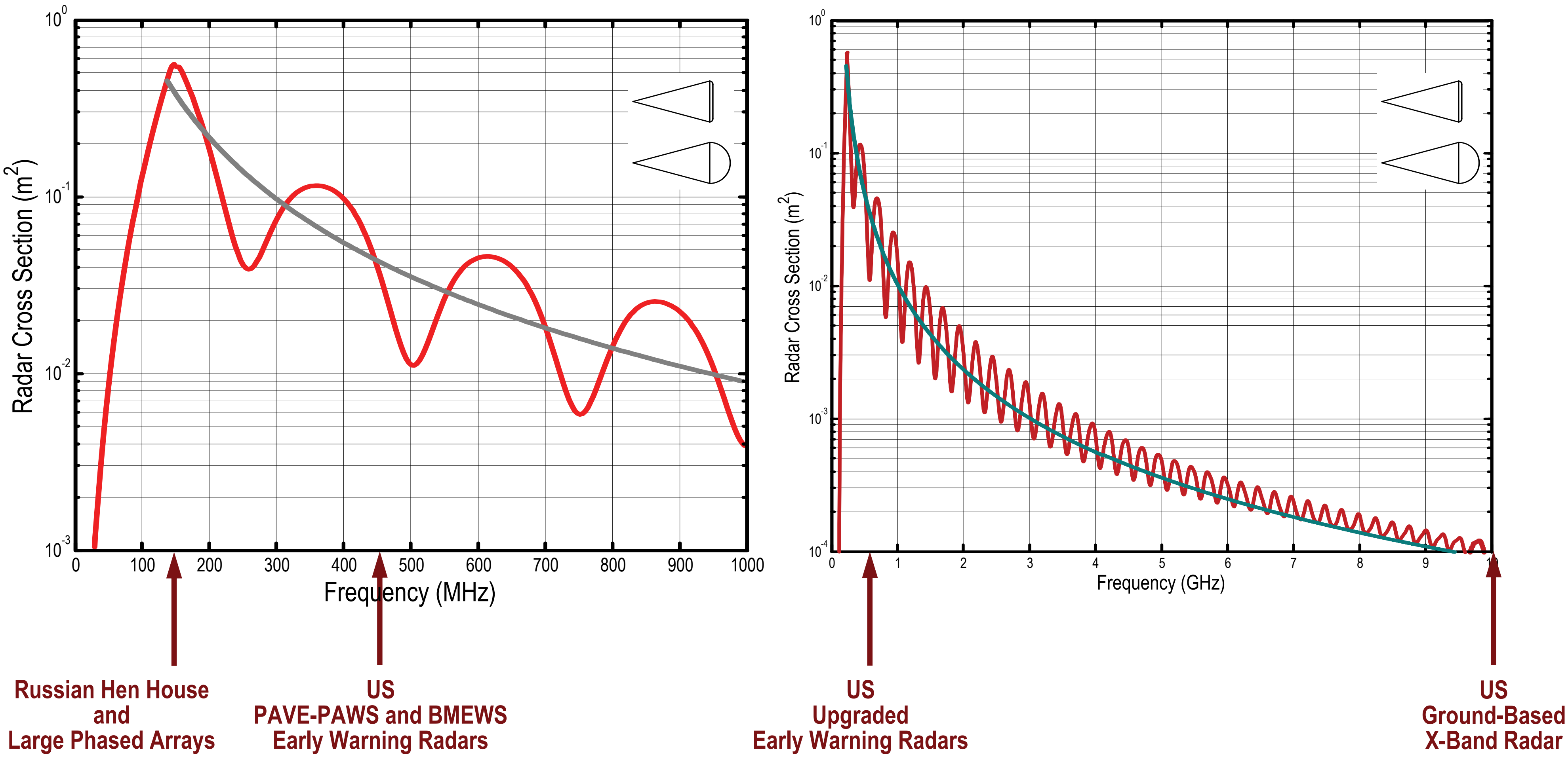
- Step-Stare - Theater Major Regional Conflict (MRC)
- Step-Stare - TI Fast Revisit Focused Area (FR FA)
- Dedicated Stare – Fast Frame Focused Area (FF FA)*
- *Step-Stare - TI High Sense Focused Area (HS FA) – not shown*

The Characteristics of Russian Early Warning Radars

Operating Frequencies of Russia’ Early Warning Radars

Radar Cross Section of Rounded-Back Cones

The operating frequency of Russia’s Early Warning Radars was chosen so that the radar reflectivity of warheads approaching Russia would be as large as possible, thereby making it easier for the radars to detect the approaching warheads at very long range. However, a serious drawback associated with radars operating at these frequencies is that they highly vulnerable to blackout effects from high-altitude nuclear explosions.



