



# Military Aircraft Systems

Weapon Types and Definitions

# Objectives

- Parts of LO1 P1 - Identify types of air-launched weapons used by military aircraft
- LO2 P4 – Identify the type of target that each air-launched weapon is designed for
- LO4 P8 - List advantages and disadvantages of unguided weapons
- LO4 P9 - List advantages and disadvantages of guided weapons

# Objectives

Explain:

- The advantages and disadvantages of guided and unguided weapons
- The different types of ordnance
- The platform-to-target categorisation
- The different types of gun
- Types of warhead

# Guided vs Unguided

- In a guided weapon, the path can be changed after launch
- What do you think the advantages and disadvantages of fitting guidance systems to weapons are?

# Guided vs Unguided

## Guided

- Less collateral damage
- Less friendly fire
- Fewer weapons needed to destroy a target
- 'Stand-off' ability

## Unguided

- Cheaper
- Smaller

# Accuracy - CEP

- Circular area probable (CEP) is the distance at which the weapon will hit 50% of the time



## Circular Error Probable

# Terminology

- Missile – powered, guided
  - Ballistic missile – arcs through the air

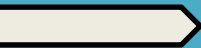




## Ballistic Missile

# Terminology

- Missile – powered, guided
  - Ballistic missile – arcs through the air
  - Cruise missile – flies



**Cruise Missile**

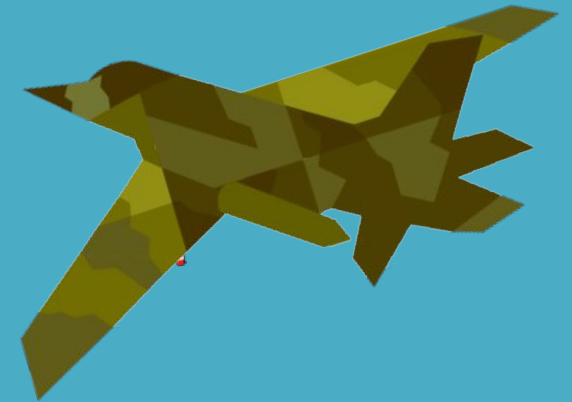
# Terminology

- Missile – powered, guided
  - Ballistic missile – arcs through the air
  - Cruise missile – flies
- Rocket – powered, unguided
- Bomb – unpowered, guided or unguided
- Torpedo – powered through water
- Mine – lays in wait
- Depth charge – underwater bomb used against submarines

# Platform to target

Platform and target are categorised as:

- Air
- Surface
- Sub-surface



## Air-to-surface

(anti-ship)

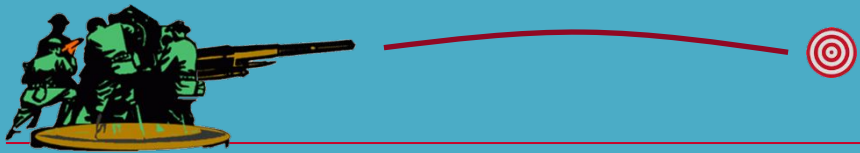


## Sub-surface-to-surface (anti-ship)

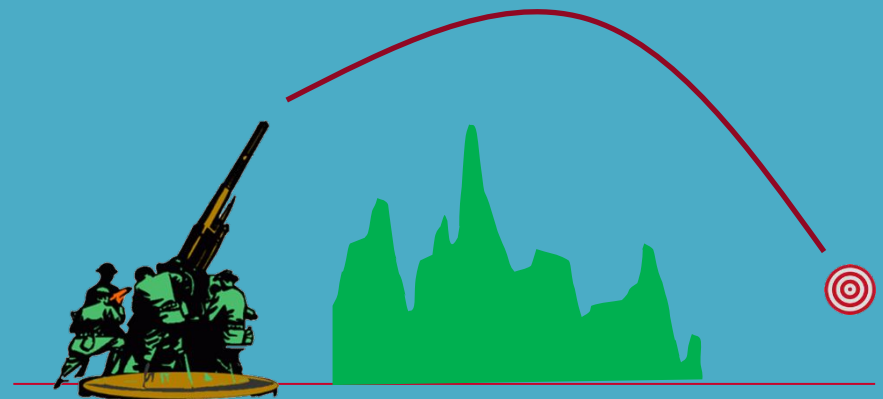
# Gun Classification

- A gun is a direct fire support weapon





**Direct fire**  
(guns)



**Indirect fire**  
(howitzers and mortars)

# Gun Classification

- A gun is a direct fire support weapon
- A shell is a projectile big enough to carry explosives
- A bullet is a projectile which is not

# Gun Sub-classifications

- A cannon is a gun that fires shells
- An autocannon is an automatically loaded cannon
- A machine-gun is an automatically loaded gun firing bullets

# Warheads

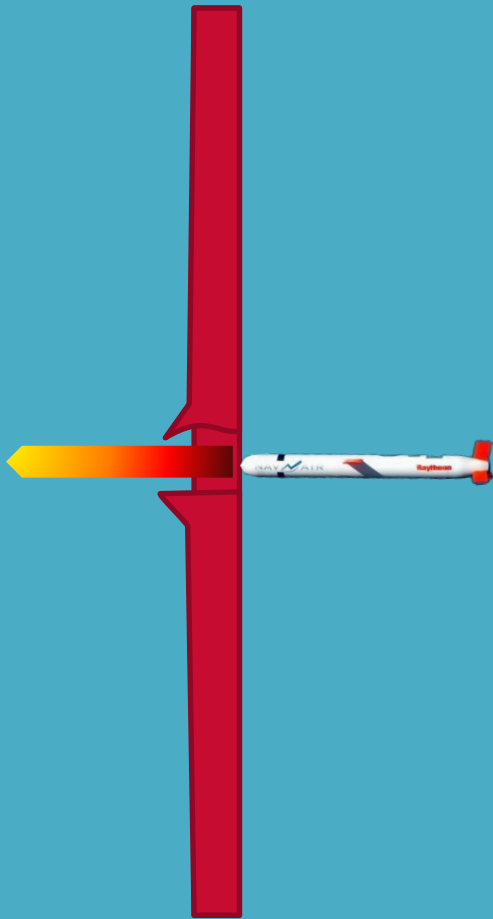
- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)



**Kinetic energy penetration**

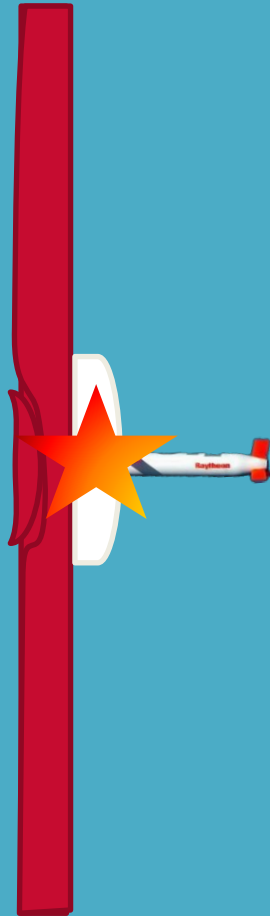
# Warheads

- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)
- Chemical energy:
  - Direct contact – focuses explosive effect onto target
    - Small area, heavy damage
    - Types of shaped charge include:
      - HEAT – high-explosive anti-tank
      - HESH – high-explosive squash head
    - May also work by penetrating first (kinetic energy) before exploding



## Direct contact explosion

Shaped charge (HEAT)



## Direct contact explosion

Shaped charge (HESH)





## Direct contact explosion

Penetrating warhead

# Warheads

- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)
- Chemical energy:
  - Direct contact – focuses explosive effect onto target
  - Fragmentation – damage is from flying fragments – large area, less damage



Fragmentation

# Warheads

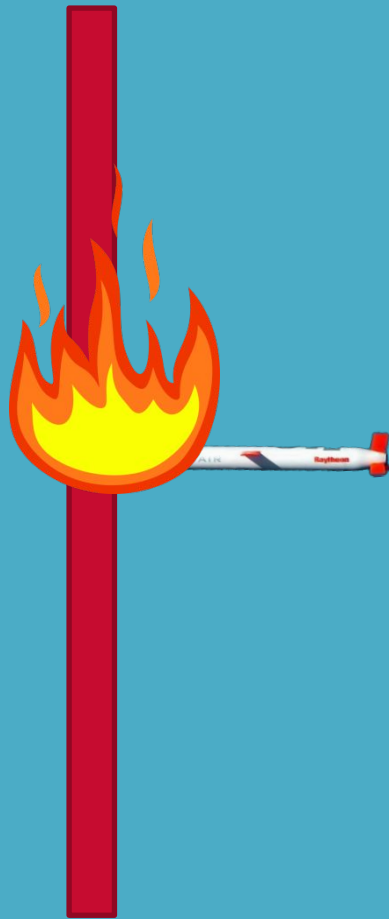
- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)
- Chemical energy:
  - Direct contact – focuses explosive effect onto target
  - Fragmentation – damage is from flying fragments
  - Thermobaric – damage is from a high-temperature pressure wave



Thermobaric

# Warheads

- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)
- Chemical energy:
  - Direct contact – focuses explosive effect onto target
  - Fragmentation – damage is from flying fragments
  - Thermobaric – damage is from a high-temperature pressure wave
  - Incendiary – starts fires

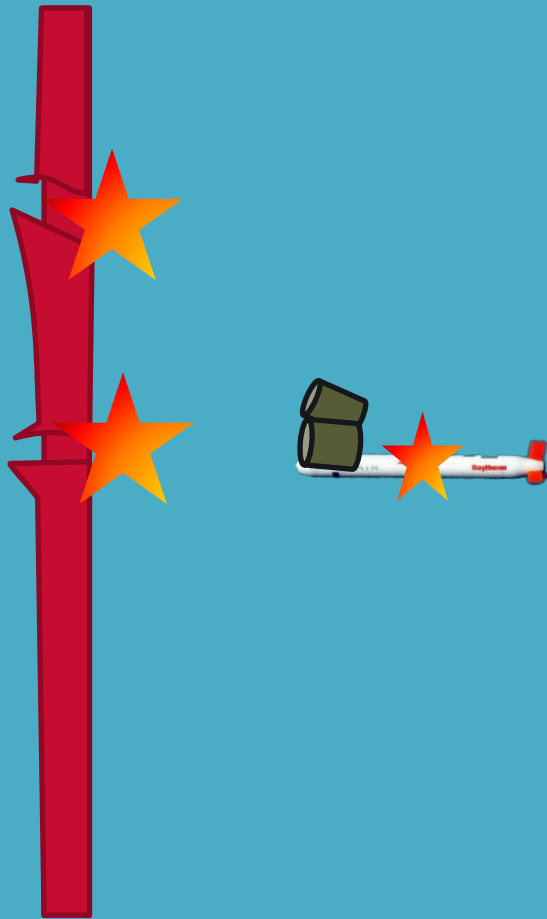


Incendiary

# Warheads

- Kinetic – uses speed and mass of the projectile to cause damage (like a bullet)
- Chemical energy:
  - Direct contact – focuses explosive effect onto target
  - Fragmentation – damage is from flying fragments
  - Incendiary – starts fires
  - Submunition – warhead splits into multiple warheads (any of the above types)





Submunition

# Practise Questions

- Which of the following describes a weapon that is unguided and follows a ballistic arc?
  - Rocket
  - Ballistic missile
  - Cruise missile
  - Torpedo

# Practise Questions

- Which of the following fires only solid projectiles?
  - Cannon
  - Auto-cannon
  - Machine gun
  - Mortar

# Practise Questions

- Which of the following would not be found in the surface environment?
  - Armoured vehicles
  - Warships
  - Aircraft on the ground
  - Submerged submarines

# Practise Questions

- Which of these warhead types would be **un-suitable** for attacking a heavily-protected target such as an armoured vehicle?
  - HEAT
  - Kinetic energy
  - Fragmentation
  - Shaped-charge submunition

# Practise Questions

- Upon which attribute do un-guided weapons beat guided weapons?
  - Collateral damage
  - Cost
  - Friendly-fire
  - Range

# Objectives

- Parts of LO1 P1 - Identify types of air-launched weapons used by military aircraft
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# Military Aircraft Systems

Weapon Types and Definitions



# Objectives

- This lesson covers parts of Learning Objective 3 - Know how air-launched weapons work as systems and interact with the aircraft on which they are carried

# Objectives

Explain:

- The difference between "homing" systems and "navigated" systems.
- The concept of fire-and-forget
- The concept of primary and terminal guidance
- The basic types of navigation
- The types of energy used in homing systems
- The basic types of homing system
- The types of homing systems in common use
- Fuzes
- Types of weapon power
- Missile flight controls

# Guided vs Navigated

## Navigated

- Does not require line of sight
- Generally doesn't broadcast energy or rely on the target to do so
- Can't be used against a moving target unless it can be continually updated.

