Missile Launch Surveillance and Proliferation Transparency: an Introduction

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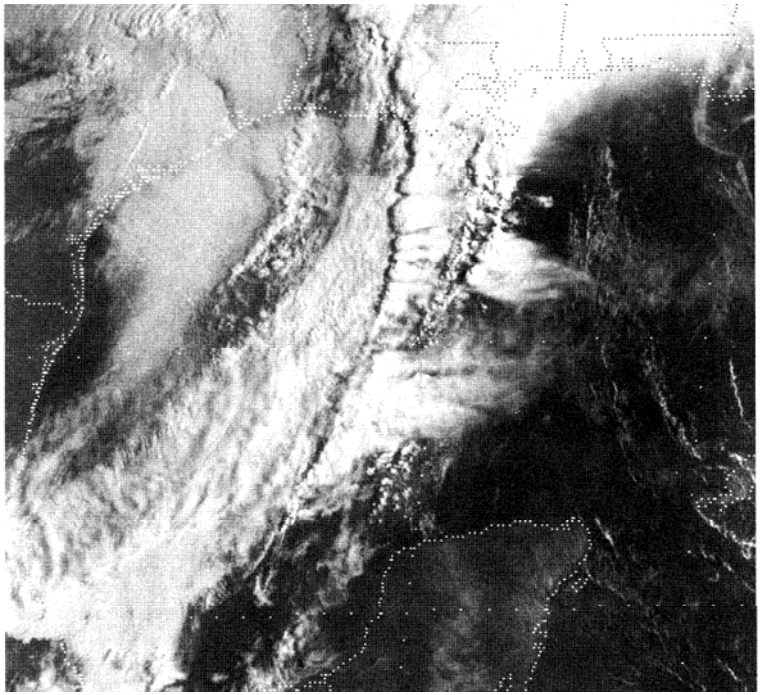
MIT's Program on Science, Technology and Society

1. **How Satellites Observe Missiles from Space**
2. **Potential Missile Characteristics to Observe**
3. **Design and Policy Choices**

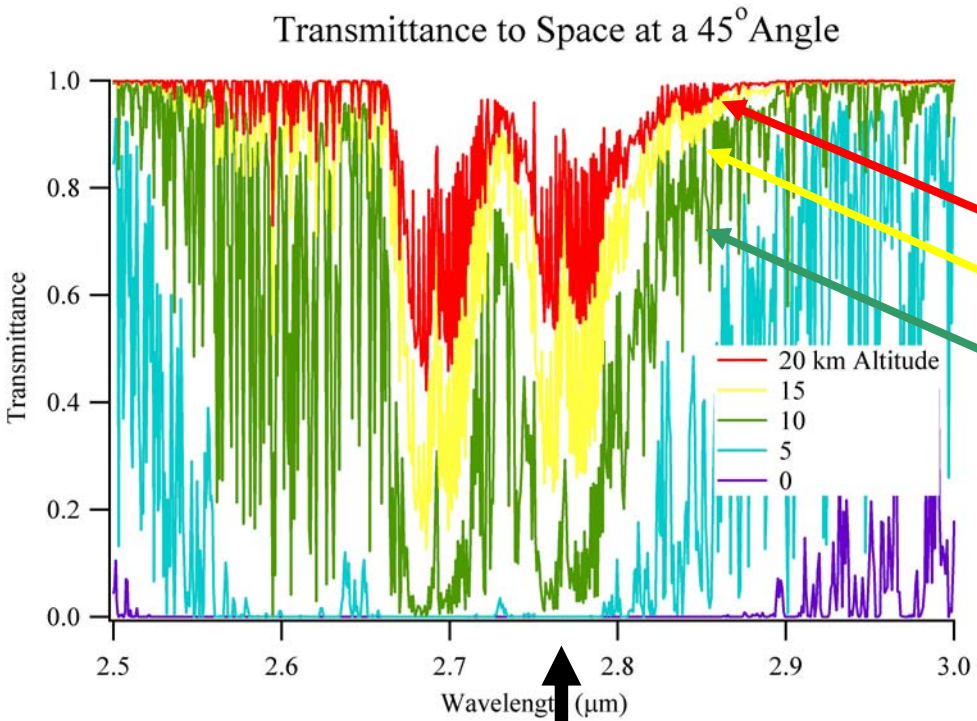
Backgrounds, which can arise from a number of natural and even man made phenomena, must eliminated.

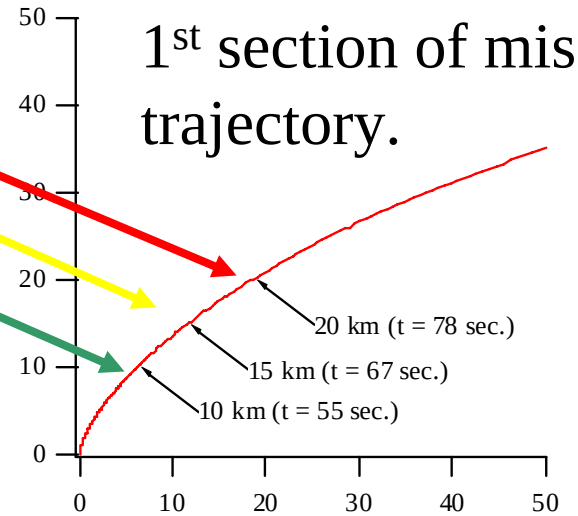


Sunlight reflected from clouds or snow fields

Forest fires (or even oil field flare-offs) could potentially cause false signals.

