



Ballistic Missiles and Satellite Launch Vehicles: Assessing the Record

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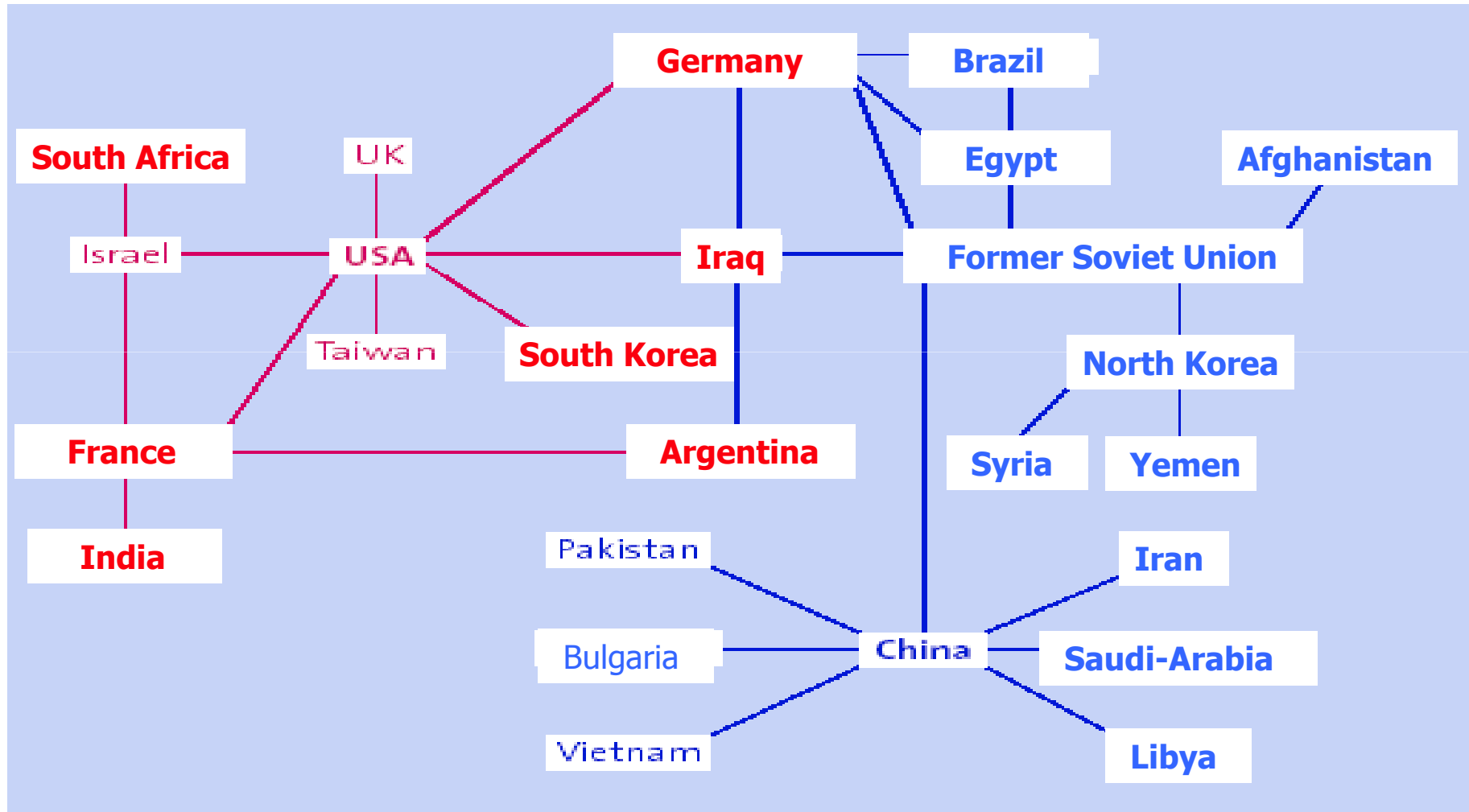
The Hague Code of Conduct Seminar
Paris 7-8th July, 2010



Contents

- Ballistic Missile Proliferation- Why?
- Ballistic Missile Proliferation- How?
- Ballistic Missile Proliferation- What?

The Tree of Missile Proliferation



The Why Question

- Discrete Choice Analysis- A Game Theory Model
- Panel data set of 119 countries from 1967- 1997
- Study reveals that the ballistic missile proliferation arose largely out of micro-level interaction between bordering States
- The probability of a state acquiring ballistic missile increases nonlinearly as the number of neighboring states with ballistic missiles increases
- It appears to be the most logical outcome of States to counter perceived threats arising from neighboring states
- International norms- contained, delayed but didn't work!
- Future disarmament will solely depend on how one addresses the question to reduce the perceived threat of ballistic missiles
- Missile defense not taken into account