Russian Voronezh Class Third Generation Upgraded VHF Early Warning Radar that is Potentially Usable in a "Light" National Missile Defense System

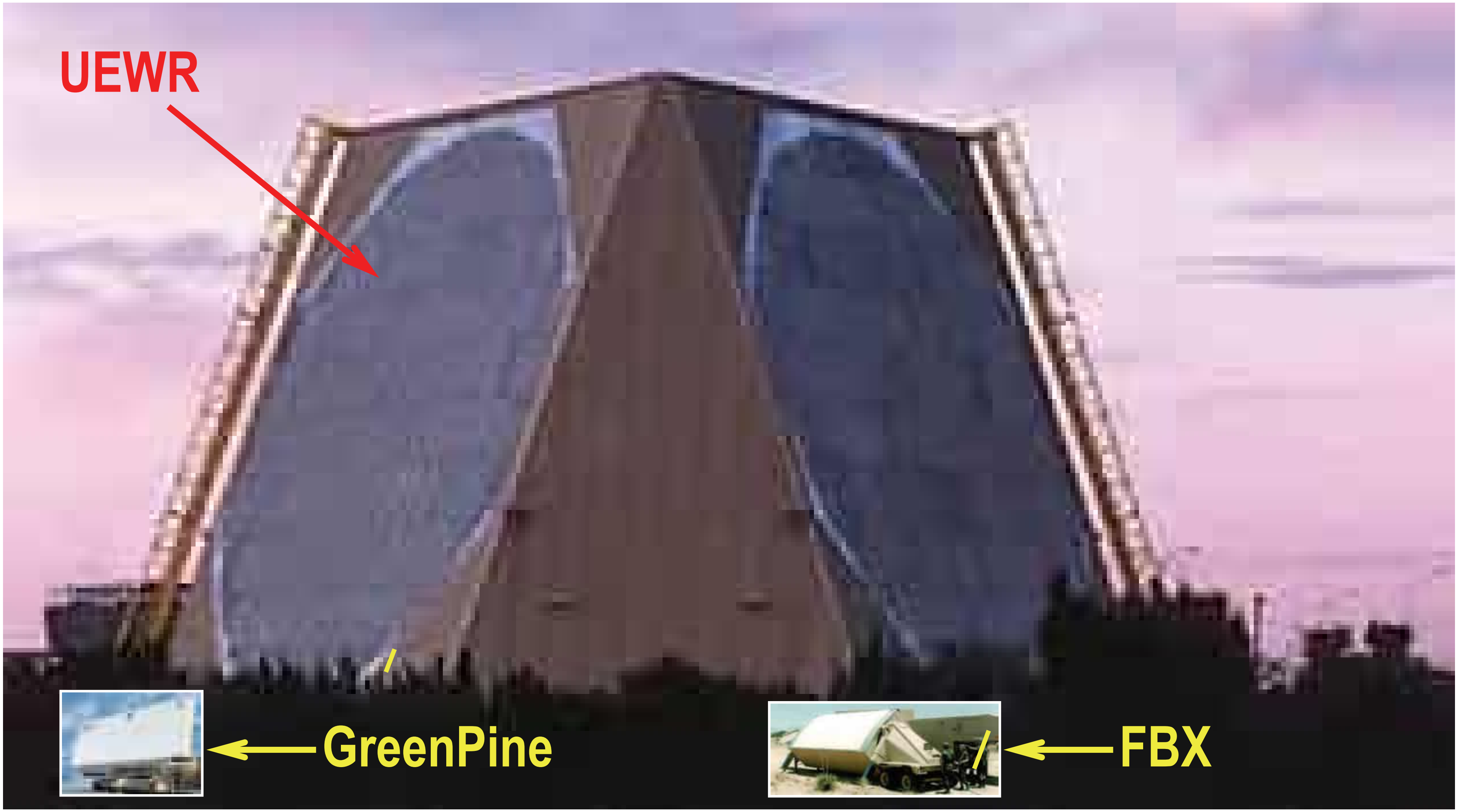
The size of the FBX and its limited average power make it considerably less capably than large lower frequencies radars like the US UEWR and the Russian Voronezh VHF radars for acquiring and and tracking naturally stealthy ballistic missile warheads at long-range.

