Armament Systems

(Warheads and Fuzing)

Gregg Bock

Armament Systems

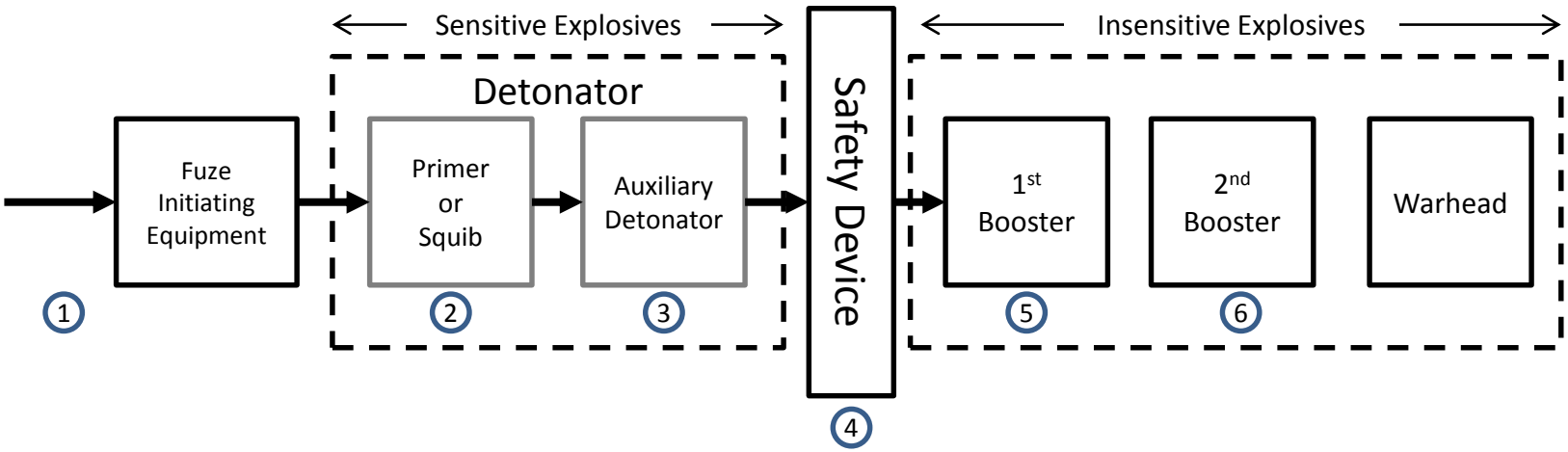
- The mission of a projectile weapon is to inflict an amount of damage required to either destroy the intended target or render it ineffective
- For missiles, the armament system responsible for inflicting damage on the target
- Armament systems are classified by the means of inflicting damage
  - Explosive
  - Nuclear
  - Chemical, Bacteriological, Radiological
  - Other
- Many of the systems will not be discussed as they are either
  - Classified
  - Seldom used
  - Banned by existing treaties

Focus of this Section Will Be on Explosive Systems

Categories of Explosives

- Military explosives are defined by their rate of decomposition
- Low Explosives
  - Used as propellant
  - Provide a large volume of gas which produces enough gas to generate thrust
  - Combustible material that decompose rapidly but do not detonate (deflagration)
- High Explosives
  - Extremely rapid decomposition (detonation)
  - Detonates with a “high” exit velocity (up to 30,000 ft/sec)
  - Extremely sensitive
    - Impact, friction, shock or heat may cause a reaction
    - Small quantities may deflagrate rather than detonate if not confined