## Homing

- Can be used against a moving target

# Fire and Forget

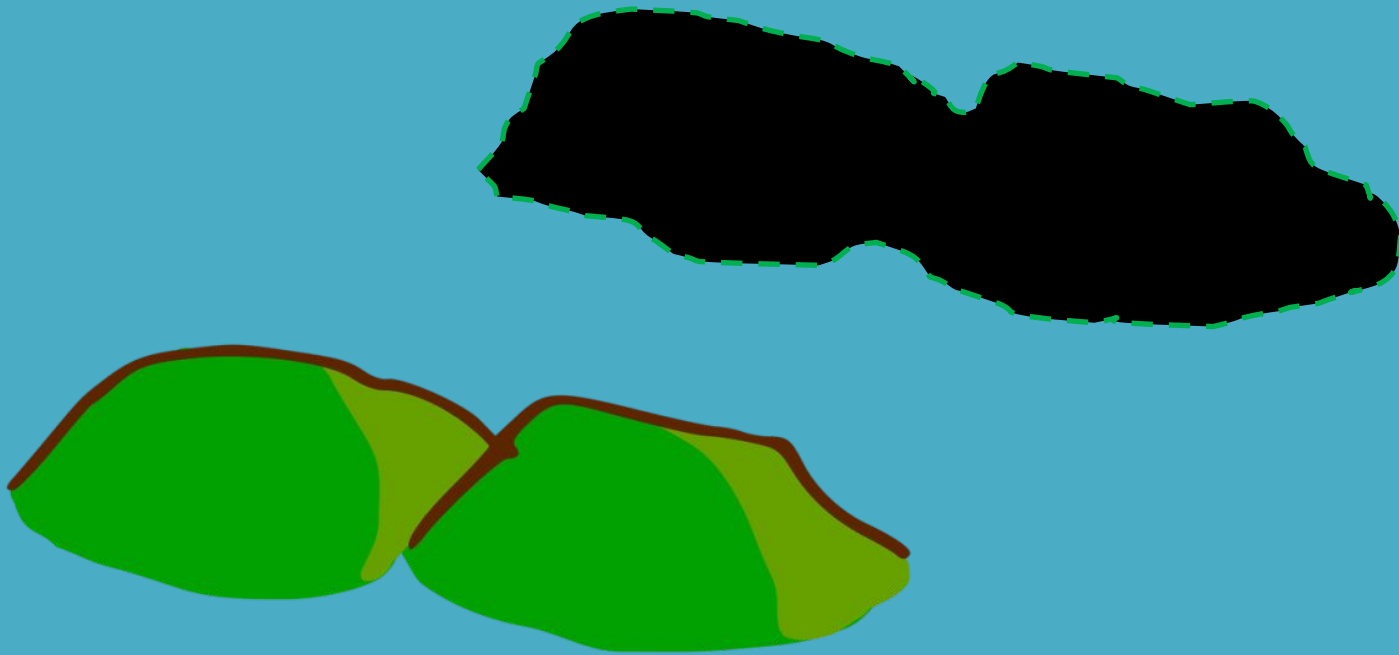
- Some guidance types require input from the launch platform (or a third party) after launch
- Others are entirely self-sufficient after launch – these are known as “Fire and Forget”
- Unguided weapons are inherently fire and forget and so aren’t described as such

# Primary and Terminal Guidance

- Some long range weapons use accurate but short-ranged guidance systems for the final moments of their flight – known as *terminal* guidance
- These weapons will also need a guidance system suitable for the earlier stages – the *primary* or *mid-course* guidance.

# Navigation Systems

- Terrain contour matching systems ‘see’ using radar and match their surroundings to an on-board map. Types include TERCOM and TERPROM
  - Self contained
  - Accurate
  - Expensive



## Terrain Contour Matching

TERCOM and TERPROM

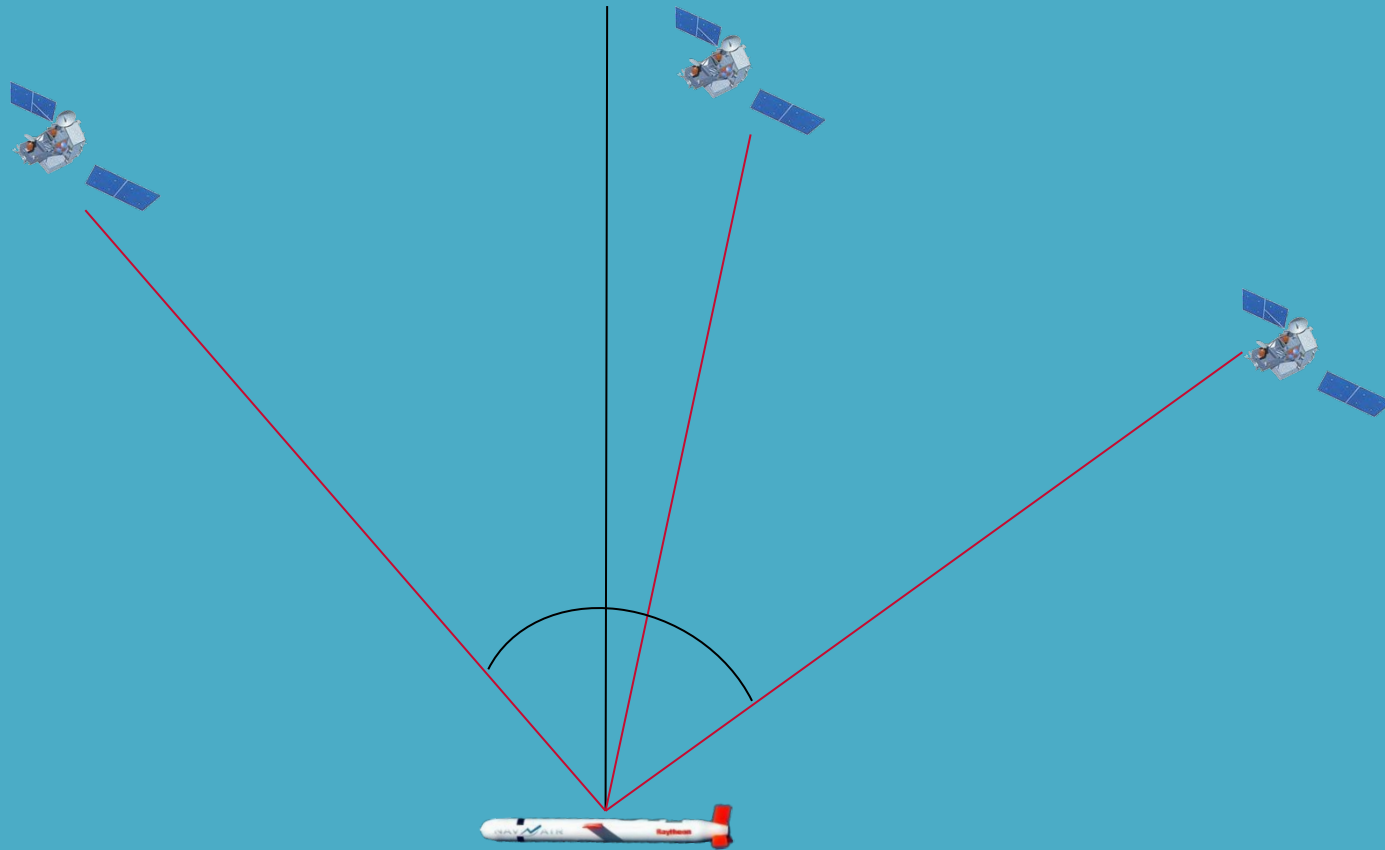
# Navigation Systems

- Terrain contour matching systems 'see' using radar and match their surroundings to an on-board map. Types include TERCOM and TERPROM
- Inertial navigation systems use an autopilot based on gyroscopes or accelerometers to keep the weapon flying on an axis.
  - Self-contained
  - No emissions
  - Accuracy decreases with range



# Navigation Systems

- Terrain contour matching systems 'see' using radar and match their surroundings to an on-board map. Types include TERCOM and TERPROM
- Inertial navigation systems use an autopilot based on gyroscopes or accelerometers to keep the weapon flying on an axis.
- Satellite guided systems use satellites to triangulate their positions. Types include GPS, GLOSNASS and Galileo.
  - No emissions
  - Reliant on jammable/destroyable satellites



## Satellite Guidance

# Navigation Systems

- Terrain contour matching systems 'see' using radar and match their surroundings to an on-board map. Types include TERCOM and TERPROM
- Inertial navigation systems use an autopilot based on gyroscopes or accelerometers to keep the weapon flying on an axis.
- Satellite guided systems use satellites to triangulate their positions. Types include GPS, GLOSNASS and Galileo.
- Command line of sight systems are essentially remote-controlled by an operator (manual) or a computer (semi-automatic)

# Homing Systems

How does the firer find the target?



- Light from the sun reflects off of the target
- The firer's eyes detect the light
- The firer's brain processes information – in the form of wavelengths – to identify the target

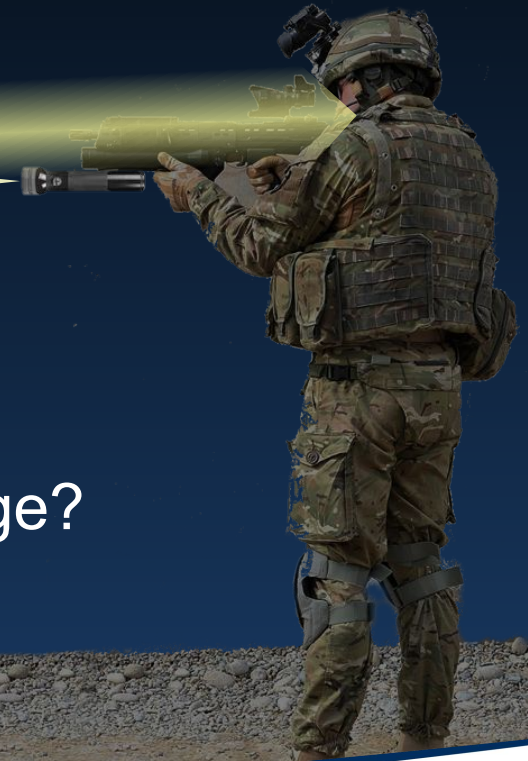


# Homing Systems

What if there is no light?



- Who holds the torch?
- What if it's a firefight instead of a range?



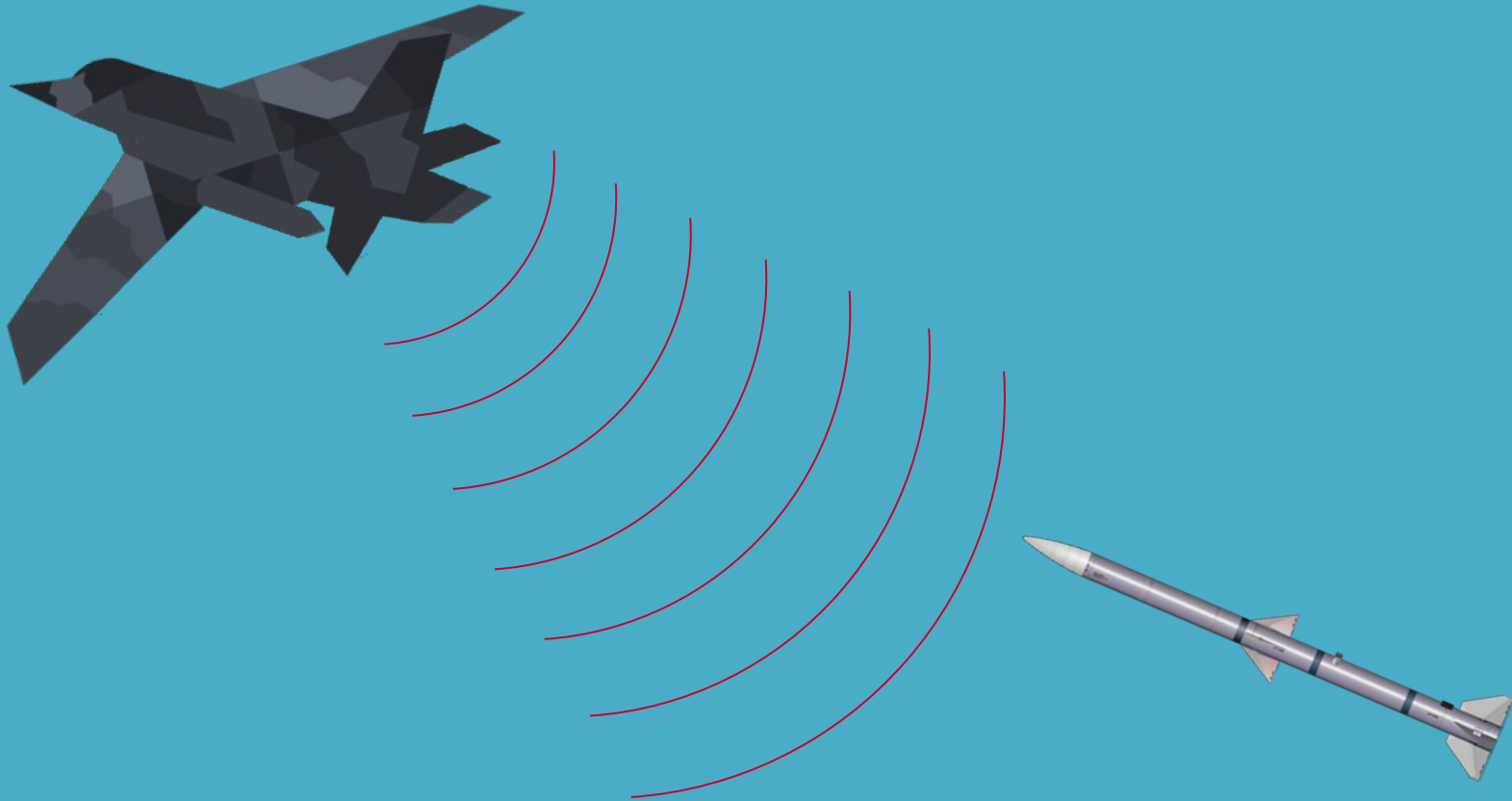
# Homing Systems

*Energy types.* All homing on target weapons rely on some form of energy. The following types of energy are used:

- IR (heat)
- Visible light (laser)
- Radio waves (radar)
- Acoustic (sonar)

# Homing Systems

- Passive – the weapons receives its energy from the target, emitted either:
  - Intentionally – Radar, radio transmissions, jamming
  - Incidental – aircraft engine heat or submarine noise