Arrow GreenPine
Missile Defense
Radar

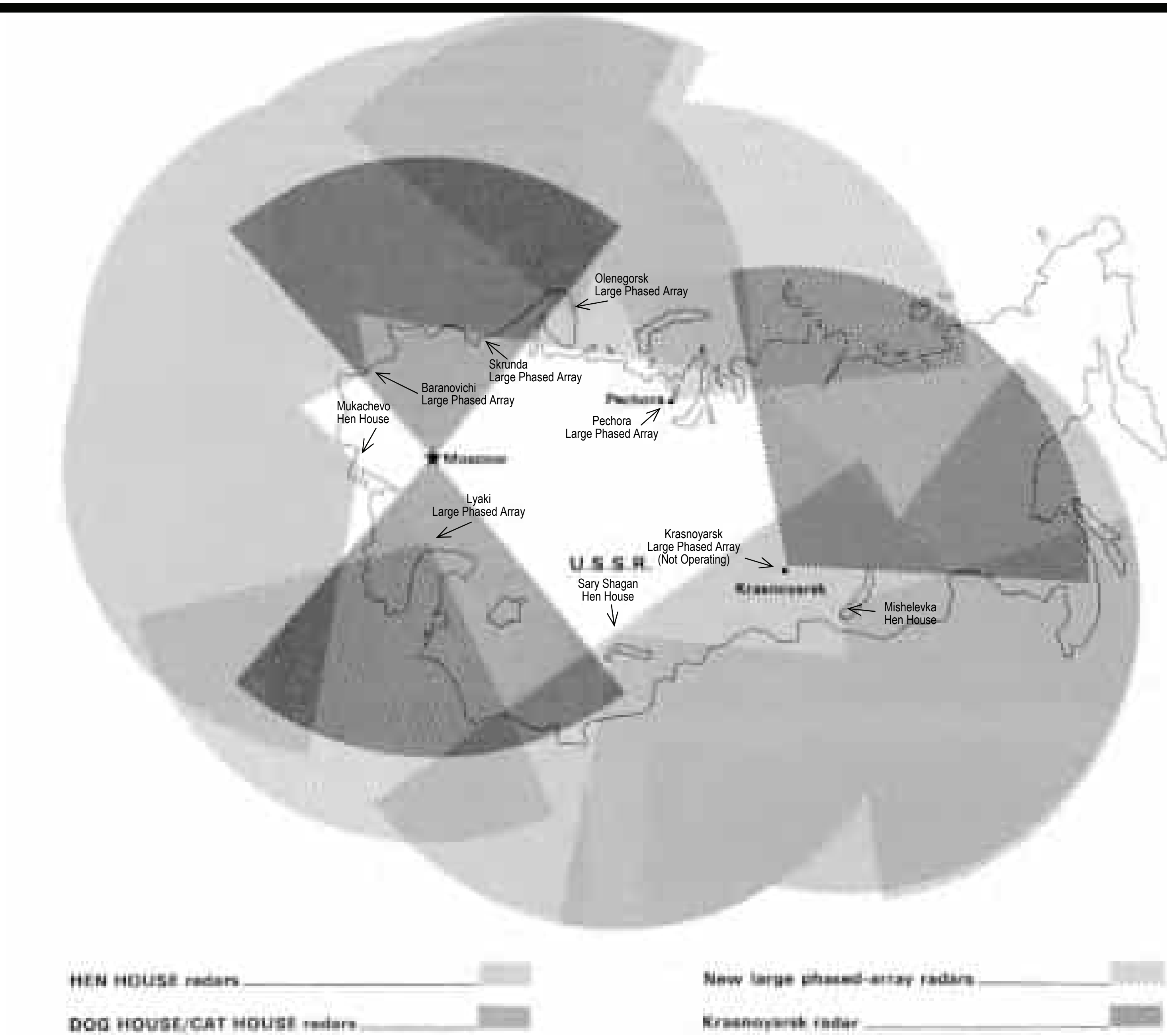
Forward-Based
X-Band Radar
(FBX)

Phased Array Warning System (PAVE PAWS)
UHF Radar Being Used in National Missile Defense System