Explosive Train

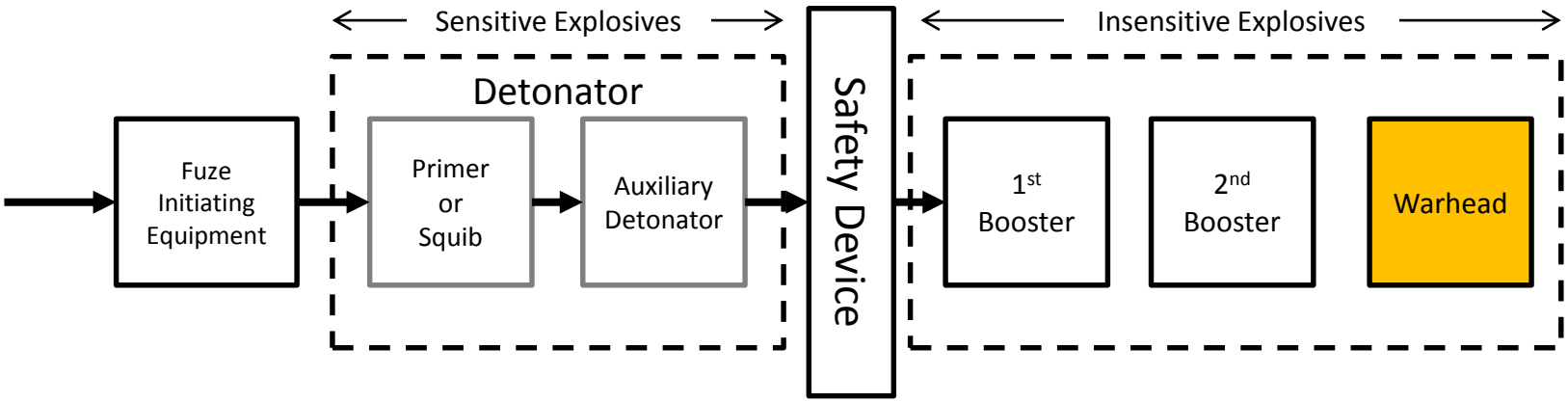


1. RF signals, acoustic impulse, electromagnetic impulse, electronic impulse, photoelectric signal, hydroelectric pressure
2. Small explosive component that converts electrical or mechanical energy to explosive energy
3. Sensitive explosive capable of igniting a higher order explosive
4. Barrier between sensitive and insensitive munitions to prevent interaction except by signal initiation
5. Amplified detonation wave ensures detonation of second booster
6. Contains more explosive material to increase detonation wave to a level to initiate warhead energy release

Components of a High Explosive Armament (Warhead) System

- Fuze system
- Explosive fill
  - The material that provides the force to the warhead
- Warhead casing
  - Outer shell
  - Often uniquely constructed to assist in delivering the most damage from a particular type of warhead
- Safe and Arm system
  - Part of the fuze system
  - Prevents inadvertent detonation
  - Ensures proper detonation

Warhead



- Warhead – the thing that makes the big boom

Warhead Characteristics

- Damage Volume
  - Defines the destructive effectiveness of a given payload
- Attenuation
  - A function of distance from the origin of the blast, as the blast travels outward, the energy given off is dispersed over a greater area
- Propagation
  - How energy released from the blast spreads

Blast Warheads

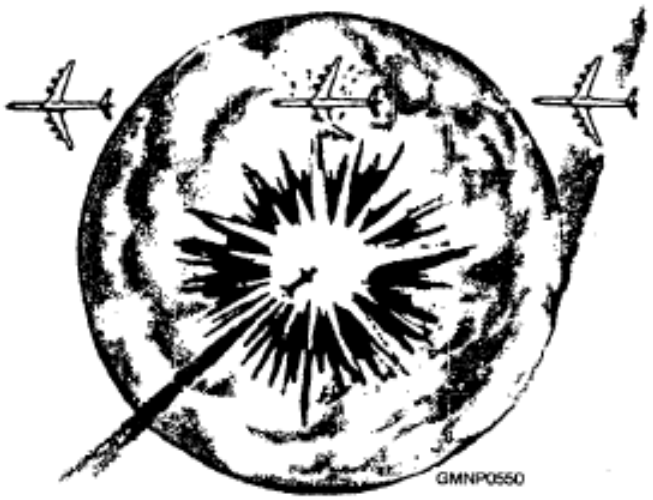
Types of Warheads

- Types of blasts:
  - Isotropic - Blast propagates equally in all directions.
  - Aeolotropic - Blast propagates directionally.
- Blast warheads are designed to inflict optimal damage from multiple delivery methods
  - Initial blast produces heat and overpressure
  - Followed by a suction or underpressure
  - Pressure differential can result in the target exploding
- Warhead blasts close to the ground provide a third means of inflicting damage
  - Pressure wave resulting from the reflected wave (of a surface detonation)
  - The point at which the three waves combine is called the “Triple Point”
  - Increases weapon effectiveness/lethal range

Fragmentation Warheads

Types of Warheads

- Blast energy is translated to the fragments of the weapons casing
  - Weapon casing fragments are hurled outward at high speed
  - Warhead designer can control the size, velocity, and dispersion pattern
    - Aeolotropic vs isotropic blast
- Most effective against air targets
  - Exceeds the radius of a blast weapon
  - Allows for greater inaccuracies in weapon use
    - Can build a less expensive seeker/guidance section for the weapon