Viewing missile plumes in an absorption band reduces natural backgrounds.

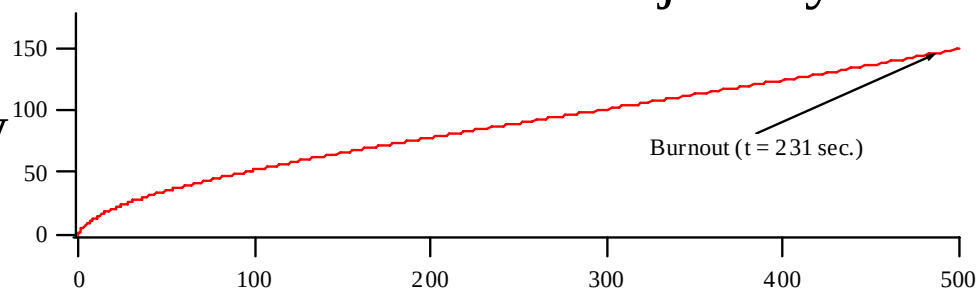




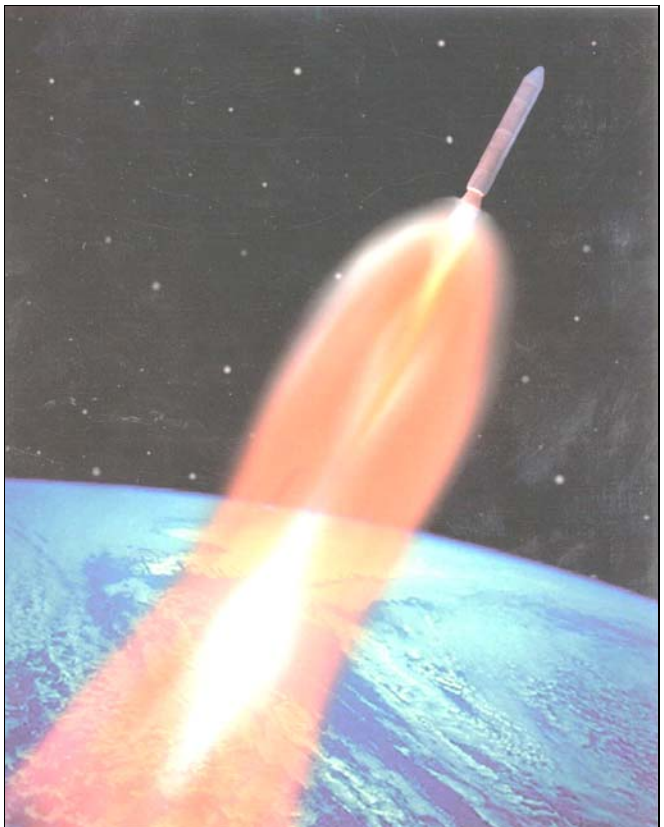
1st section of missile trajectory.