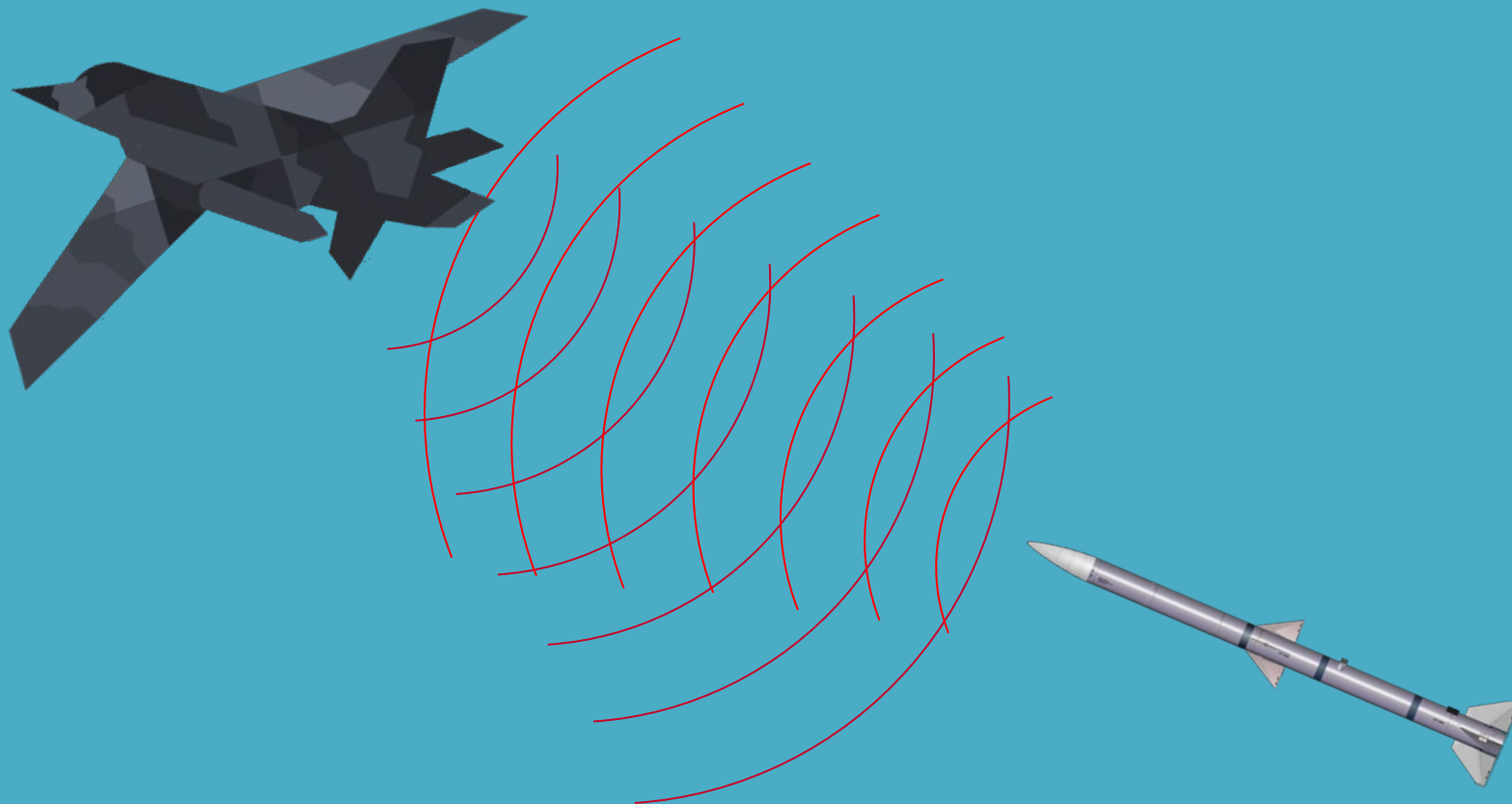


## Passive homing



# Homing Systems

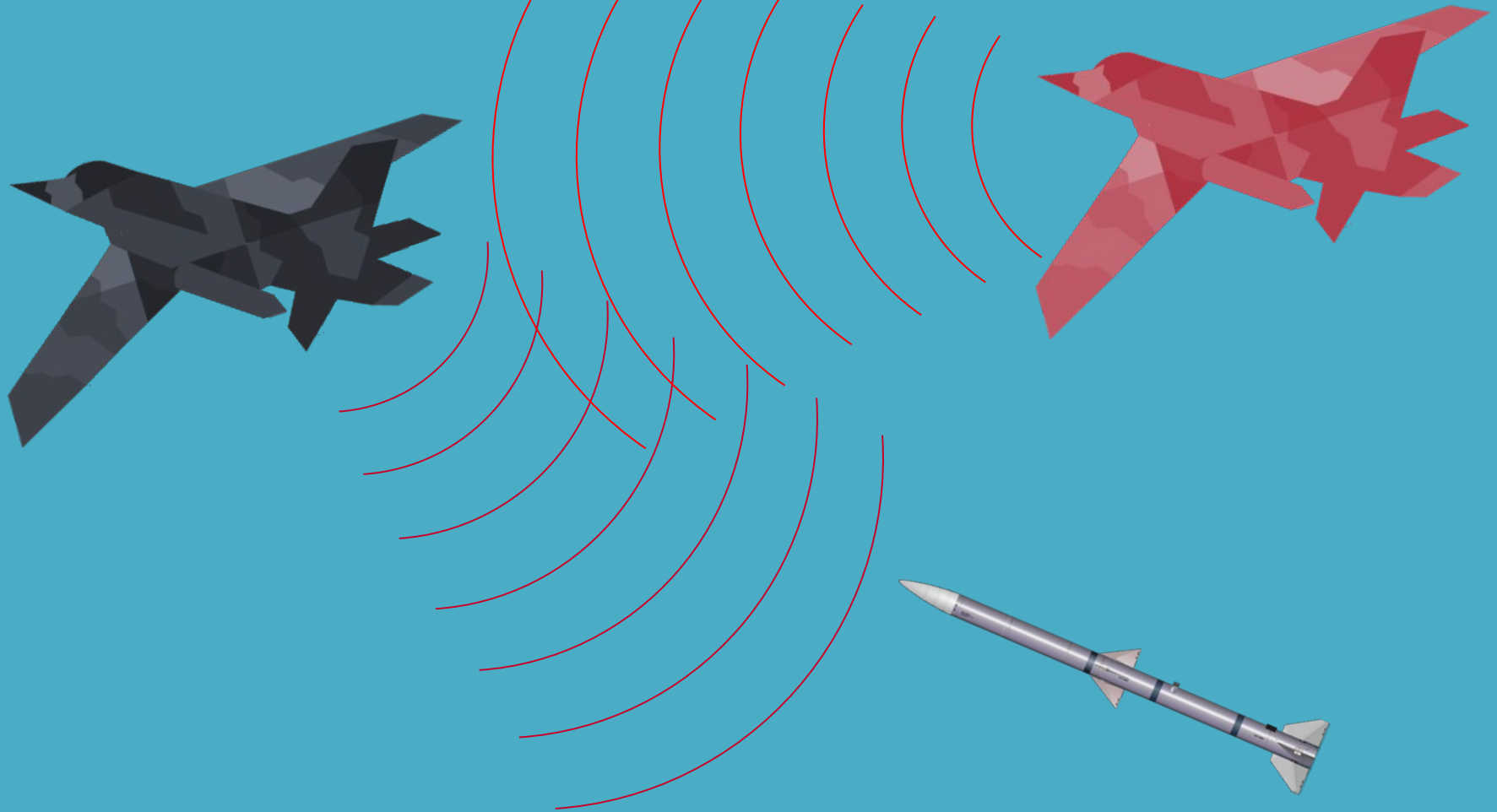
- Passive – the weapons receives its energy from the target, emitted either:
  - Intentionally – Radar, radio transmissions, jamming
  - Incidental – aircraft engine heat or submarine noise
- Active – the weapon transmits the energy



## Active homing

# Homing Systems

- Passive – the weapons receives its energy from the target, emitted either:
  - Intentionally – Radar, radio transmissions, jamming
  - Incidental – aircraft engine heat or submarine noise
- Active – the weapon transmits the energy
- Semi-active – a third party transmits the energy, such as:
  - The launch aircraft
  - Another aircraft
  - Friendly ground forces



## Semi-active homing

# Homing Systems

*Advantages and disadvantages.*

Passive –

- Receive only, relies on target producing energy
- Gives no warning
- Fire and forget

# Homing Systems

*Advantages and disadvantages.*

Active –

- Self contained
- Fire and forget
- Can only hold a small, low powered transmitter (often battery-powered)

# Homing Systems

*Advantages and disadvantages.*

Semi-active –

- Not self-contained
- Allows for more powerful transmitter
- Potentially a more expensive transmitter, as the transmitter is not disposable.
- Not fire and forget.

# Homing Systems

Types used in practice

- Passive IR
- Semi-active laser
- All types of radar (active, semi-active and passive)
- Passive and active sonar



# Fuzes

- Time



Time fuze

# Fuzes

- Time
- Impact



Impact fuze

# Fuzes

- Time
- Impact
- Delay



Delay fuze

# Fuzes

- Time
- Impact
- Delay
- Proximity



Proximity fuze





# Fuzes

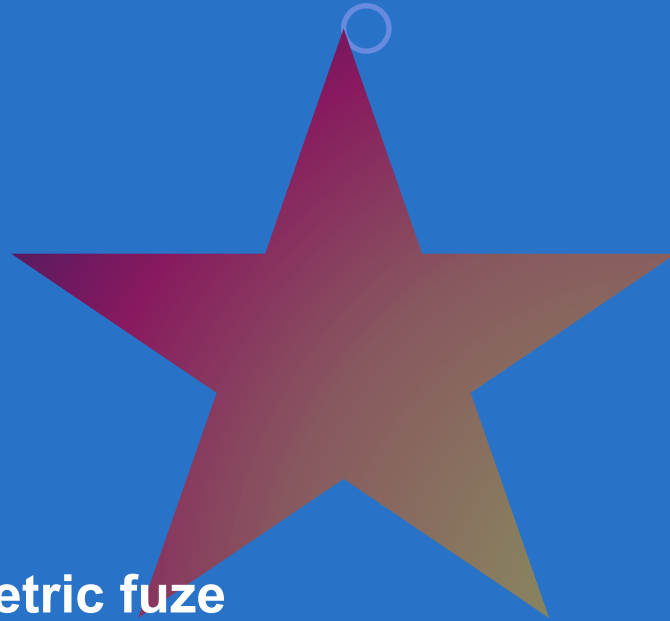
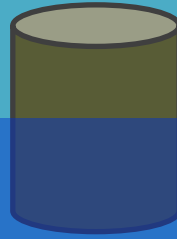
- Time
- Impact
- Delay
- Proximity
- Remote



Remote fuze

# Fuzes

- Time
- Impact
- Delay
- Proximity
- Remote
- Barometric



**Barometric fuze**

# Fuzes

- Time
- Impact
- Delay
- Proximity
- Remote
- Barometric
- Combination – more than one of the above types

# Powered vs Unpowered

- Discuss - what do you think are the relative advantages and disadvantages?

# Powered vs Unpowered

## Powered

- Engage scattered targets
- Stay out of range of defences
- Extra kinetic energy for destructive effect (especially at low level or low launch speed)

## Unpowered (bombs)

- Cheaper
- Lighter – more can be carried on an aircraft

# Powerplants

- Discuss – What factors are important when choosing the propulsion system for a missile?



# Powerplants

- Cost
- Speed and acceleration
- Weight
- Diameter/frontal area
- Power generation for other systems
- Safety
- Maintenance

# Powerplants

## Rockets

- Solid fuel
  - Cheap
  - Stable
- Liquid fuel
  - Complex
  - Expensive
  - Modern versions becoming more stable

# Powerplants

## Jets

- Pulse jet
  - Very simple
  - Low powered and obsolete
- Turbo jet
  - Relatively simple
  - Low frontal area
- Turbo fan
  - Efficient
  - Greater frontal area
- Ram jet
  - High fuel consumption
  - Good for supersonic flight

# Powerplants

## Torpedoes

- Electric motor with battery
- Fuel and oxidiser or monopropellant powering:
  - Turboshaft jet engine
  - Internal combustion engine
- Rocket

# Flight Controls

- Cruise missiles – generally similar to an aircraft (possibly missing rudder or ailerons)
- Ballistic missile – manoeuvring fins

# Practise Questions

- Which of the following is a means of navigating a weapon to a fixed location?
  - Passive IR
  - TERPROM
  - Active radar
  - Semi-active radar

# Practise Questions

- What type of weapon would most likely be powered by liquid-fuelled rocket?
  - Air-to-surface cruise missile
  - Surface-to-surface ballistic missile
  - Bomb
  - Unguided rocket

# Practise Questions

- What type of weapon would most likely be powered by a gas turbine engine such as a turbofan or turbojet?
  - Air-to-surface cruise missile
  - Surface-to-surface ballistic missile
  - Bomb
  - Unguided rocket



# Practise Questions

- What type of weapon would most likely be powered by solid-fuelled rocket?
  - Long-range air-to-surface cruise missile
  - Long-range surface-to-surface ballistic missile
  - Bomb
  - Unguided rocket

# Practise Questions

- Which guidance system would be most suitable for an air-to-air missile?
  - Semi-active Laser
  - Active Radar
  - MCLOS
  - GPS

# Objectives

Explain:

- The difference between "homing" systems and "navigated" systems.
- The concept of fire-and-forget
- The concept of primary and terminal guidance
- The basic types of navigation
- The types of energy used in homing systems
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- Fuzes
- Types of weapon power
- Missile flight controls



# Military Aircraft Systems

Air-to-surface Ordnance

# Objectives

- LO1 P1 - Identify types of air-launched weapons used by military aircraft
- LO2 P3 - Describe capability and limitations of air-to-ground missiles

# Objectives

Explain:

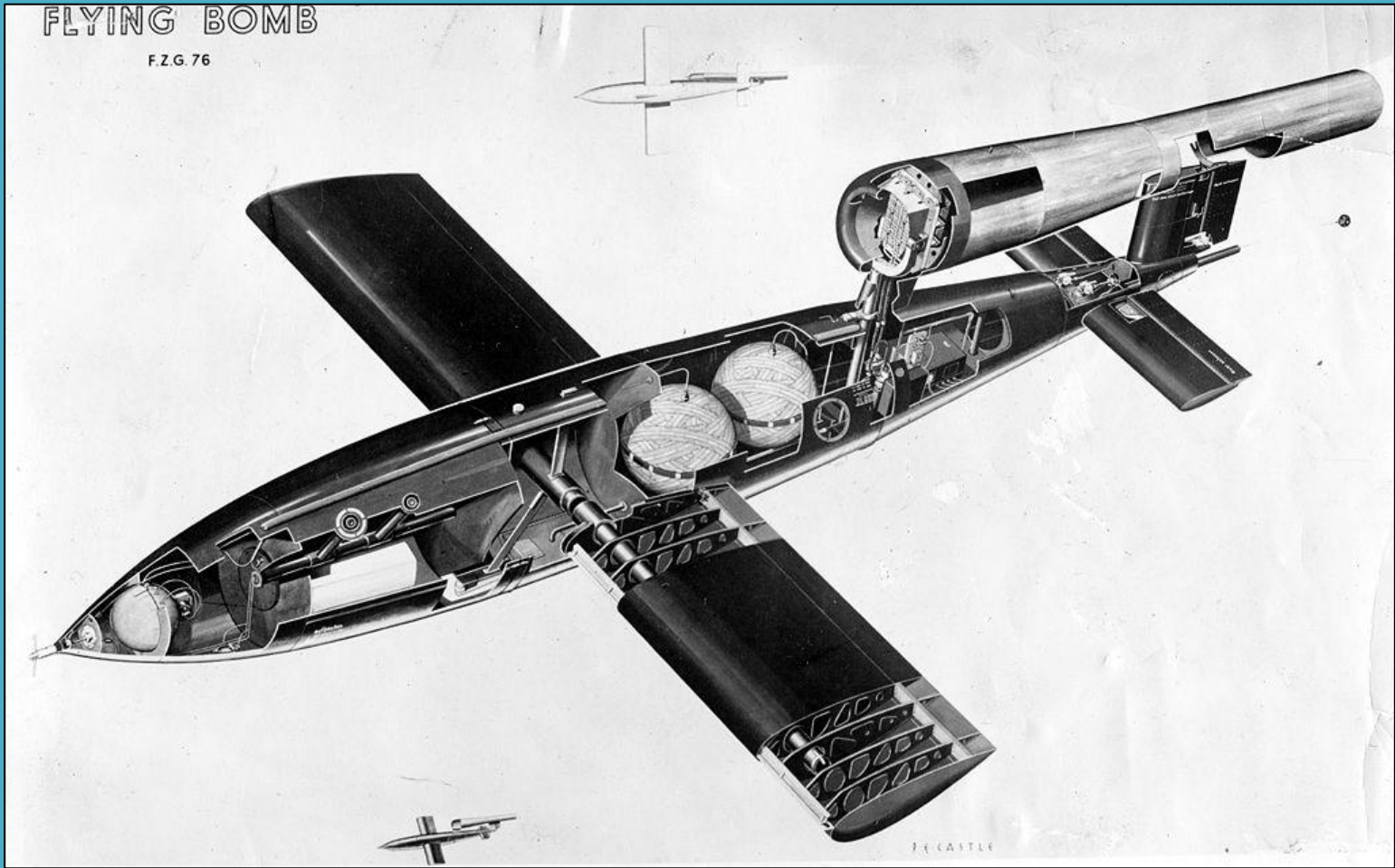
- The history of air-to-surface and surface-to-surface missiles
- The main roles for air-to-surface missiles
- Explain the type of damage required to disable target types
- Details of the main missiles launched from aircraft in British service

# History

- World War II - V1 and V2 developed as 'stand-off' weapons. Inertially guided, V1 was a cruise missile and V2 a ballistic missile

# FLYING BOMB

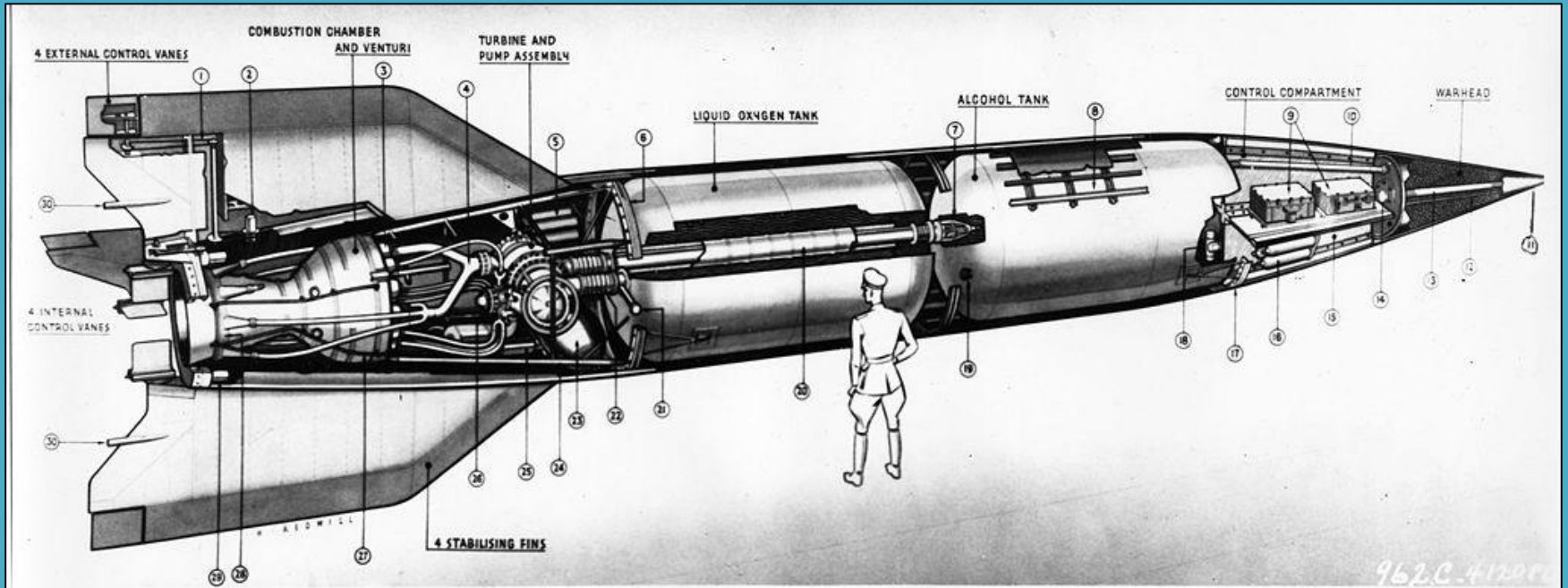
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## V-1

Early German cruise missile





## V-2

Early German ballistic missile

# History

- Cold War
  - Stand-off weapons allowed nuclear attack of heavily-defended targets, such as Hound Dog and Blue Steel.



## AGM-28 Hound Dog

US Air-launched cruise missile

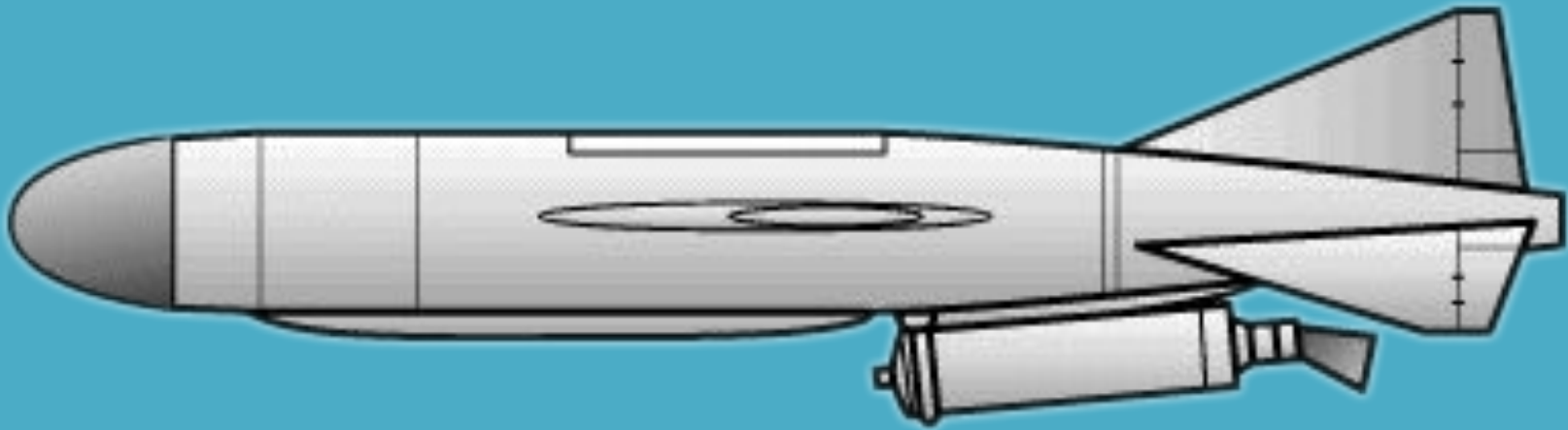


## Blue Steel

British Air-launched cruise missile

# History

- Cold War
  - Stand-off weapons allowed nuclear attack of heavily-defended targets, such as Hound Dog and Blue Steel.
  - Anti-ship weapons were developed by the USSR to counter NATO's superiority at sea, such as the Styx. Soon, weapons were small enough for air launch, such as the Exocet.



## SS-N-1 Styx

Soviet anti-ship missile

# History

- Gulf War
  - Guided weapons now commonplace – 10% of all air-surface weapons launched were guided
  - In 2003 invasion, 90% of air-surface weapons launched were guided

# Roles

- Strategic strike
- Suppression of enemy air defence (SEAD)
- Anti-tank
- Anti-shipping
- Close air support (CAS)



# Damage Levels

- **Strategic strike**
  - Large targets
  - Long term effect
  - Large warhead required

# Damage Levels

- **Suppression of enemy air defence (SEAD)**
  - Delicate targets
  - Short term effect
  - Speed and accuracy more important than destructive effect

# Damage Levels

- **Anti-tank**
  - Categorised as M-Kill or K-Kill
    - Mobility-Kill – tank unable to move
    - Complete destruction
  - A relatively small amount of explosive is required to achieve M-Kill or K-Kill
  - Friendly troops or neutral personnel may be in the vicinity
  - Accuracy is favoured over warhead size

# Damage Levels

- **Anti-shipping**
  - Ships can be damaged or sunk
  - Larger ships may require multiple hits to sink
  - Ships defences may need to be penetrated, by:
    - Speed
    - Stealth
    - Low-altitude
    - A combination of the above

# Damage Levels

- **Anti-shipping**

- Ships can be damaged or sunk
- Larger ships may require multiple hits to sink
- Ships defences may need to be penetrated
- Defences include:



- Surface-to-air missiles (SAM) – these may target either the missiles or the launch aircraft



- Close-in weapons systems (CIWS) – point defence systems based on guns or short-range missiles



- Decoys and electronic counter-measures (ECM)

# Weapons

# Weapons



## Storm Shadow

Strategic Strike Cruise Missile

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Turbojet	240+ km	1,300 kg	Mach 0.8	450 kg Dual Charge HE	INS, GPS TERPROM; terminal IR	Tornado

## Storm Shadow

Strategic Strike Cruise Missile





# Weapons



## Hellfire

Anti-armour and General Purpose Missile

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket	8 km	45 kg	> Mach 1	9 kg tandem or thermo-baric	Semi-active laser	Reaper and Apache

## Hellfire

Anti-armour and General Purpose Missile



# Weapons



## Brimstone

Long-range Anti-armour Missile

# Weapons

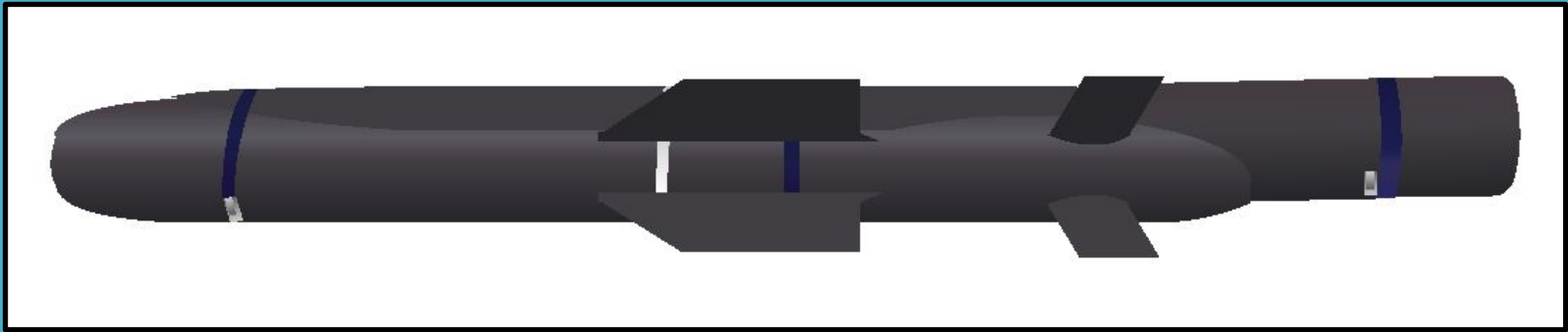
Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket	60+ km	49 kg	> Mach 1	Tandem HEAT	INS; terminal active radar or SA laser	Tornado and Reaper

## Brimstone

Long-range Anti-armour Missile



# Weapons



## Sea Venom

Short-range Anti-ship Missile (Royal Navy)