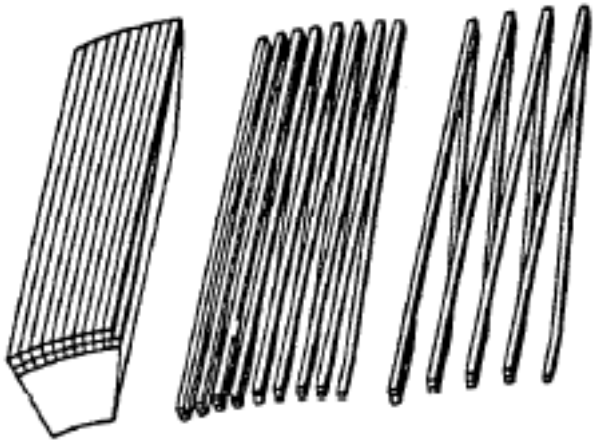
Illustrations taken from reference 3

Continuous-Rod Warheads

Types of Warheads

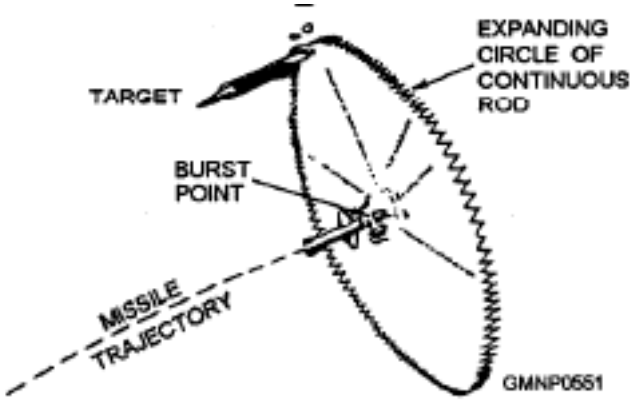
- Used to damage aircraft in the event of a near miss
- Series of rods connected and folded so that the series expands circularly
  - Imagine something similar to a child safety gate
- Doesn't produce as much destructive energy as the average fragmentation weapon
  - Damage is caused by cutting iron

Expanding warhead bundle



Illustrations taken from reference 3

Continuous rod pattern after burst



Illustrations taken from reference 3

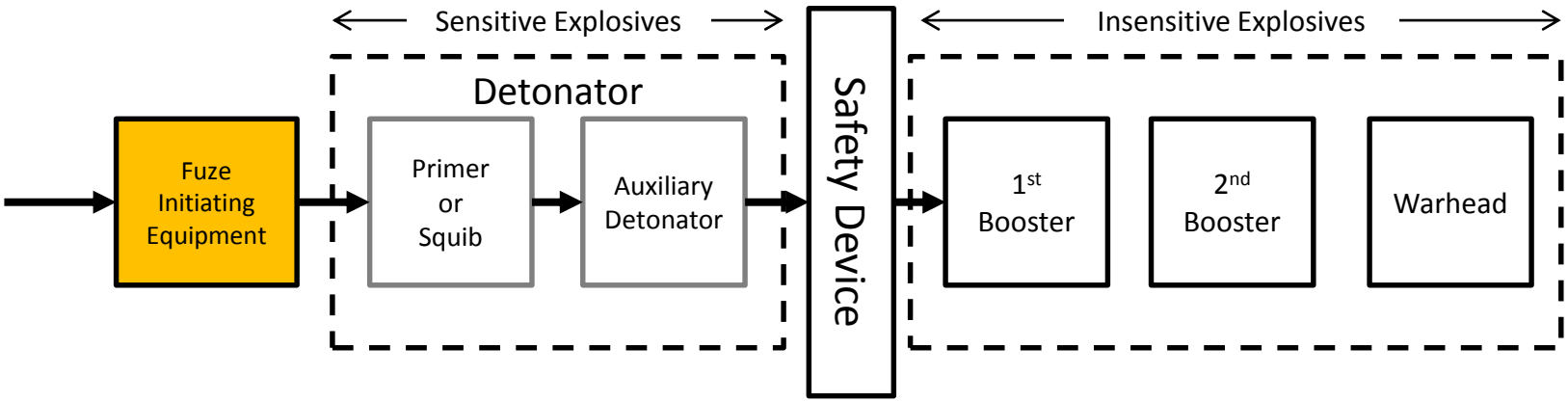
Special Purpose

Types of Warheads

- Thermal Weapons
  - Used to start fires
  - Napalm, etc.
- Biological & Chemical Weapons
  - Used to kill with a minimal amount of destruction
  - Biological - microbes (Anthrax, Ebola, Plague)
  - Chemical - (Nerve Agents, Mustard Gas)
- Radiation Weapons (e.g.- Neutron Bomb)
- Pyrotechnic Warheads
  - Flares (for lighting or signaling)
  - Smoke