Region used by DSP satellites

Missile Trajectory



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



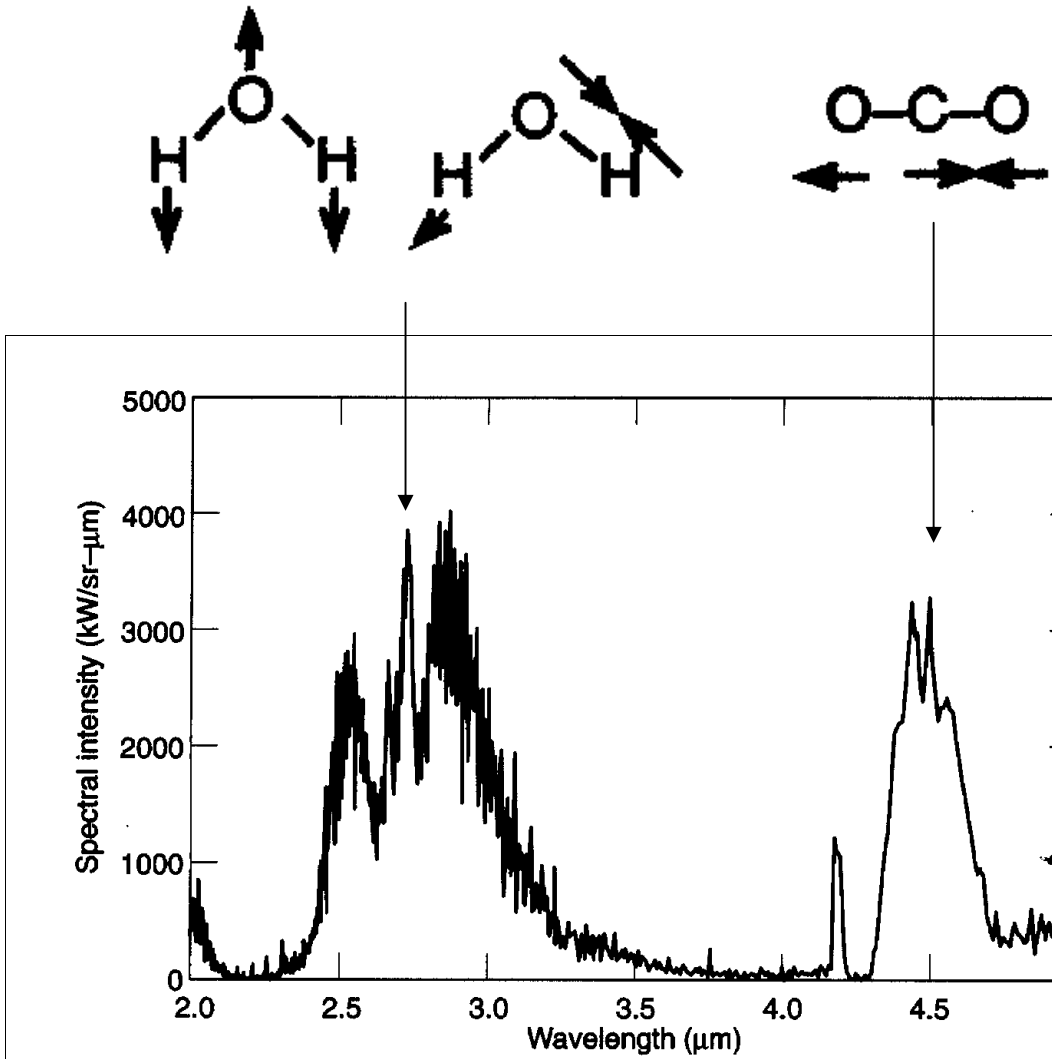
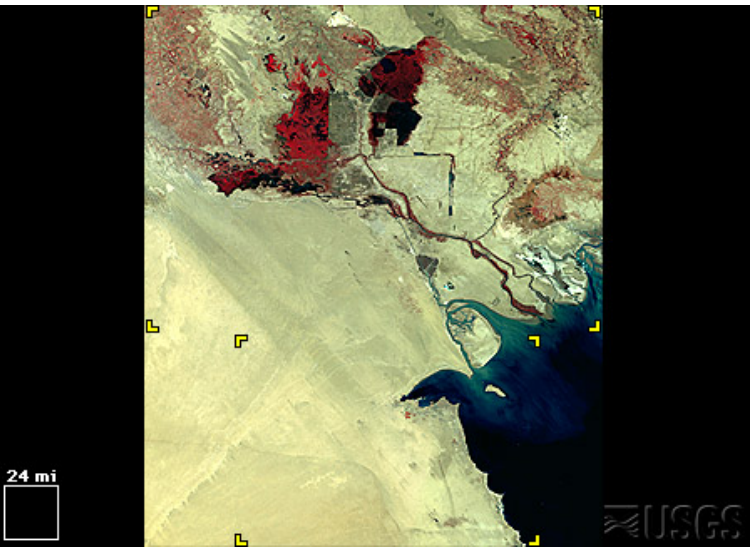


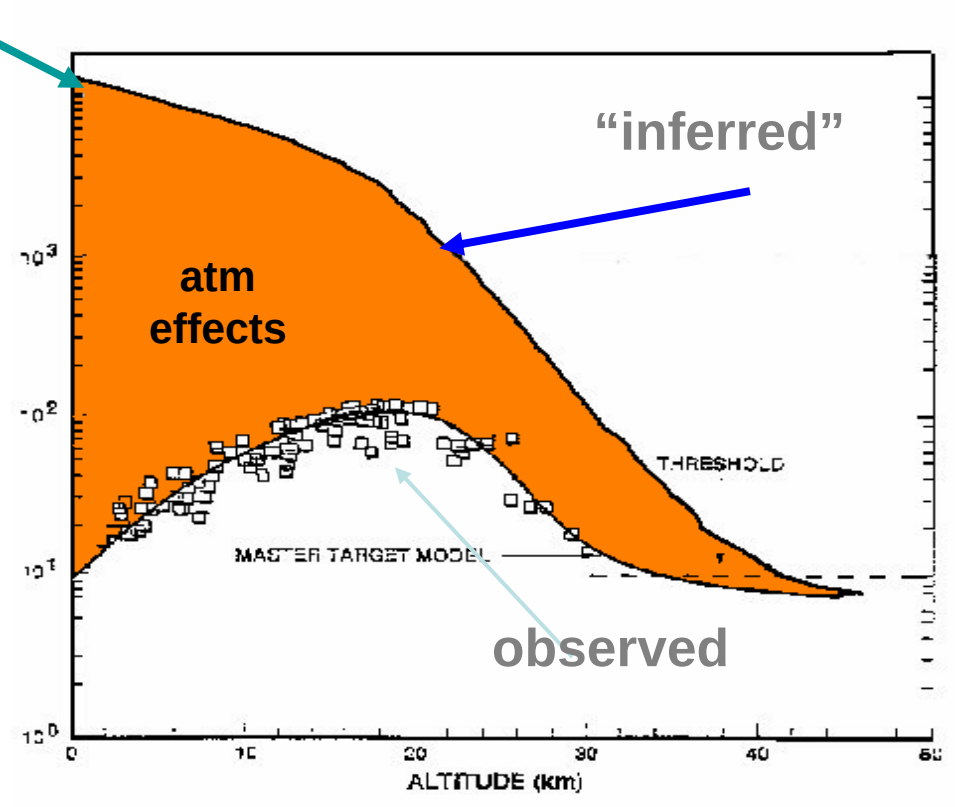
Fig. 5.3. Spectra of Titan IIIB at 18 km and viewing aspect of 48 deg.

