Physics 280: Session 14

Plan for This Session

Questions

Extra Credit Opportunity A

Midterm Exam, Thursday March 20th

Schedule Midterm Review Session

Module 4: Reducing the Threat of Nuclear Terrorism

News

Module 5: Nuclear Weapon Delivery Systems

Extra Credit Opportunity (I)

Teach-In: Crisis in Crimea & Ukraine

Sponsors: Program in Arms Control, Disarmament and International Security (ACDIS), Center for Global Studies, European Union Center and Russian East European and Eurasian Center (REEEC)

Extra Credit Opportunity (I)

Teach-In on the Crisis in Crimea + Ukraine

4-5.15 PM, Tuesday, March 11th, 160 English Building

(1) Attend Teach In – sign in sheet (!)
(2) Submit essay electronically by Friday March 14th at 5pm
(prompt is available on course web-page)

Schedule Midterm Review

Please click

A if "can't make time"

B if "can make time but inconvenient"

	A	B
(1) Saturday, March 15, 5-7pm		
(2) Saturday, March 15, 6-8pm		
(3) Saturday, March 15, 7-9pm		

	A	B
(4) Sunday, March 16, 5-7pm		
(5) Sunday, March 16, 6-8pm		
(6) Sunday, March 16, 7-9pm		

	A	B
(7) Tuesday, March 15, 5-7pm		
(8) Tuesday, March 15, 6-8pm		
(9) Tuesday, March 15, 7-9pm		

What We Need To Do

What We Need to Do (Important)

The centerpiece of a strategy to prevent nuclear terrorism must be to deny terrorists access to nuclear weapons or materials

To accomplish this, nuclear terrorism experts argue that we must insist on “Three No’s” —

1. No loose nukes
2. No new nascent nukes
3. No new nuclear weapon states

What We Need to Do (Important)

1. No Loose Nukes

Insecure nuclear weapons or materials anywhere pose a grave threat to all nations everywhere.

The international community can therefore rightly insist that all weapons and materials—wherever they are—be protected to a standard sufficient to ensure the safety of citizens around the world.

Russia has been the principal focus of concern for the past decade, but other countries—such as Pakistan and North Korea— are of growing concern.

What We Need to Do (Important)

2. No New Nascent Nukes

Construction of any national production facilities for enriching uranium or reprocessing plutonium must be prevented.

The former head of the IAEA, Mohamed ElBaradei, has said that the existing NPT system made a mistake in allowing non-nuclear weapon states to build uranium enrichment and plutonium production plants.

Closing this loophole will require deft diplomacy, imaginative inducements, and demonstrable readiness to employ sanctions to establish a bright line.

What We Need to Do (Important)

3. No New Nuclear Weapons States

This means drawing a line under the current eight nuclear powers (the United States, Russia, Great Britain, France, China, India, Pakistan, and Israel) and unambiguously declaring "no more".

North Korea poses a decisive challenge to this policy. But if North Korea is accepted as a nuclear weapons state, South Korea and Japan are likely to follow within a decade, making Northeast Asia a far more dangerous place than it is today

The spread of nuclear weapons states makes it more likely that nuclear weapons or materials will be sold to others, including terrorists, or stolen by them.

End of Nuclear Terrorism Module

News and Discussion

REUTERS

Russia test-fires ICBM amid tension over Ukraine

Tue, Mar 4 2014

MOSCOW (Reuters) - Russia said it had successfully test-fired an Intercontinental Ballistic Missile (ICBM) on Tuesday, with tensions running high over its military intervention in Ukraine's Crimea region.

A U.S. official said the United States had received proper notification from Russia ahead of the test and that the initial notification pre-dated the crisis in Crimea. The Russian Defence Ministry could not be reached for comment.

The Strategic Rocket Forces launched an RS-12M Topol missile from the southerly Astrakhan region and the dummy warhead hit its target at a proving ground in Kazakhstan, Defence Ministry spokesman Igor Yegorov told state-run news agency RIA.

The launch site, Kapustin Yar, is near the Volga River about 450 km (280 miles) east of the Ukrainian border. Kazakhstan, a Russian ally in a post-Soviet security grouping, is further to the east.

US Reaction on Missile Tests in North Korea

US Wants UN to Act Against N Korea for Missile Tests

UNITED NATIONS March 6, 2014 (AP)

By EDITH M. LEDERER Associated Press

The United States is asking the U.N. Security Council to take action against North Korea for firing two rounds of ballistic missiles in the past week in "clear and calculated violations" of U.N. sanctions.

…

Under U.N. sanctions dating back to 2006, North Korea is prohibited from carrying out any launches that use ballistic missile technology. Subsequent U.N. resolutions require the North to abandon all ballistic missile programs.

…

The report said that according to U.S. government information, North Korea launched two Scud short-range ballistic missiles from its southeastern coast on Feb. 27 and two more Scud missiles from the same coast on March 3. It said all four missiles flew in a northeasterly direction and landed in the sea.

…

The launches appear to be a continuation of North Korea's protest of the ongoing annual military exercises between South Korea and the United States. Pyongyang calls the exercises preparation for an attack, and a test of weapons systems.

…

Last spring, North Korea repeatedly threatened to launch a nuclear war following its third nuclear test in February 2013. Recently, North Korea has pushed for improved ties with South Korea and taken conciliatory gestures, including rare reunions of Korean War-divided families last month.

Module 5: Delivery Systems

Part 1: Overview

Basic Propulsion Mechanisms

- None
  (examples: mines, depth charges)
- Explosives
  (example: artillery shell)
- Propellers
  (example: torpedo, speeds ~ 50 mph)
- Jet engines
  (example: bomber, speeds ~ 600 mph)
- Rocket motor
  (example: missile, speeds ~ 18,000 mph)
- Unconventional
  (examples: barge, boat, Ryder truck, backpack, shipping container)

Examples of Weapon Delivery Methods

Air-breathing vehicles —

- Aircrafts (manned)
- Cruise missiles (unmanned aircraft)

Rocket-propelled vehicles —

- Land-based ballistic missiles
- Submarine-based ballistic missiles
- Surface ship-based ballistic missiles*
- Space-based ballistic missiles*
- Short range rockets (no guidance)

Other —

- Artillery/howitzers
- Land mines
- Torpedoes

* Never deployed by US or USSR/Russia for nuclear weapons

Important Attributes of Delivery Systems

- Range
- Speed
- Accuracy
- Recallability
- Reliability
- Payload/throw-weight
- Ability to penetrate defenses
- Survivability (at deployment base)
- Capital and operational costs
- Safety

Air-Breathing Vehicles

Aircraft (manned) —

- Long-range ("heavy") bombers
  (examples: Bear, Blackjack, B52, B-1, B-2)
- Intermediate-range bombers
  (examples: B-29, FB-111, …)
- Tactical aircraft
  (examples: F-16, F-18, F-22, …)

Cruise missiles (unmanned) —

- Air-launched cruise missiles (ALCMs)
- Sea-launched cruise missiles (SLCMs)
- Ground-launched cruise missiles (GLCMs)

Rocket-Powered Vehicles

Land-based ballistic missiles —

- Intercontinental-range ballistic missiles (ICBMs)
- Shorter-range ballistic missiles

Sea-based ballistic Missiles —

- Submarine-launched ballistic missiles (SLBMs)
- Surface-ship-launched ballistic missiles

Historical Examples of Other Nuclear Weapon Delivery Methods

Nuclear artillery shells:

- 16” naval guns
- 280 mm cannons (howitzer)

"Atomic Annie" 1953: 15-kt projectile to range of 17 miles

Operation Upshot/Knothole (1953)

Davy Crocket Nuclear Bazooka

- 76 lb., 10–250 t yield, 1.2–2.5 mile range
- Deployed 1961–1971; 2,100 produced

Atomic Demolition Munitions (ADMs)

Carried by back pack, 0.01 kt yield?

Nuclear-armed torpedoes

The U.S. Cold-War Strategic "Triad" – 1

Initially US nuclear weapons delivery systems were developed without a coherent plan, in the —

- Truman administration
- Eisenhower administration

McNamara (Kennedy's Secretary of Defense) changed this —

- Survivable basing
- Secure command and control
- Determine how much is enough by calculation!

    Concluded 400 'effective' megatons (EMT) would be "enough"

- The need to give roles to the USAF and the USN defined the "Triad" paradigm
- Established the SIOP (Single Integrated Operational Plan) for targeting

The U.S. Cold-War Strategic "Triad" – 2

Strategic nuclear delivery vehicles (SNDVs) —

The definition of "strategic" nuclear weapons was important for arms control but was controversial during the Cold War: the Soviet Union wanted to count weapons on its periphery whereas the U.S. did not want to count these:

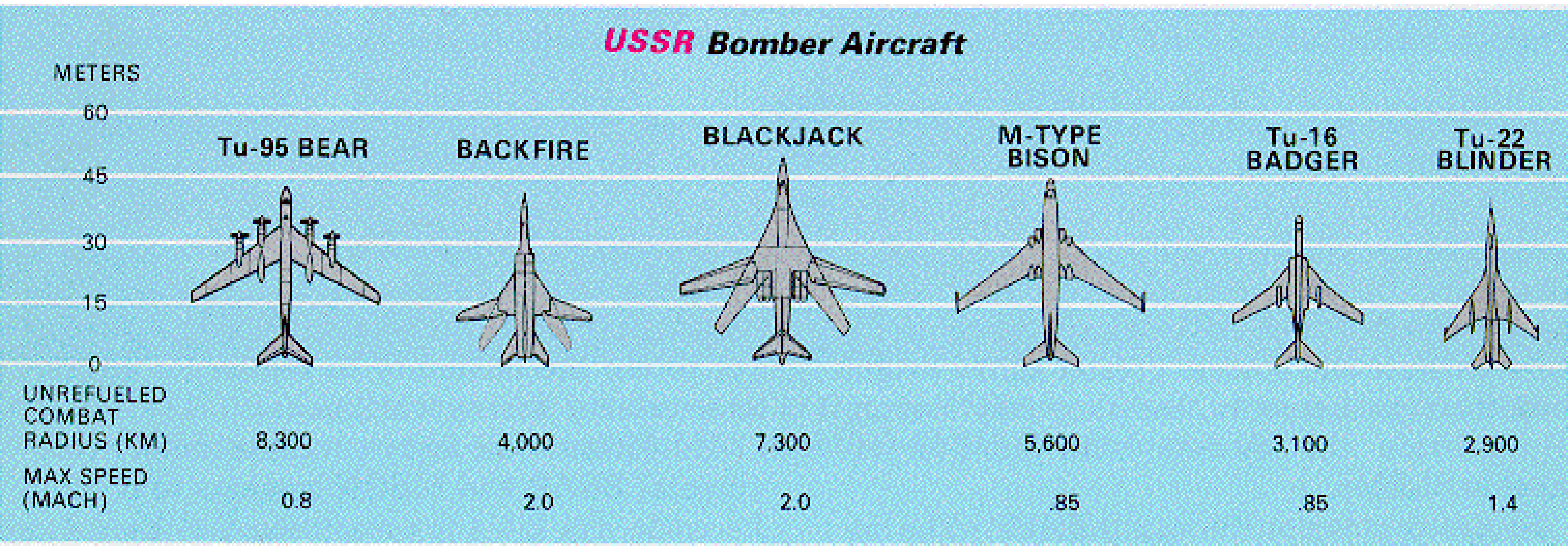
- Systems with intercontinental range (U.S. def.)
- Systems able to strike directly the homeland of the adversary (Soviet def.)

Systems in the Triad —

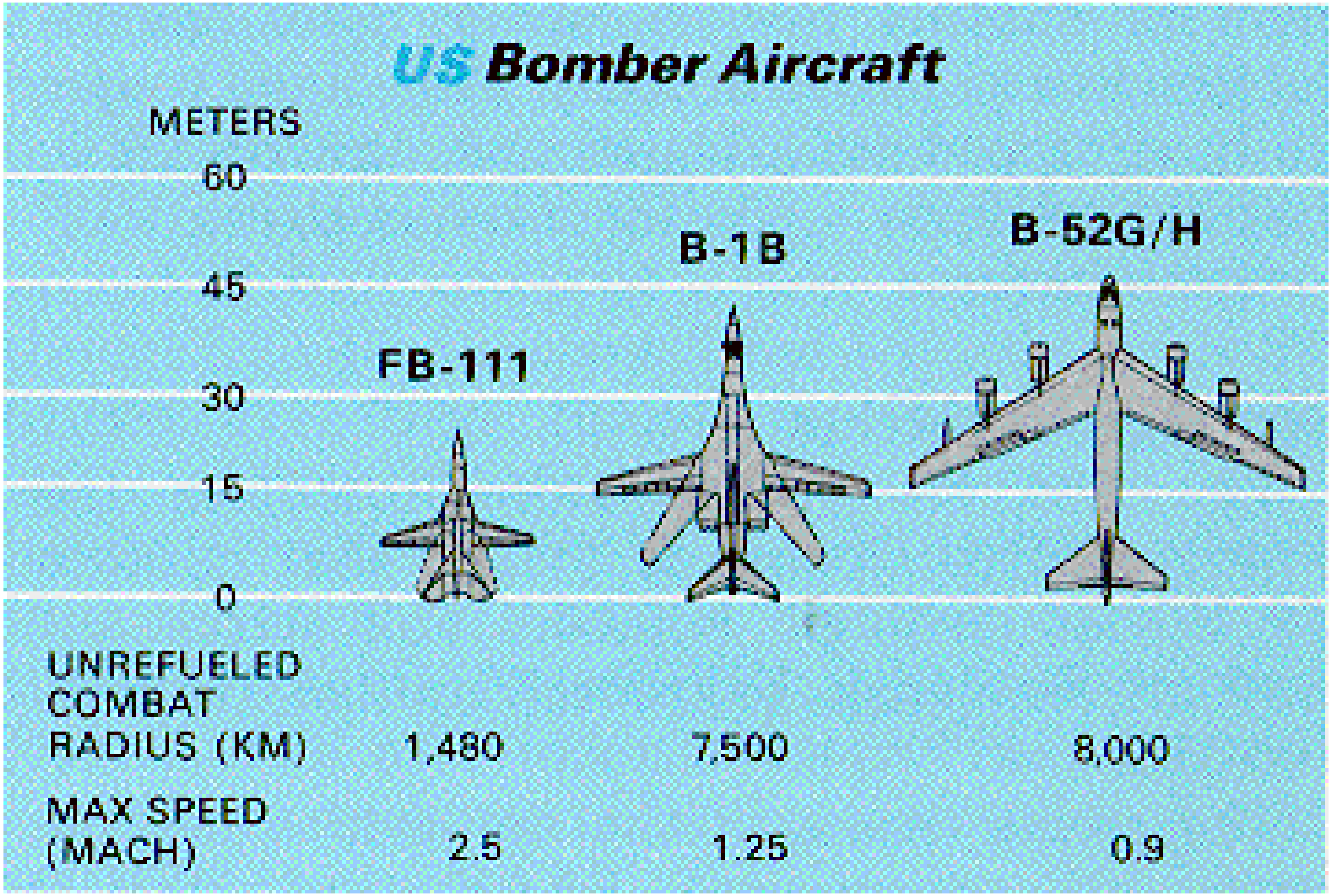
- Intercontinental-range bombers
- Intercontinental-range ballistic missiles (ICBMs)
- Submarine-launched ballistic missiles (SLBMs)

Part 2: Aircraft

Examples of Intercontinental Bombers – 1



Examples of Intercontinental Bombers – 2



U.S. B-2 Stealth Bomber

Speed: Mach 0.85

Height: 50,000 feet

Range: 7,600 miles

Possible payloads:
- 16 B83 gravity bombs
- 20 B61 bombs
- 80 500 lb bombs

Currently Deployed U.S. and Russian Bombers

Current US bombers —

- B-52 Hs, carrying bombs, or cruise missiles
- B1-s, each can carry 16 B83 bombs
- B-2, each can carry 16 B83 bombs

Russian bombers* —

- Bear-H16s, carrying bombs
- Bear-H6s, carrying bombs
- Blackjacks, carrying bombs

*Very few are currently operational

Intercontinental Bomber Issues

Evolution of bomber missions —

- High-altitude bombing
- Low-altitude penetration and bombing
- As a stand-off launch platform for Air-launched cruise missiles (ALCMs)

Operational considerations —

- Launch, release to targets, and arming of weapons requires permission from the National Command Authority (NCA) (in the United States, the President or his designated successor)
- Can be recalled until weapons (e.g., bombs, cruise missiles, or air-to-surface ballistic missiles) are dropped or fired from the bomber
- The United States has substantial in-flight refueling capability; other countries have none

iClicker Question

Which one of the following is *not* one of Richardson's "Three Goals of Terrorists"?

(A) Revenge

(B) Reaction

(C) Resources

(D) Renown

iClicker Question

iClicker Answer

Which one of the following is *not* one of Richardson's "Three Goals of Terrorists"?

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Which one of the following delivery vehicles was *not* considered a leg of the Cold War nuclear "Triad"?