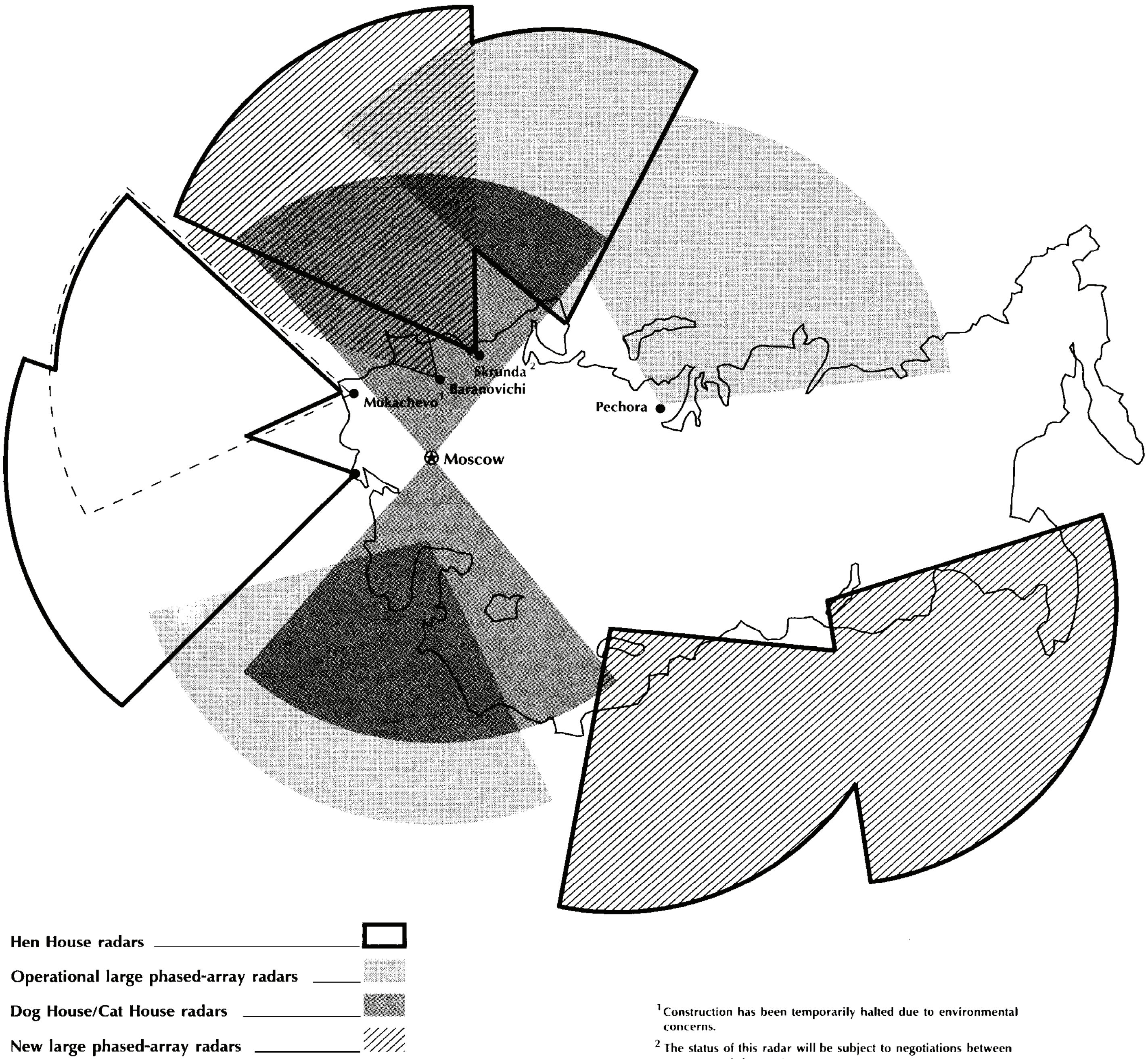
The size of the FBX and its limited average power make it considerably less capable than large lower frequencies radars like the US UEWR and the Russian Voronezh VHF radars for acquiring and and tracking naturally stealthy ballistic missile warheads at long-range.



Locations of the Radars of the Planned But Not Fully Completed Russian Radar Early Warning System



Locations of Russian Hen House and Large Phased Array Early Warning Radars in 1995



[1] Construction has been temporarily halted due to environmental concerns.

[2] The status of this radar will be subject to negotiations between Moscow and the Latvian government.