These declassified data appear to show the response of DSP to SCUD missiles during the Gulf War



At launch

Observed from Satellite



Time or Altitude

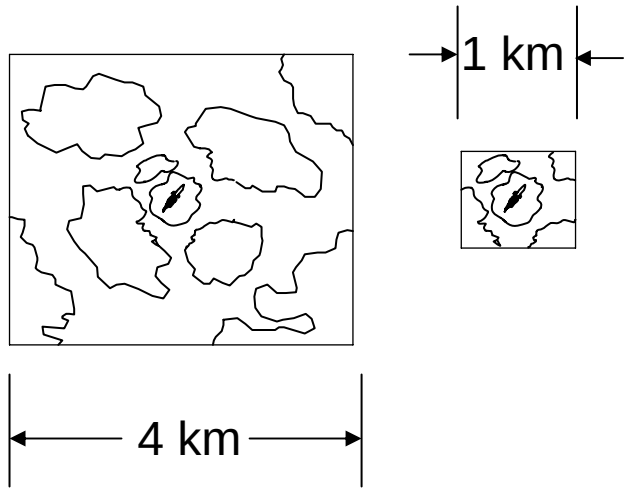
Potential Missile Characteristics that Might be Observed

- Missile Range
- Propellant Type (solid vs. liquid)
- Number of Stages
- Throw weight (i.e. nuclear capable?)
- Development Path Followed

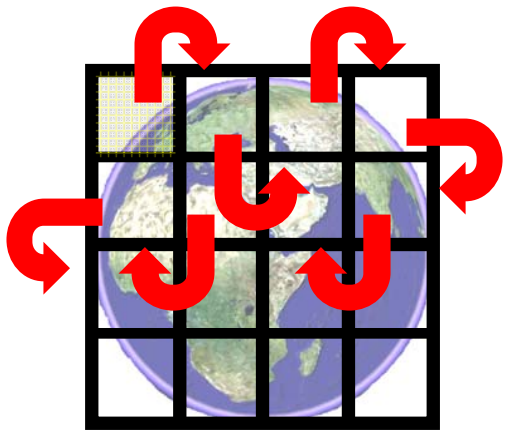
The ability to measure all of these can be either increased or decreased by choices in design.

There are two key design parameters that determine capabilities:

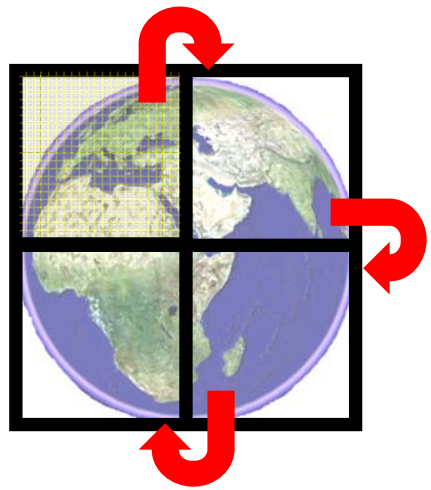
- Pixel size (as projected onto the Earth's surface)



- Revisit Time (time between observations of the same place on Earth)