Fuze

Warhead



- Fuze –the trigger that sets the trap

Fuze System

- Purpose is to detonate the warhead at the point of maximum effectiveness
- Virtually all modern projectile weapons require a fuze
  - Propulsion systems
    - Rockets, missiles, torpedoes
  - Warhead detonation systems
    - Rockets, missiles, torpedoes
    - Bombs, mines
  - Propulsion-aided projectiles
    - Guns, cannons

Common Fuze Types

Fuze Systems

- Time fuze
- Proximity fuze
- Contact (percussive or impact) fuze
- Barometric fuze (depth charge)
- Command detonation fuze

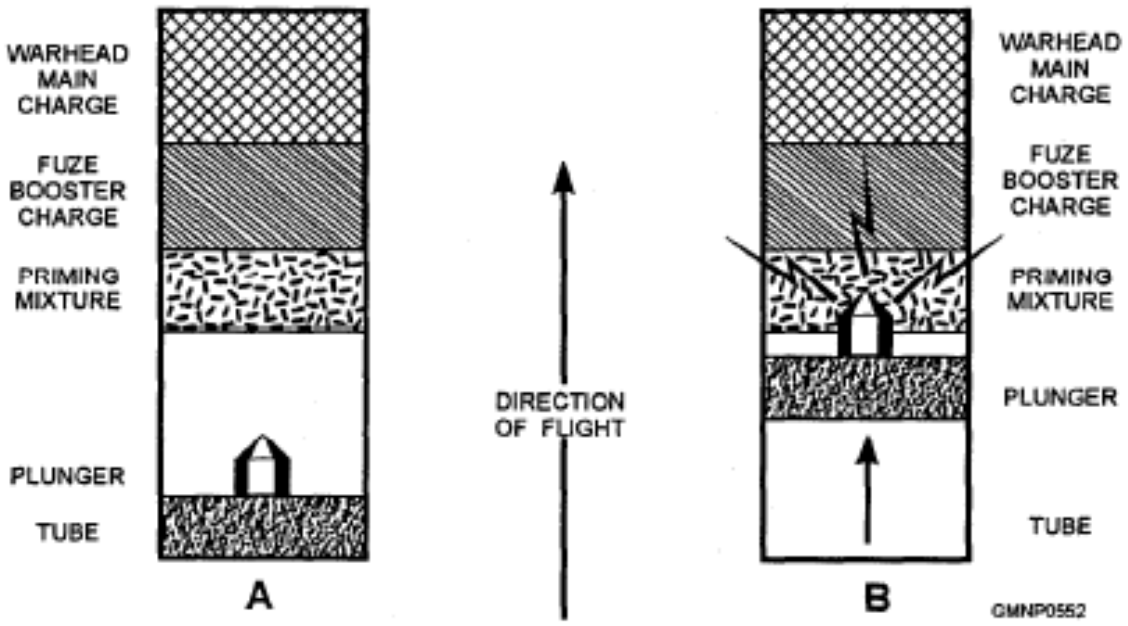
Contact Fuzes

Fuze System

- There are two main types of contact fuzes
  - Contact fuze
  - Impact fuze
  - There are only subtle differences between them
- Contact fuze
  - Detonates upon a physical contact
  - Relies upon a device (sensor, trip wire, circuit card, etc.) designed to break upon contact to indicate contact
- Impact fuze
  - Detonates upon impact with target
  - Threshold level of force (measured in G's) is required to trigger detonation

Effectiveness of a Contact Fuze System Depends Upon Warhead Penetration Before Detonation

Contact Fuze



Illustrations taken from reference 3

Proximity Fuzes

Fuze System

- Detects presence of target via RF energy
- Locates target using radar
  - Range
  - Angle
  - Range rate
- Computes a detonation time which will inflict maximum damage
  - More intelligent design than a contact fuze
  - Requires knowledge of
    - Warhead velocity, missile speed, target speed
    - Missile body orientation, relative range and angle from missile to target
  - More forgiving than a contact fuze
    - Direct contact by the missile is not required to succeed