# Weapons

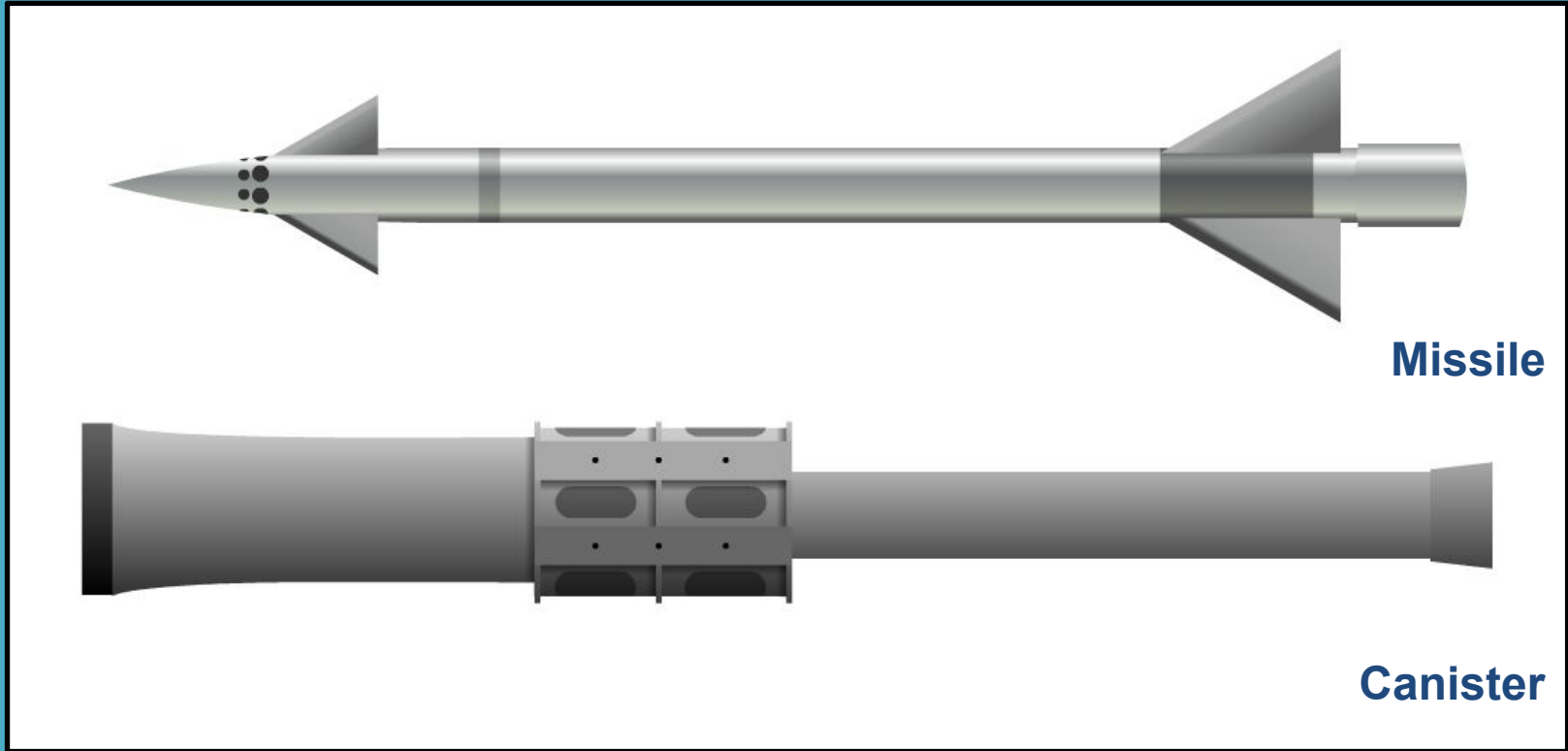
Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket + booster rocket	Not known	110 kg	High-sub sonic	30kg penetrating HE	IIR and datalink	Wildcat HMA2

## Sea Venom

Short-range Anti-ship Missile (Royal Navy)



# Weapons



## Martlet

Short-range Anti-ship Missile (Royal Navy)

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
2-stage rocket	8 km	13 kg	Mach 1.5	3 kg dual-effect	Laser SACLOS	Wildcat HMA2

## Martlet

Short-range Anti-ship Missile (Royal Navy)





# Practise Questions



- What is this weapon?
  - Brimstone
  - Martlet
  - Sea Venom
  - Storm Shadow

# Practise Questions

- How large is the warhead of a Sea Venom missile?
  - 3 kg
  - 30 kg
  - 300 kg
  - 3,000 kg

# Practise Questions

- What is the range of a Martlet missile?
  - 0.8km
  - 8km
  - 80km
  - 800km

# Practise Questions

- Which weapon would **not** be suitable for attacking an armoured fighting vehicle?
  - Hellfire
  - Sea Venom
  - Brimstone
  - Martlet

# Objectives

Explain:

- The history of air-to-surface and surface-to-surface missiles
- The main roles for air-to-surface missiles
- Explain the type of damage required to disable target types
- Details of the main missiles launched from aircraft in British service



# Military Aircraft Systems

Air-to-surface Ordnance

# Objectives

- LO1 P1 - Identify types of air-launched weapons used by military aircraft

# Objectives

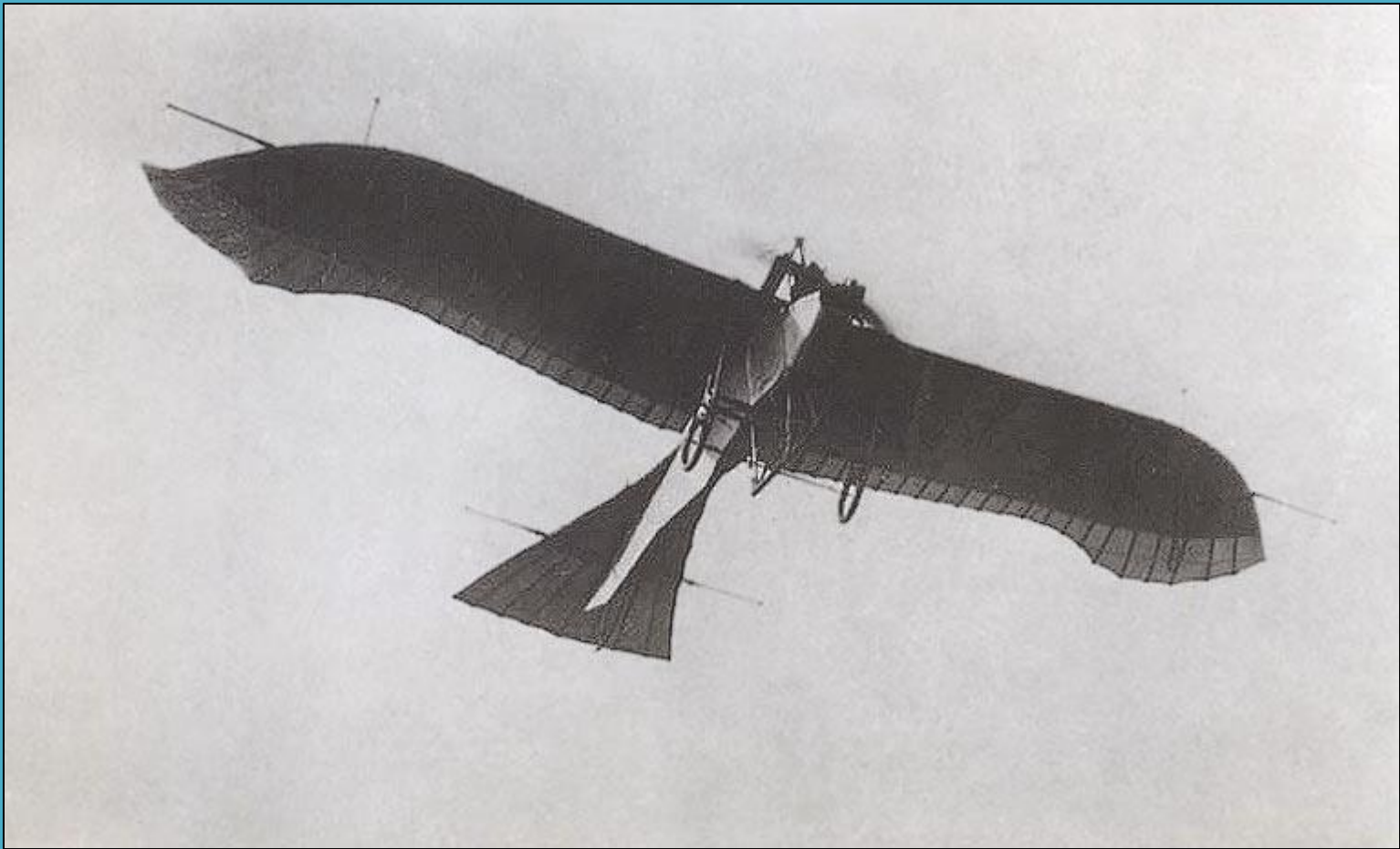
Explain:

- The history of bombs and air-to-surface rockets
- Details of the main bombs and rockets launched from aircraft in British service.



# History

- Early Bombing
  - First raid in 1911 from Italian reconnaissance aircraft
  - First bomber carried just 55 kg
  - At the start of WWII bombers could carry 100 times that

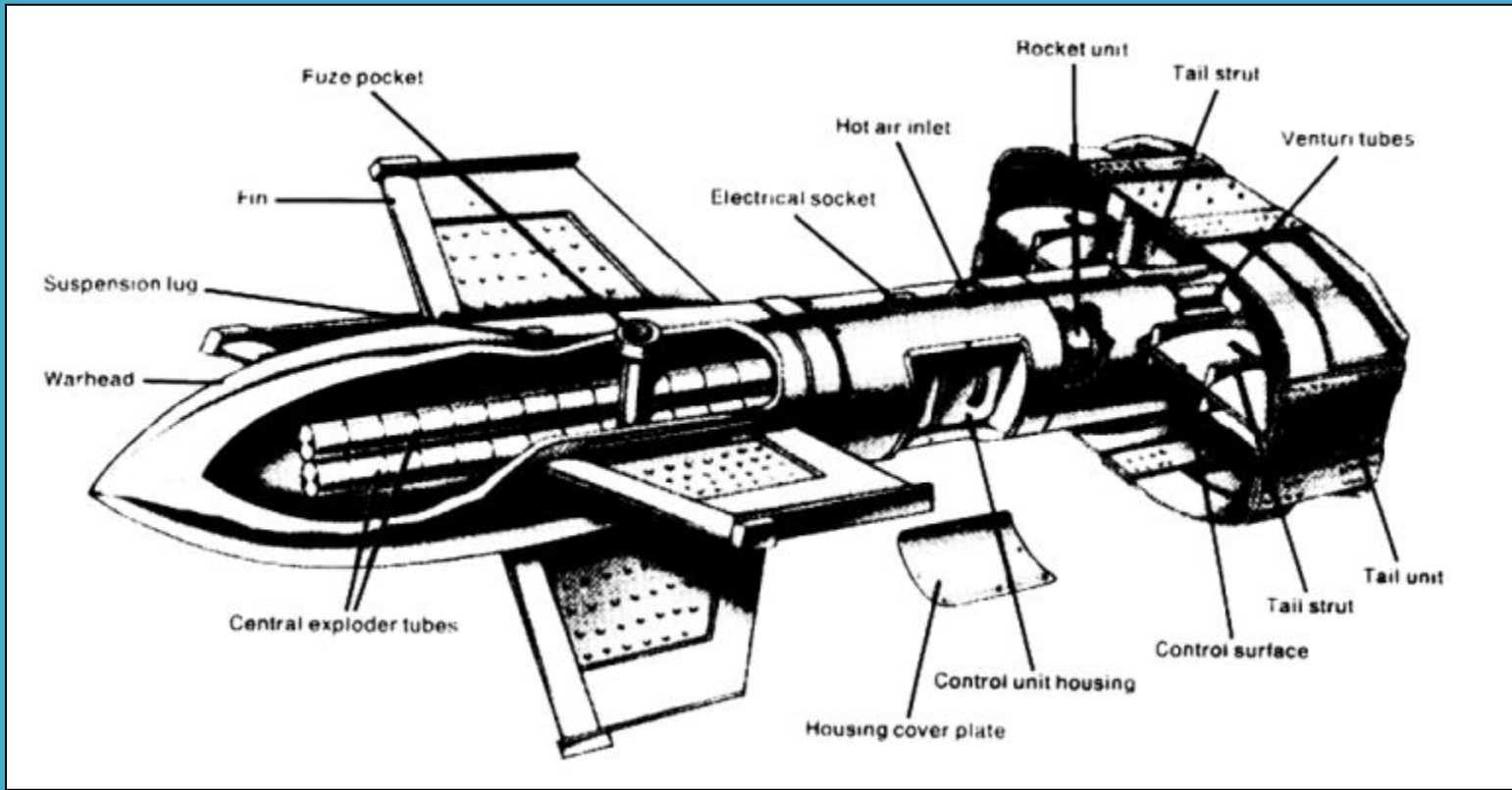


## Etrich Taube

German-made reconnaissance aircraft used for the first bombing raid

# History

World War II - Fritz X was a guided anti-ship bomb – hitting a moving ship was very difficult in WWII without risky dive-bombing.

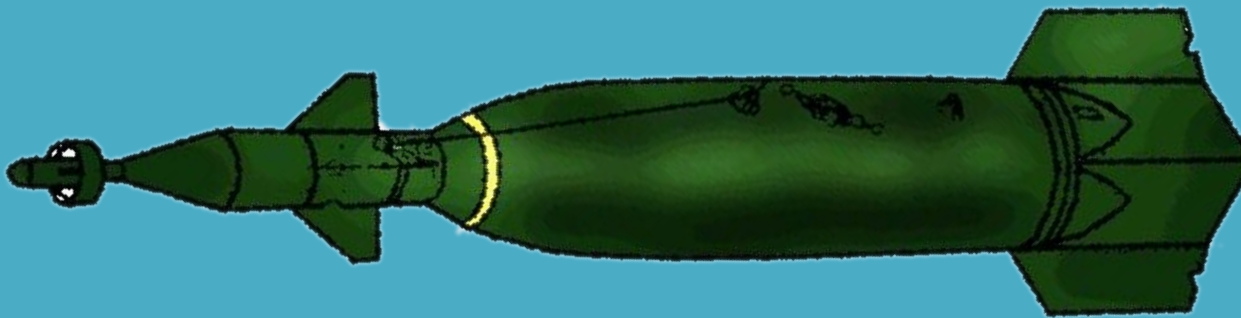


## Fritz-X

Early German guided bomb

# History

- Cold War
  - Paveway guided bombs grew from a USAF need to engage point targets accurately in Vietnam
  - Against the Thanh Hoa bridge one Paveway did what 800 dumb bombs couldn't.