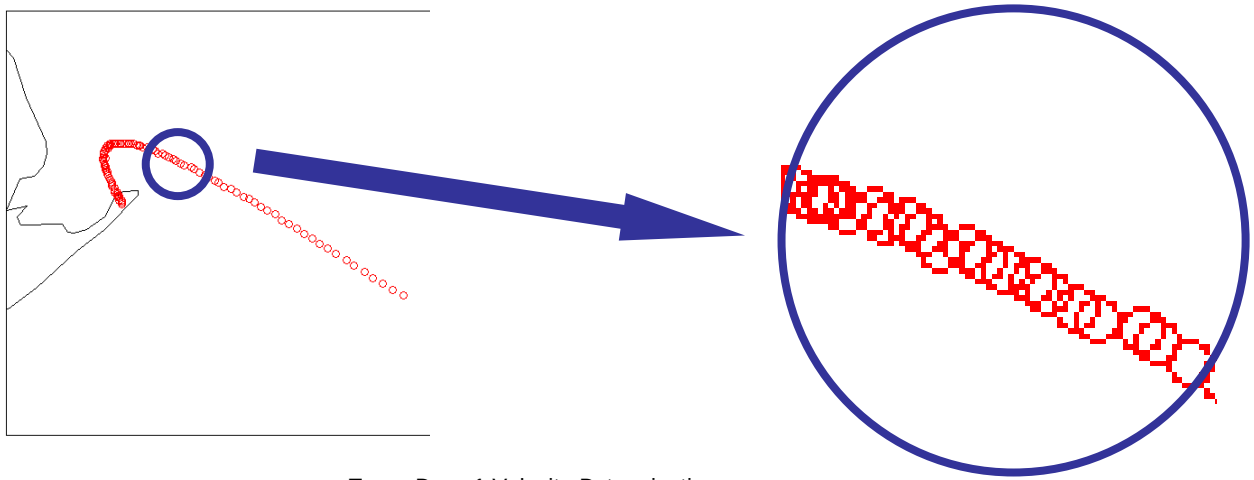


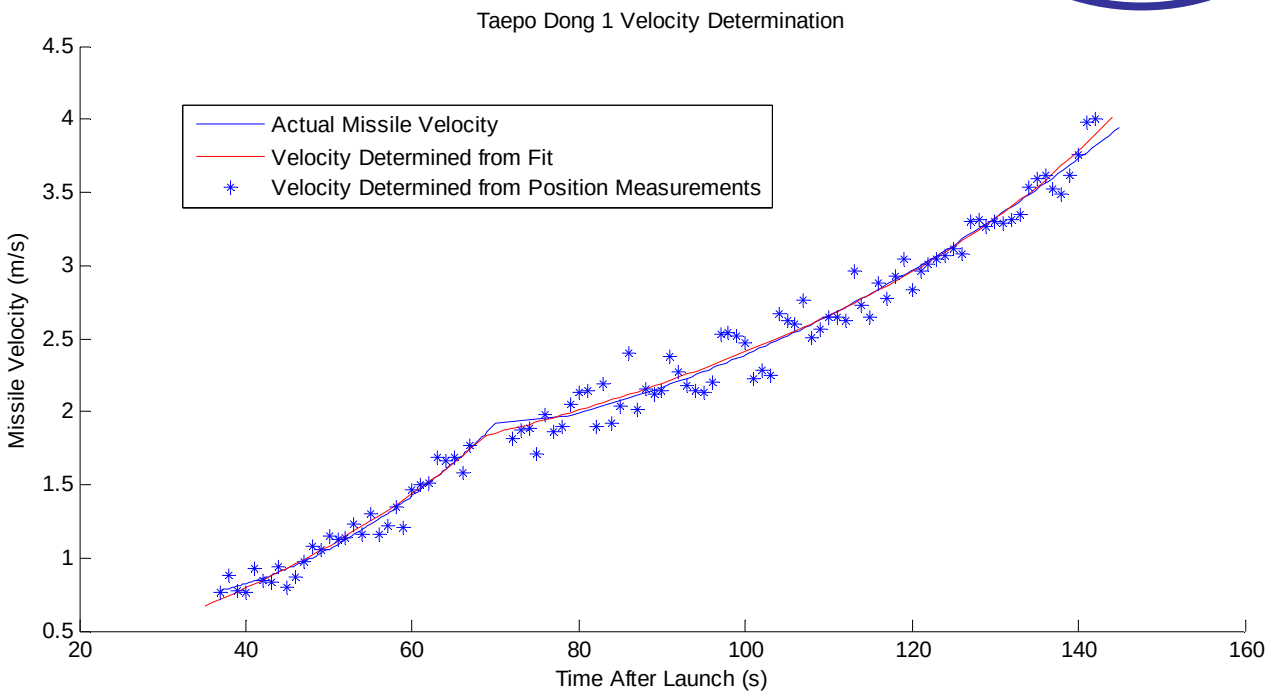
16 steps

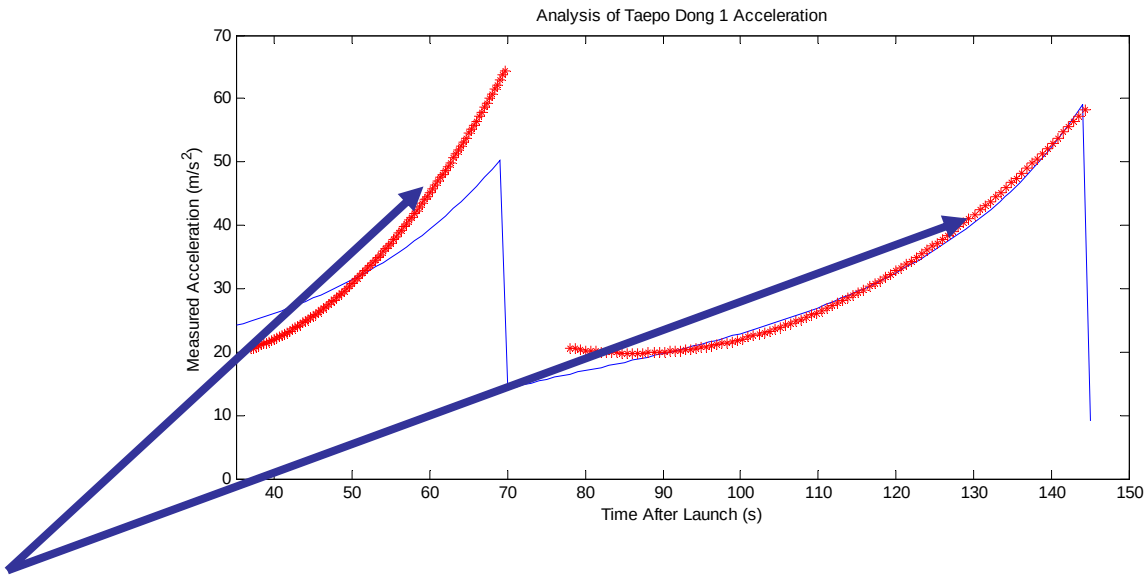


4 steps

Pixel size influences how accurately velocity and acceleration can be determined







For a given pixel size, acceleration is determined better for faster moving missiles; second (or third) stage accelerations are better determined

Estimates of how well missile characteristics can be determined:

	Range	Error on Range Estimate	Payload	Error on Payload Estimate
SCUD-B	288 km	±25 km (±9%)	1 tons	±0.35 tons (±35%)
Nodong	981	±50 (±5%)	1	±0.35 (±35%)
Taepo-Dong 1	2309	±80 (±3.5%)	0.45	±0.15 (±33%)
Long March 2C	5711	±100 (±1.8%)	2.8	±1.0 (±37%)

These assume pixels equal to 1 square km, with a 1 second revisit time.