Operation of a Single Beam Fuze

Proximity Fuzes

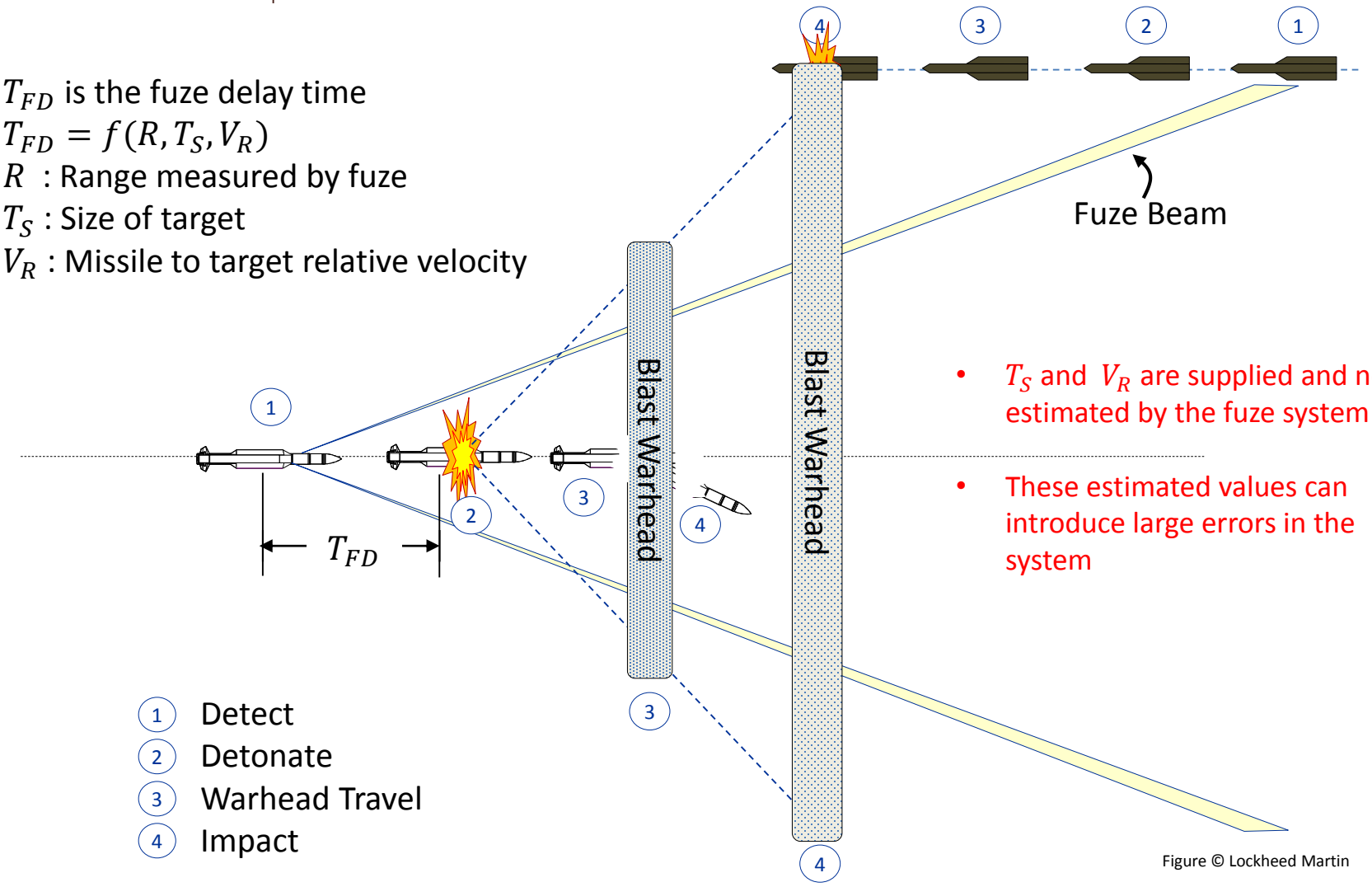
T_{FD} is the fuze delay time

$T_{FD} = f(R, T_S, V_R)$

R : Range measured by fuze

T_S : Size of target

V_R : Missile to target relative velocity



- T_S and V_R are supplied and not estimated by the fuze system
- These estimated values can introduce large errors in the system