(A) Submarine-launched ballistic missiles

(B) Ship-launched ballistic missiles

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(B) **Ship-launched ballistic missiles**

(C) Land-based intercontinental ballistic missiles

(D) Land-based intercontinental bombers

Part 3: Cruise Missiles

Introduction to Cruise Missiles – 1 (Important)

Cruise missiles (CMs) are pilotless vehicles powered by jet engines:

- Fly within the atmosphere
- Speeds are subsonic

Although cruise missiles were conceived 60 years ago, CMs did not become important until the late 1970s, when technological advances made them militarily useful. These advances were:

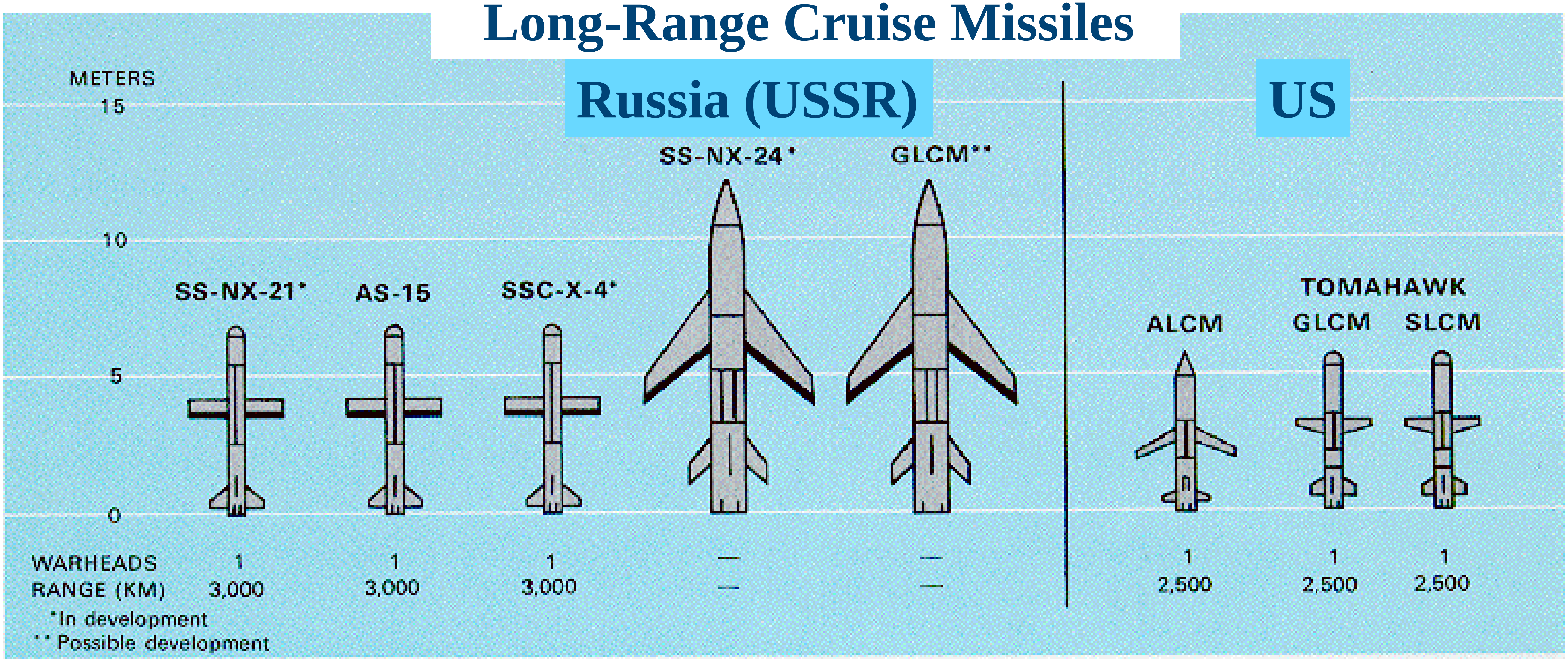
- Smaller and lighter nuclear warheads
- Efficient turbofan engines
- Highly capable miniaturized computers
- GPS, TERCOM (Terrain Contour Matching), and terminal guidance
- “Stealth” airframe technology

Introduction to Cruise Missiles – 2 (Important)

Key properties —

- Small
- Easily stored and launched
- Highly penetrating
- Versatile
- Highly accurate
- Very cheap (about ~ $1 million per copy)

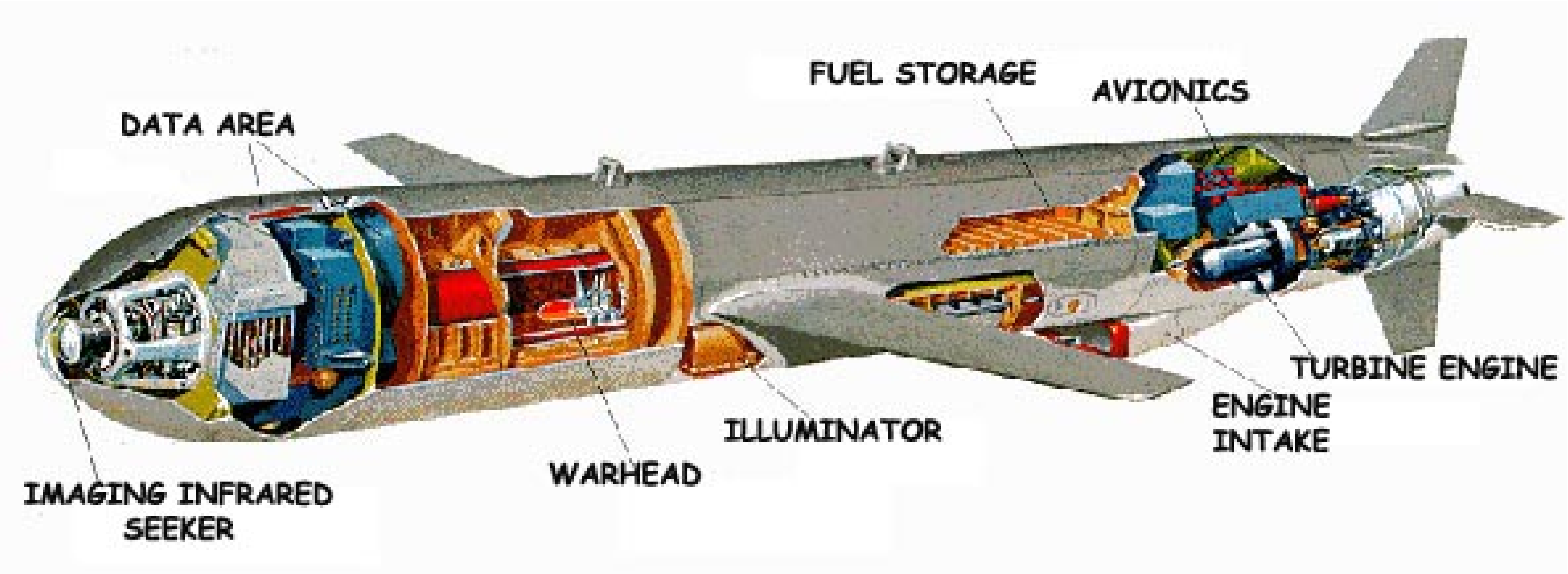
Long-Range Cruise Missiles – 1



range :1000 – 2000 miles

pay loads : 500 – 1200 lbs

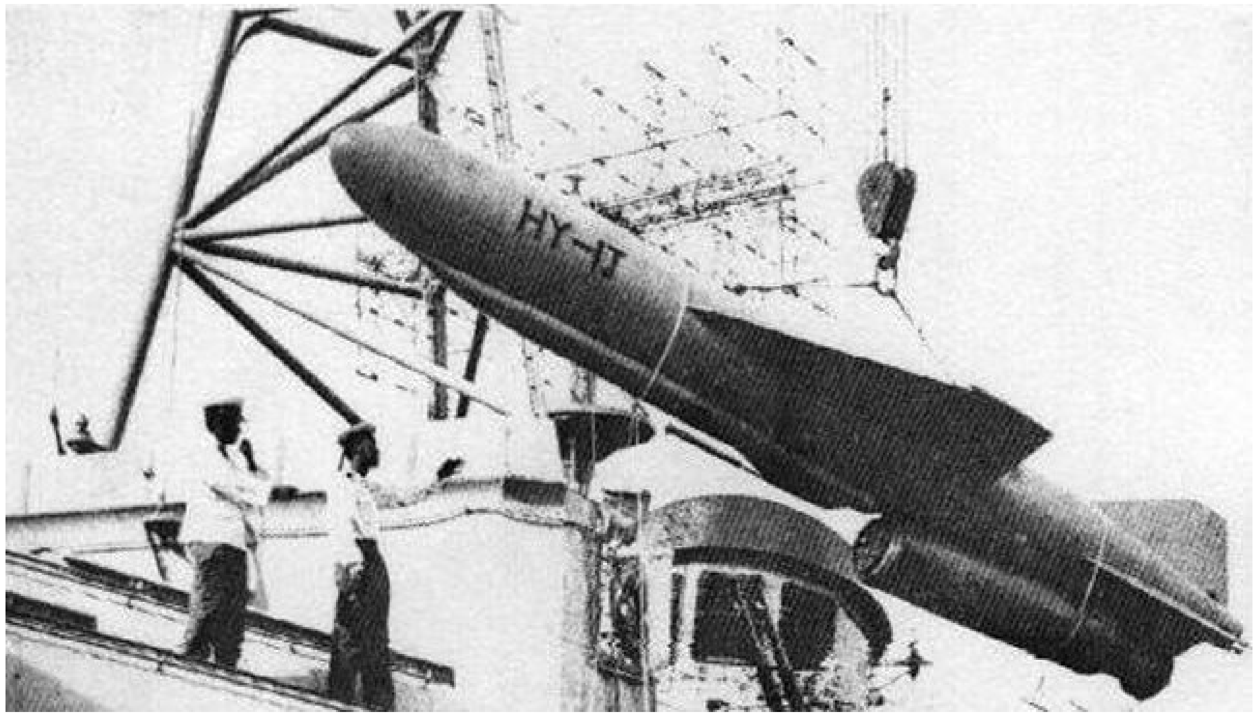
Long-Range Cruise Missiles – 2



Conventionally-Armed Tomahawk Cruise Missile

velocity: 550 mph
pay load: 1000 lbs
range : 1550 miles

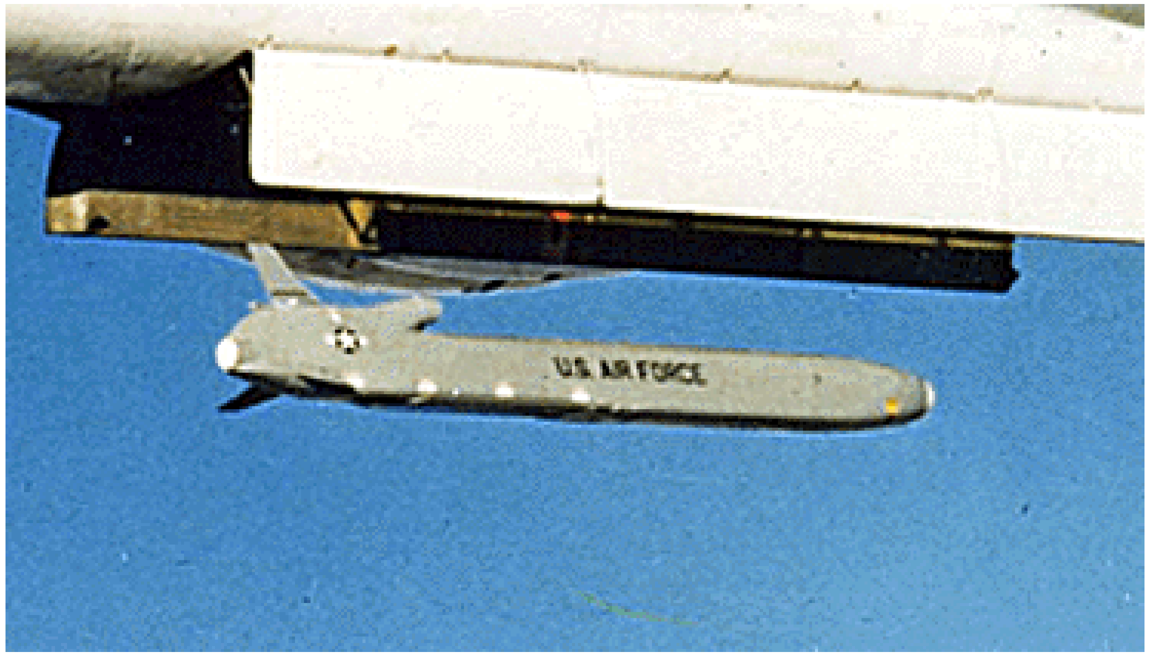
Chinese Silkworm Anti-Ship Cruise Missile



Chinese CSS-C-2 SILKWORM / HY-1 / SY-1 Anti-Ship Cruise Missile

Velocity: 680 mph
payload: 660 lbs
range: 180 miles

Launching Cruise Missiles – 1

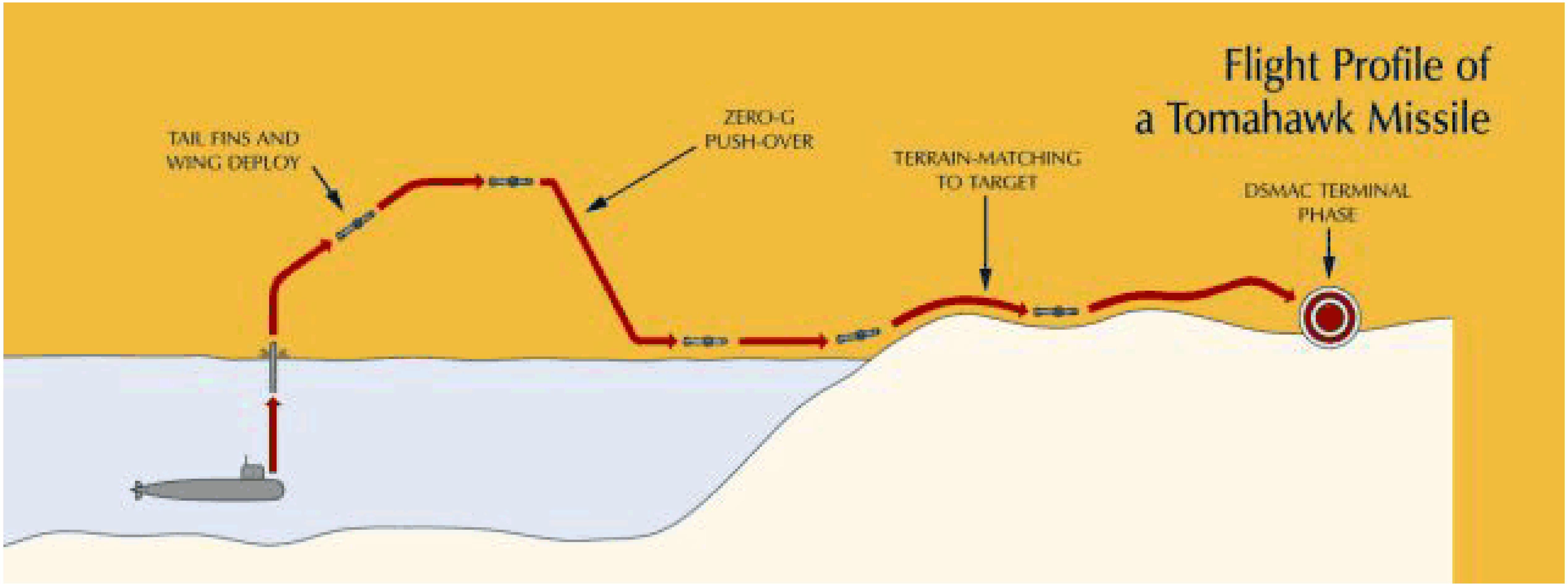


Launching Cruise Missiles – 2

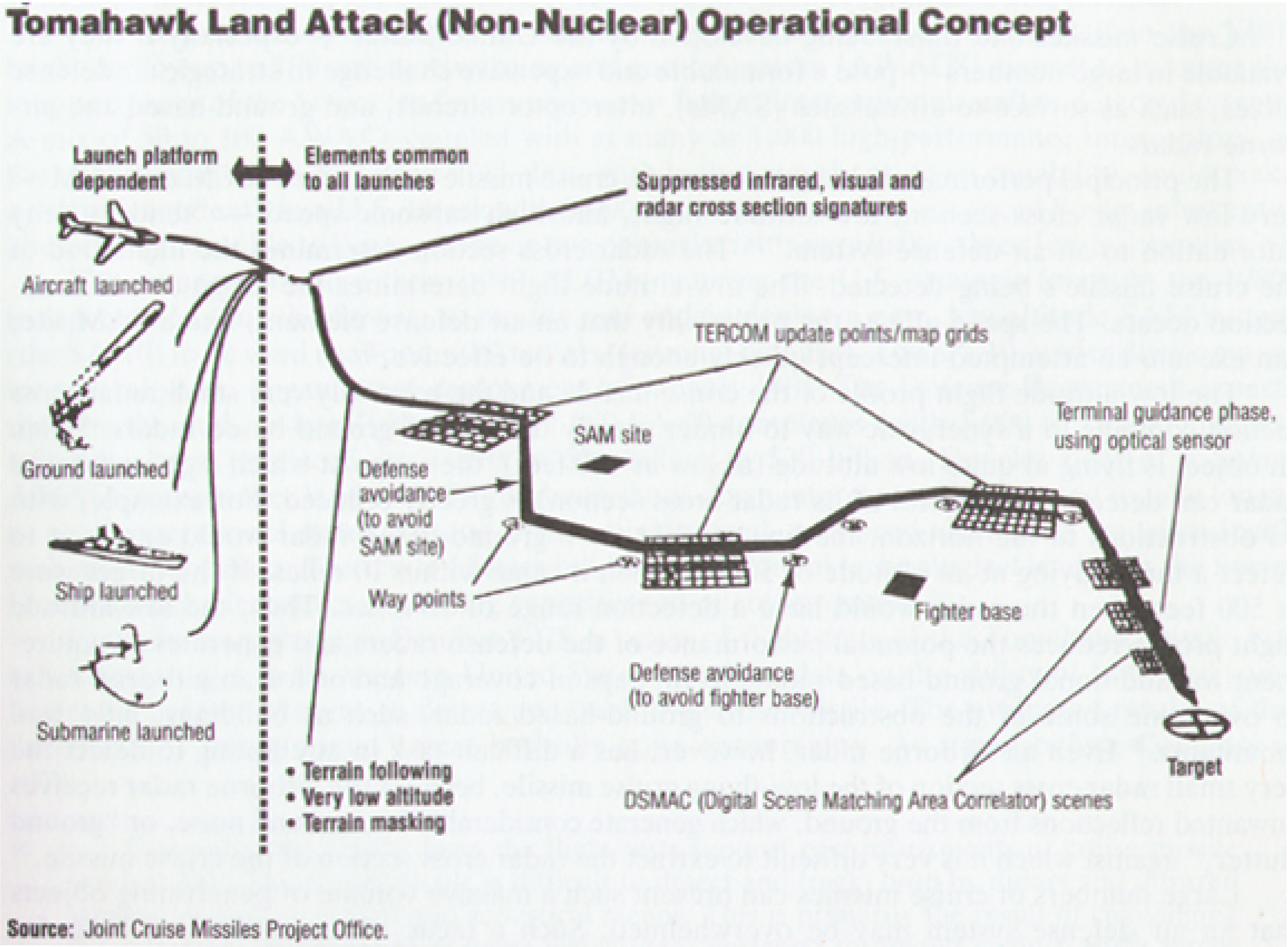
Cruise-Missile Guidance – 1

TERCOM: Terrain Contour Matching
DSMAC: Digital Scene Matching Area Correlation

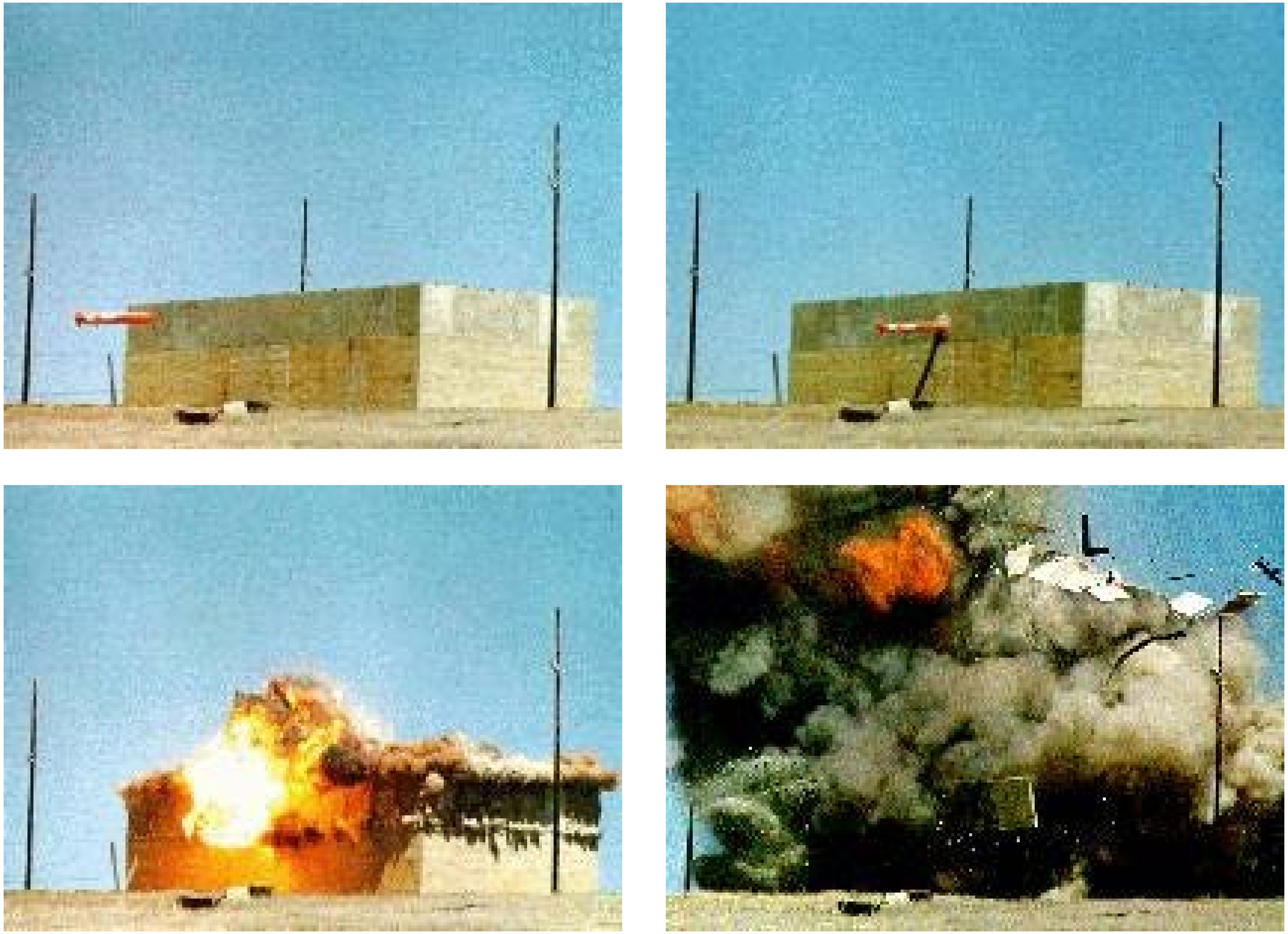
Cruise-Missile Guidance – 2



Cruise-Missile Guidance – 3



Accuracy of Cruise Missiles



Implications of Cruise Missiles – 1

The US developed and deployed CMs without coherent plan that considered the offensive, defensive, and long-range impact of their deployment.