Russian Radars Currently Usable for Purposes of Early Warning

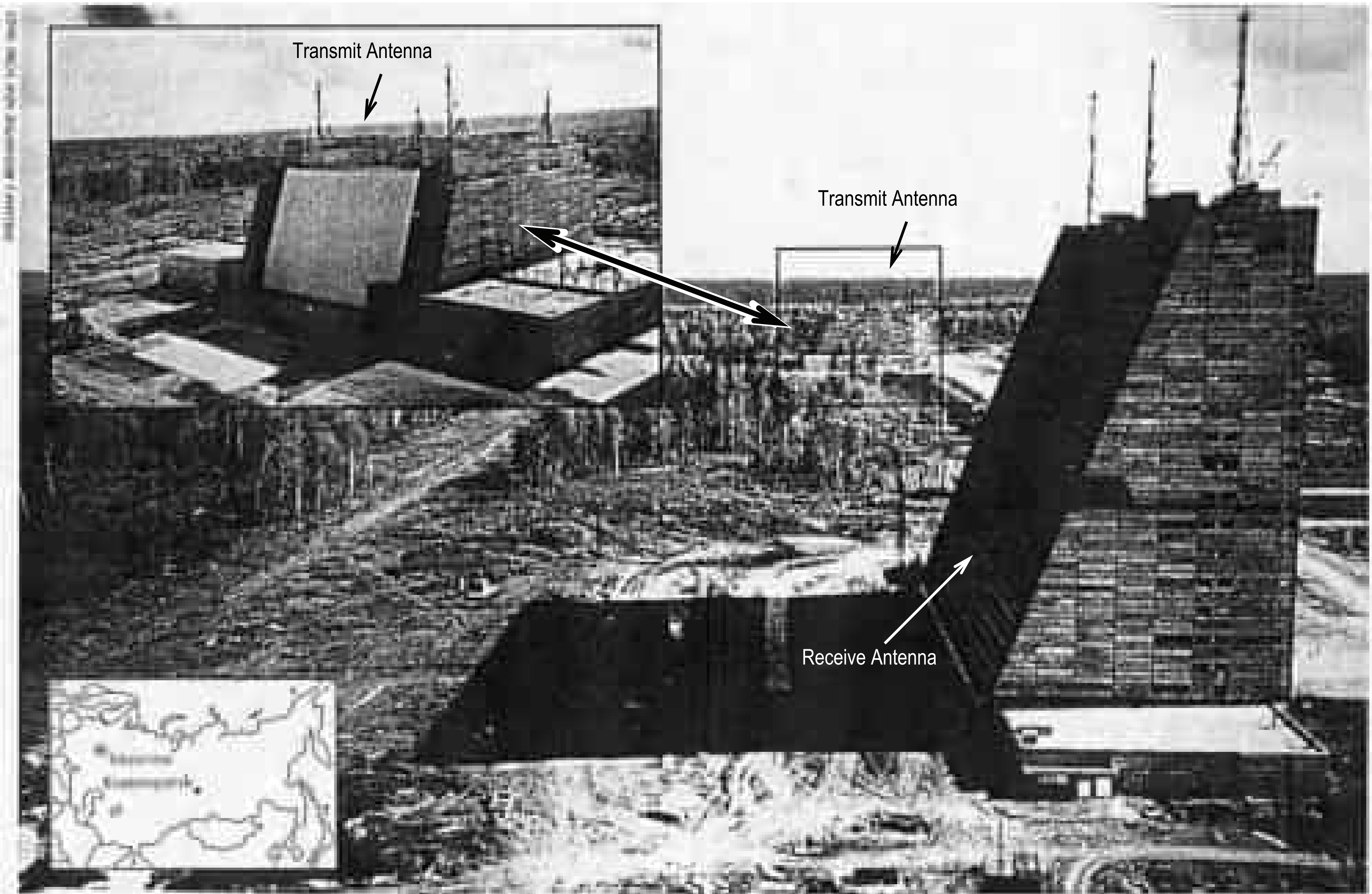

"Cat/Dog House" First Generation Russian ABM Radar

"Pushkino" Second Generation Russian ABM Radar


"Hen House" First Generation Russian Early Warning Radar


"Large Phased Array" Second Generation Russian Early Warning Radar

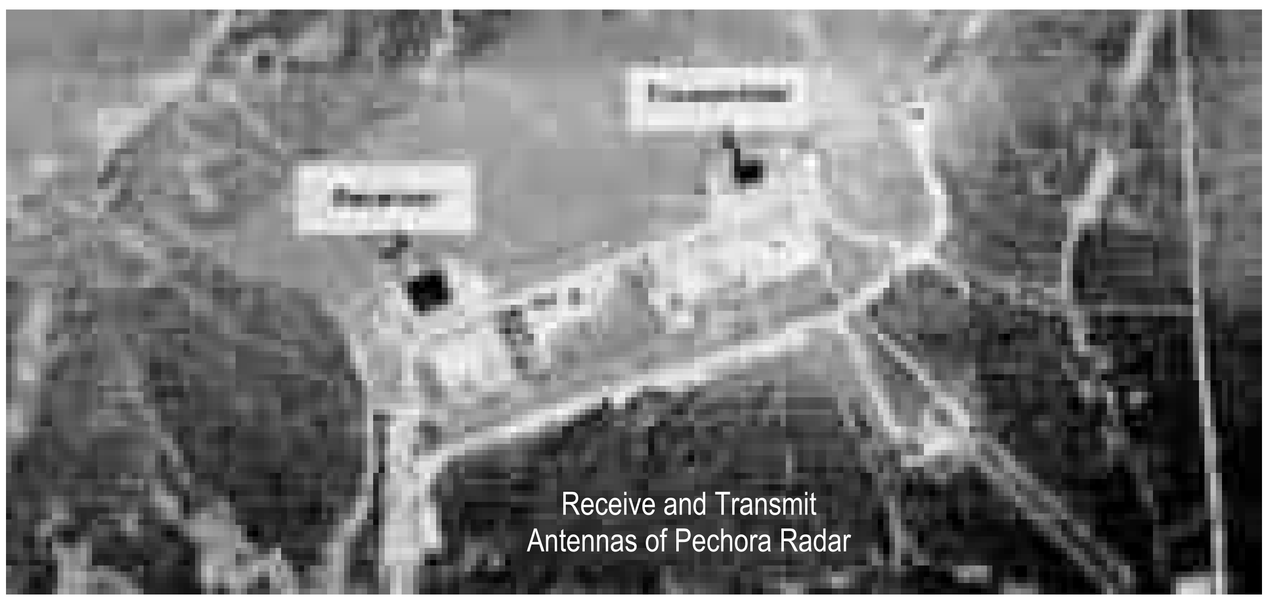
Russian Large Phased Array Early Warning Radar at Krasnoyarsk