1. Detect
2. Detonate
3. Warhead Travel
4. Impact

Figure © Lockheed Martin

Common Issues a Single Beam Fuze

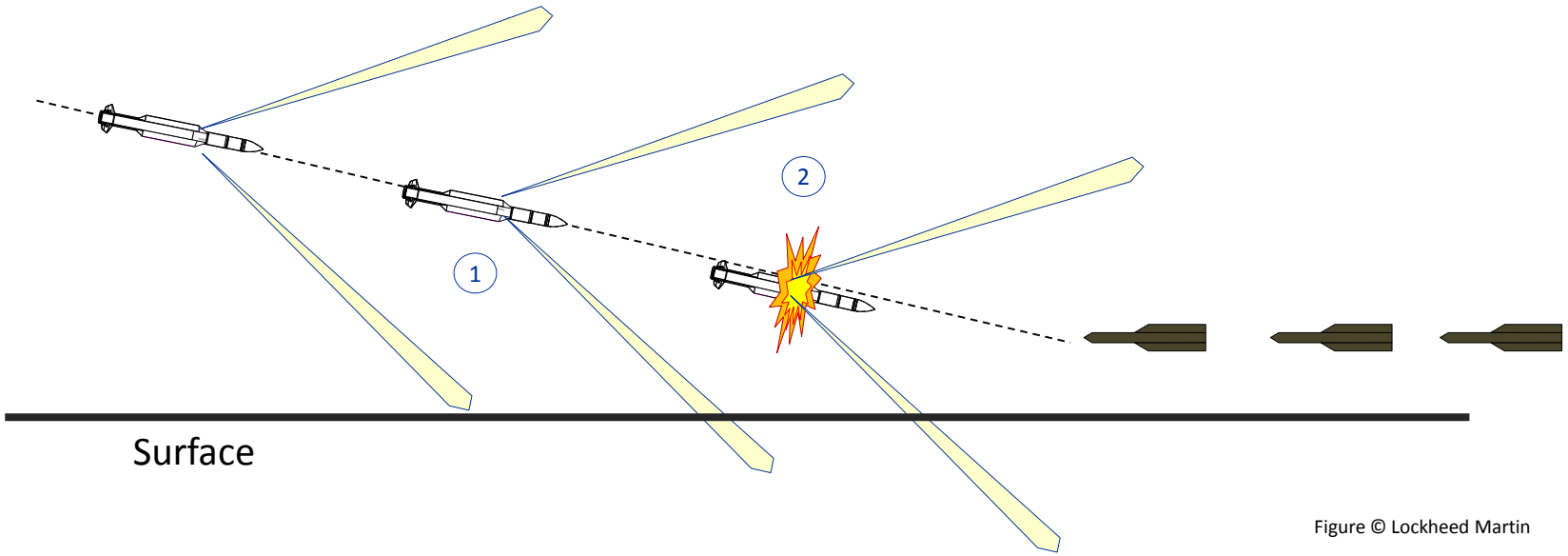
Proximity Fuzes

- Single beam fuzes suffer performance issues since target information is only gathered when the target flies through the beam of the fuze
- Fuze is typically fixed in orientation relative to the missile body
- Typical problems
  - Target extent (target size is assumed or provided, not measured)
  - Low altitude surface detonations
  - Noise jamming of the RF fuze
    - Target to missile range information is denied
    - Fuze time delay $T_F = f(R, V_R, T_S)$ is inaccurate
      - R is relative range from target to missile
      - V_R is the relative speed of target to missile (provided as input)
      - T_S is the target size (assumed)

Low Altitude Problem

Single Beam Fuze Issues

- Fuze can trip on surface of the earth prior to target detection



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1. Detect
2. Detonate
3. Warhead Travel
4. Impact