Key Components of a Delivery System



Payload

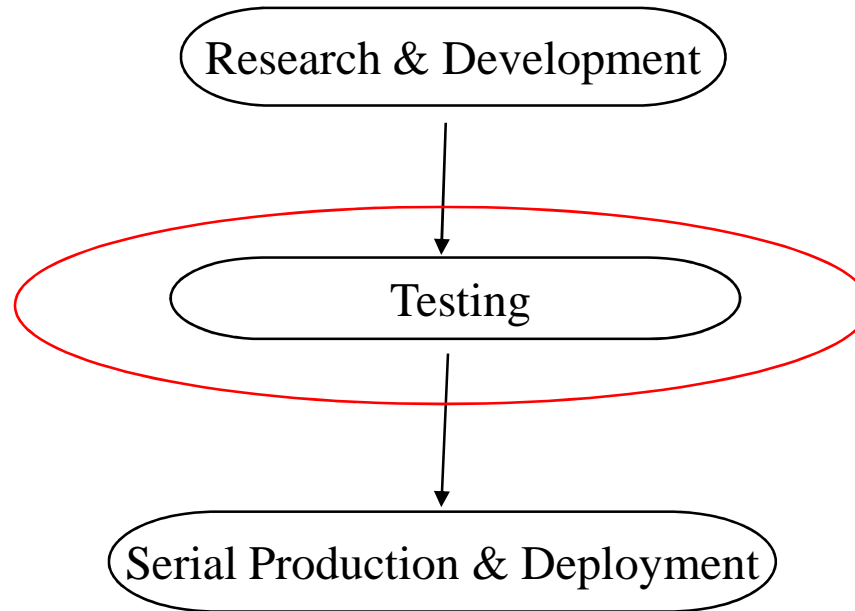
Guidance & control

Propulsion

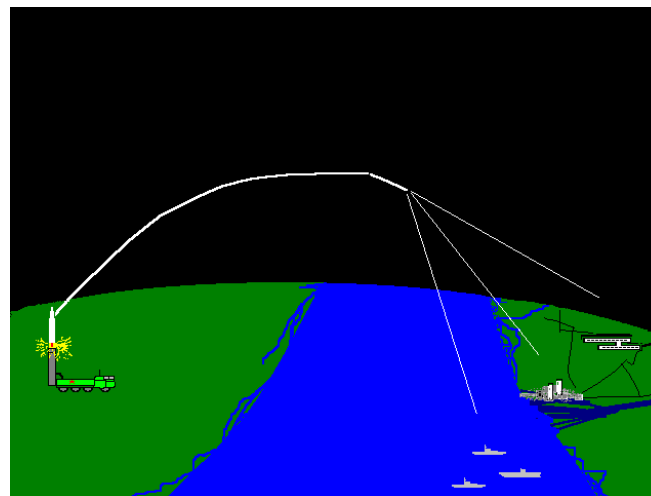
Liquid

Solid

Important Stages in Acquisition



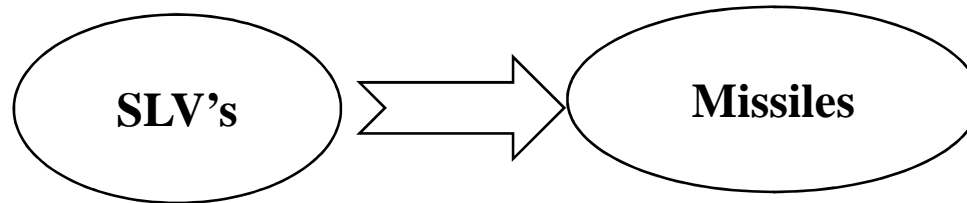
Differences Between an SLV and a Ballistic Missile



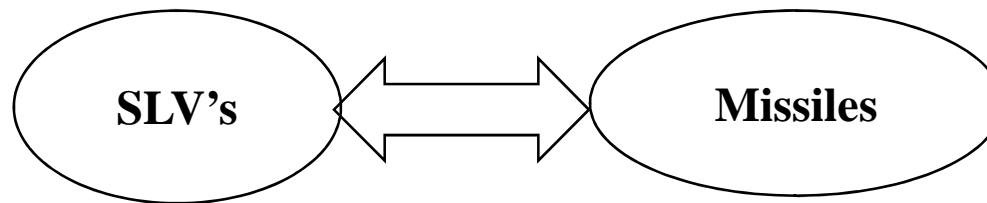
Hague Code of Conduct

- Reflected the concern of Satellite Launch Vehicles and Ballistic Missiles
- Explicitly stated that
 - “ states should not be excluded from utilizing the benefits of space for peaceful purposes, but that, in reaping such benefits and in conducting space related cooperation, they must not contribute to the proliferation of Ballistic Missiles capable of delivering weapons of mass destruction” (2f).
 - “Space Launch Vehicle Programs should not be used to conceal Ballistic Missile programmes” (2g).

Questions?



**Hatf-I, Alacran, Sonda Series and
SLV-3**



RSA-3, Taepodong-I, Al abed/Tammouz, Jherico-2/Shavit, Shahab-3



Korean Sound Rockets, Rohini, KSLV, PSLV/GSLV and VLS

Approach

- Published Sources
- Trajectory Modeling Softwares using fundamental equations of motion
- In process- Imagery analysis softwares
- Data Obtained from Infrasonic sensors

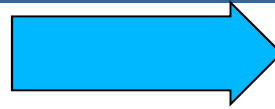
Space Launchers Converted to Missiles

Case Studies:

- Pakistan's Hatf-1 and Argentinian Alacran/Condor -1
- Brazil's MB/EE series missiles derived from Sonda series of rockets
- India's SLV-3 a four stage
- A speculative Case of Taiwan's SLV

Status : Except India' Agni series more or less all these programs are abandoned!!!!

Space Launchers



Missiles

- Technical Factors:
 - Hatf-1 and Alacran had very similar physical dimensions, similar thrust levels, thrust ratings were similar and almost identical specific impulses!
 - Both of them were single staged solid rocket motors
 - Similarly SLV-3 and Sonda-3 had striking similar physical dimensions
 - Similarities with regard to their thrust and specific impulse levels
 - Not a lot of flight testing.....
 - All programs had foreign assistance!



SLV's ↔ **Ballistic Missiles**

- **Six Cases:**

South Africa's RSA-3

Argentina's Condor-SLV project

North Korea's Taepodong-I,

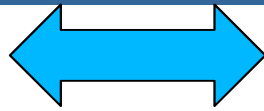
Iraq's Al Abid/Tammouz

Israel's Jericho-2/Shavit

Iran's Shehab-3

Common Themes: All the above weigh approximately 15-25 tons (2 stages each of 10-15 tons), can carry a payload across to around 1000-2500 Kms and are capable of launching a few 100 kgs of payload to Low Earth Orbit