Transmit Antenna of
the Krasnoyarsk Radar


Receive Antenna of
the Krasnoyarsk Radar


Face of the Receive Antenna
of the Krasnoyarsk Radar


Receive and Transmit
Antennas of Pechora Radar

The Russian Experience with the False Alert of January 25, 1995

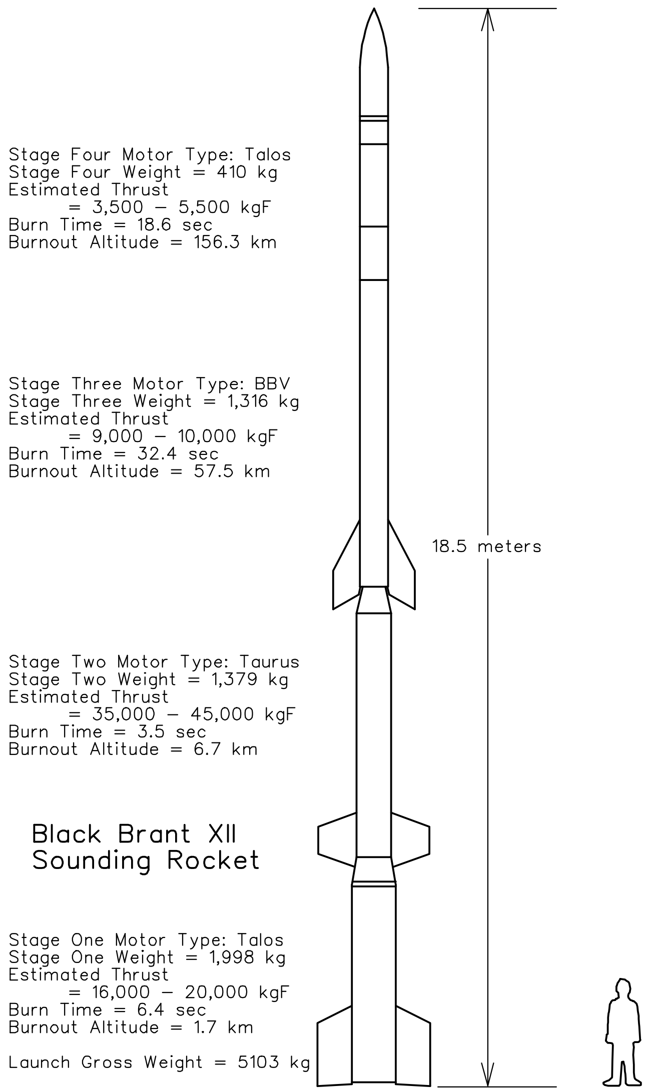
The Russian False Alert of January 1995

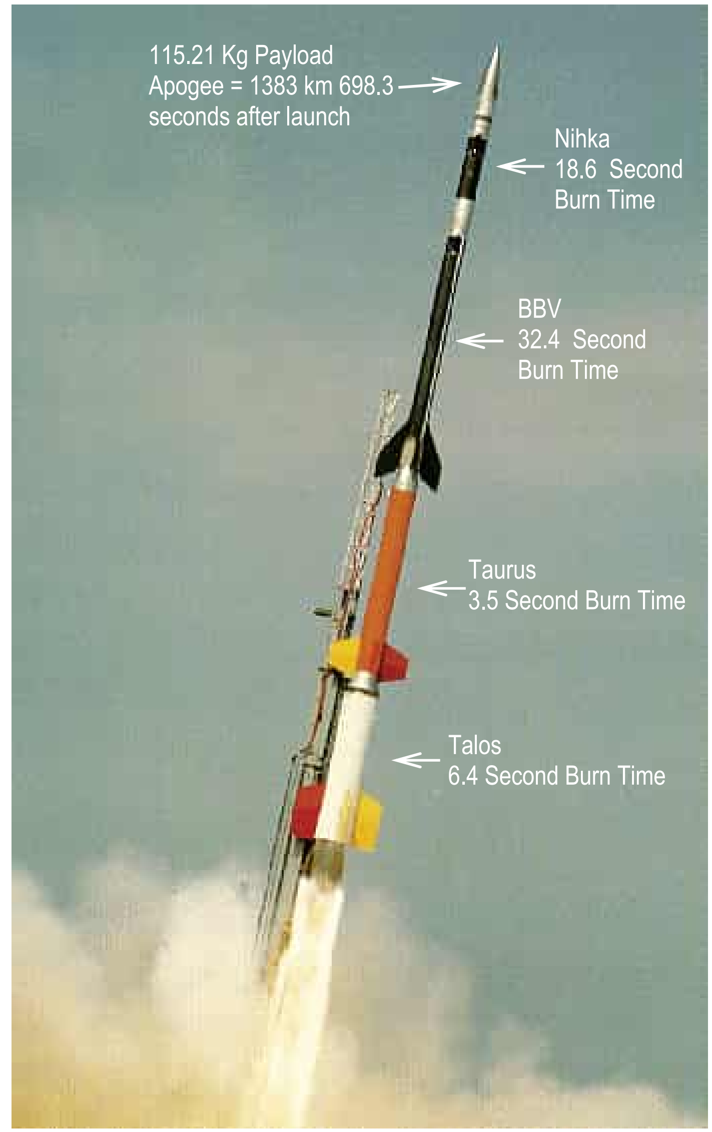
What seems to have happened?

What events led to the false alert?