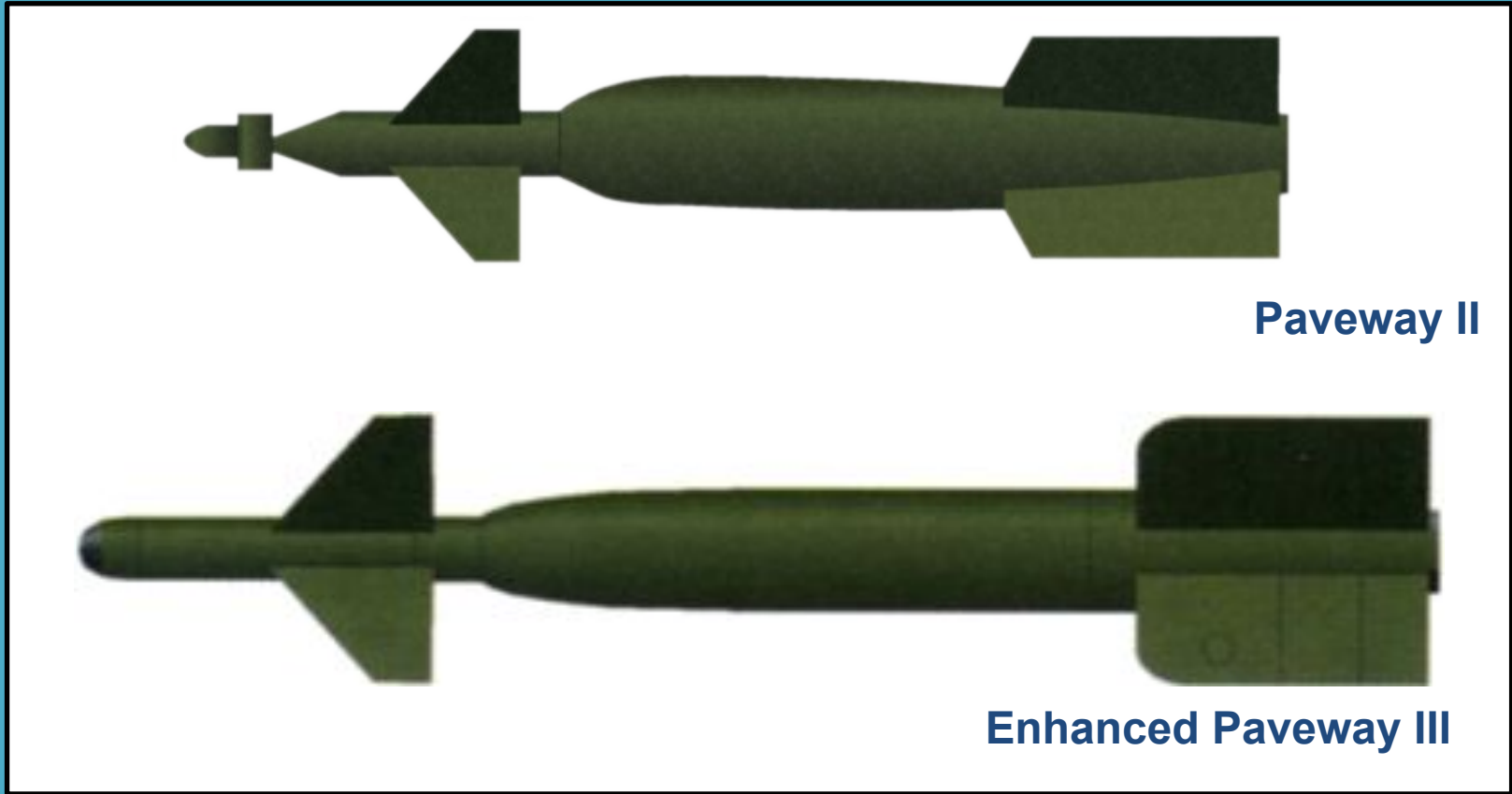


## GBU-11/B Paveway 1

American guided bomb

# Weapons

# Weapons



Paveway II

Enhanced Paveway III

## Paveway II & III and Enhanced Paveway II & III

Guided Bombs



# Weapons

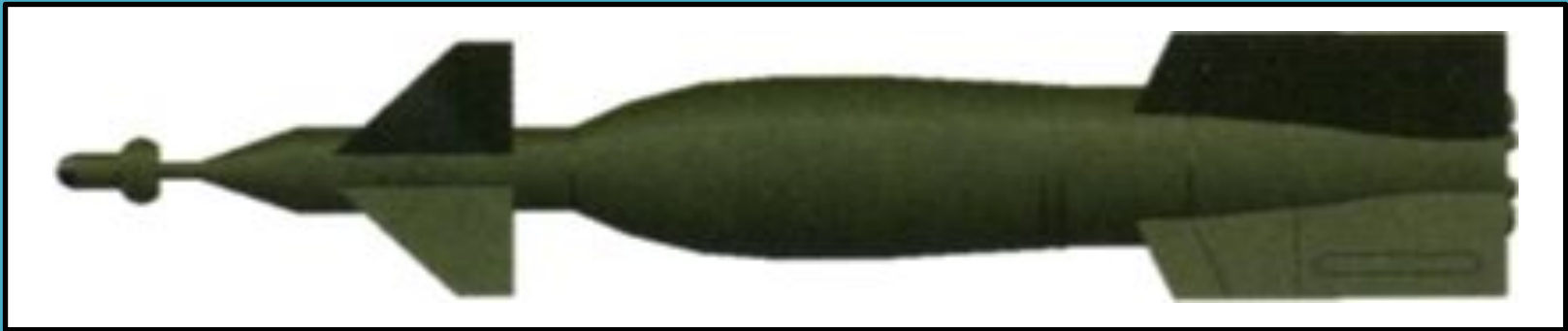
	Launch Weight	Warhead	Guidance	Aircraft
PW II	546 kg	227 kg HE filling	Laser	Tornado and Typhoon
EPW II			Laser, INS, GPS	
PW III	1241 kg	500 kg HE filling	Laser	Tornado
EPW III			Laser, INS, GPS	

**Paveway II & III and Enhanced Paveway II & III**

Guided Bombs



# Weapons



## Paveway IV

Guided Bomb

# Weapons

Launch Weight	Warhead	Guidance	Aircraft
225 kg	?	Laser, INS, GPS	Tornado and Typhoon

## Paveway IV

Guided Bomb



# Weapons



## GP Bomb

505kg Unguided Bomb

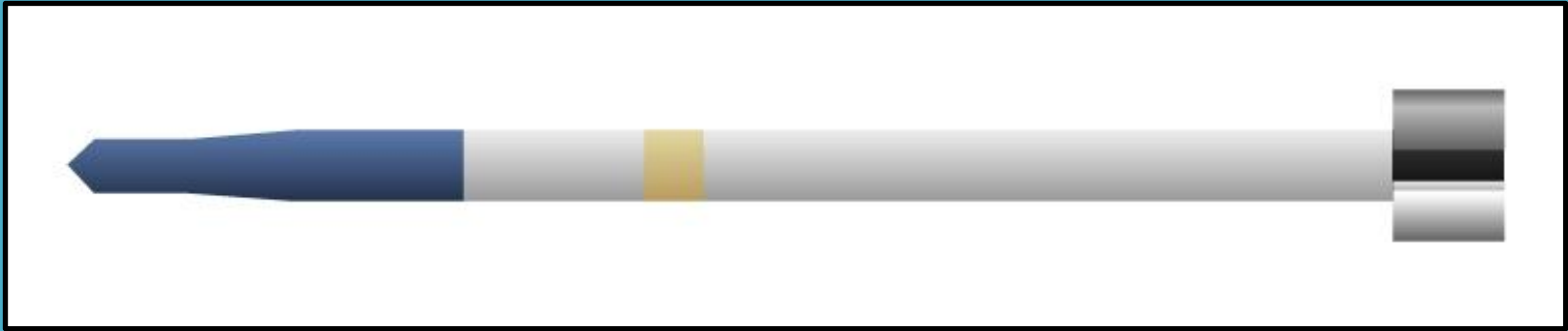
# Weapons

Launch Weight	Warhead	Guidance	Aircraft
505 kg	227 kg HE filling	None	Tornado

## GP Bomb

505kg Unguided Bomb

# Weapons



**CRV-7**

Unguided Rocket (Army)

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket	5.5 km	11 kg	?	6 kg HE or kinetic penetrator	None	Apache, Harrier (former)

## CRV-7

Unguided Rocket (Army)

# Practise Questions



- What is this weapon?
  - CRV-7
  - Paveway IV
  - GP Bomb
  - Storm Shadow



# Practise Questions

- How large is the warhead of a CRV-7 rocket?
  - 6kg
  - 60kg
  - 600kg
  - 6,000kg

# Practise Questions

- What is the range of a CRV-7 rocket?
  - 0.55 km
  - 5.5 km
  - 55 km
  - 550 km

# Practise Questions

- Which of the following is not a bomb?
  - 505kg GP
  - Paveway IV
  - Brimstone
  - Paveway II

# Objectives

Explain:

- Advantages and disadvantages of missiles, bombs and rockets
- The history of air-to-surface and surface-to-surface weapons
- The main roles for air-to-surface missiles
- Explain the type of damage required to disable target types
- Details of the main missiles, bombs and rockets launched from aircraft in British service



# Military Aircraft Systems

Air-to-air Ordnance

# Objectives

- LO1 P1 - Identify types of air-launched weapons used by military aircraft
- LO2 P2 - Describe capability and limitations of air-to-air missiles

# Objectives

Explain:

- The history of air-to-air missiles
- The concept of "dogfight" and beyond-visual-range weapons
- Types of countermeasure
- The details of:
  - Meteor
  - AMRAAM
  - ASRAAM

# History

- World War I - Unguided rockets used in the air-to-air role, fired electronically from biplanes and balloons
- World War II – Germany faced Allied air superiority so created weapons like the Ruhrstahl X-4



# History



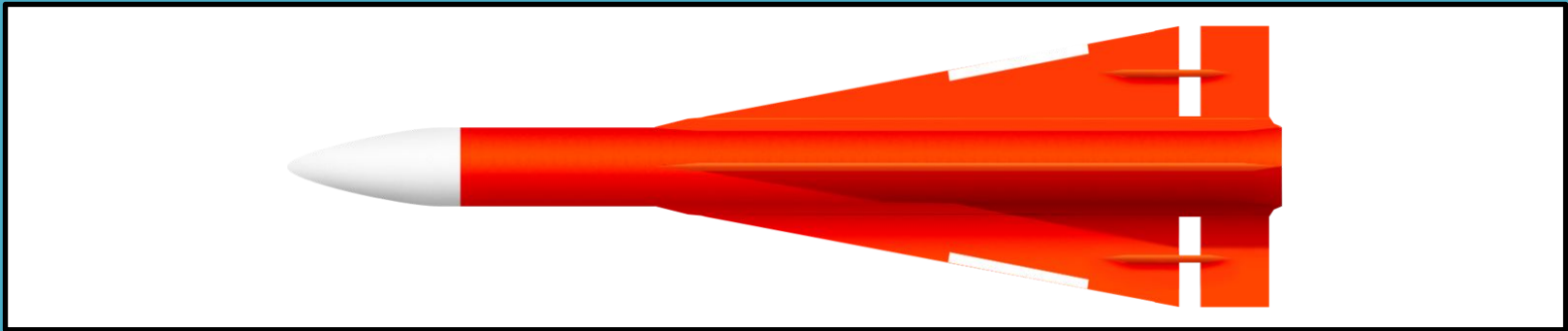
## Ruhrstahl X-4

World War II German Prototype Air-to-air Missile

# History

- World War I - Unguided rockets used in the air-to-air role, fired electronically from biplanes and balloons
- World War II – Germany faced Allied air superiority so created weapons like the Ruhrstahl X-4
- Cold War – US developed weapons in the 50's:
  - USAF – AIM-4 Falcon

# History



## AIM-4 Falcon

Cold War USAF Air-to-air Missile

# History

- World War I - Unguided rockets used in the air-to-air role, fired electronically from biplanes and balloons
- World War II – Germany faced Allied air superiority so created weapons like the Ruhrstahl X-4
- Cold War – US developed weapons in the 50's:
  - USAF – AIM-4 Falcon
  - USN – AIM-9 Sidewinder

# History



## AIM-9 Sidewinder

US Air-to-air Missile

# History

- World War I - Unguided rockets used in the air-to-air role, fired electronically from biplanes and balloons
- World War II – Germany faced Allied air superiority so created weapons like the Ruhrstahl X-4
- Cold War – US developed weapons in the 50's:
  - USAF – AIM-4 Falcon
  - USN – AIM-9 Sidewinder
- Early F-4 actually made without a gun
- In the Falklands British Harriers could defeat Argentinian opponents using upgraded Sidewinders

# Types

- Short-ranged
  - Less than 30km range
  - Within visual range
  - Range less important than agility
  - Often IR guided
  - Known as
    - SRAAM
    - WVRAAM
    - Dogfight missiles