Changing these to, for instance 4x4 km pixels and 10 second revisit time would eliminate any payload estimation capability and reduce range estimating to “short,” “medium,” and “long range” missile categorizing

Development Path effects infrastructure requirements

Clustering engines

Engine Dimensions scale as $\sim T^{1/2}$ (Thust, for a given turbopump pressure etc.)

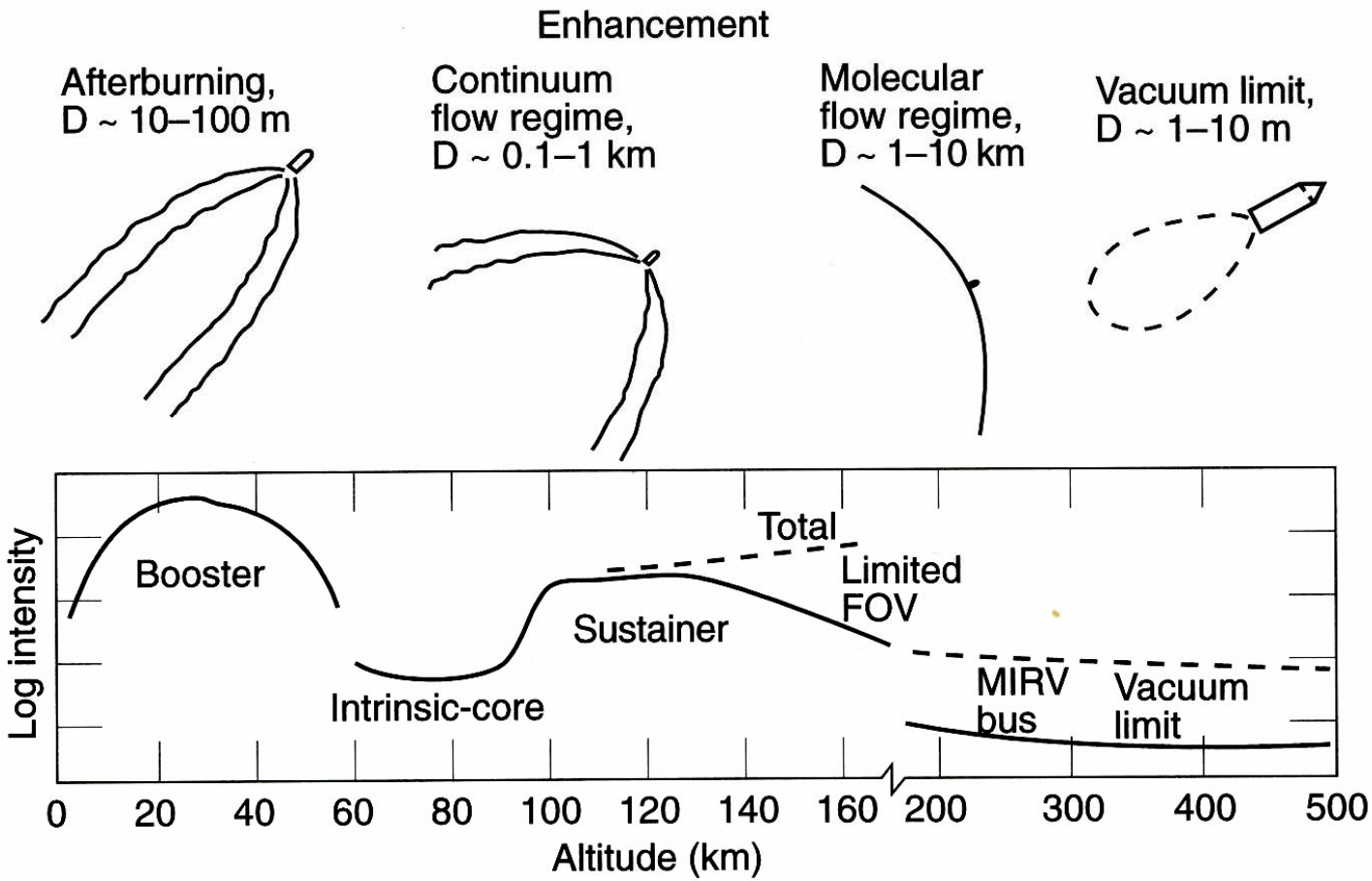
Examples of required infrastructure changes required:

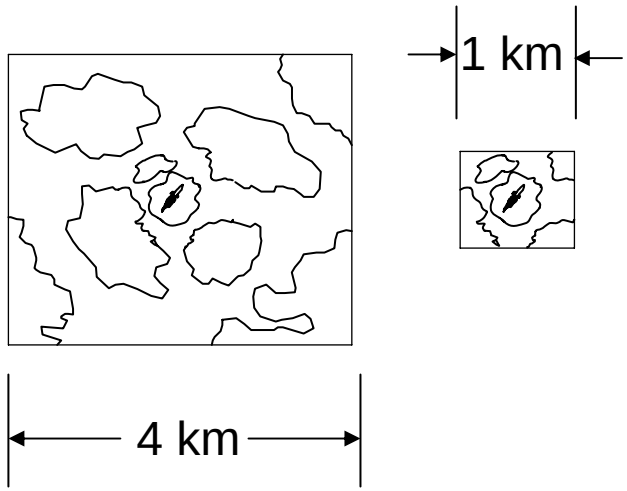
Larger flow forming machines needed to form chamber shells

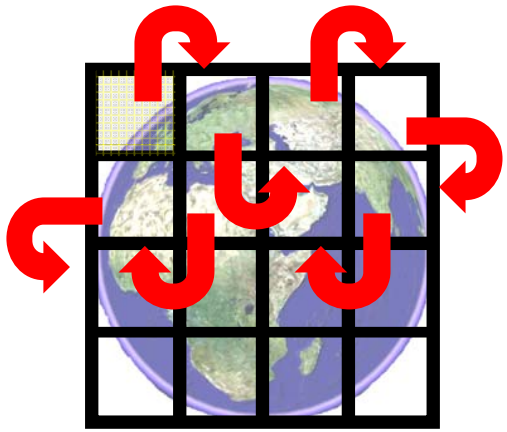
Larger vacuum furnaces for engine brazing.

Some Policy Implications

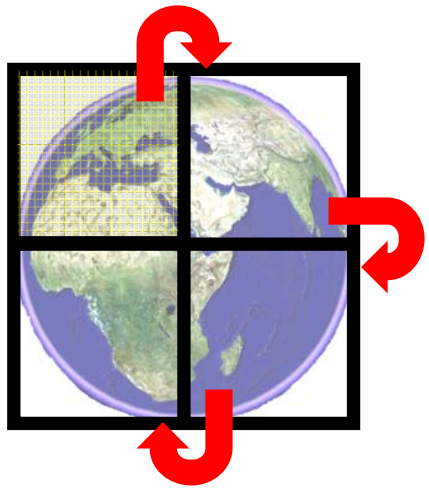
- Launch surveillance can increase missile proliferation transparency or it can be designed not to reveal much information.
- Nonproliferation policy can be made independently of any sole “information provider” country.
- In the absence of information, nations tend to over-estimate the threat from other countries’ weapons development—this can be reduced by the proposed system.


Enhancement
Afterburning,
D ~ 10–100 m
Continuum
flow regime,
D ~ 0.1–1 km
Molecular
flow regime,
D ~ 1–10 km
Vacuum limit,
D ~ 1–10 m
Log intensity
Booster
Intrinsic-core
Sustainer
Total
Limited
FOV
MIRV
bus
Vacuum
limit
0
20
40
60
80
100
120
140
160
200
300
400
500
Altitude (km)