Dual Beam Fuzes

RF Proximity Fuzes

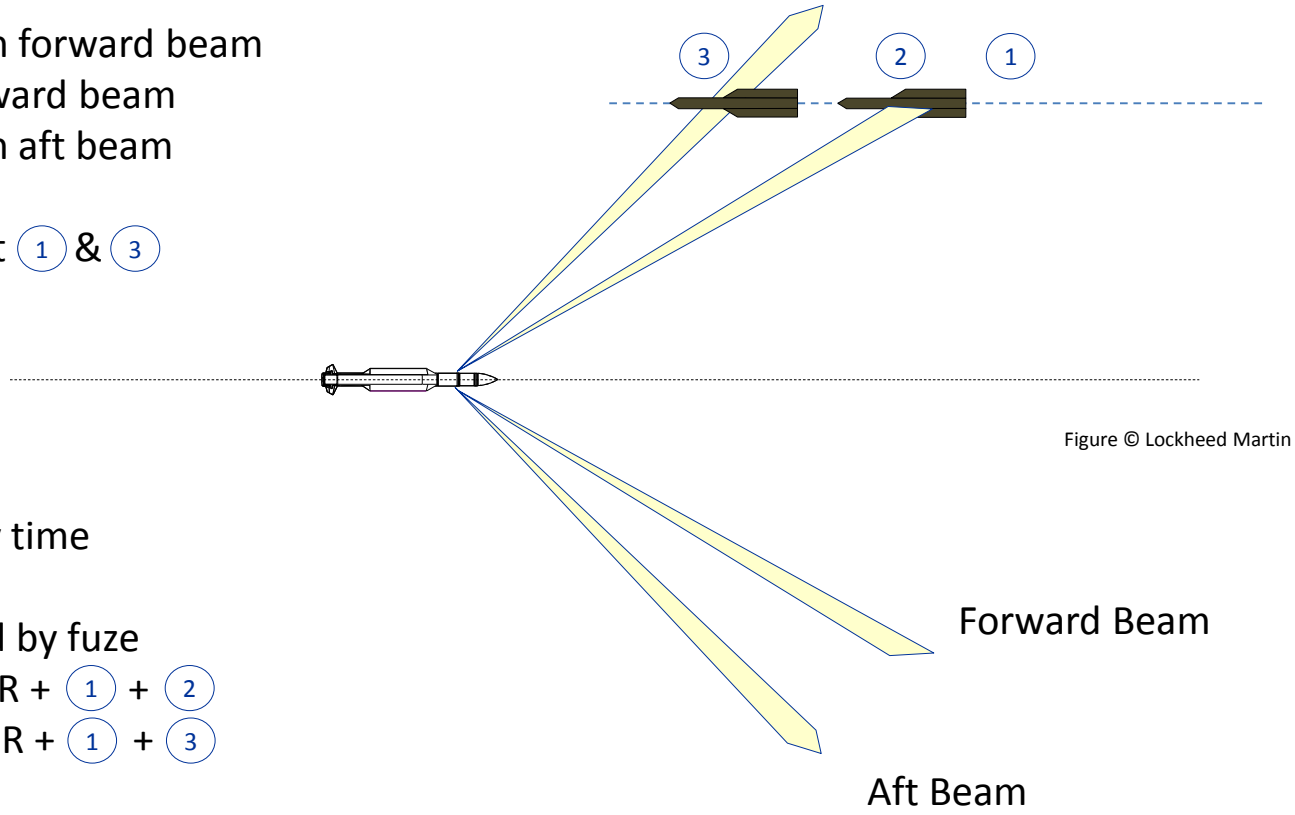
- The introduction of the dual beam proximity fuze addresses many of the short comings of the single beam fuze
- More accurate relative velocity (V_R) computations
- Target size can be estimate by the fuze system
  - Target extent problem resolved
  - Fuze still must determine the appropriate aimpoint relative to the target body
    - Where is the most vulnerable area?
- More robust to jamming environment
  - Each fuze can be denied range estimates
  - Time between detection of first and second fuze can provide a range estimate

Operation of a Dual Beam Fuze

RF Proximity Fuzes

1. Time of entrance in forward beam
2. Time of exit of forward beam
3. Time of entrance in aft beam

Range measured at 1 & 3



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T_{FD} is the fuze delay time