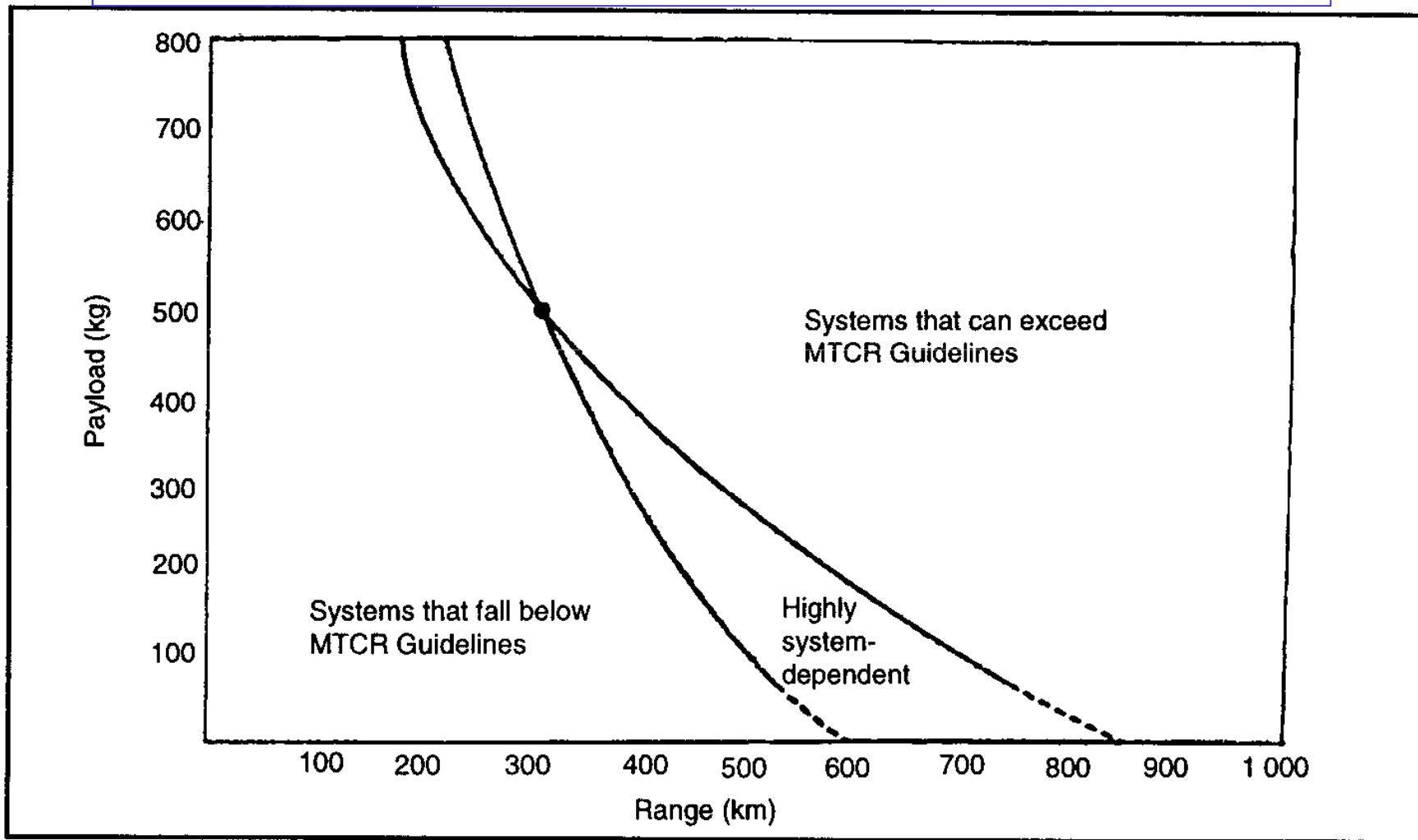
SLV's



Ballistic Missiles

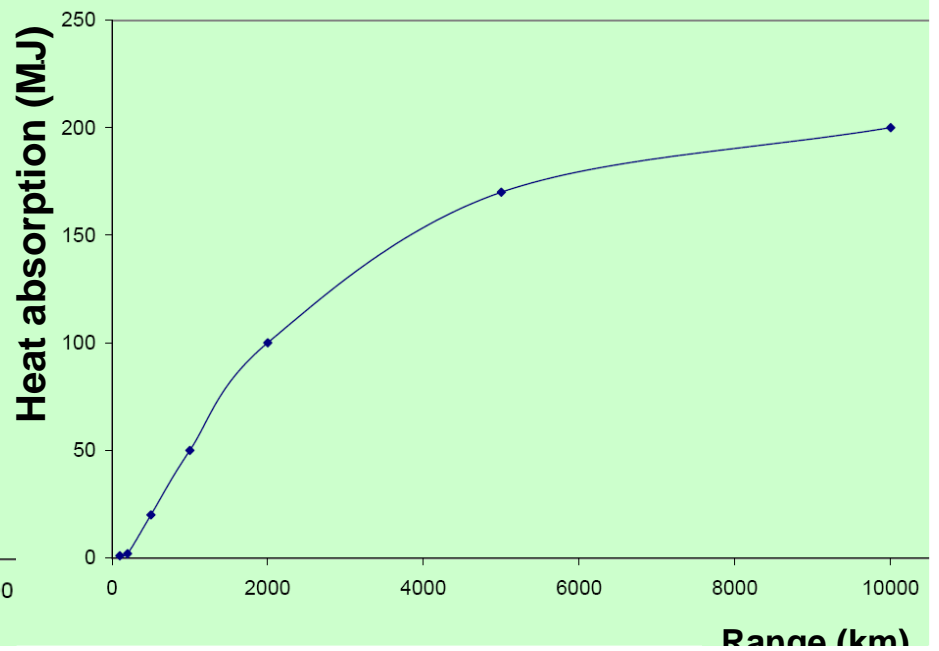
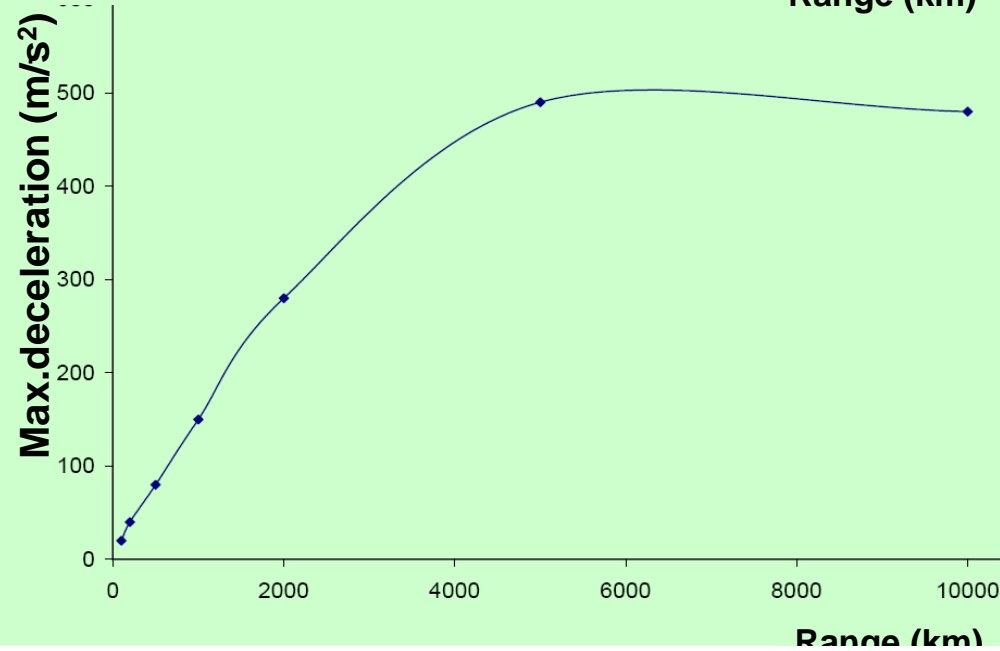
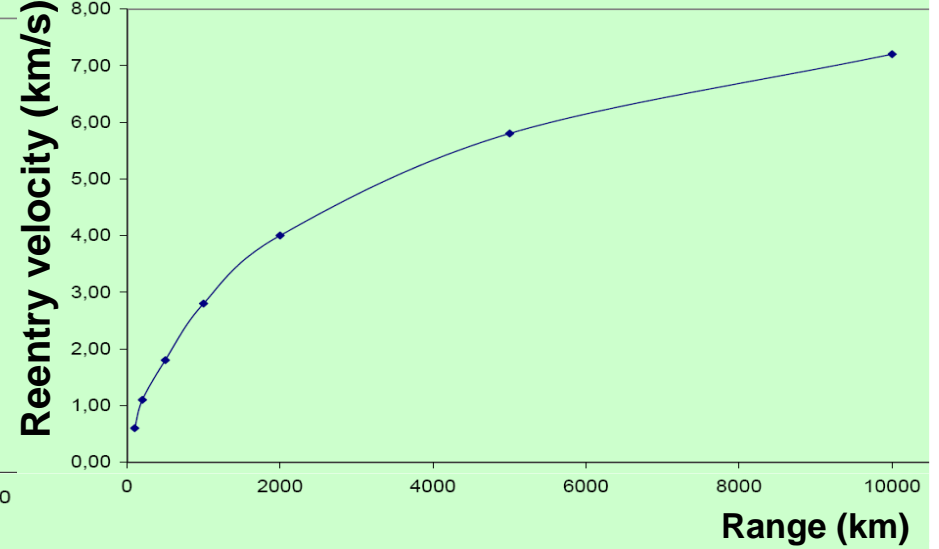
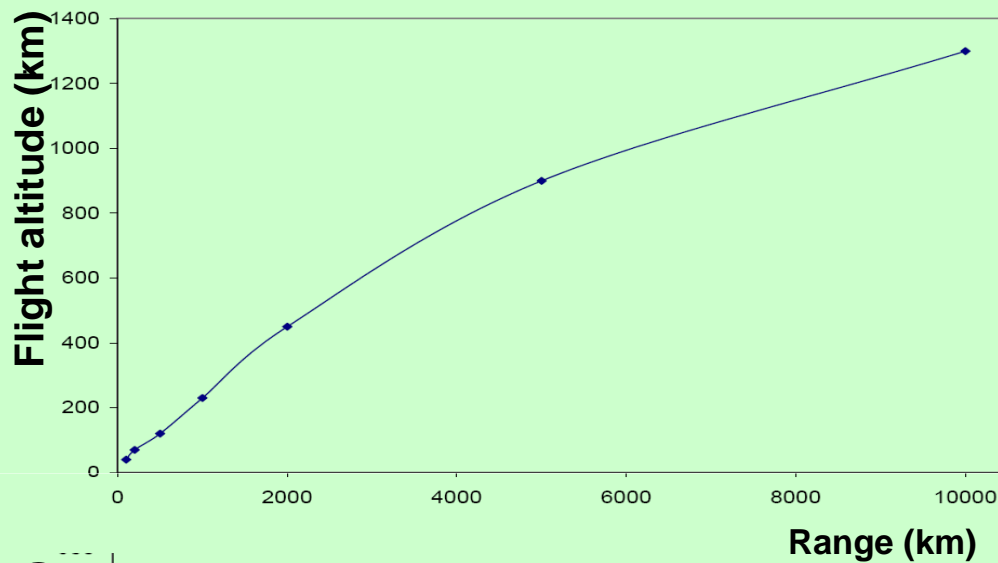
- Technical Factors:
 - RSA-3, Taepodong-I, Jericho-2, Shaviyt and Tammouz had very identical physical dimensions
 - Identical Thrusts
 - Iraq, Iran and N. Korea employed liquid propellant technology while Israel and S. Africa used the solid propellant route
 - Staging
 - Clustering in the case of Iraq's Tammouz
 - Trend seems to be moving towards solid propellants
 - Not a lot of flight testing
 - The role of foreign assistance