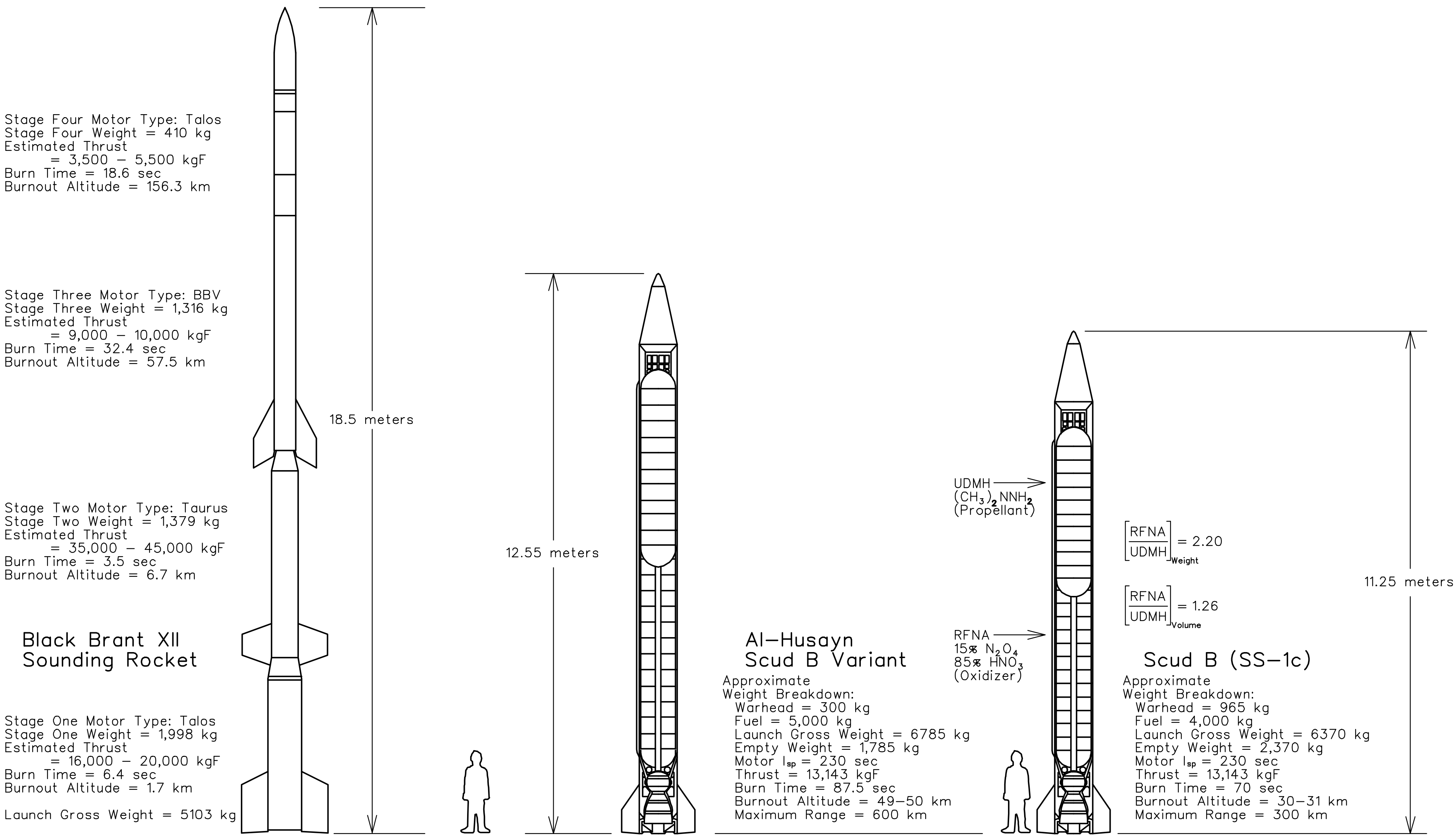
(“The Dog that Didn’t Bark)