Military history —

- Cruise missiles were the US countermeasure to the heavy Soviet investment in air defenses
- They capitalized on the temporary US lead in this technology
- However, the US is more vulnerable to CMs than Russia due to the proximity of potential targets to the sea shores.

Implications of Cruise Missiles – 2

Implications for U.S. security—

- Very small (hard to find and count with National Technical Means)
- Can be based almost anywhere (hard to count)
- Dual capable (almost impossible to distinguish nuclear from high-explosive warhead)
- Cheap (can be produced in very large numbers)

"Several countries could develop a mechanism to launch SRBMs, MRBMs, or land-attack cruise missiles from forward-based ships or other platforms; a few are likely to do so—more likely for cruise missiles— before 2015."

– *Foreign Missile Developments and the Ballistic Missile Threat Through 2015*, Unclassified Summary of a National Intelligence Estimate, December 2001

Physics 280: Session 15

Plan for This Session (1)

Questions

Extra Credit Opportunities this week:

(1) Teach-In on the Crisis in Crimea + Ukraine
4.00 – 5.15pm, Tuesday, March 11th, 160 English Building
deadline for extra credit essay: Friday 5pm (electronic upload)

(2) Seminar on “Protecting the Reconstruction in Afghanistan from Fraud”,
Gene Aloise, Deputy Inspector General in the Office of the Special Inspector General for Afghanistan Reconstruction
4.00 – 5.00pm, Wednesday, March 12, Room 46 of the Library & Information Science Building, 501 E. Daniel
deadline for extra credit essay: Friday 5pm (electronic upload)

followed by student meeting with the speaker **at 5.00pm**

➔ At each event, a 280 TA will be present with a sign-in sheet.
The extract credit essay prompts are linked to the course web-page

Plan for This Session (2)

Midterm Review Session, Tuesday March 18th, 5.00-7.00pm

Midterm Exam, Thursday March 20th, 2.00-3.20pm

Module 5: Nuclear Weapon Delivery Systems

Part 4: Ballistic Missiles

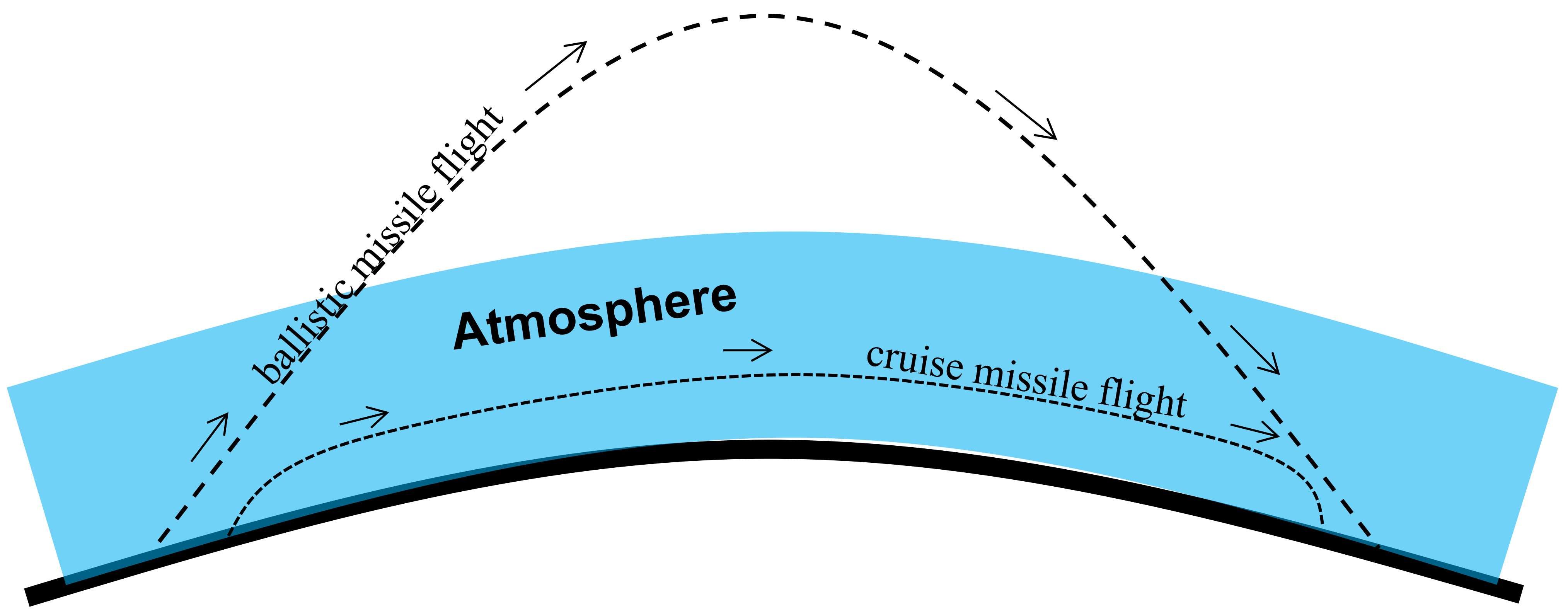
Air Breathing Delivery Systems (Bombers & Cruise Missiles) vs Ballistic Missiles

Air breathing systems:

- o carry the fuel on board but take the oxidizer from the atmospheres ➔ operate endo-atmospheric

Ballistic missiles:

- o carry fuel and oxidizer ➔ can operate exo-atmospheric



Attributes of Ballistic Missiles

Basing modes —

- Fixed (e.g., blast-hardened silos in the ground)
- Mobile (e.g., on railroad cars)

Propellants —

- Liquid (fuel and oxidizer are separate)
- Solid (fuel and oxidizer are mixed)

Payloads —

- Single warhead + penetration aids (“penaids”)
- Multiple warheads + penetration aids

Categories of Ballistic Missiles Based on Their Ranges (Important)

Short-range ballistic missiles (SRBMs) —

- Ranges under 1,000 km

Medium-range ballistic missiles (MRBMs) —

- Ranges between 1,000 km and 3,000 km

Intermediate-range ballistic missiles (IRBMs) —

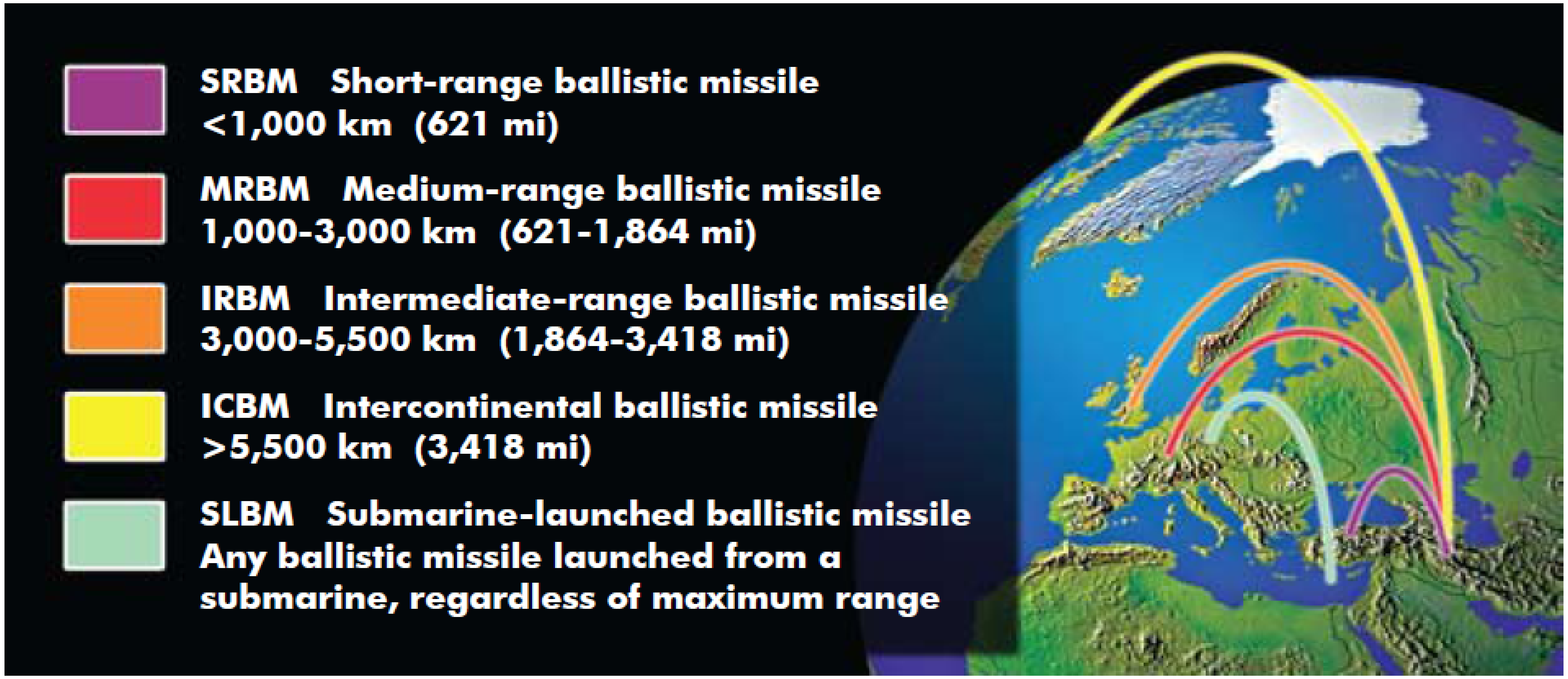
- Ranges between 3,000 km and 5,500 km

Intercontinental-range ballistic missiles (ICBMs, SLBMs) —

- Limited-range ICBMs (LRICBMs): 5,500 to 8,000 km
- Full-range ICBMs (FRICBMs): > 8,000 km
- Ranges of US and Russian ICBMs are ~ 12,000 km

These categories are not fluid, because they are based on the performance characteristics of the missile.

Categories of Ballistic Missiles Based on Their Ranges (Important)



Source: national air and space intelligence center

"Ballistic and Cruise Missile Threat", 2009

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Intercontinental-range ballistic missiles (ICBMs, SLBMs) —

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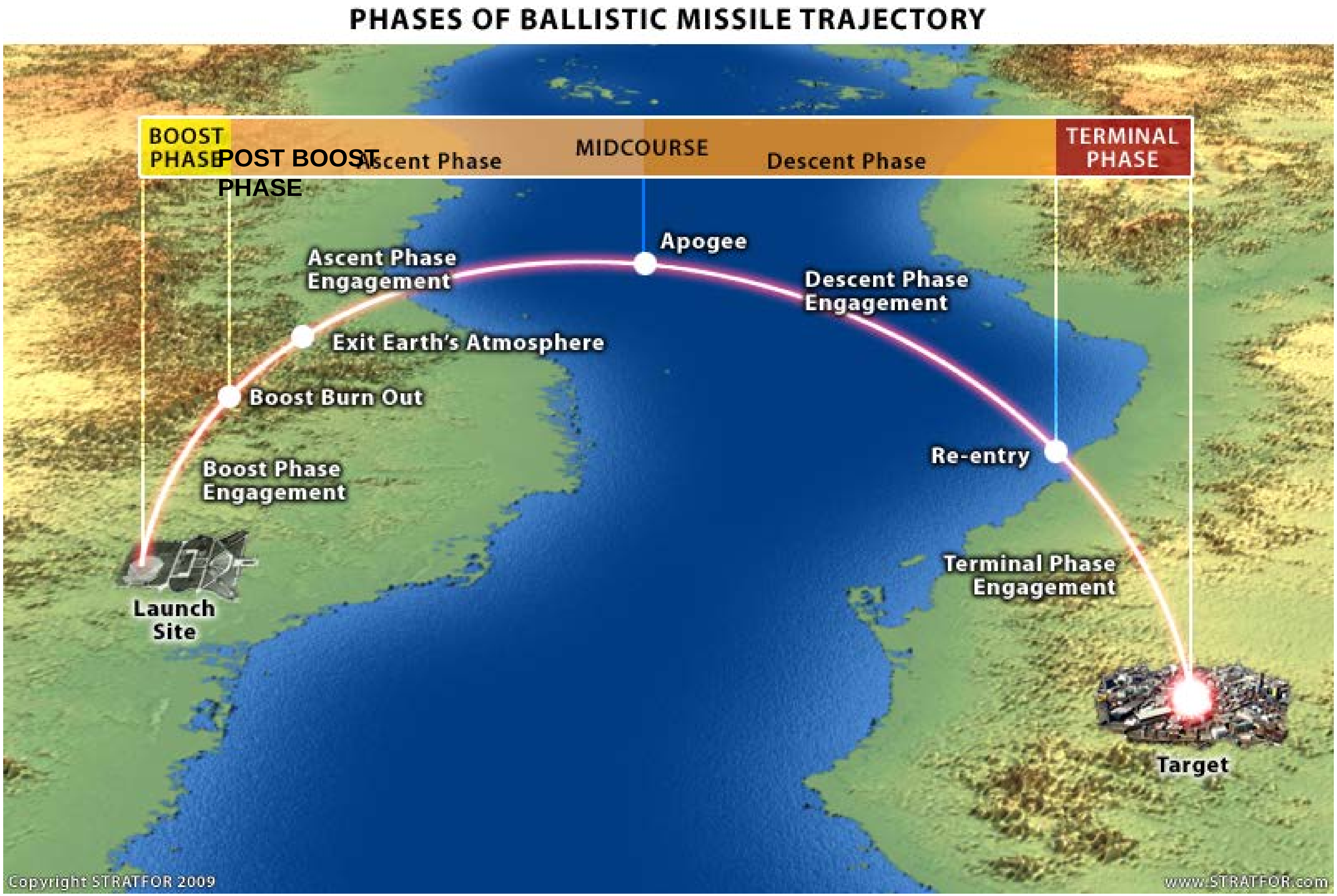
Phases of Flight of Intercontinental-Range Ballistic Missiles (Important)

Basic phases of flight of a MIRVed intercontinental ballistic missile (ICBMs and SLBMs) —

- Boost phase: rocket motors burning
- Post-boost phase (release of payload from bus)
- Midcourse phase: ballistic motion in space
- Terminal phase: re-entrance into atmosphere and passage through atmosphere

Phases of Flight of Intercontinental-Range Ballistic Missiles (Important)



Categories of Ballistic Missiles Based on Their Purposes

Tactical ballistic missiles (TBMs) —

- For use on the battlefield (e.g., on a particular front)
- Usually have shorter ranges (SRBMs)

Theater ballistic missiles (TBMs) —

- For use in an entire theater of war (e.g., the Middle East)
- Usually have longer ranges than tactical missiles

Strategic ballistic missiles (an example of SNDVs – Strategic Nuclear Weapons Delivery Vehicle) —

- For attacking the homeland of the adversary
- May have longer, possibly intercontinental ranges

These categories are fluid, because they are based on the intent of the user at the time the missile is fired.