Range-Payload Tradeoff



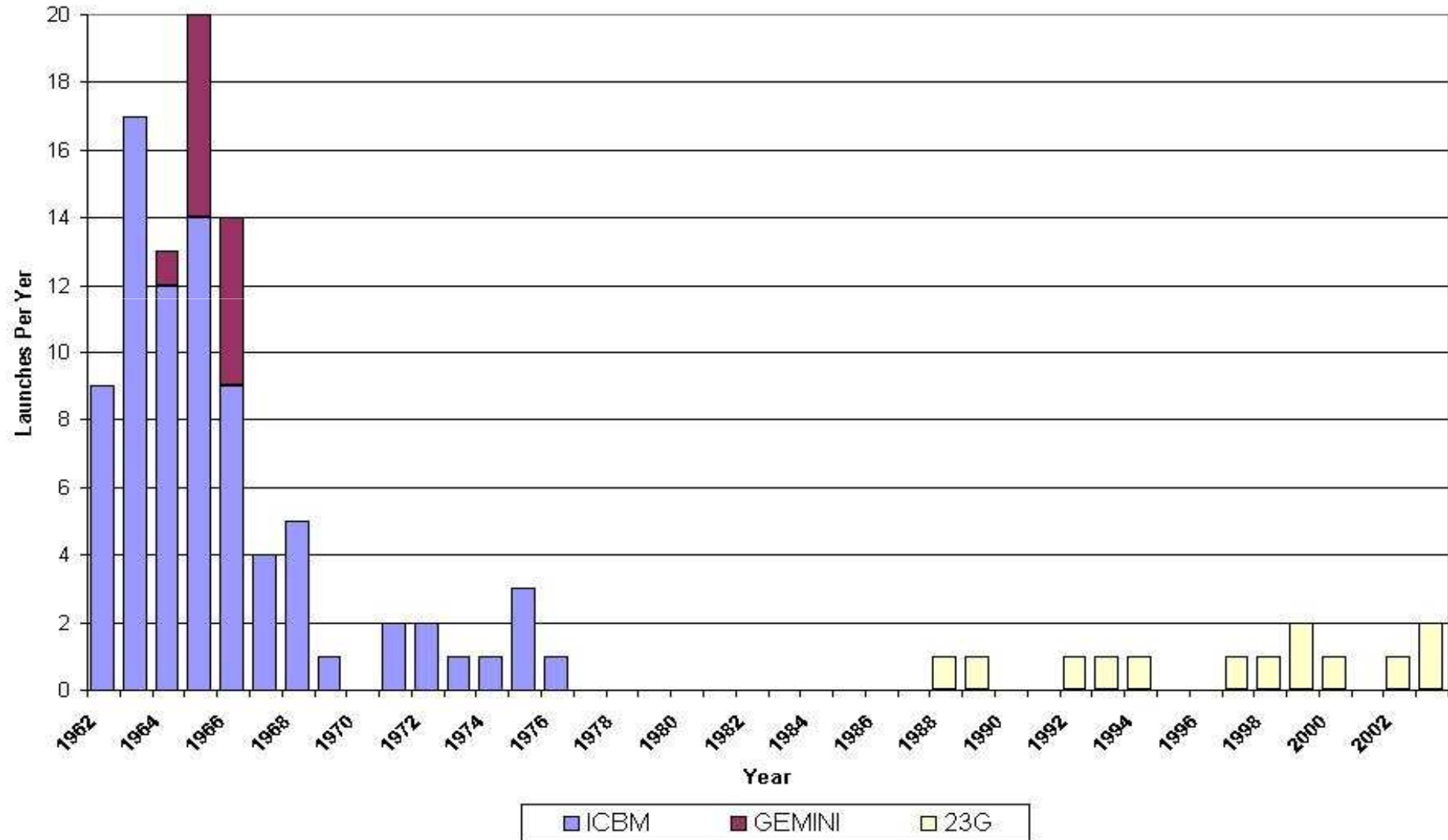
MTCR is the 1987 Missile Technology Control Regime to restrain missile exports