The Russian Experience with the False Alert of January 25, 1995





The Russian Experience with the False Alert of January 25, 1995



The Russian Experience with the False Alert of January 25, 1995

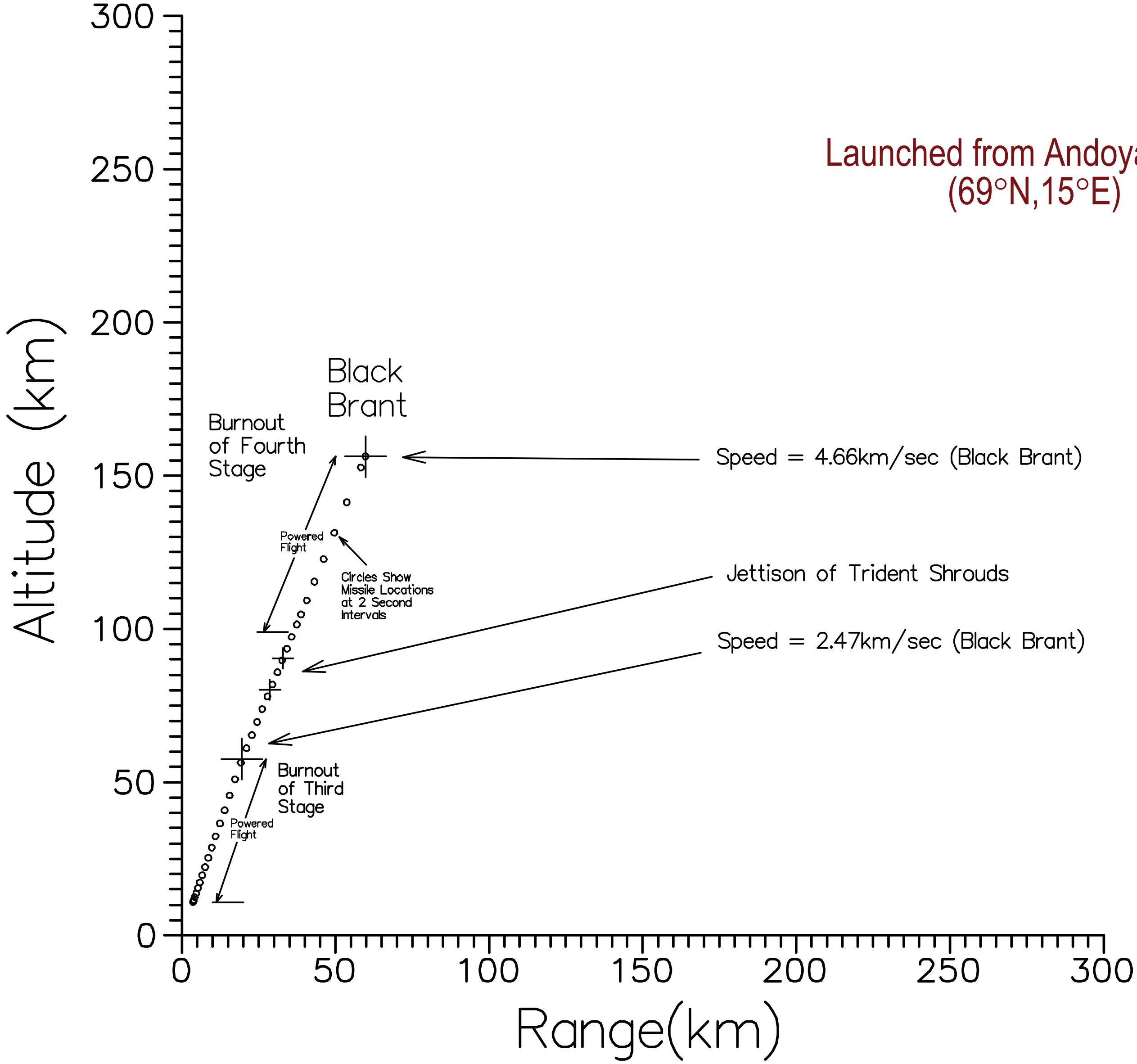
Black Brant XII
Nominal Sequence of Events
115.21 kg Payload

Event	Time (sec)	Altitude (km)	Range (km)	Velocity (mps)
Rail Exit	0.5	0.1	0.0	42.7
Spin Motor Ignition	0.9	0.1	0.0	72.8
Spin Motor Burnout	1.1	0.1	0.0	91.3
Talos Burnout	6.4	1.7	0.4	464.4
Taurus Ignition	14.0	4.7	1.1	341.7
Taurus Burnout	17.5	6.7	1.6	841.9
Taurus Separation	20.0	8.7	2.2	785.2
BBV Ignition	23.0	10.9	2.8	732.7
BBV Burnout	55.4	57.5	19.6	2472.0
Nose Cone Deploy	65.0	79.2	28.0	2385.3
LEO Slug Deploy	67.5	84.7	30.2	2362.9
BBV Separation	70.0	90.1	32.4	2340.7
Nihka Ignition	74.0	98.7	35.9	2305.4
Nihka Burnout	92.6	156.3	59.8	4656.6
Despin to 1.25 hz	96.0	170.6	65.7	4627.8
5.5 m Weitzmann Booms Deploy	99.0	183.3	71.0	4602.1
TECHS & E-field Booms Deploy	102.0	196.0	76.2	4576.6
HEEPS & BEEPS Deploy	105.0	208.6	81.5	4551.1
UNH HV & MSFC HV On	108.0	221.1	86.7	4525.8
Begin Data Period	180.5	500.1	207.5	3945.7
Apogee	698.3	1383.1	913.9	1529.3
End Data Period	1216.2	500.0	1618.5	3945.2
Ballistic Impact	1342.5	0.0	1829.1	

The Russian Experience with the False Alert of January 25, 1995

Locations and Speeds of the Black Brant XII NASA Sounding Rocket in Powered Flight in January 1995

Launched from Andoya Island
(69°N,15°E)



The Russian Experience with the False Alert of January 25, 1995

Comparison of the Locations and Speeds of the Black Brant XII NASA Sounding Rocket with the Powered Flight Trajectories of Trident C-4 and D-5 Missiles