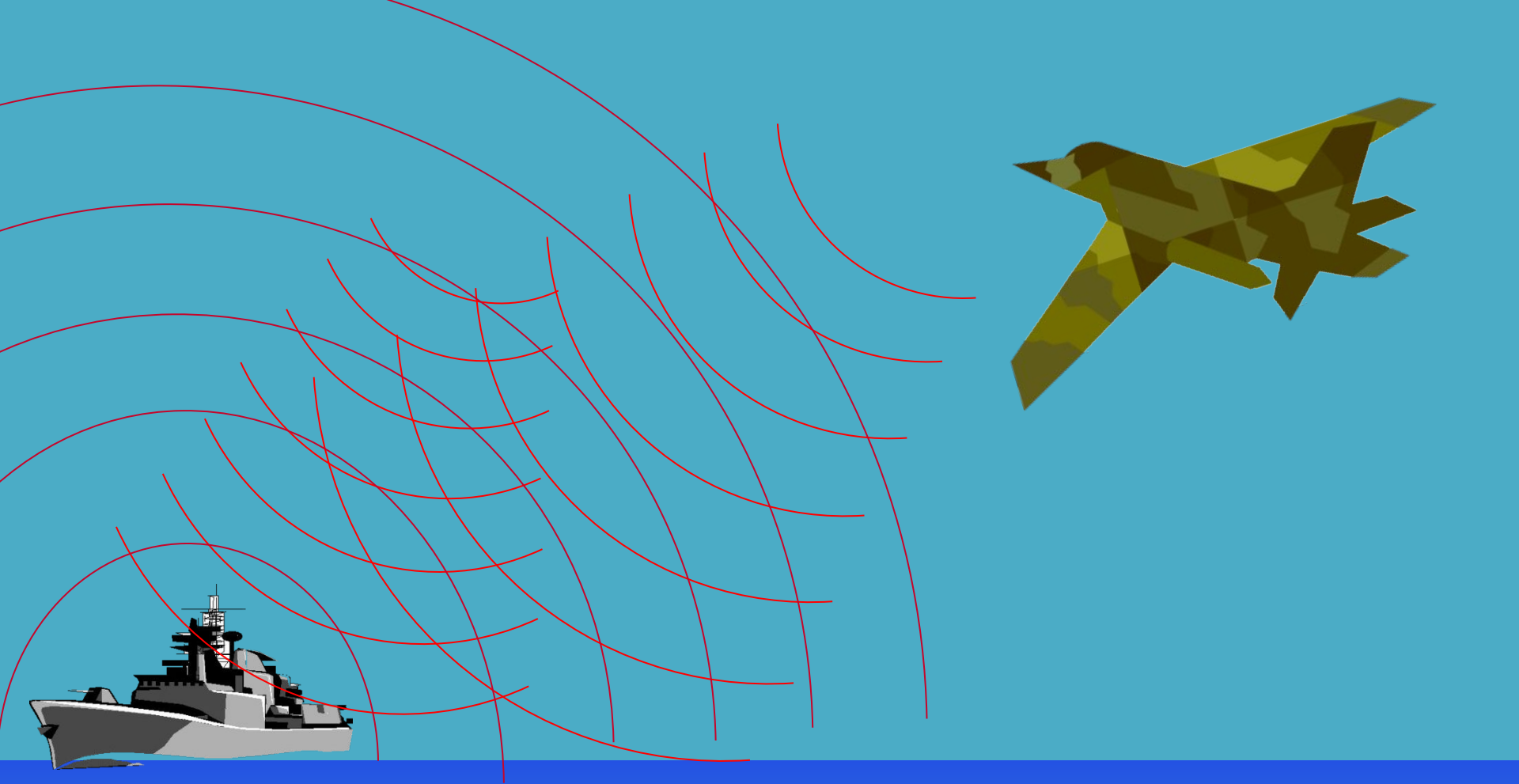
# Types

- Short-ranged
- Medium- and Long-ranged
  - Beyond visual range
  - Usually radar-guided
  - May also have inertial guidance and/or mid-course updates from the launch aircraft
  - May be called:
    - BVRAAMs
    - MRAAMs
    - LRAAMs



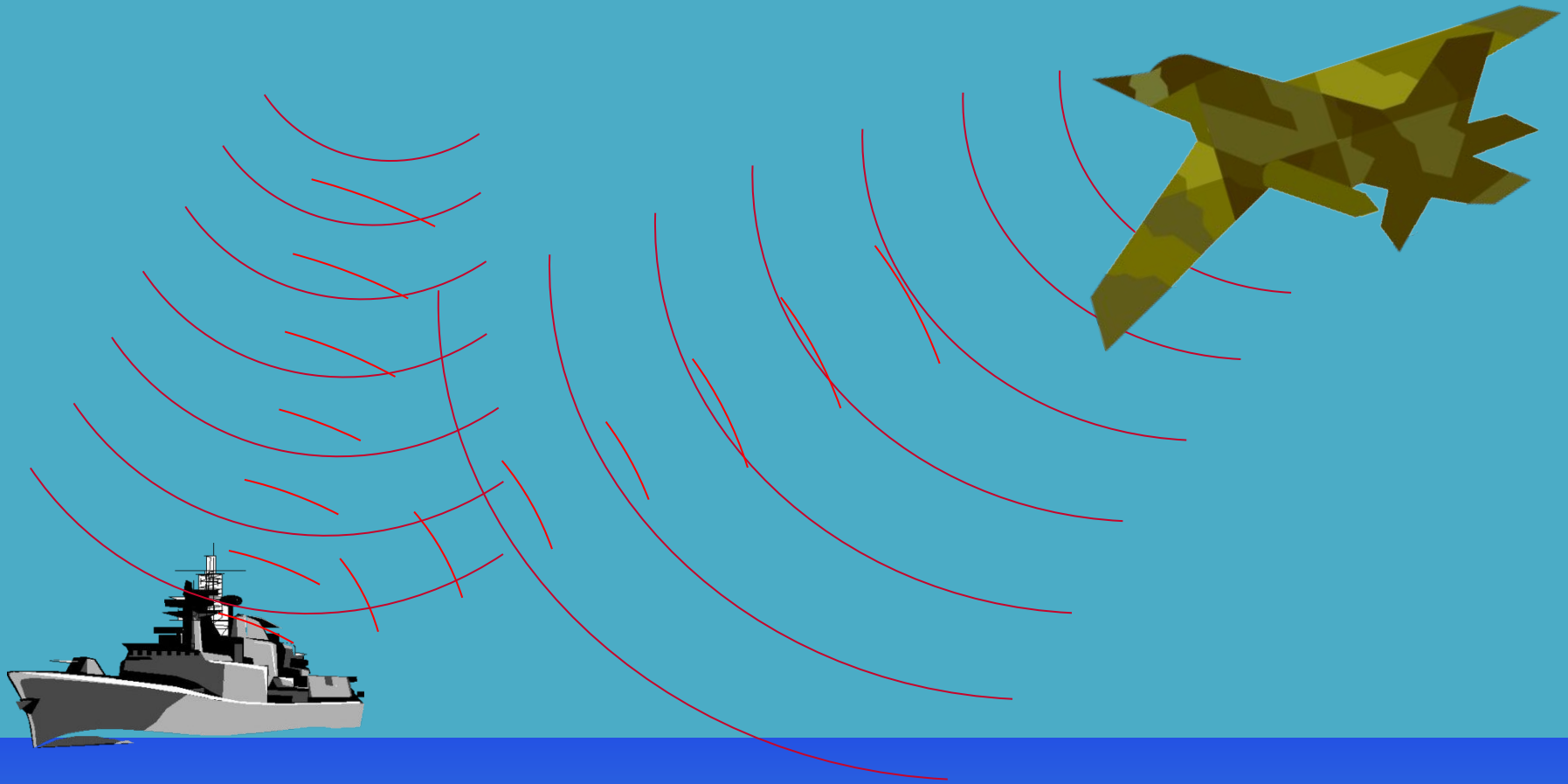
# Radar Lock

- Wide beam for searching
- Narrow, steered beam for targeting



## Search Radar

Surface-to-air engagement

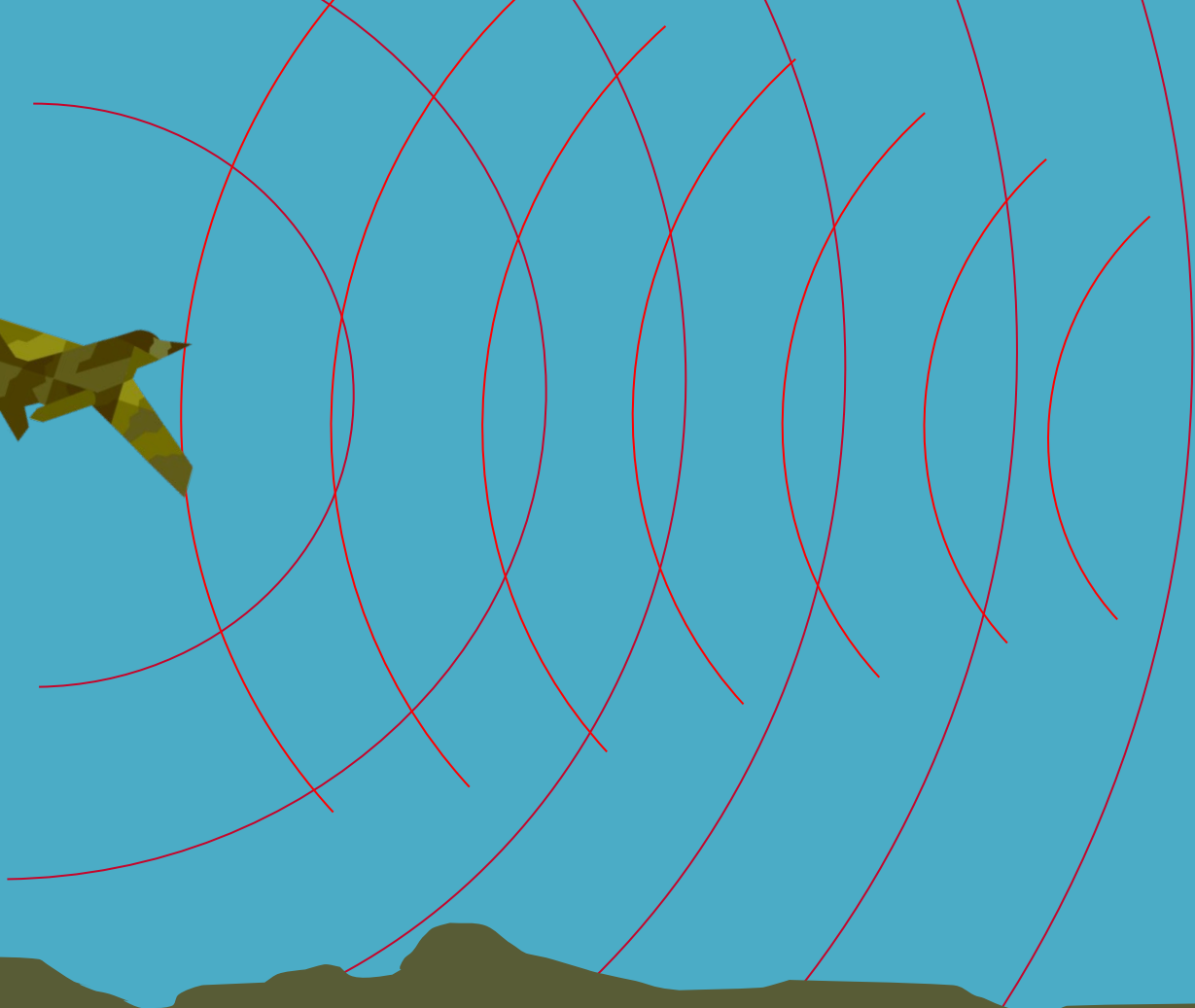


## Track Radar

Surface-to-air engagement

# Look-down, shoot-down

- Background clutter makes radar detection and lock very difficult when positioned above a target



## Radar – no backdrop

Air-to-air engagement



## Radar – against a backdrop

Air-to-air engagement

# Look-down, shoot-down

- Background clutter makes radar detection and lock very difficult when positioned above a target
- Computer processing and wavelength sensing allow modern systems to separate moving objects from static ones.

# Countermeasures

- Carried to protect against AAMs
- Create a better target than the actual aircraft
- Chaff:
  - Used against radar-guided missiles
  - Cloud of metal strips to reflect radar
- Flares:
  - Used against IR missiles
  - Create a much hotter target



# Weapons

# Weapons



**ASRAAM**

WVRAAM

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket	15 km	87 kg	> Mach 3	10 kg HE, laser proximity fuze	Imaging IR	Typhoon & Tornado

**ASRAAM**

WVRAAM



# Weapons



**AMRAAM**

BVRAAM

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Rocket	>40 km	150 kg	Mach 4	18 kg fragmentation	INS with datalink; terminal active radar	Typhoon

**AMRAAM**

BVRAAM



# Weapons



**Meteor**

BVRAAM

# Weapons

Engine	Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
Solid-fuel ramjet	>300 km	185 kg	> Mach 4	Fragmentation	INS with datalink; terminal active radar	Typhoon

**Meteor**

BVRAAM



# Practise Questions

- Which of the following is generally a feature of short-range (WVRAAMs) rather than long-range (BVRAAMs) missiles?
  - Infra-red guidance
  - Mid-course updates
  - Semi-active radar guidance
  - Inertial navigation



# Practise Questions

- Which statement is not true?
  - Chaff can be used to decoy active radar-guided missiles
  - Flares can be used to decoy semi-active radar-guided missiles
  - Electronic-counter-measures are often part of a defensive aids suite
  - Basic counter-measures work by creating a target that is more inviting than the aircraft deploying them

# Practise Questions

- Which of the following guidance systems is unlikely to be found on an air-to-air missile?
  - Passive infra-red
  - Active radar
  - Inertial navigation
  - Semi-active laser

# Practise Questions

- What is the stated range of a Meteor missile?
  - 3+ km
  - 30+ km
  - 300+ km
  - 3,000+ km

# Practise Questions

- Which feature is not found on any current AAM in British service?
  - Ramjet engine
  - Active radar guidance
  - Solid-rocket motor
  - Semi-active radar guidance

# Objectives

Explain:

- The history of air-to-air missiles
- The concept of "dogfight" and beyond-visual-range weapons
- Types of countermeasure
- The details of:
  - Meteor
  - AMRAAM
  - ASRAAM



# Military Aircraft Systems

Other Aircraft Weapons

# Objectives

- LO1 P1 - Identify types of air-launched weapons used by military aircraft

# Objectives

Explain:

- The main roles for aircraft guns:
  - Air-to-air combat
  - Strafing
  - Dual-role
- The details of aircraft guns
- The types of anti-submarine weapon
- The details of Sting Ray and Mk 54



# Guns

## Roles:

- Air-to-air – for close-range combat
- Strafing – attacking ground targets
- Dual-role – combines the two roles