Missile Guidance Technologies

Inertial —

- Uses gyroscopes and accelerometers
- No contact with outside world

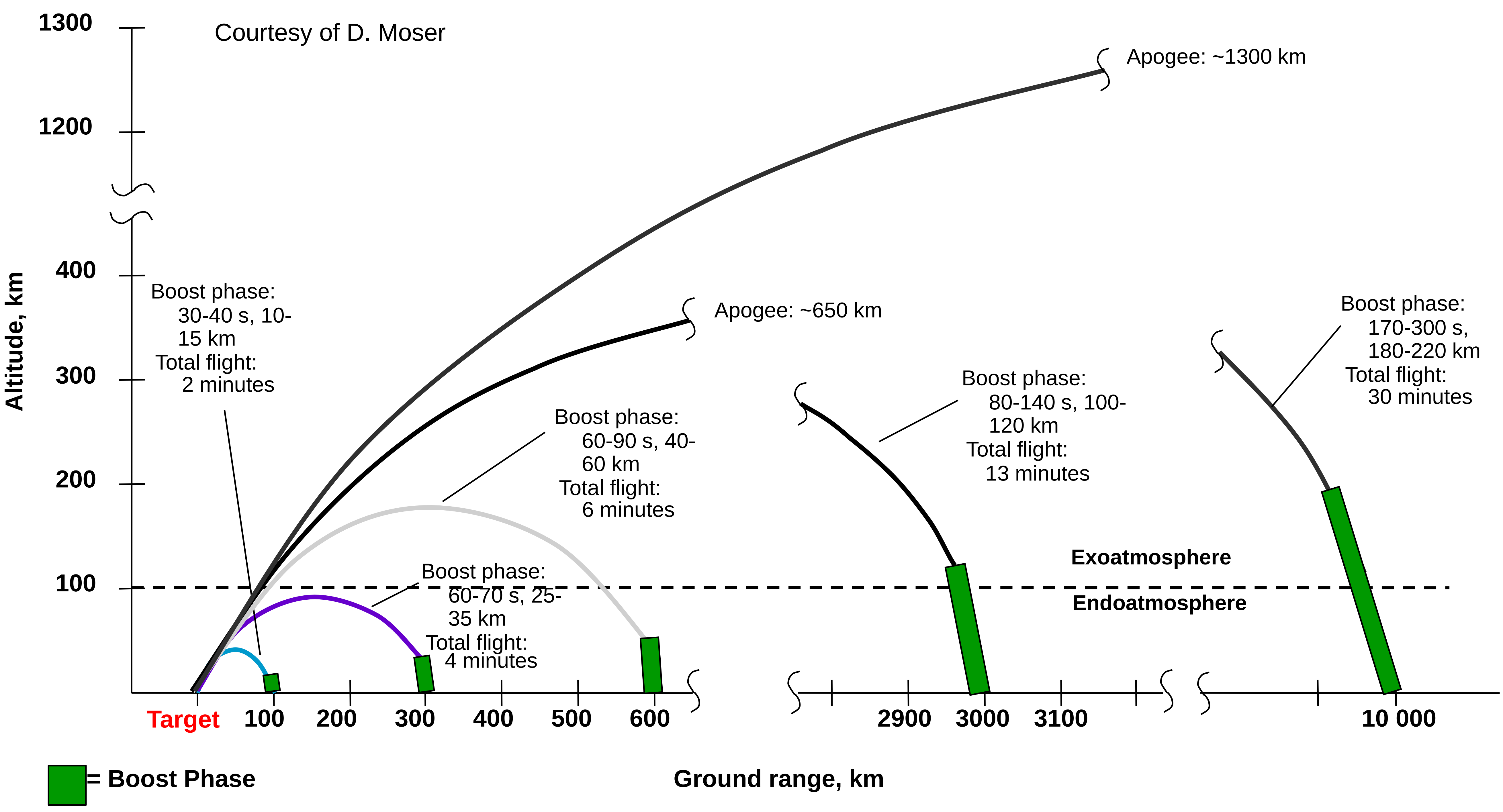
Stellar —

- Star trackers update inertial guidance system

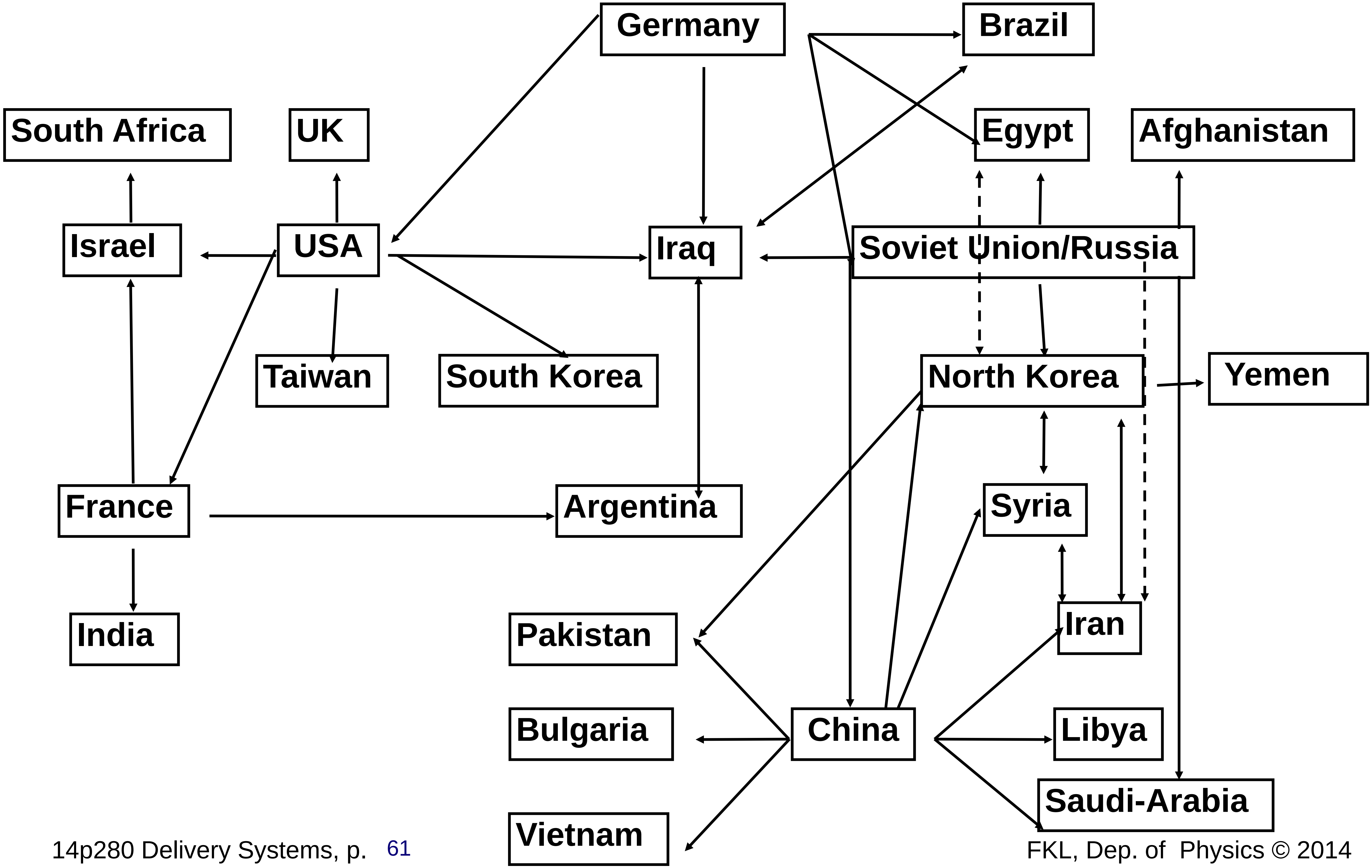
Satellite —

- Uses accurate (atomic) clocks on satellites
- Uses coded radio transmissions
- Uses sophisticated receivers
- Can determine both position and velocity very accurately using signals from 3 to 4 satellites

Trajectories and Phases of Flight of Missiles With Various Ranges

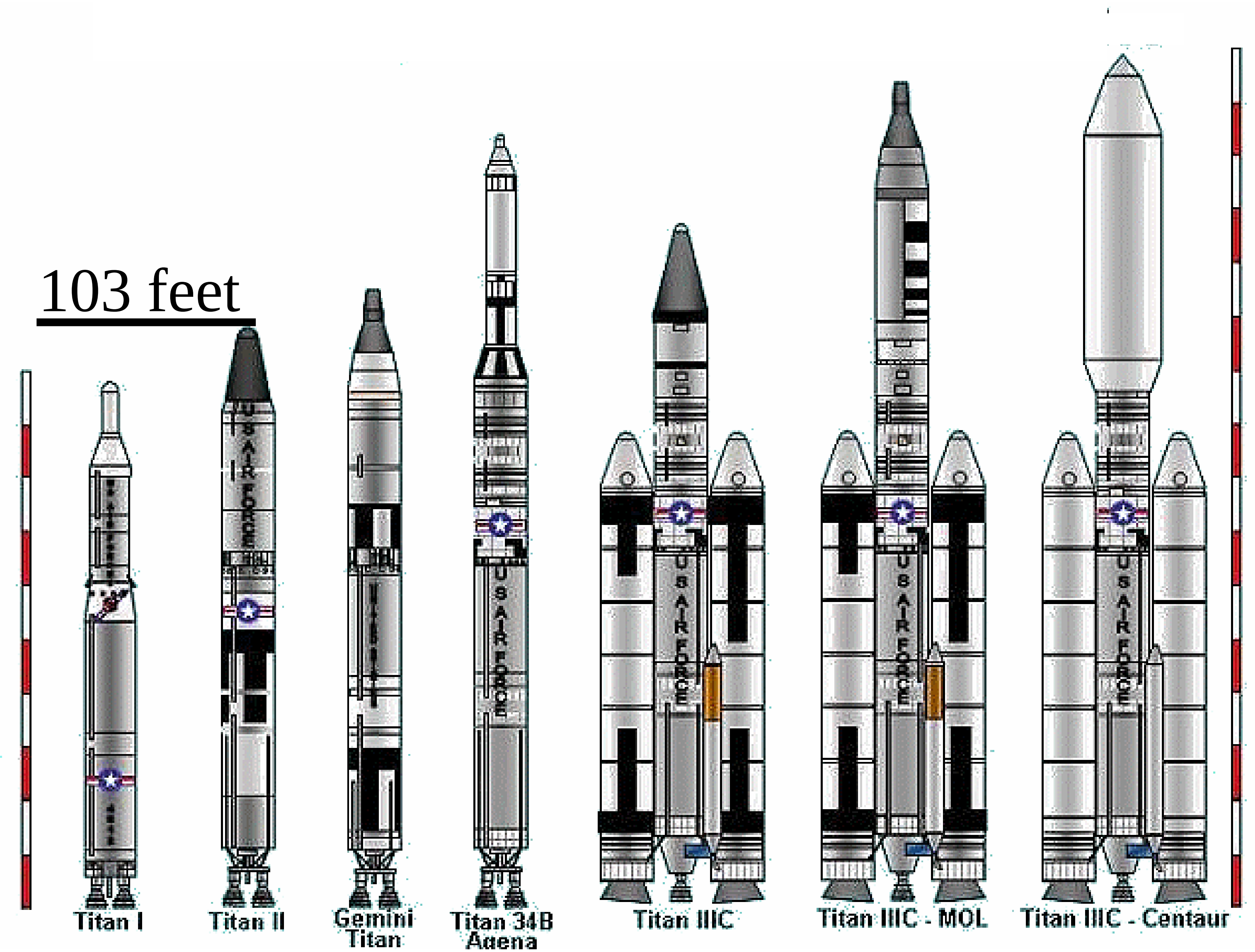


Proliferation of Ballistic Missile Technologies



Titan Family of Missiles and Launch Vehicles

1959 – 2005 ICMB & civilian uses



TIME Magazine, **Monday September 29th 1980**

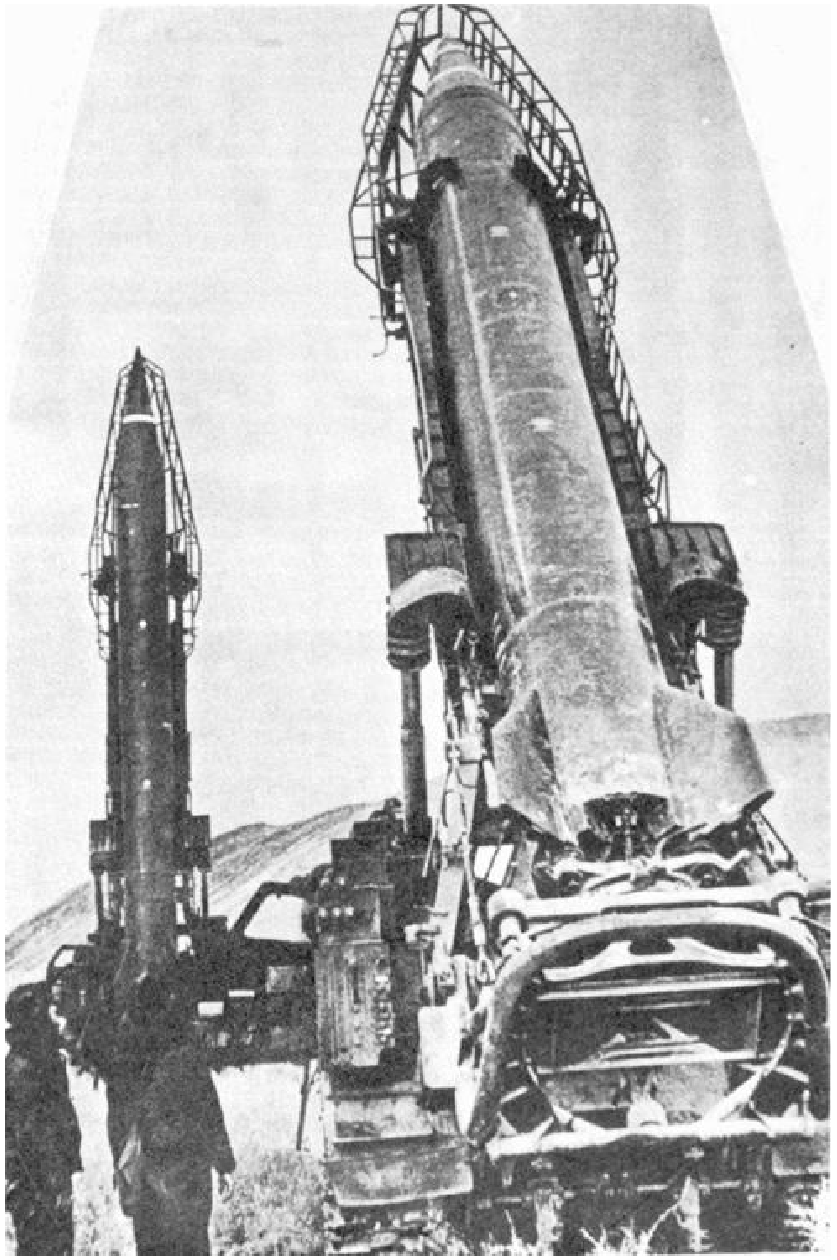
Light on the Road to Damascus

Titan terror explodes in the Arkansas hills

Shortly after sunset one day last week, a maintenance worker on the third level of a silo housing a 103-ft. Titan II Intercontinental ballistic missile near Damascus, in the Arkansas hills north of Little Rock, dropped the socket of a wrench. The 3-lb. tool plummeted 70 ft. and punctured a fuel tank. As flammable vapors escaped, officials urged the 1,400 people living in a five-mile radius of the silo to flee. The instructions: "Don't take time to close your doors—just get out.“ And with good reason. At 3:01 a.m., as technicians gave up trying to plug the leak and began climbing from the silo, the mixture of fuel and oxygen exploded. Orange flames and smoke spewed out, lighting up the sky over Damascus. The blast blew off a 750-ton concrete cover. One worker was killed; 21 others were hurt.

Today: LGM-30G Minuteman III ➔ 3 stage solid rocket fuel
Range: 11,000km +
Speed : 24,100 km/h or 6.7km/s (terminal phase)

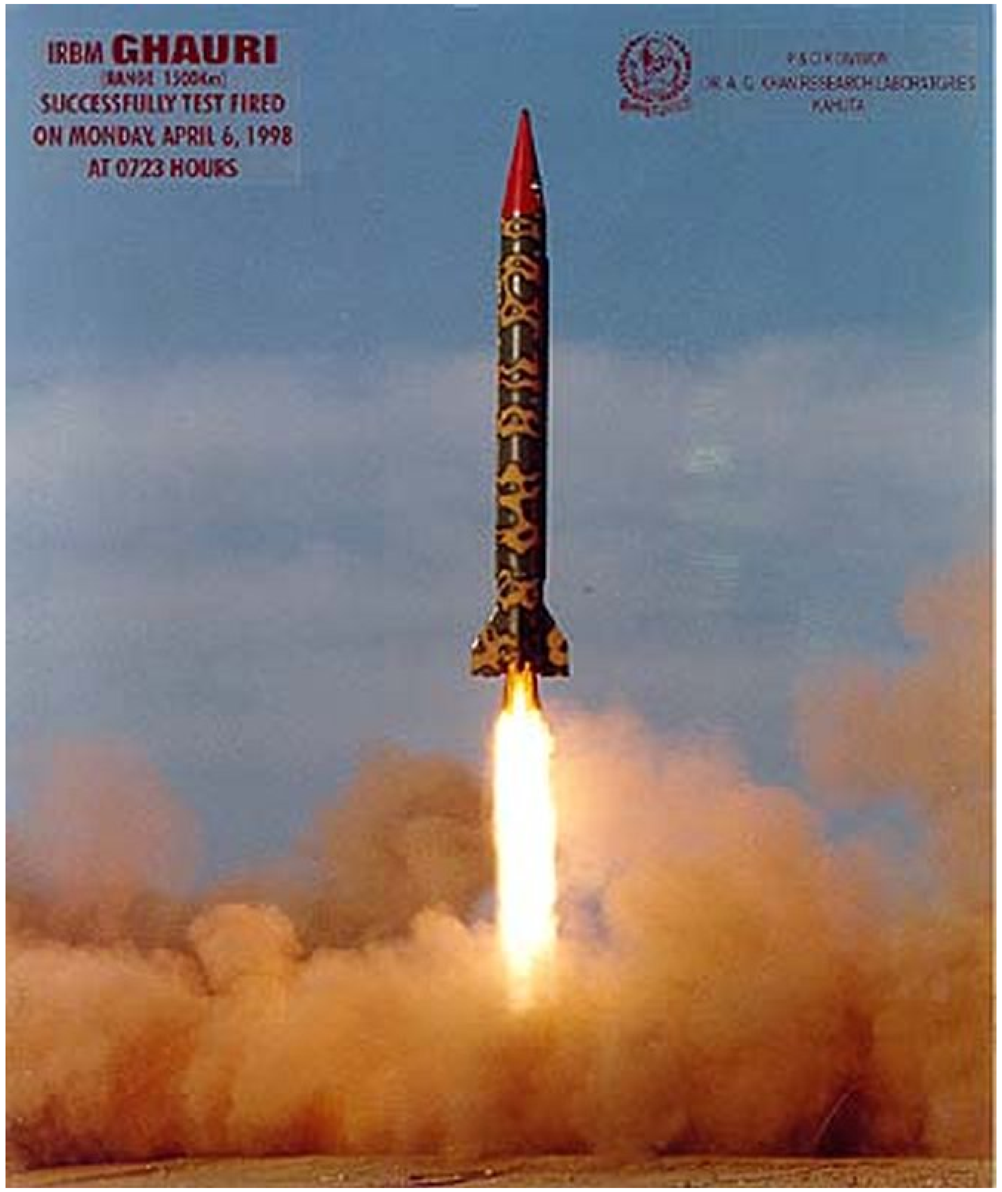
Soviet Scud Missiles and Derivatives - 1



Soviet Scud-B Missile
(based on the German V2)
Range: 300 km

Iraqi Al-Hussein SRBM
Range: 600–650 km

Scud Missiles and Derivatives – 2



Pakistan's Ghauri MRBM and transporter (range 1,300 km).
It is almost identical to North Korea's No Dong MRBM, which is based on Scud technology that North Korea got from Egypt in the 1970s.

iClicker Answer

Which one of the following technologies was *not* crucial in developing militarily useful cruise missiles?

A. Light carbon fiber materials for the airframes
B. More efficient engines
C. Much smaller and more capable computers
D. GPS and other methods for more accurate guidance
E. “Stealth” technologies to make them harder to detect

iClicker Question

iClicker Answer

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C. Land-based intercontinental ballistic missiles

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iClicker Question

Which one of the following strategic nuclear delivery vehicles can be recalled after launch?