$T_{FD} = f(R, T_S, V_R)$

R : Range measured by fuze

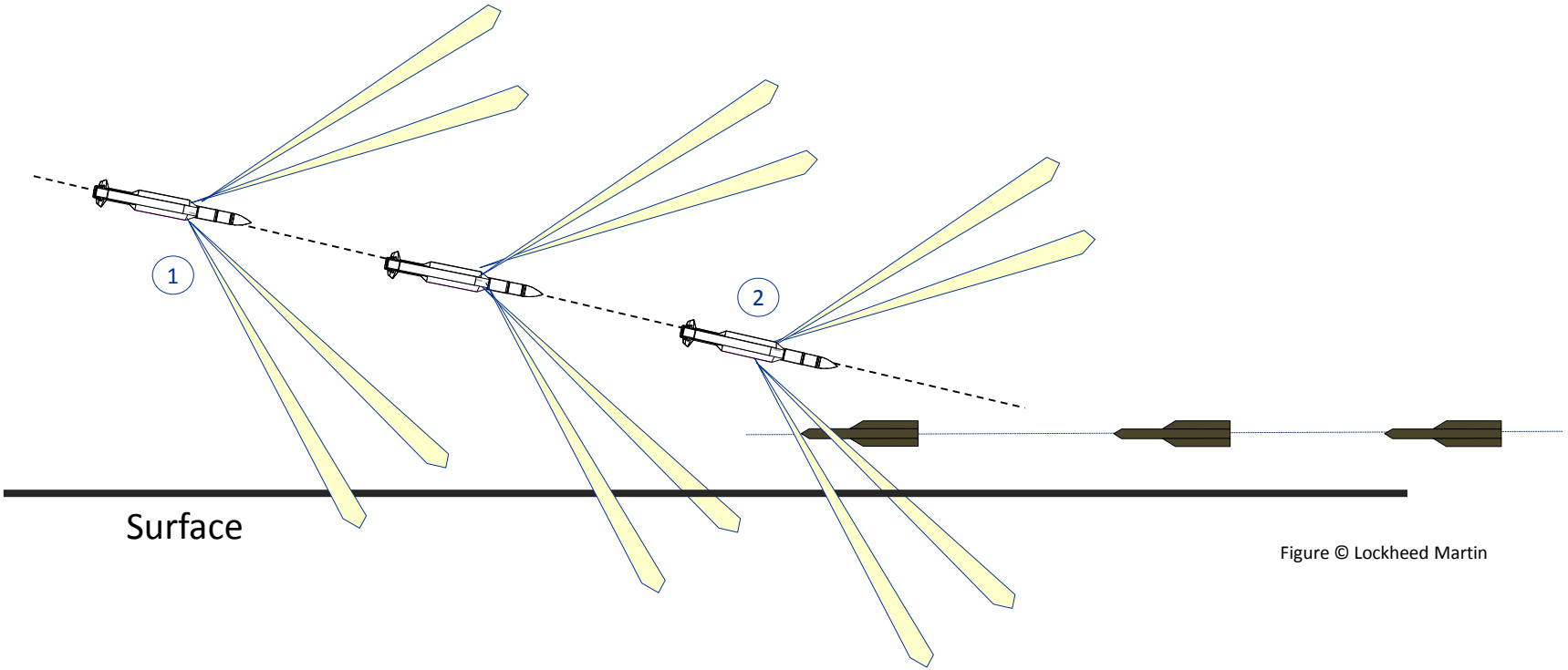
T_S : Measured from R + 1 + 2

V_R : Measured from R + 1 + 3

Dual Beam Surface Gating

RF Proximity Fuze

1. Fuze does not trip on the surface detection because the aft beam detects the surface prior to the forward beam
2. Fuze detects target in forward beam, initiating the warhead detonation procedure



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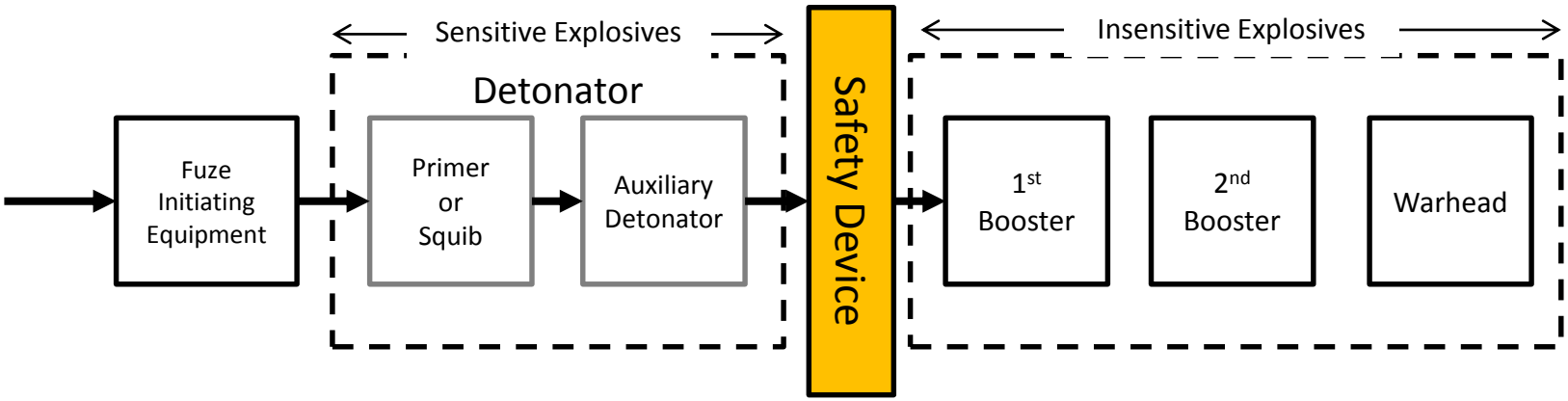
Safety and Arming

Warhead



- Safety device – barrier between fuze and warhead prevents inadvertent warhead detonation
- Arming the warhead removes the safety device from the path above
- Safety - Devices placed in series in firing path for safety.
- Reliability - Components placed in parallel in firing path for arming & firing reliability.

References

1. Missiles System Engineering Fundamentals, *Guided Missile Armament Systems*. Lockheed Martin Course, ~ 1984
2. Naval Weapon Systems Class, Lecture 12 *Fuzing.*
3. NAVEDTRA 14110, *Gunner's Mate 1 & C*. November 1996.