1 km
4 km

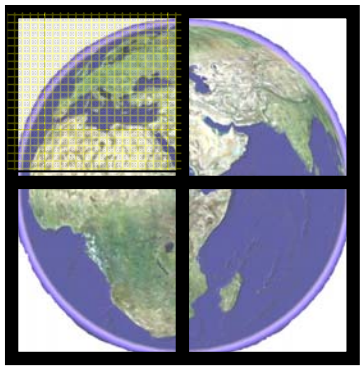


16 steps

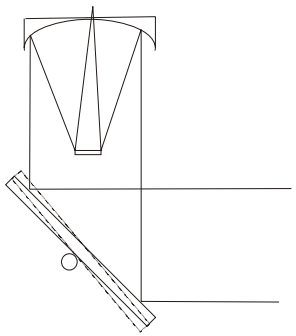


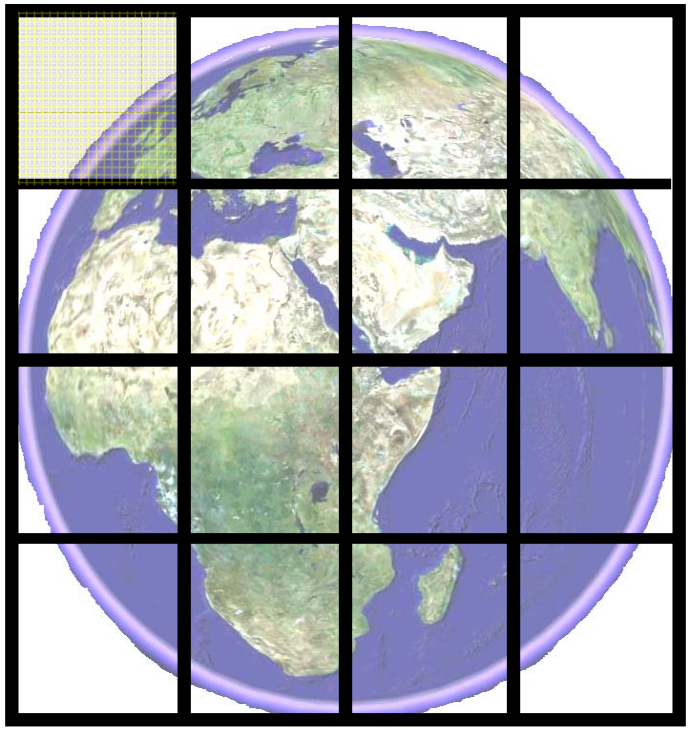
4 steps

Design parameters for single 2048x2048 FPA



4 steps





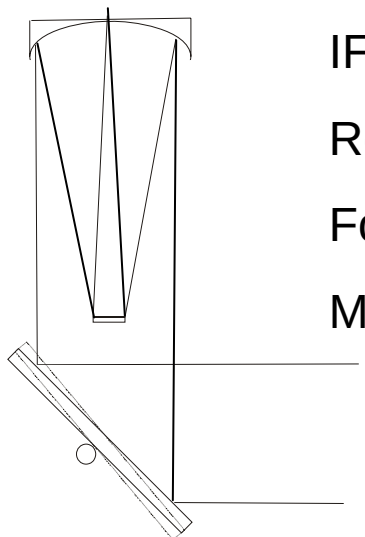
16 steps

IFOV=3.11 km

Revisit time = 1 sec.

Focal length = 0.5 m

Mirror diameter = 0.11 m



IFOV=1.6 km

Revisit time = 4 sec.

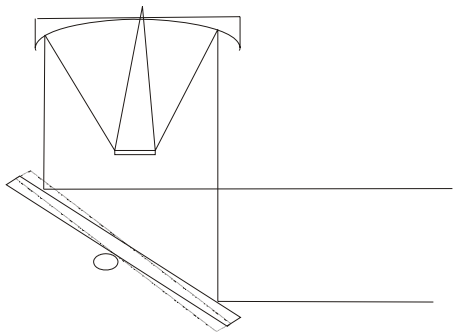
Focal length = 1 m

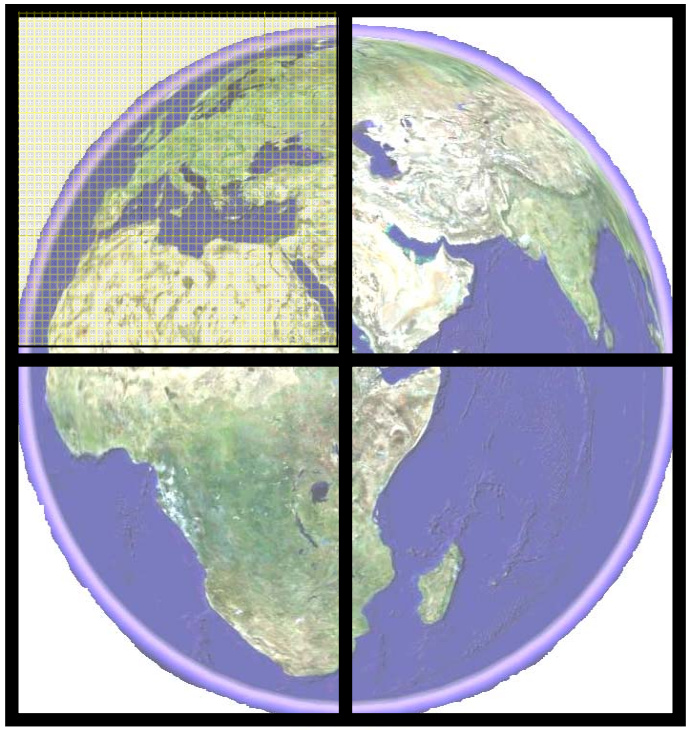
Mirror diameter = 0.11 m

Determines Earth image size.

Determines size of FPA illuminated.

No steps





4 steps

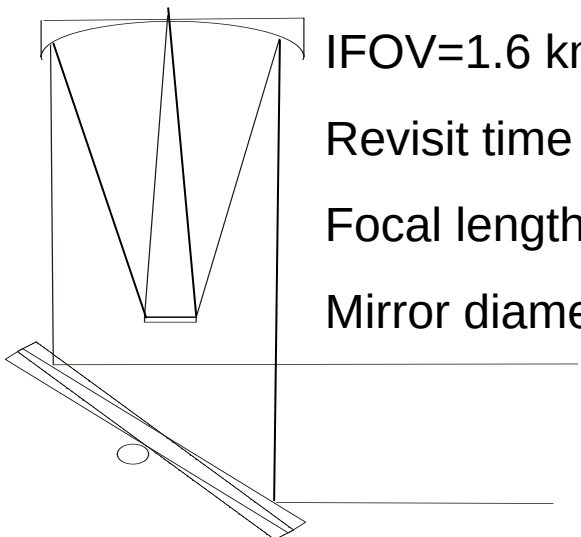
Design parameters for array of 4 2048x2048 FPAs

IFOV=3.11 km

“Revisit time” = integration time ~ millisec.

Focal length = 0.5 m

Mirror diameter = 0.22 m



IFOV=1.6 km

Revisit time = 1 sec.

Focal length = 1 m

Mirror diameter = 0.22 m