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B. Land-based intercontinental ballistic missiles

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Re-Entry Vehicles (RVs)

Basic types —

- MRV = multiple RV
  - —Final stage carries more than 1 RV
  - —Final stage has no propulsion
  - —RVs are *not* independently targetable
- MIRV = multiple, independently targetable RV
  - —Final stage carries more than 1 RV
  - —Final stage has guidance package and propulsion
  - —RVs are independently targetable
- MARV = maneuverable RV
  - —RV has a guidance package
  - —RV maneuvers during the terminal phase, using, e.g., thrusters or aerodynamic forces

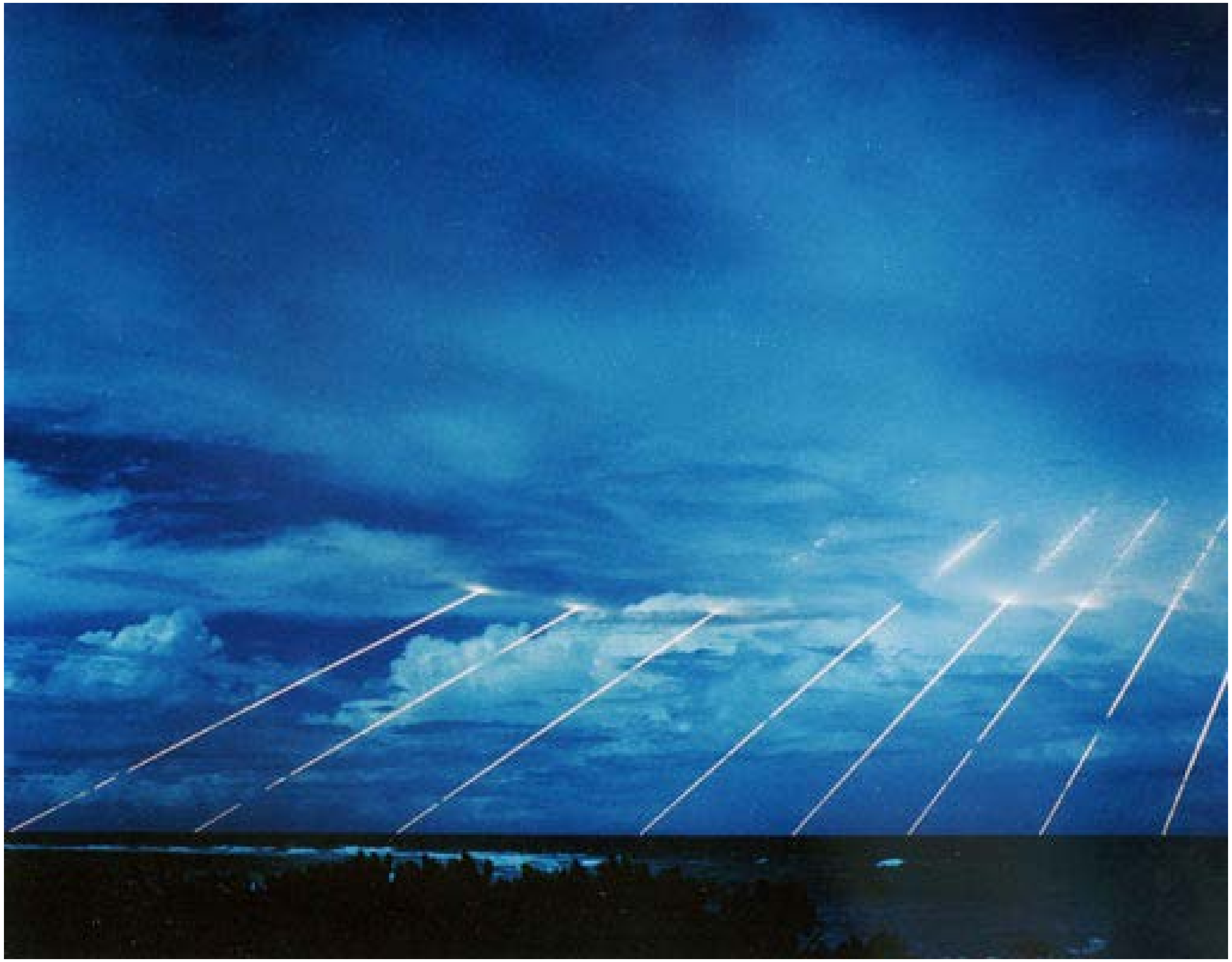
MK21 re-entry vehicles on Peacekeeper MIRV bus

MIRV Technology

MX Peacekeeper MIRV

Soviet SS-20 ICBM MIRV

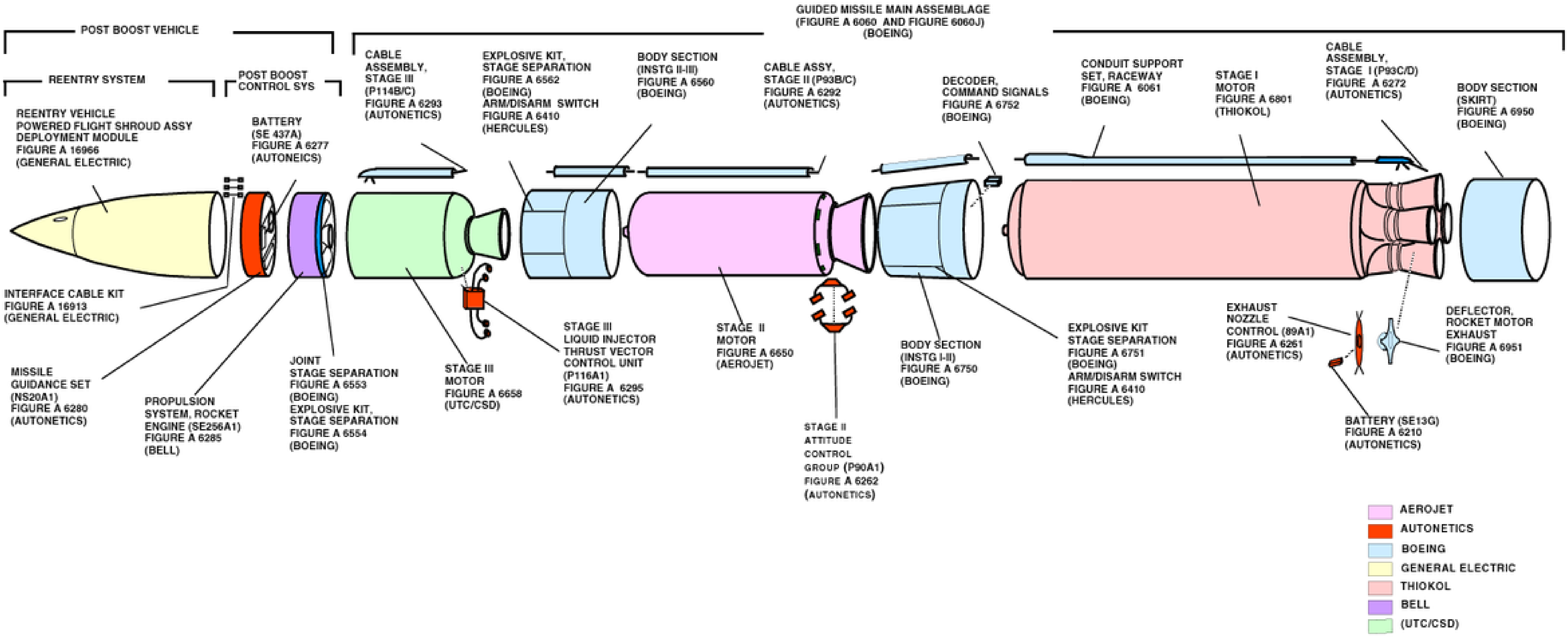
MIRV Technology



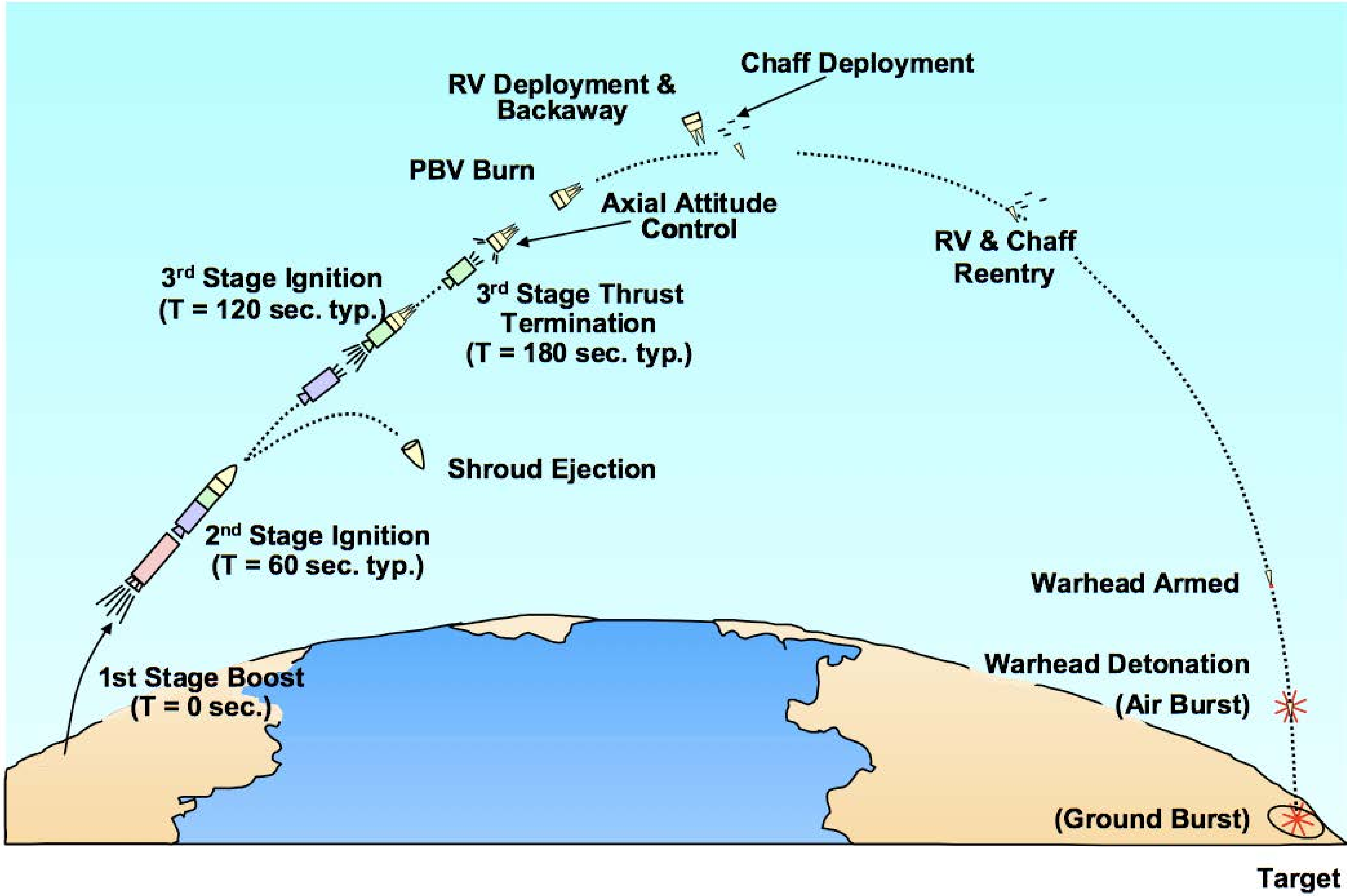
MX Peacekeeper missile tested at Kwajalein Atoll

Source:www.smdc.army.mil/kwaj/Media/Photo/missions.htm

Minuteman ICBM (Schematic)



Flight of a Minuteman ICBM (Schematic)



Flight of MIRV'd ICBMs

Four phases of the flight of an intercontinental-range missile armed with MIRVs (Multiple Independently Targetable Reentry Vehicles)—

- Boost phase (lasts about 1–5 min)
  - — Rocket motors are burning
  - — Missile rises through the atmosphere and enters near-Earth space
  - — Stages drop away as they burn out
- Post-boost phase (lasts 5–10 min)
  - — Bus separates from the final stage
  - — Bus maneuvers and releases RVs
- Midcourse phase (lasts about 20 min)
  - — RVs fall ballistically around the Earth, in space
- Terminal phase (lasts about 20–60 sec)
  - — RVs re-enter the Earth's atmosphere and encounter aerodynamic forces
  - — RVs fall toward targets, until detonation or impact

Historical Examples of US and Russian ICBMs

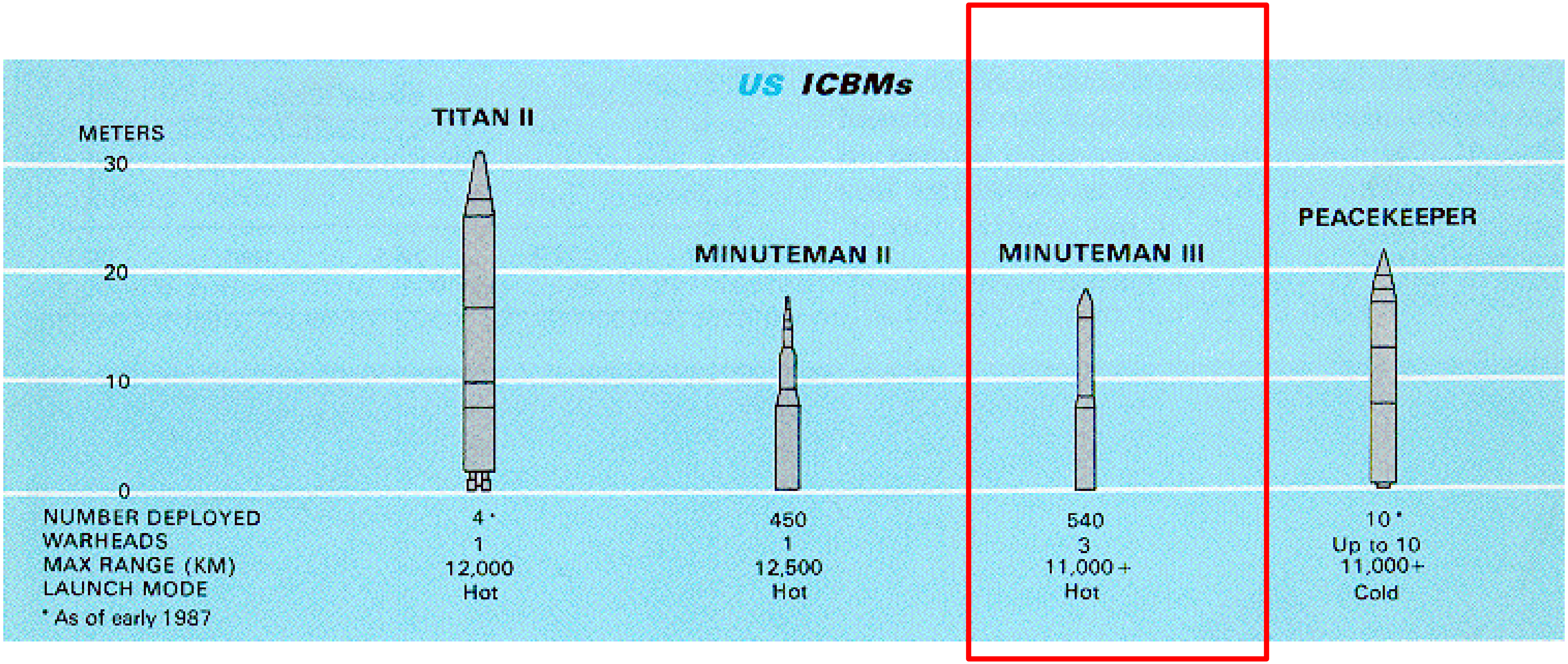
Recent US ICBMs —

- MMIII Solid-propellant, range ~ 12,000 km, 3 warheads (Minuteman)
- MX Solid-propellant, range ~ 12,000 km, 10 warheads (Peacekeeper, retired 2005)

Recent Russian ICBMs —

- SS-18 Liquid-propellant (storable), range ~ 12,000 km, 12 to 18 warheads
- SS-24 Solid-propellant, range > 9,000 km
- SS-25 Solid-propellant, range > 9,000 km

US ICBMs – 1



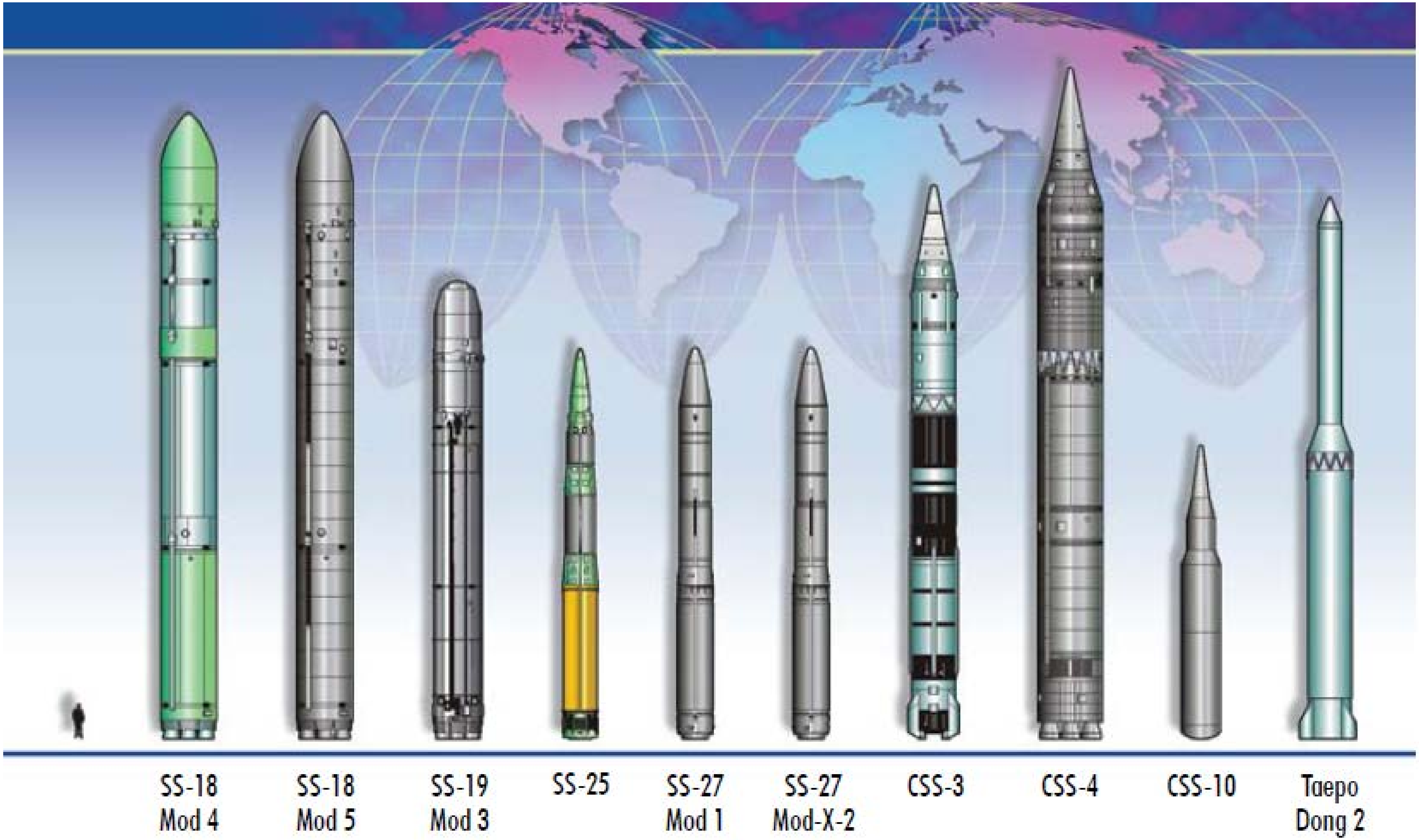
current land based
US ICMB

US ICBMs – 2

Launch of a Minuteman

Launch of an MX

Russian, Chinese (and North Korean) ICBMs – 1



Source: national air and space intelligence center
"Ballistic and Cruise Missile Threat", 2009

Russian, Chinese (and North Korean) ICBMs – 2

Missile	Number of Stages	Warheads per Missile	Propellant	Deployment Mode	Maximum Range* (miles)	Number of Launchers
Russia						
SS-18 Mod 4	2 + PBV	10	Liquid	Silo	5,500+	104
SS-18 Mod 5	2 + PBV	10	Liquid	Silo	6,000+	(total for Mods 4 & 5)
SS-19 Mod 3	2 + PBV	6	Liquid	Silo	5,500+	122
SS-25	3 + PBV	1	Solid	Road-mobile	7,000	201
SS-27 Mod 1	3 + PBV	1	Solid	Silo & road-mobile	7,000	54
SS-27 Mod-X-2	3 + PBV	Multiple	Solid	Silo & road-mobile	7,000	Not yet deployed
China						
CSS-3	2	1	Liquid	Silo & transportable	3,400+	10 to 15
CSS-4 Mod 2	2	1	Liquid	Silo	8,000+	About 20
CSS-10 Mod 1	3	1	Solid	Road-mobile	4,500+	Fewer than 15
CSS-10 Mod 2	3	1	Solid	Road-mobile	7,000+	Fewer than 15
North Korea						
Taepo Dong 2	2	1	Liquid	Undetermined	3,400+	Not yet deployed

Source: national air and space intelligence center
“Ballistic and Cruise Missile Threat”, 2009