Increasing Demands with Missile Range



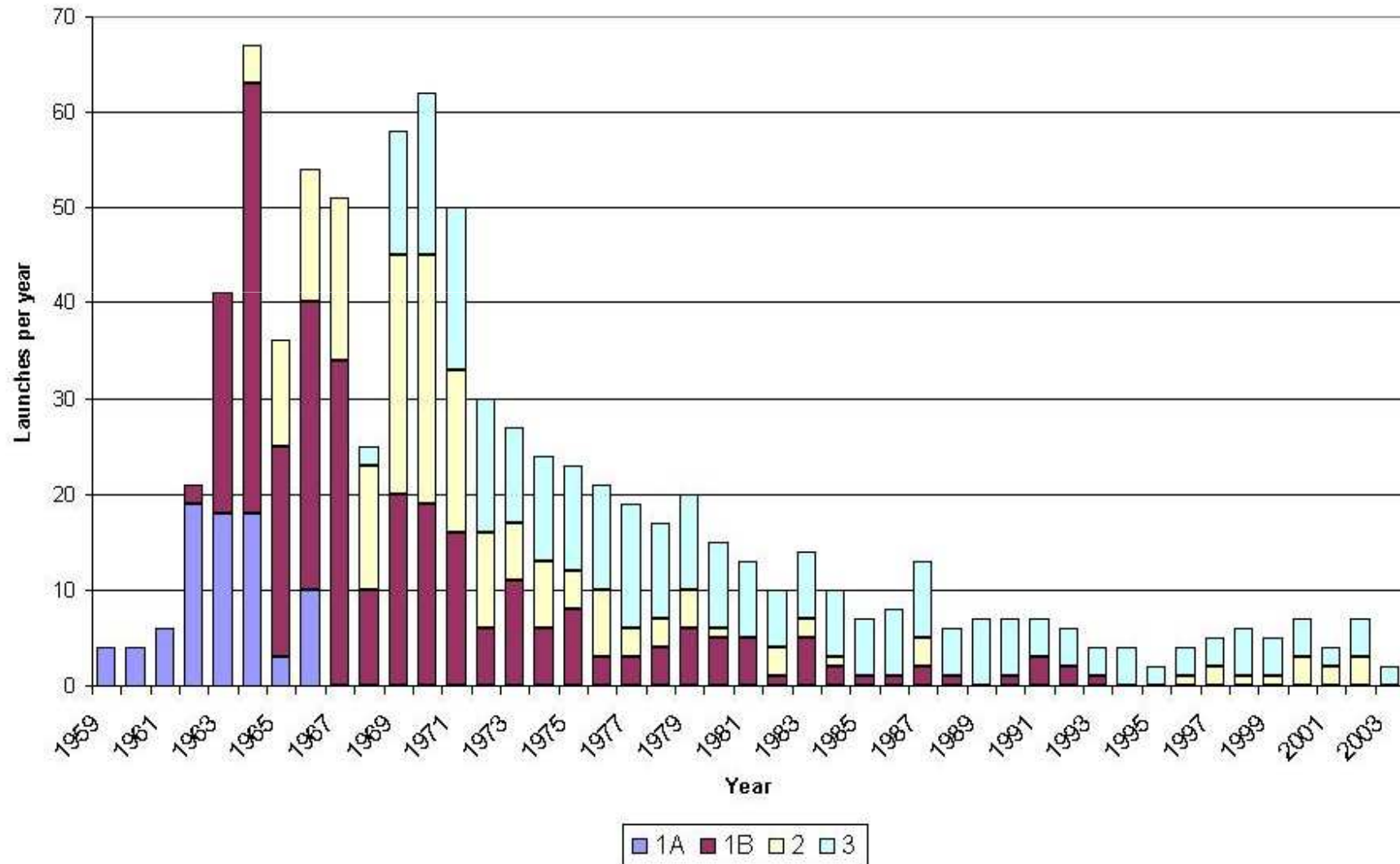
Missile Launches: Titan 2

Titan 2 Launches by Year by Type



Missile Launches: Minuteman

Minuteman ICBM Launches by Type by Year

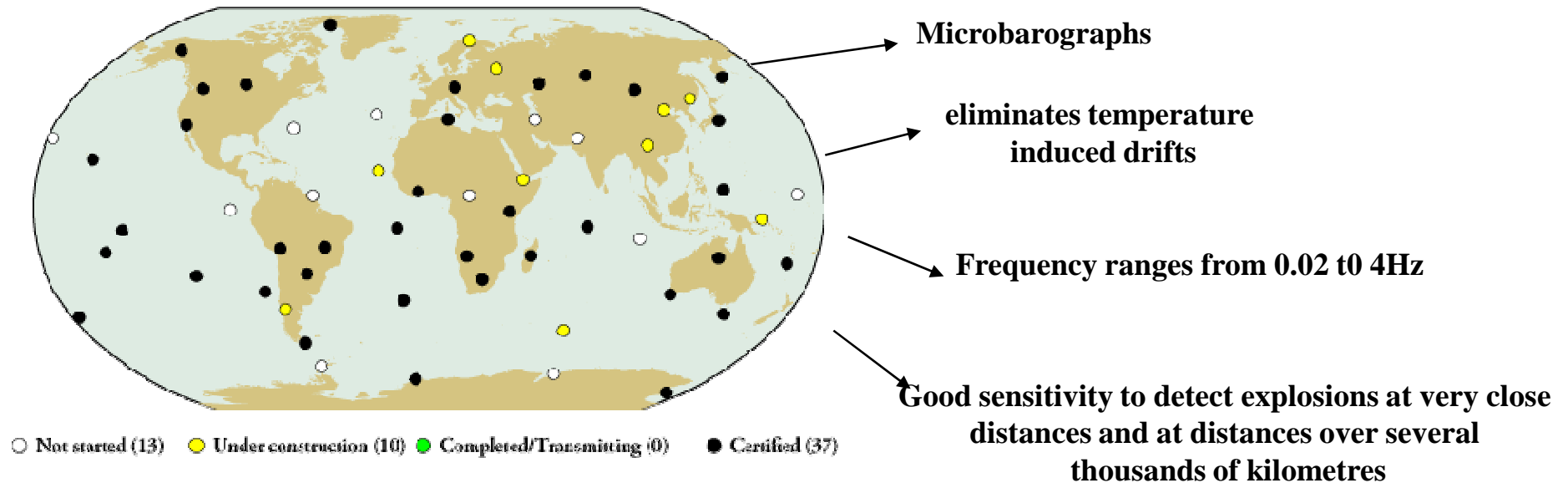


The What Question

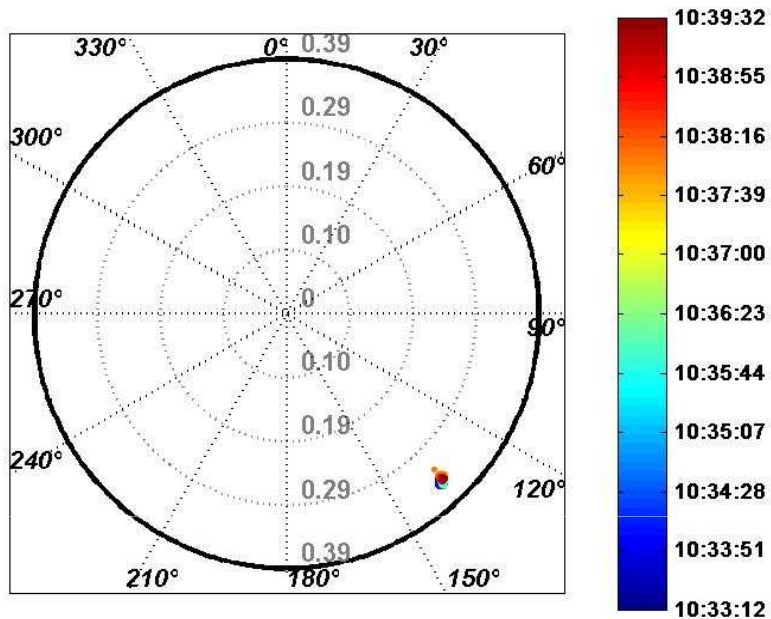
- The role of foreign support/collaboration- Political Question
- Requires Extensive Flight Testing - Technical Question
- Address Threat Perception - Psychological Question/Political Question