# Guns



## Minigun

Rotary gun

# Guns

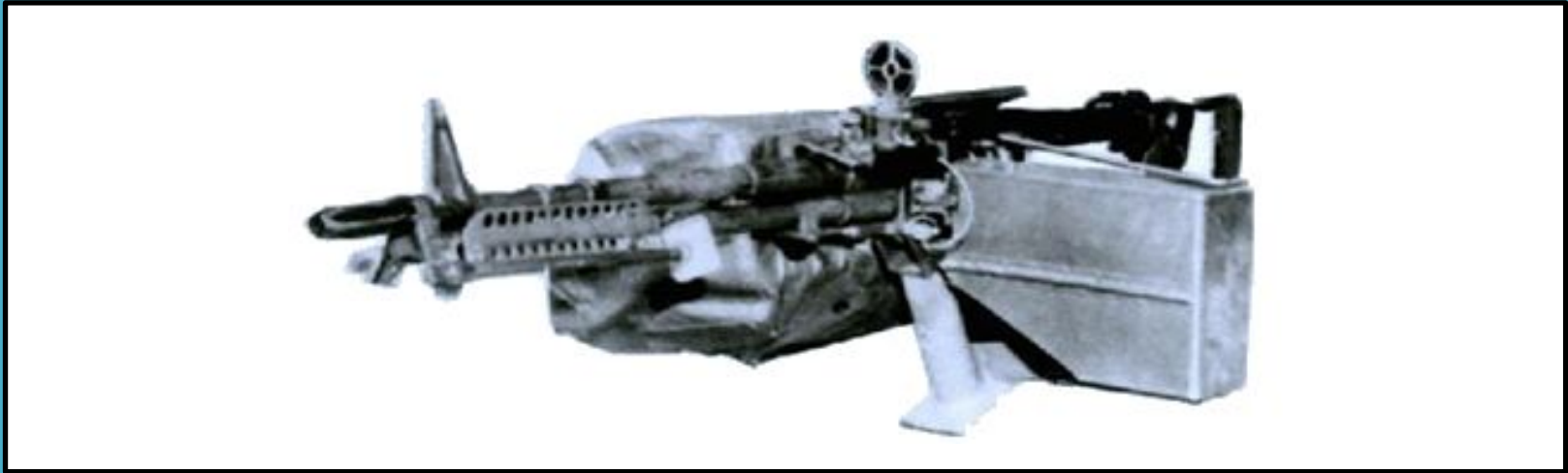
Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
1 km	39 kg	7.62mm rifle bullets	Electric rotary	4,000 RPM	Ground	Chinook

## Minigun

Rotary gun



# Guns



**M60**

Machine gun

# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
2 km	11 kg	7.62mm rifle bullets	Gas	550 RPM	Ground	Chinook

**M60**

Machine gun



# Guns



## L112A1 GPMG

Machine gun

# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
2 km	14 kg	7.62mm rifle bullets	Gas	600-800 RPM	Ground	Puma, Wildcat & Merlin

## L112A1 GPMG

Machine gun



# Guns



**M3M**

Machine gun



# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
2.5 km	37 kg	12.7mm bullets	Recoil	1,025 rpm	Surface	Wildcat & Merlin

**M3M**

Machine gun



# Guns



**Mauser**

27mm cannon

# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
~4 km	100 kg	27mm explosive shells	Gas-cycle d revolver	1,000 or 1,700 rpm	Dual-pu rpose	Tornado and Typhoon

## Mauser

27mm cannon



# Guns



**GAU-22A**

25 mm cannon

# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
3.7 km	104 kg	25mm explosive shells	Pneumatic rotary	3,300 rpm	Dual-purpose	Lightning II

**GAU-22A**

25 mm cannon



# Guns



## Chain Gun

30mm cannon

# Guns

Range	System Weight	Projectile	Operation	Rate of fire	Target	Aircraft
1.5 km	55 kg	30mm explosive shells	Electric	625 rpm	Ground	Apache

## Chain Gun

30mm cannon



# Anti-submarine Weapons

Types:

- Torpedoes – main weapon type used
- Depth charges – still useful in shallow water



# Anti-submarine Weapons



## Sting Ray

Anti-submarine torpedo

# Anti-submarine Weapons

Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
11 km	265 kg	80+ km/h	45 kg shaped charge	Active sonar	Merlin HM2 & Wildcat HMA2

## Sting Ray

Anti-submarine torpedo



# Anti-submarine Weapons



**Mk 54 Mod 0**

Anti-submarine torpedo

# Anti-submarine Weapons

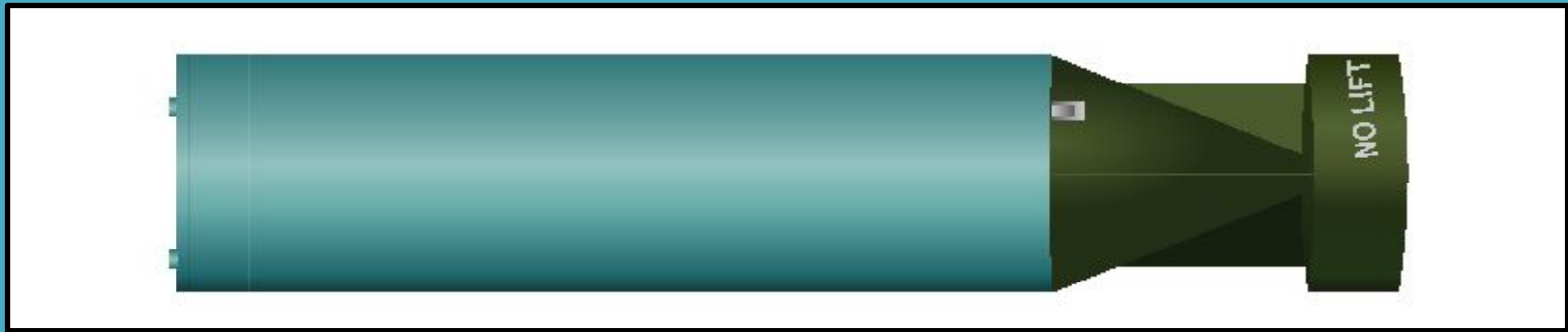
Range	Launch Weight	Speed	Warhead	Guidance	Aircraft
11+ km	276 kg	74+ km/h	44 kg high explosive	Active/passive sonar	Poseidon

## Mk 54 Mod 0

Anti-submarine torpedo



# Anti-submarine Weapons



## Mk 11 Mod 3

Anti-submarine depth charge

# Anti-submarine Weapons

Launch Weight	Warhead	Guidance	Aircraft
112 kg	77 kg high explosive	Nil	Merlin HM2 & Wildcat HMA2

## Mk 11 Mod 3

Anti-submarine depth charge

# Practise Questions

- Which of these weapons is not used for self-defence by helicopters?
  - GPMG
  - GAU-22
  - M60
  - Minigun

# Practice Questions

- Which of the following is a 30mm calibre weapon?
  - Minigun
  - M3M
  - GPMG
  - Chain Gun



# Practise Questions

- Which of the following is a multi-barrel (Gatling-type) weapon?
  - M60
  - Mauser
  - GAU-22
  - Chain Gun

# Practise Questions

- Which weapon cannot fire explosive shells?
  - M3M
  - Mauser
  - GAU-22
  - Chain Gun

# Practise Questions

- How is the Sting Ray guided?
  - Radar
  - Laser
  - Infra-red
  - Acoustic

# Objectives

Explain:

- The main roles for aircraft guns:
  - Air-to-air combat
  - Strafing
  - Dual-role
- The details of aircraft guns
- The types of anti-submarine weapon
- The details of Sting Ray and Mk 54



# Military Aircraft Systems

Carriage and Safety

# Objectives

- LO3 P6 - Identify safety mechanisms used to protect the launch aircraft
- Parts of LO3 P7 - Describe how an air-launched weapon is released from the aircraft and guided towards its target

# Objectives

Explain:

- Weapon type and version markings
- Carriage equipment
- Details of the rail launchers and ejection release units in RAF service

# Terminology

- Station – point to which a store is attached; also hardpoint
  - *Wet* – plumbed for fuel tanks
  - *Dry* – not plumbed
- Pylon – a device to carry stores (attached to a station)



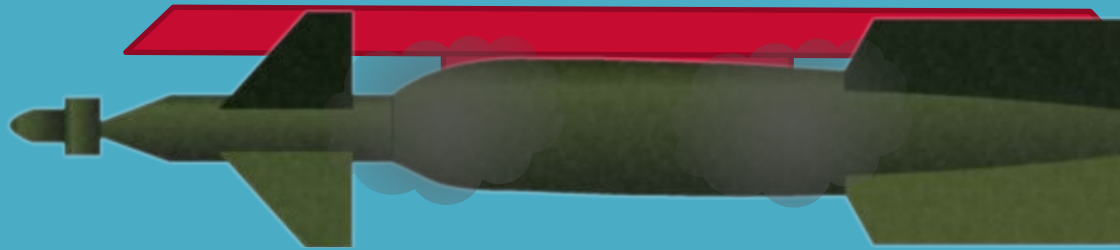
# Markings

Marked either in full or by bands

- **Yellow** Live Warhead
- **Brown** Live Rocket Motor
- **Pink** Live Seeker (on Training Missile)
- **Blue** Inert (Training) Weapon

# Carriage

- Ejection release units
  - Use compressed gas to push the store down away from the aircraft
  - Prevent damage to the aircraft from rocket exhaust
  - Limited flight envelope to prevent collision



## Carriage

Ejection Release Unit

# Carriage

- Ejection release units
  - Use compressed gas to push the store down away from the aircraft
  - Prevent damage to the aircraft from rocket exhaust
  - Limited flight envelope to prevent collision
- Rail launchers
  - Rocket motor drives weapon directly off of rail
  - Wide flight envelope
  - Rely on power, so unsuitable for bombs

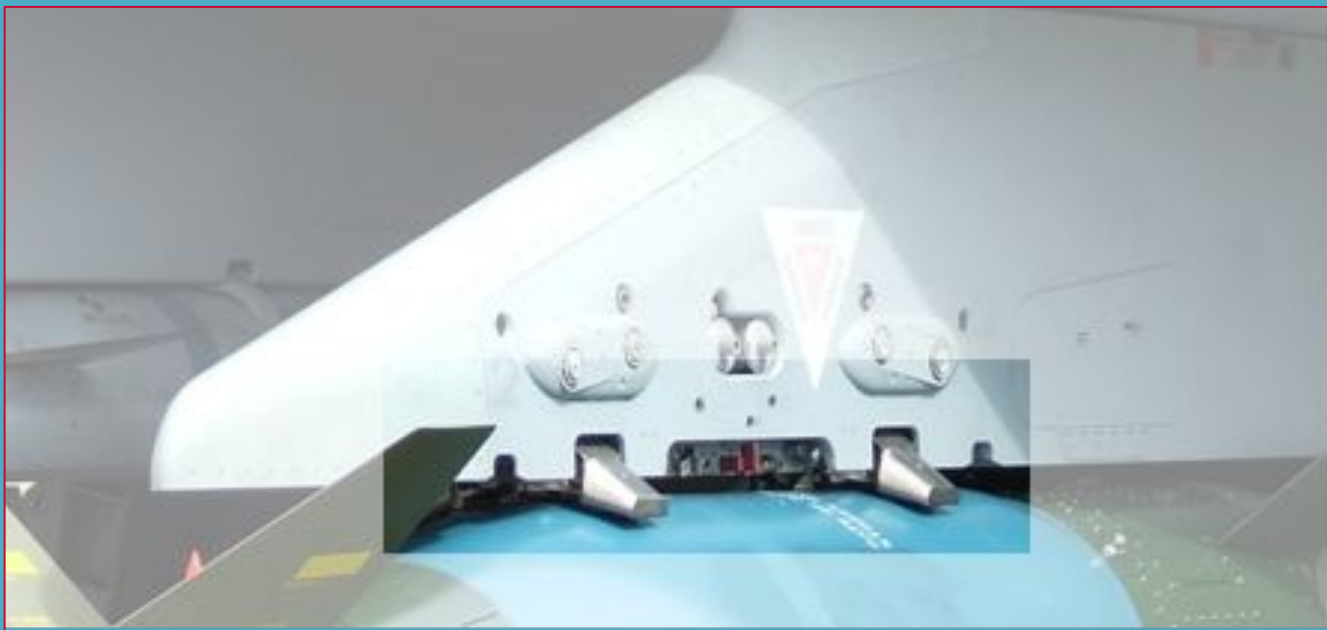


## Carriage

Rail Launcher

# Carriage

Sway brace - Adjustable bracket to prevent damage from swinging



# Carriage

## Rail launchers:

- Tornado ASRAAM launchers
  - LAU7/A - launcher only
  - BOL-304 – added chaff dispenser
- Typhoon
  - ITSPL (Integrated Tip Stub Pylon Launcher) - similar to BOL-304 but integral to the aircraft
  - MFRL (Multi-function Rail Launcher) – optional pylon for all AAMs

# Carriage

- Eject launchers (recessed) – semi-recessed carriage on Typhoon for AMRAAM or Meteor
- Along with ITSPL means Typhoon can carry six AAMs without affecting other weapons load



**Eject Launchers**

**ITSPL**





# Safety Features

Protect the aircraft and ground crew, ensure that weapons are only armed and released when required

- **Before deployment** – rigorous testing before clearance for use
- **On the ground** – safety pins prevent initiation on the ground. Pins are clearly marked and removed only when the aircraft is ready to depart

# Safety Features



## Safety Pins

Orange tags make the pins obvious

# Safety Features

- In the air
  - MASS (Master Armament Safety Switch) – arms the weapons so that they can be released and detonate
  - Late-arm Switch – needs to be selected to allow weapons to be released
  - Emergency Stores Jettison Switch – allows the pilot to release all external stores in an emergency

# Practise Questions

- What colour denotes a live warhead?
  - Blue
  - Yellow
  - Brown
  - Pink

# Practise Questions

- Which of the following cannot be removed from the aircraft?
  - LAU7/A
  - BOL-304
  - ITSPL
  - MFRL

# Practise Questions

- Which of the following has the role of preventing a store from swinging under g-loading?
  - Hardpoint
  - Sway brace
  - Safety pins
  - Ejector release units

# Practise Questions

- Which of the following can launch AMRAAM?
  - LAU7/A
  - BOL-304
  - ITSPL
  - MFRL

# Practise Questions

- Which of the following contains a chaff dispenser?
  - Recessed Ejection Launchers
  - BOL-304
  - ITSPL
  - MFRL



# Objectives

Explain:

- Weapon type and version markings
- Carriage equipment
- Details of the rail launchers and ejection release units in RAF service