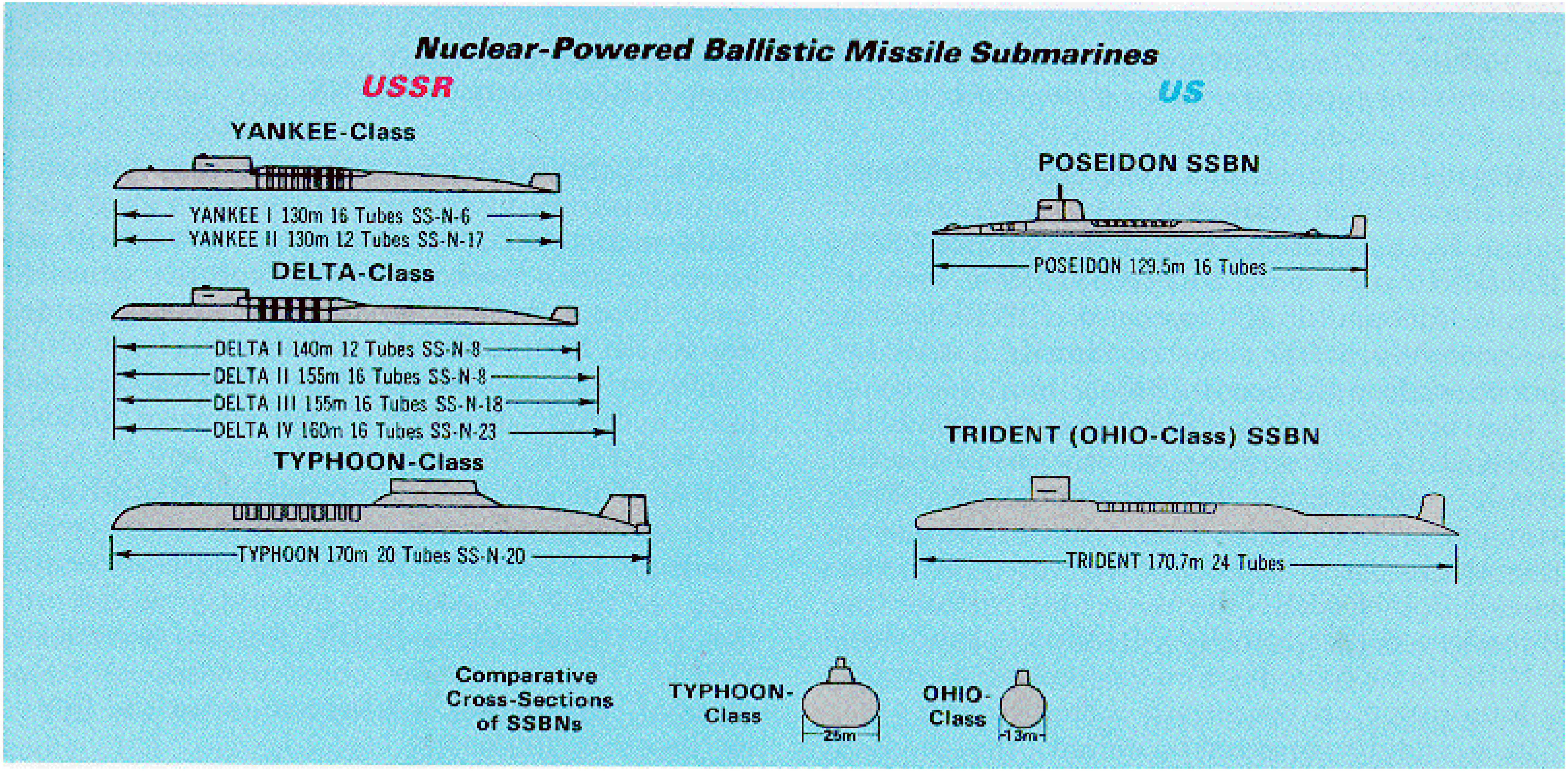
Russian, Chinese (and North Korean) ICBMs – 3

The Russian Dnepr space launch vehicle is based on the SS-18 ICBM.

Chinese CSS-10 Road-Mobile Launcher

Russian SS-27 Road-Mobile Launcher

US and Russian SSBNs



Physics 280: Session 16

Plan for This Session

Questions

Midterm Review, Tuesday, March 18th, **Everitt 163**, 5-7pm

Midterm Exam, Thursday March 20th, **Burrill 124**, 2-3.20pm

News and discussion

Module 5: Nuclear Weapon Delivery Systems

North Korea Ably Evades Its Sanctions, March 11th

SEOUL, South Korea — Recent inspections and seizures of banned cargo have shown that North Korea is using increasingly deceptive techniques to circumvent international sanctions, a panel of experts said in a report to the United Nations Security Council published Tuesday. After a series of nuclear and long-range ballistic missile tests by North Korea over the past decade, the Security Council has adopted resolutions calling for increasingly vigorous sanctions aimed at crippling the North's financial and technical capability to build weapons of mass destruction.

In its latest annual report, posted Tuesday on the United Nations website, the panel of eight experts said that North Korea has persisted in defying those resolutions not only by continuing its nuclear and ballistic missile programs but also by engaging in illegal arms trade. "It is experienced in actions it takes to evade sanctions," the panel said. "It makes increasing use of multiple and tiered circumvention techniques."

The panel said the case of the North Korean cargo ship Chong Chon Gang had provided unrivaled insight into some of those techniques. The vessel was stopped by the Panamanian authorities in July 2013 while carrying undeclared weapons that had been hidden under 10,000 tons of sugar from Cuba. An investigation showed that the North Korean crew had used secret codes in communications, falsified the ship's logs and switched off an electronic system that would otherwise have provided real-time information on the ship's location to the international maritime authorities, the panel said. It added that it suspected the North Korean embassies in Cuba and Singapore of helping to arrange the arms shipment.

The hidden cargo amounted to six trailers associated with surface-to-air missile systems and 25 shipping containers loaded with two disassembled MIG-21 jet fighters, 15 MIG-21 engines, and missile and other arms components, the panel said. Cuba has acknowledged that it was sending Soviet-era weapons to be repaired in North Korea.
The Chong Chon Gang case helped confirm that one of North Korea's most profitable sources of revenue remains weapons exports, as well as technical support to manufacture and refurbish arms produced in the former Soviet Union in the 1960s and 1970s, the panel said.

Japan Has Nuclear 'Bomb in the Basement,' and China Isn't Happy, March 11th

No nation has suffered more in the nuclear age than Japan, where atomic bombs flattened two cities in World War II and three reactors melted down at Fukushima just three years ago. But government officials and proliferation experts say Japan is happy to let neighbors like China and North Korea believe it is part of the nuclear club, because it has a "bomb in the basement" -– the material and the means to produce nuclear weapons within six months, according to some estimates. And with tensions rising in the region, China's belief in the "bomb in the basement" is strong enough that it has demanded Japan get rid of its massive stockpile of plutonium and drop plans to open a new breeder reactor this fall.

Japan signed the international Nuclear Non-Proliferation Treaty, which bans it from developing nuclear weapons, more than 40 years ago. But according to a senior Japanese government official deeply involved in the country's nuclear energy program, Japan has been able to build nuclear weapons ever since it launched a plutonium breeder reactor and a uranium enrichment plant 30 years ago.

…

Japan now has 9 tons of plutonium stockpiled at several locations in Japan and another 35 tons stored in France and the U.K. The material is enough to create 5,000 nuclear bombs. The country also has 1.2 tons of enriched uranium. Technical ability doesn't equate to a bomb, but experts suggest getting from raw plutonium to a nuclear weapon could take as little as six months after the political decision to go forward.

…

In fact, many of Japan's conservative politicians have long supported Japan's nuclear power program because of its military potential. "The hawks love nuclear weapons, so they like the nuclear power program as the best they can do," said Jeffrey Lewis, director of the East Asia Non-Proliferation Program at the Monterey Institute of International Studies in California. "They don't want to give up the idea they have, to use it as a deterrent."

NBC News – Robert Windrem

Japan Has Nuclear 'Bomb in the Basement,' and China Isn't Happy, March 11th

But pressure has been growing on Japan to dump some of the trappings of its deterrent regardless. The U.S. wants Japan to return 331 kilos of weapons grade plutonium … that it supplied during the Cold War. Japan and the U.S. are expected to sign a deal for the return at a nuclear security summit next week in the Netherlands.

…

Yet Japan is sending mixed signals. It also has plans to open a **new fast-breeder plutonium reactor in Rokkasho** in October. The reactor would be able to produce 8 tons of plutonium a year, or enough for 1,000 Nagasaki-sized weapons.

…

China seems to take the basement bomb seriously. It has taken advantage of the publicity over the pending return of the 331 kilos to ask that Japan dispose of its larger stockpile of plutonium, and keep the new Rokkasho plant off-line. Chinese officials have argued that Rokkasho was launched when Japan had ambitious plans to use plutonium as fuel for a whole new generation of reactors, but that those plans are on hold post-Fukushima and the plutonium no longer has a peacetime use.

…

Japan, of course, has its own security concerns with China and North Korea. North Korea's nuclear weapons program is a direct threat to Japan. Some of its Nodong missiles, with a range capability of hitting anywhere in Japan, are believed to be nuclear-armed. "Nodong is a Japan weapon," said Spector.

…

There are fears that if Japan opens the Rakkosho plant, it will encourage South Korea to go the same route as its neighbor. The U.S. and South Korea have been negotiating a new civilian nuclear cooperation pact. The South wants to reprocess plutonium, but the U.S. is resisting providing cooperation or U.S. nuclear materials.

REUTERS

News and Discussion

Japan puts two reactors on shortlist for restart screening, March 13th

Japan put two reactors on a shortlist for a final round of safety checks on Thursday, moving a step closer to a revival of the country's nuclear industry, three years after the Fukushima disaster led to the shutdown of all plants. No timing for a potential restart was decided and the next stage of checks incorporates a period of public hearings, which may be a fraught process given widespread skepticism nationally about a return to nuclear power.

Two days after the third anniversary of the meltdowns at the Fukushima nuclear station, Japan's Nuclear Regulation Authority (NRA) placed two reactors operated by Kyushu Electric Power Co on a list for priority screening at a meeting of officials reviewing restart applications.

Kyushu Electric's Sendai reactors are located about 980 kilometers (600 miles) southwest of Tokyo. The utility is one of the most reliant of Japan's regional electricity monopolies on nuclear power, which supplied about a third of Japan's electricity before Fukushima.

Prime Minister Shinzo Abe, a strong supporter of nuclear power, finalized a mid-term energy plan last month, which embraces nuclear power and calls for the restart of reactors deemed safe by regulators, overturning the previous administration's plan to eventually mothball all units. "The NRA checks if standards are met and if it concludes they have been, the government would like to restart (reactors)," Chief Cabinet Secretary Yoshihide Suga said after the decision. "We want the NRA to properly inspect the plants.“

Tokyo Electric Power Co's Fukushima Daiichi station had three reactor meltdowns after a devastating earthquake and tsunami on March 11, 2011, sending a massive radioactive plume into the air and ocean. In the worst nuclear disaster since Chernobyl in 1986, thousands were forced to flee their homes and much of the area around the Fukushima plant, about 220 kilometers north of Tokyo, remains a no-go zone due to high levels of radiation. Cleaning up Fukushima is expected to take decades and cost at least 11 trillion yen ($108 billion).

US Trident SSBN (14 SSBNs, 4 SSGNs)

Trident Missile Tubes
With Covers Open

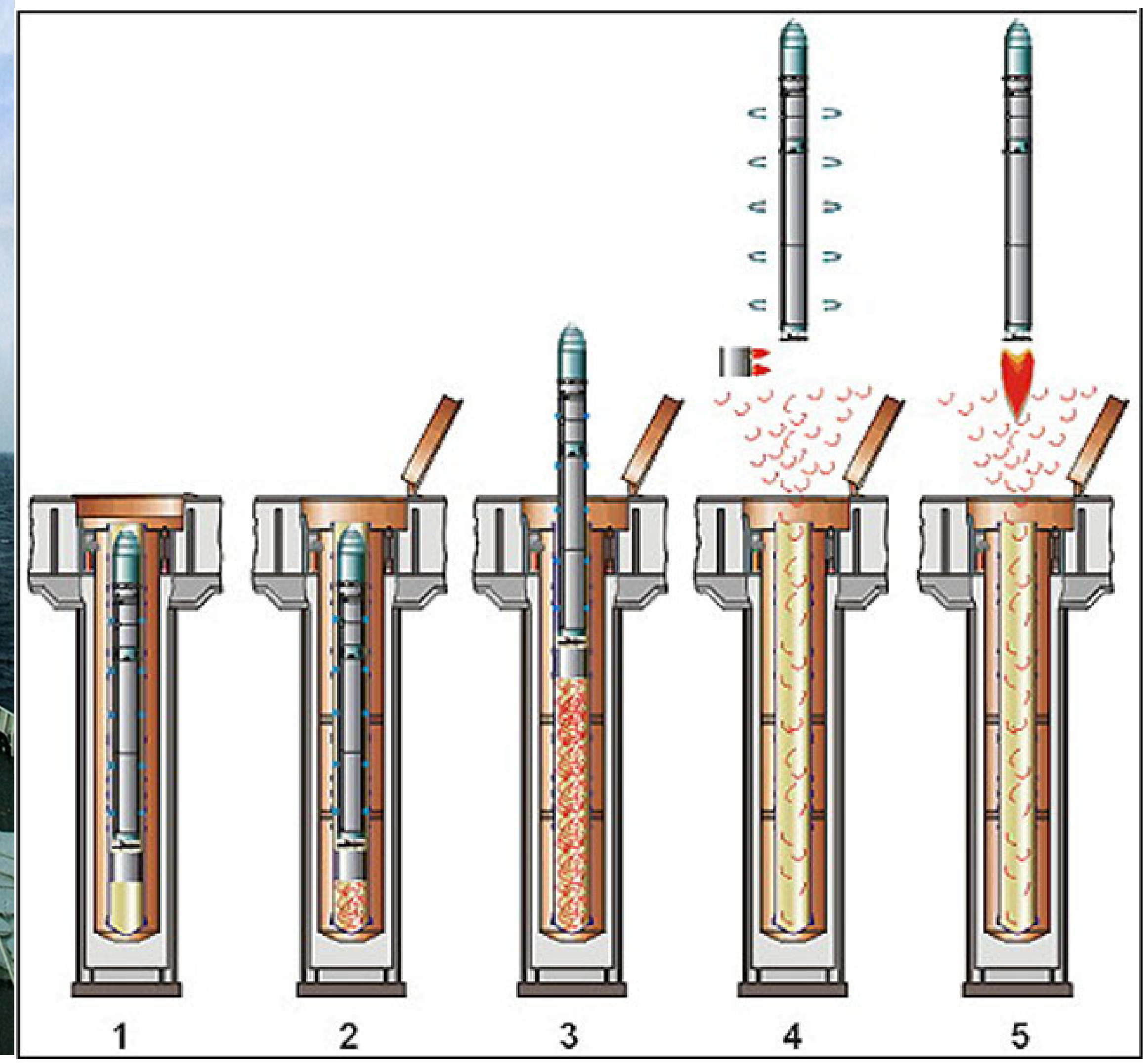
Trident Submarine Underway

24 Trident C4 SLBMs
8 MIRVs with 100kt W76
➔ up to192 targets
SLBM range 7400 km

speed : 20 knots
SSBN range : unlimited
deployment : 70-90 days, two rotating crews
Displacement : 16500 tons
Length : 170 m
width : 13 m

Cold Launch Mode

Missile is ejected with high pressure steam before rocket engines are started: “Cold Launch”



US Trident SSBN

Submarine-Based Missiles

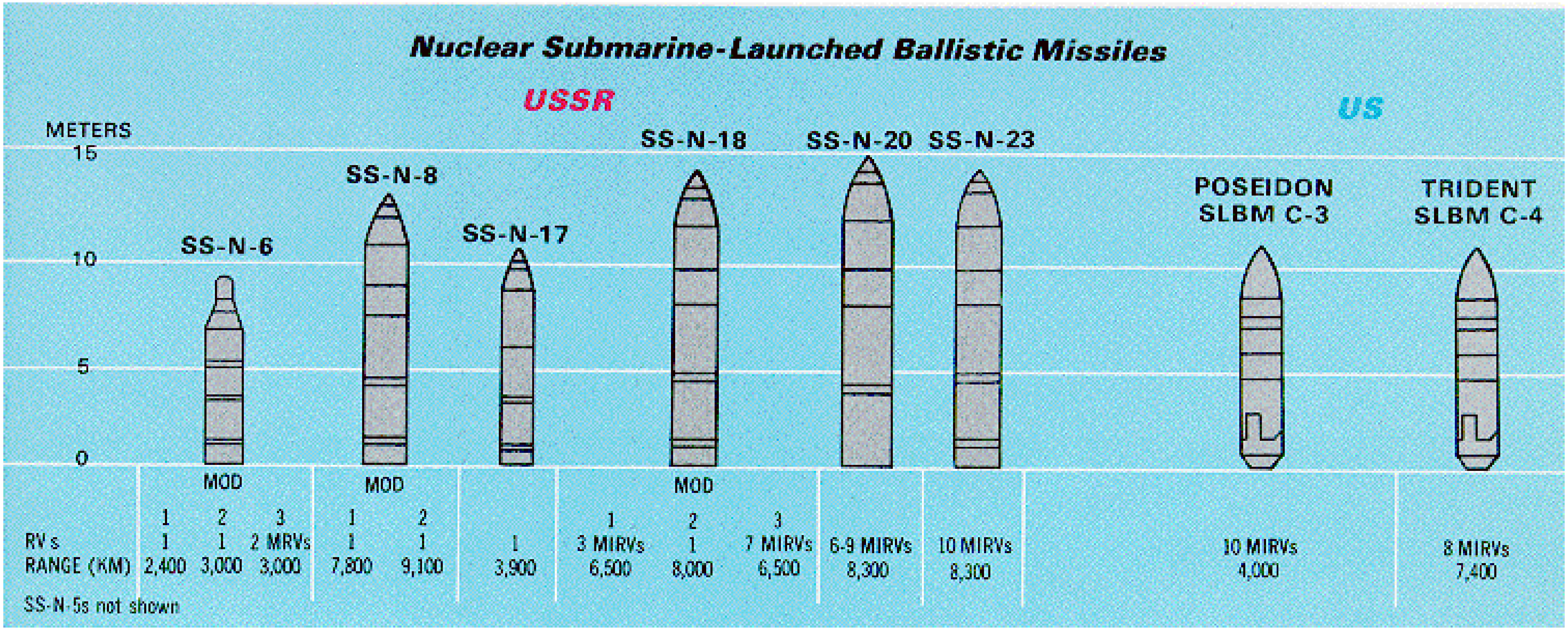
US SLBMs —

- Trident C4 missiles carried 8 MIRVs each (solid propellant, range 7400 km)
- Trident D5 missiles carry 8 MIRVs each (solid propellant, range 7400 km)