IMS Infrasound Network

Infrasound Network (60 Stations)



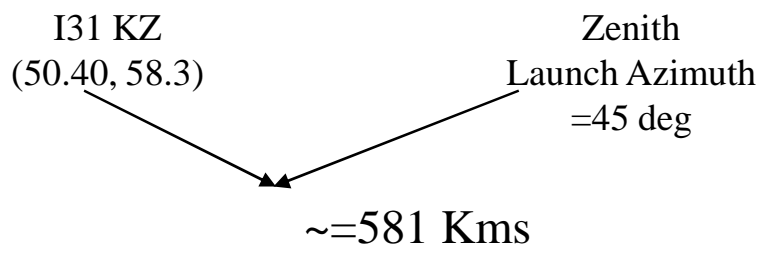
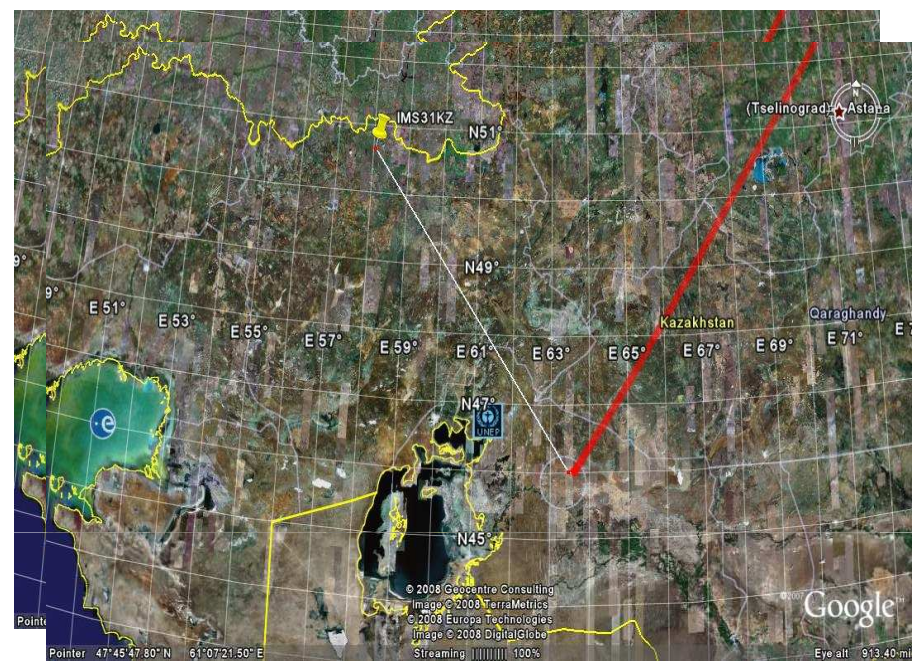
Source: www.ctbto.org



Time (HH:MM:SS) ▾

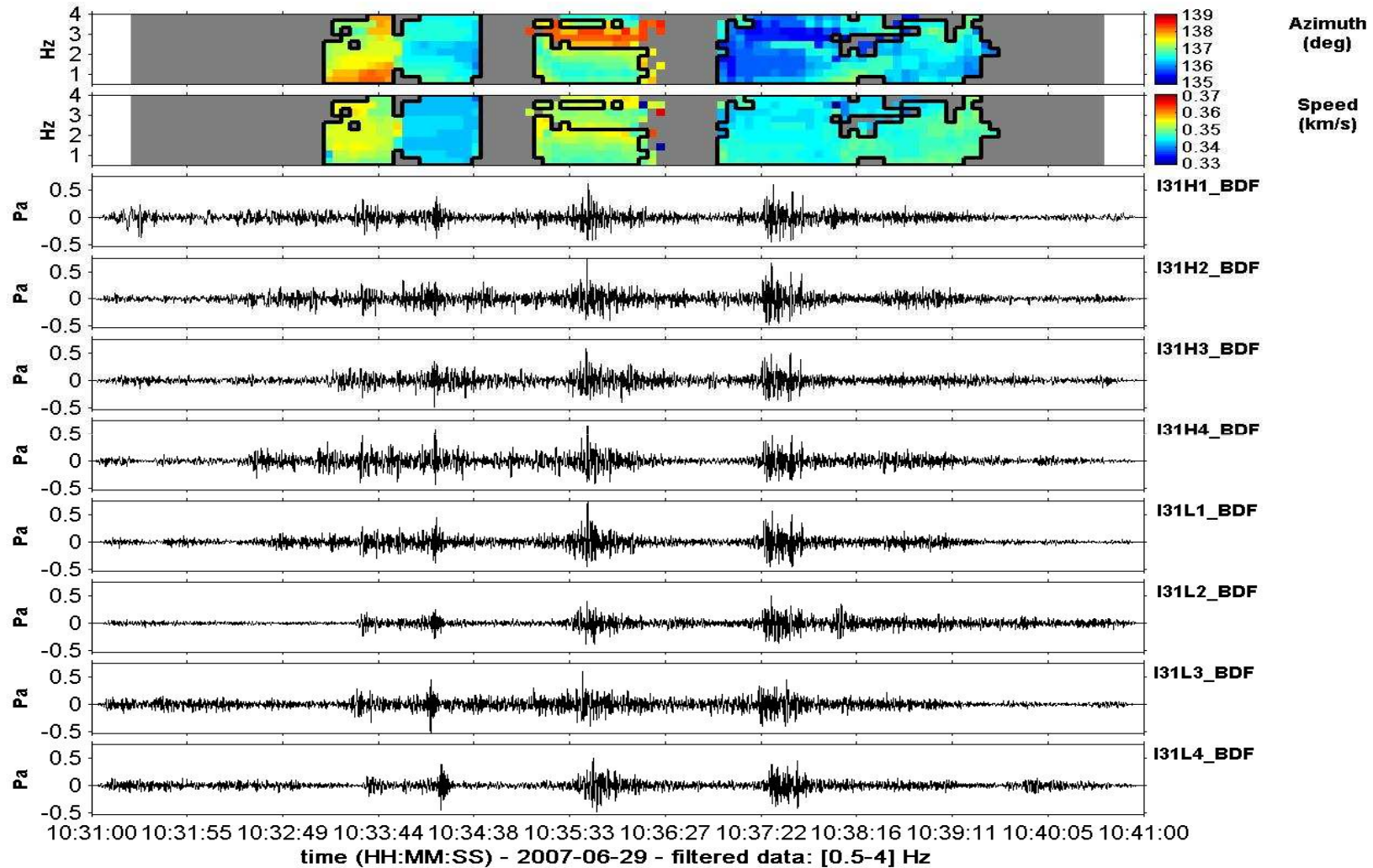
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489 pixels ▾
 Speed = 0.347 ± 0.004 km/s
 Azimuth = 136.5 ± 0.6 °
 Frequency = 2.061 ± 1.060 Hz
 Amplitude = 0.042 ± 0.032 Pa RMS