Russian SLBMs —

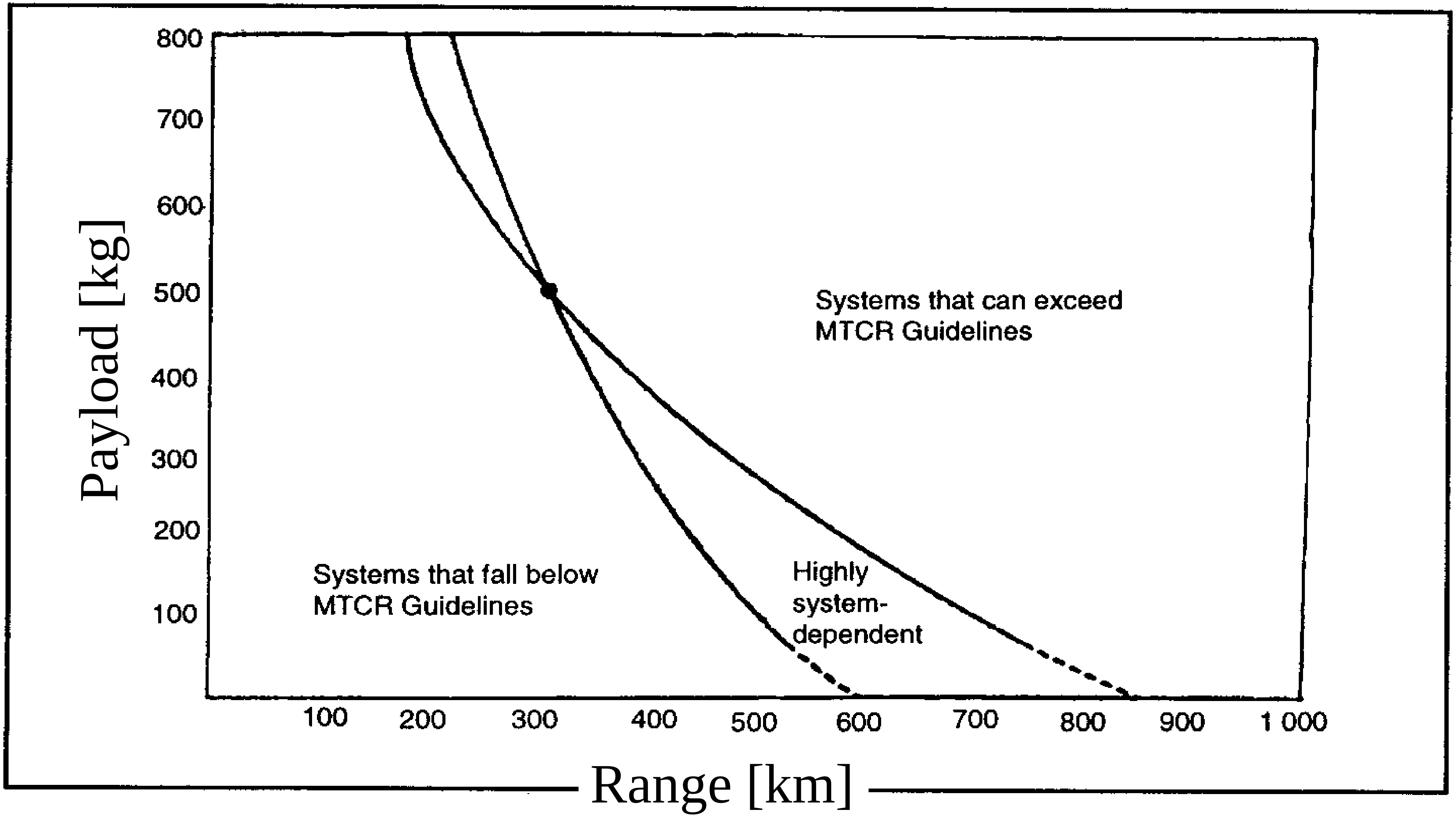
- SS-N-8 missiles carried 1 warhead each (range 9100 km, 64 warheads total)
- SS-N-18 missiles carried 3 warheads each (liquid propellant, range 6500 km)
- SS-N-20 missiles carried 10 warheads each (solid propellant, range 8300 km)
- SS-N-23 missiles carried 4 warheads each (liquid propellant, range 8300 km)

US and Russian SLBMs



Part 5: Technical and Operational Aspects

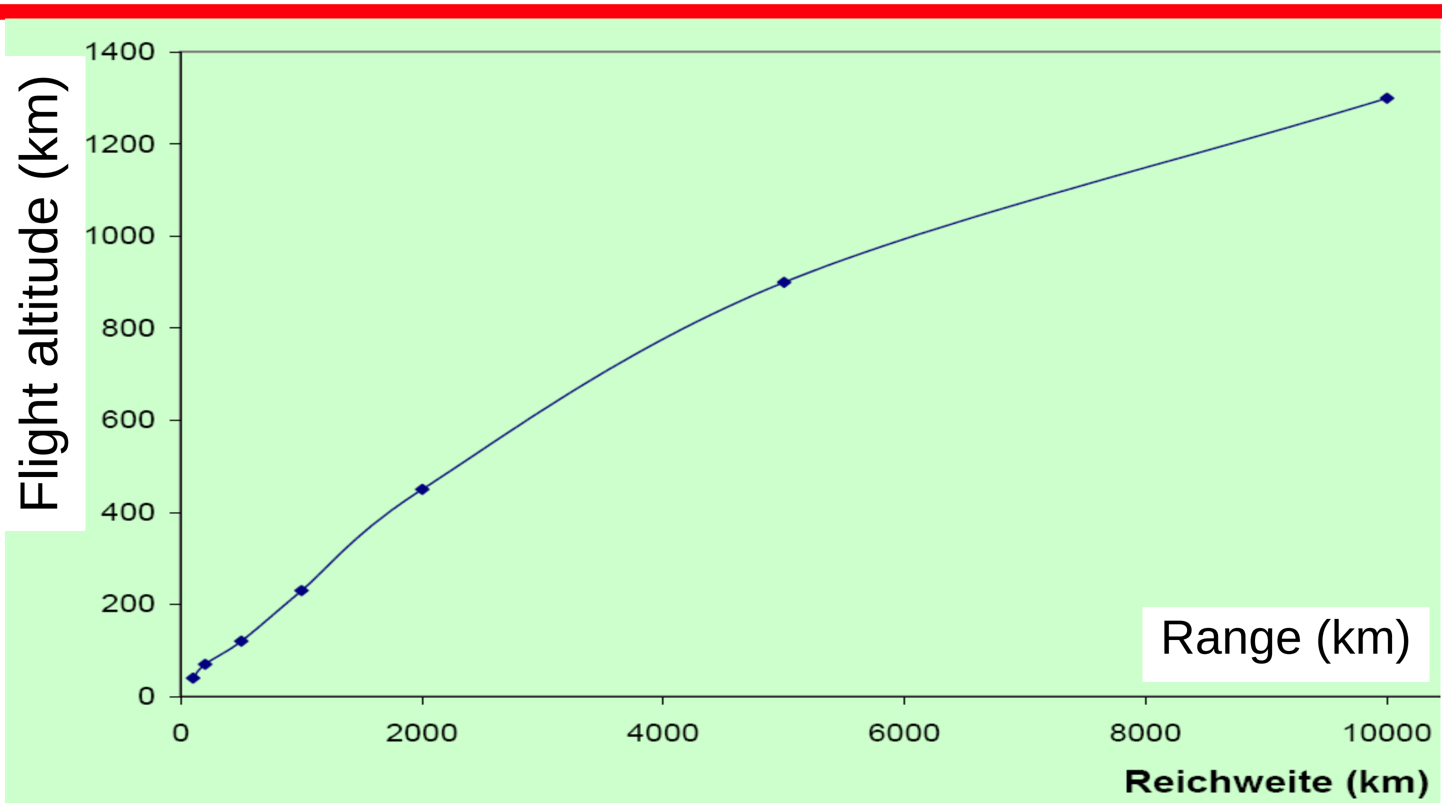
Range-Payload Tradeoff

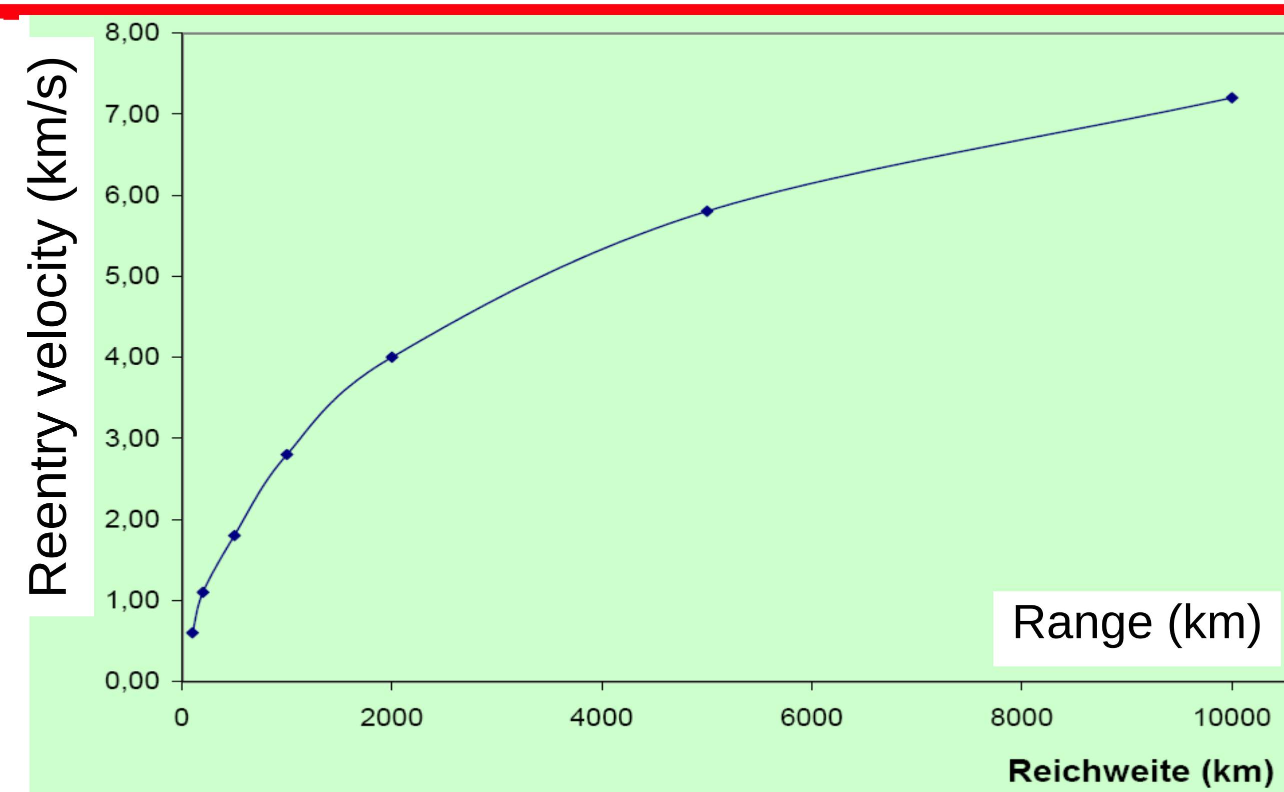


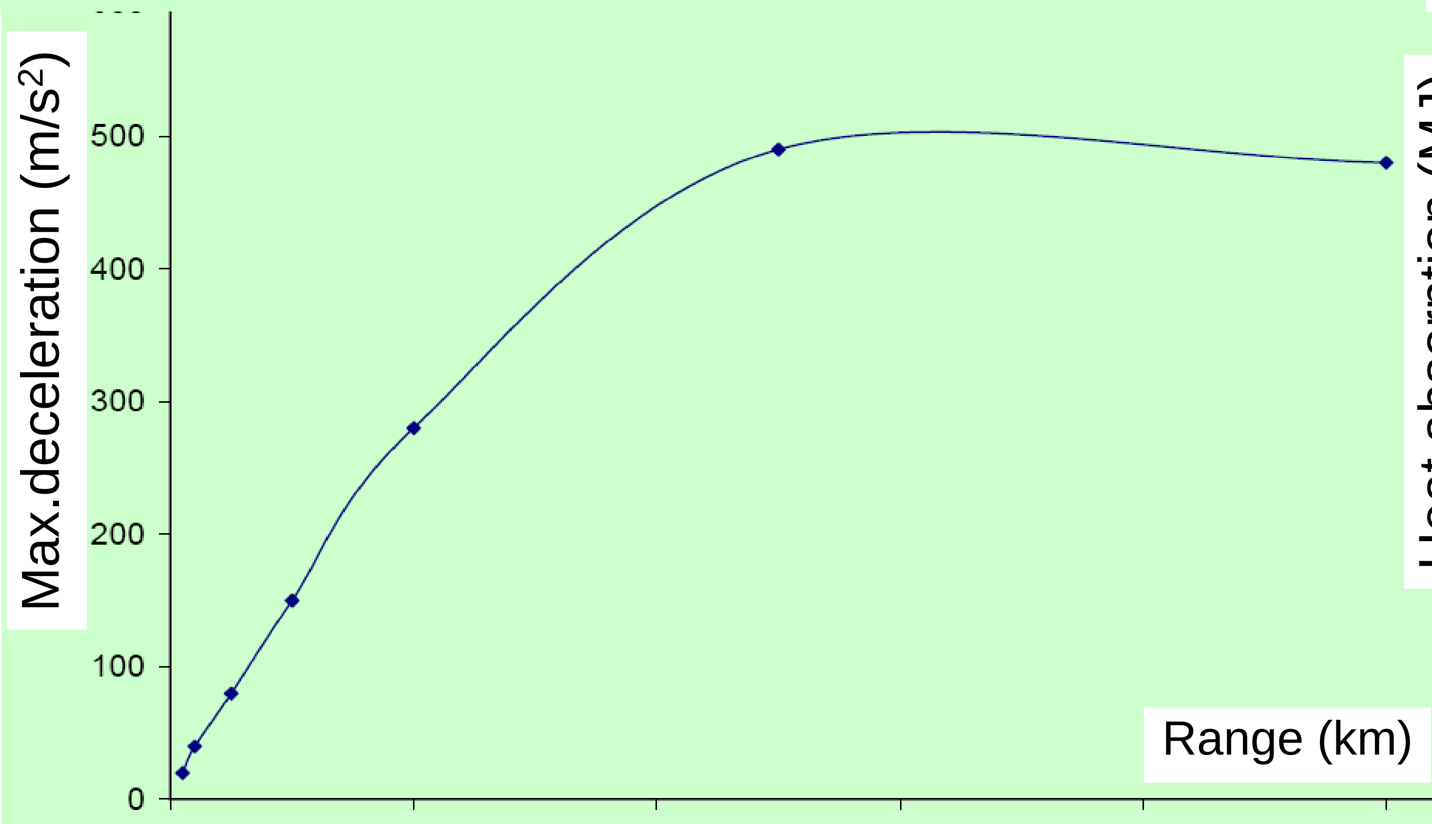
MTCR is the 1987 Missile Technology Control Regime to restrain missile exports

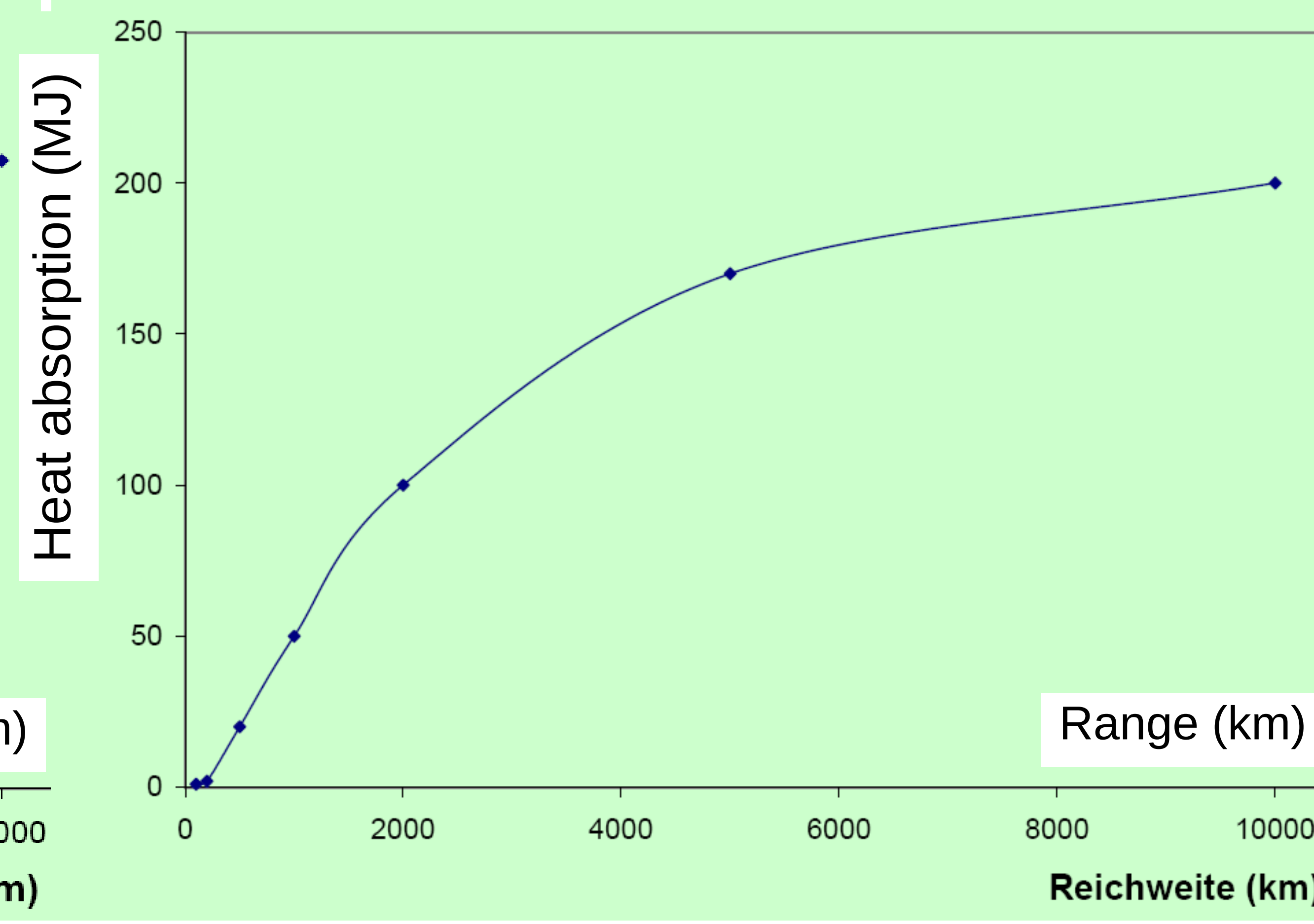
A. Karp, Ballistic Missile Proliferation, sipri, 1996, p. 157

The Performance Required for Missile Warheads Increases Greatly with Increasing Missile Range

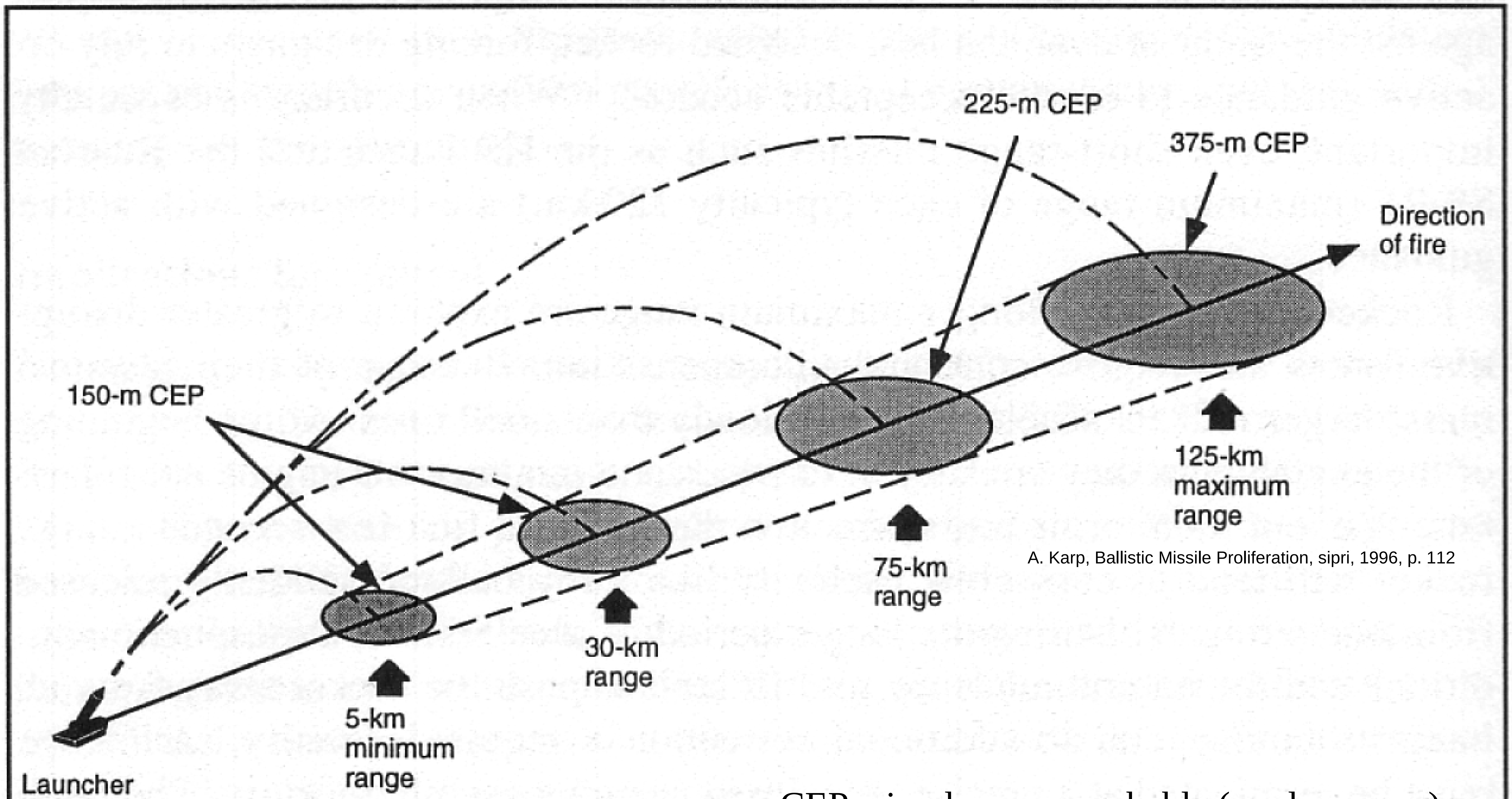








Missile Range–Accuracy Tradeoff



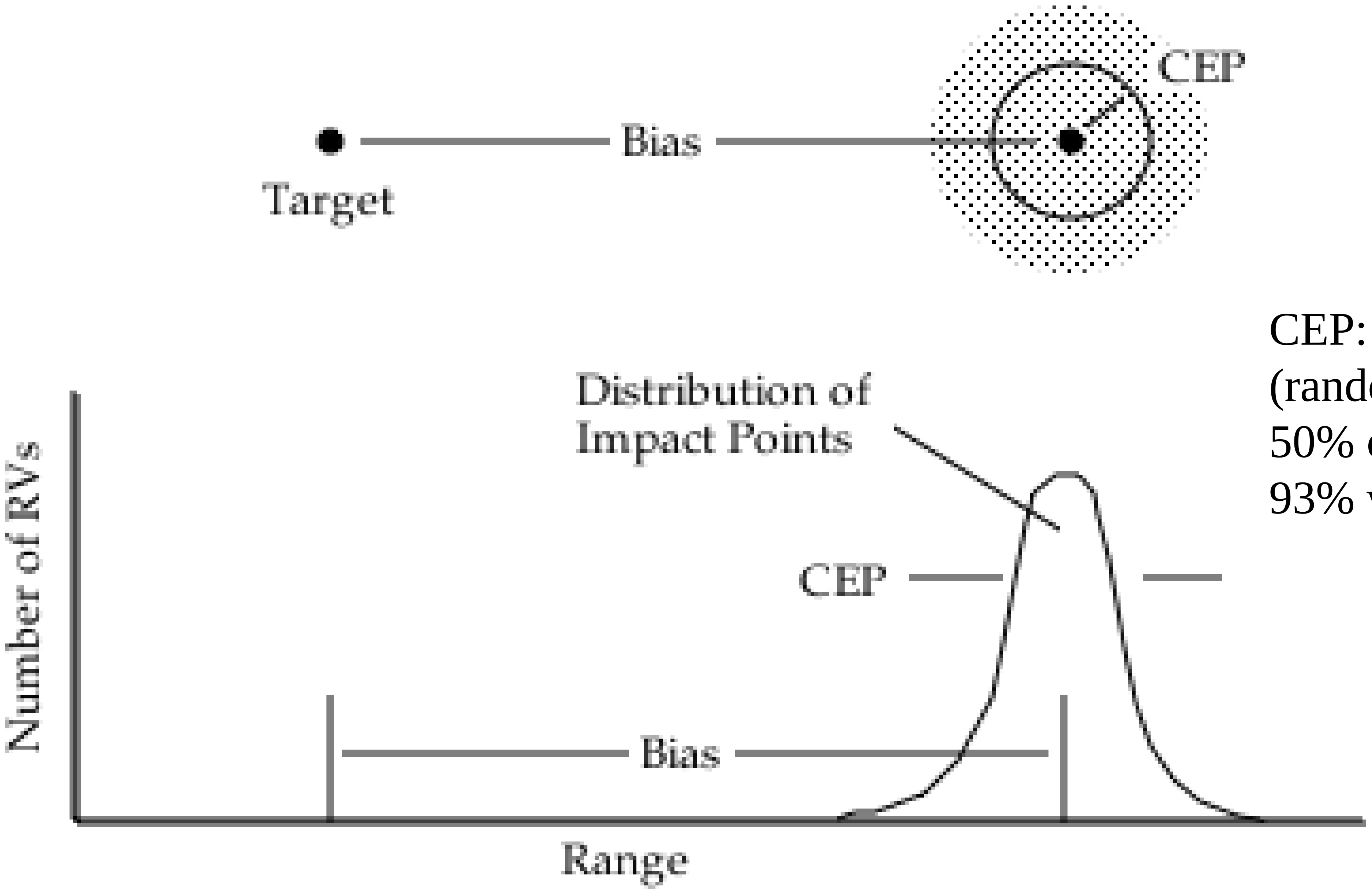
A. Karp, Ballistic Missile Proliferation, sipri, 1996, p. 112

Lance missile

CEP: circular error probable (random error)
50% of missiles land within CEP from target
93% within 2 x CEP from target

Ballistic Missile Accuracy

Distribution of RV impact points —



CEP: circular error probable
(random error)
50% of missiles land within CEP,
93% within 2 x CEP from target

Ballistic Missile Accuracy

The accuracy of a ballistic missile—like the value of *any* physical quantity—can only be specified *statistically*.

Important concepts:

- D = total miss distance
- CEP = "circular error probable" (random error)
- B = Bias (systematic error)

Relation —

$$D = (B^2 + CEP^2)^{1/2}$$

CEP is *not* a measure of the miss distance. The miss distance is *at least as large* as the CEP, but can be *much larger* if there is significant bias.

Ballistic Missile Accuracy

Published CEPs for some ICBMs and SLBMs

	Missile	CEP
US	MMIII	220 m
	Trident I	450 m
	Trident II	100 m
Russia	SS-18	450 m
	SS-N-18	600 m

ICBM Accuracy & Vulnerability

Missile accuracy steadily improved during the Cold War as the result of technological innovation.

As ICBMs become more accurate, they become more vulnerable to attack by the adversary, increasing crisis instability.

Each ICBM and each SLBM was armed with more and more warheads during the Cold War.

As each missile was armed with more warheads, it became a greater threat to the nuclear forces of the adversary and a more attractive target for a pre-emptive or first strike, increasing crisis instability.

Silo-Based Missiles

Vulnerable to attack

- Silo locations are known very accurately
- MIRVed missiles make it possible to launch several warheads against each silo or array of silos

Effect of silo hardness

- Hardening is expensive
- US assumes its silos can withstand 2,000 psi (5 psi will completely destroy a brick house)
- US assumes Russian silos can withstand 5,000 psi (example of 'worst-case' analysis)
- To destroy a silo this hard, a 300 kt warhead would have to land within 100 m

Silo-Based Missiles

Effect of missile accuracy

- Theoretically, missile survival is very sensitive to the miss distance D of incoming warheads
- An an example, assume
  - 1,000 Minuteman silos are hardened to 2,000 psi
  - Two 1.5 MT warheads are targeted to explode at ground level on each silo
- Computations predict
  - If D = 300 ft, then 20 missiles survive (60 if 5,000 psi)
  - If D = 500 ft, then 200 missiles survive (600 if 5,000 psi)

Sources of Systematic Error

- Gravitational field variations
- Atmospheric drag variations

Gravitational Field Variations

Some possible causes —

- Bumps on the Earth (mountains)
- Mass concentrations (masscons)
- Gravitational pull of the Moon

  (Motion of the Moon changes *g* by 3 ppm. An error in *g* of 3 ppm introduces a bias of 300 ft.)

The Earth's gravitational field is carefully measured over US and R (E-W) test ranges —

- US: Vandenberg to Kwajalein
- R: Plesetsk to Kamchatka and Tyuratam to Pacific

But wartime trajectories would be N-S over pole.

Atmospheric Drag Variations

Some possible sources —

- Jet streams
- Pressure fronts
- Surface winds

(30 mph surface wind introduces a bias of 300 ft.)

Density of the atmosphere —

- Is a factor of 2 greater in the day than at night
- Varies significantly with the season
- Is affected by warm and cold fronts

Data from military weather satellites and from models of weather over SU targets were reportedly used to update US warheads twice per day

Uncertainties on Silo-Based Missiles

Fundamental uncertainties

- Missile accuracy
- Warhead yield
- Silo hardness

Operational uncertainties

- System reliability
- Wind and weather
- Effects of other warheads (fratricide)
- Extent of ‘collateral damage’
  (‘digging out’ missiles creates enormous fallout)

Effects of Explosive Yield, Missile Accuracy, and Silo Hardness on Land-Base Missile Vulnerability

Probability of destroying ("killing") a missile silo: $P_K = 1 - e^{-K/f(H)}$

- A 10-fold increase of warhead yield Y increases the kill factor K by about a factor of 5.
- A 10-fold decrease in the warhead miss distance D increases the kill factor K by 100.
- For a kill factor of 20, a 10-fold increase in the silo hardness from 300 psi to 3000 psi reduces the probability of silo destruction from about 85% to about 35%.

Counterforce Capabilities in 1985

U.S. ICBMs:	K = 107,000
U.S. SLBMs:	K = 48,000
U.S. Trident II D5:	K = 475,000
Russia ICBMs:	K = 131,000
Russia SLBMs:	K = 9,500

Submarine-Based Missiles

Operational considerations

- Vulnerability depends on
  size of operational areas, ASW threat, counter-ASW capability
- Ability to survive
- US SSBNs are quieter than Russian SSBNs
  (but Russia is improving rapidly)
- US leads in anti-submarine warfare (ASW) capability
  and access to high seas
- Fraction of forces on-station
  (duration of patrols, time required for repairs)
- System reliability
- Effectiveness of command and control

Submarine-Based Missiles

Effective number of warheads (example) before New START

- United States

2688	[SLBM warheads}
x 0.75	[fraction typically on-station]
x 0.90	[estimated reliability]
= 1,814	[effective number of warheads]

- Russia

2384	[SLBM warheads}
x 0.25	[fraction typically on-station]
x 0.70	[estimated reliability]
= 447	[effective number of warheads]

These examples show that many factors *other than just the number of warheads* are important in comparing the effectiveness of nuclear forces.

Part 5: Nuclear Command and Control

Nuclear Command and Control – 1

C3I: Command, Control, Communication, Intelligence

Specific goals—

- Provide strategic and tactical warning
- Provide damage assessments
- Execute war orders from National Command Authority before, during, and after initial attack
- Evaluate effectiveness of retaliation
- Monitor development of hostilities, provide command and control for days, weeks, months

Nuclear Command and Control – 2

Some important aspects and implications —

- Organizational structure of command and control
- Available strategic communications, command, control and intelligence (C^3I) assets
- Vulnerability of strategic C^3I assets to attack

Alert levels — (Defensive Readiness Condition)

DEFCON 5 Normal peacetime readiness
DEFCON 4 Normal, increased intelligence and strengthened security measures
DEFCON 3 Increase in force readiness above normal readiness intelligence and strengthened security measures
DEFCON 2 Further Increase in force readiness
DEFCON 1 Maximum force readiness.

Nuclear Command and Control – 3

Satellite systems

- Early warning
- Reconnaissance
- Electronic signals
- Weather
- Communication
- Navigation

Response Times for Attack or Breakout

The Threat of Accidental Nuclear War – 20 Dangerous Incidents

1) November 5, 1956: Suez Crisis Coincidence

2) November 24, 1961: BMEWS Communication Failure

3) August 23, 1962: B-52 Navigation Error

4) August-October, 1962: U2 Flights into Soviet Airspace

5) October 24, 1962- Cuban Missile Crisis: A Soviet Satellite Explodes

6) October 25, 1962- Cuban Missile Crisis: Intruder in Duluth

7) October 26, 1962- Cuban Missile Crisis: ICBM Test Launch

8) October 26, 1962- Cuban Missile Crisis: Unannounced Titan Missile Launch

9) October 26, 1962- Cuban Missile Crisis: Malstrom Air Force Base

10) October, 1962- Cuban Missile Crisis: NATO Readiness

Source: www.nuclearfiles.org/kinuclearweapons/anwindex.html

The Threat of Accidental Nuclear War
20 Dangerous Incidents

11) October, 1962- Cuban Missile Crisis: British Alerts

12) October 28, 1962- Cuban Missile Crisis: Moorestown False Alarm

13) October 28, 1962- Cuban Missile Crisis: False Warning Due to Satellite

14) November 2, 1962: The Penkovsky False Warning

15) November, 1965: Power Failure and Faulty Bomb Alarms

16) January 21, 1968: B-52 Crash near Thule

17) October 24-25, 1973: False Alarm During Middle East Crisis

18) November 9, 1979: Computer Exercise Tape

19) June , 1980: Faulty Computer Chip

20) January, 1995: Russian False Alarm

Source: www.nuclearfiles.org/kinuclearweapons/anwindex.html

January, 1995: Russian False Alarm

On January 25, 1995, the Russian early warning radar's detected an unexpected missile launch near Spitzbergen. The estimated flight time to Moscow was 5 minutes. The Russian President, the Defense Minister and the Chief of Staff were informed. The early warning and the control and command center switched to combat mode. Within 5 minutes, the radar's determined that the missile's impact would be outside the Russian borders.

The missile was Norwegian, and was launched for scientific measurements. On January 16, Norway had notified 35 countries including Russia that the launch was planned. Information had apparently reached the Russian Defense Ministry, but failed to reach the on-duty personnel of the early warning system.

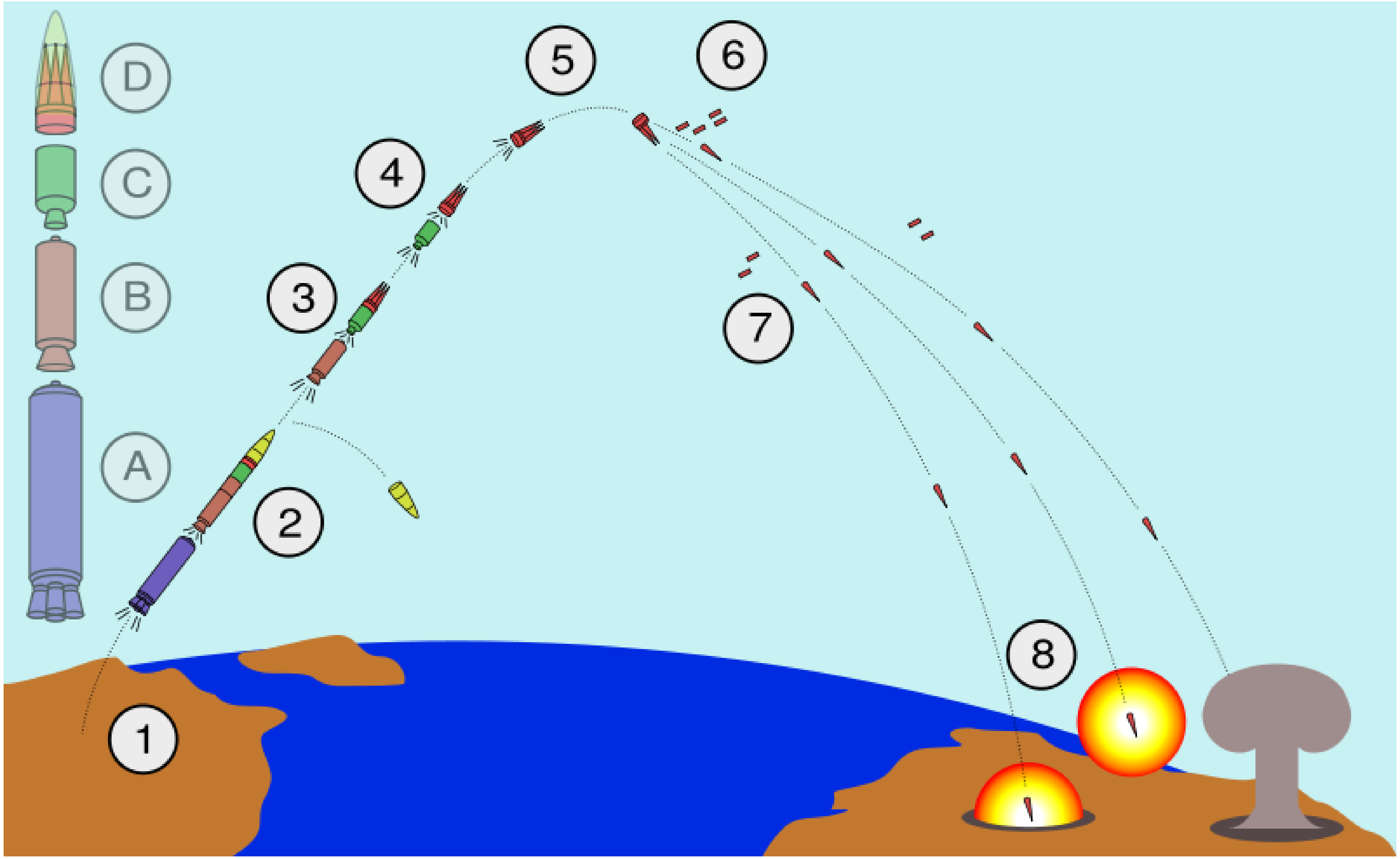
Possible Risk Reduction Measures

- Put ballistic missiles on low-level alert
- Reduce number of warheads on missiles
- Remove warheads to storage
- Disable missiles by having safety switches pinned open and immobilized
- Allow inspections and cooperative verification

Source: B. Blair, H. Feiveson. F. von Hippel, Taking Nuclear Weapons off Hair-Trigger Alert, Scientific American, November 1997

End of Module 5

Flight of a MIRV'd ICBM (Schematic)



Flight of a MIRV'd ICBM (Schematic)

1. The missile launches out of its silo by firing its 1st stage boost motor (*A*).
2. About 60 seconds after launch, the 1st stage drops off and the 2nd stage motor (*B*) ignites. The missile shroud is ejected.
3. About 120 seconds after launch, the 3rd stage motor (*C*) ignites and separates from the 2nd stage.
4. About 180 seconds after launch, 3rd stage thrust terminates and the Post-Boost Vehicle (*D*) separates from the rocket.
5. The Post-Boost Vehicle maneuvers itself and prepares for re-entry vehicle (RV) deployment.
6. The RVs, as well as decoys and chaff, are deployed during backaway.
7. The RVs and chaff re-enter the atmosphere at high speeds and are armed in flight.
8. The nuclear warheads detonate, either as air bursts or ground bursts.