Zenit Launch 29th June 2007 Detected I31 Aktyubinsk ~10:33 GMT

Zenit Launch



Zenit Launcher 29th June 2007 GMT 10:00

Verification: Flight Tests Practical Limitations

Detection Range

$\text{Log } R = -2.758 + 1.3 \log (\text{NP})$ (Brown et. al, ISROP, 2007)

R is Range in KM

NP rocket noise power in Megawatts



Scud-B

Max 130 Kilometers

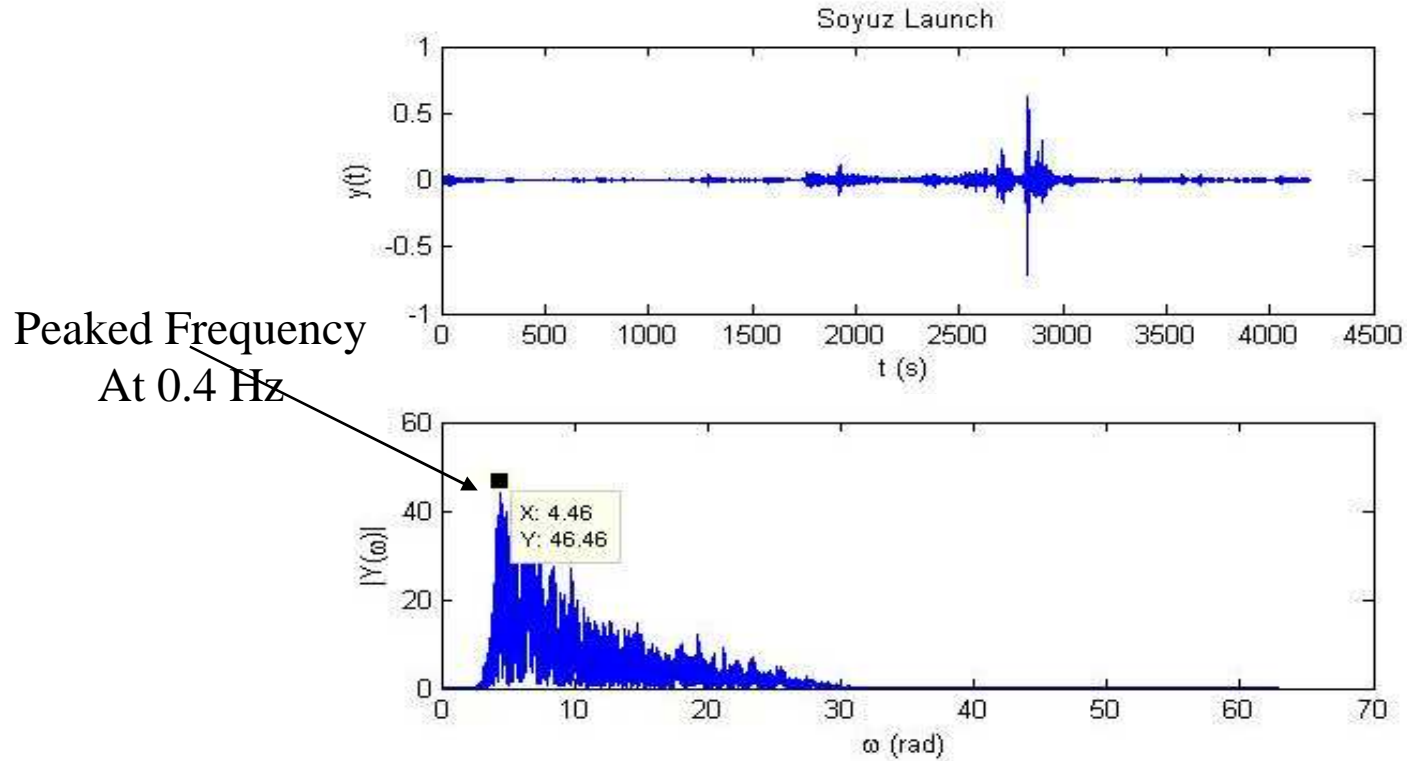


Shahab-3

Max 700 Kilometers



Rocket Launch Detection



Soyuz Launch Detected by I31 on 15th June, 2006.

Verifying advance notification of flight tests?

- Verification of pre-notification of missile tests and its impact on stability
- Article in Disarmament Forum examines use of these sensors for cooperative verification at regional level
- Verifying any future treaties against weapons in space: A treaty can be divided into a layered approach: onsite verification, launch detection and post-launch confirmation; space situational awareness and on-orbit inspection (Brunea and Lofquist-Morgan, 2007, Disarmament Forum)



Discussion