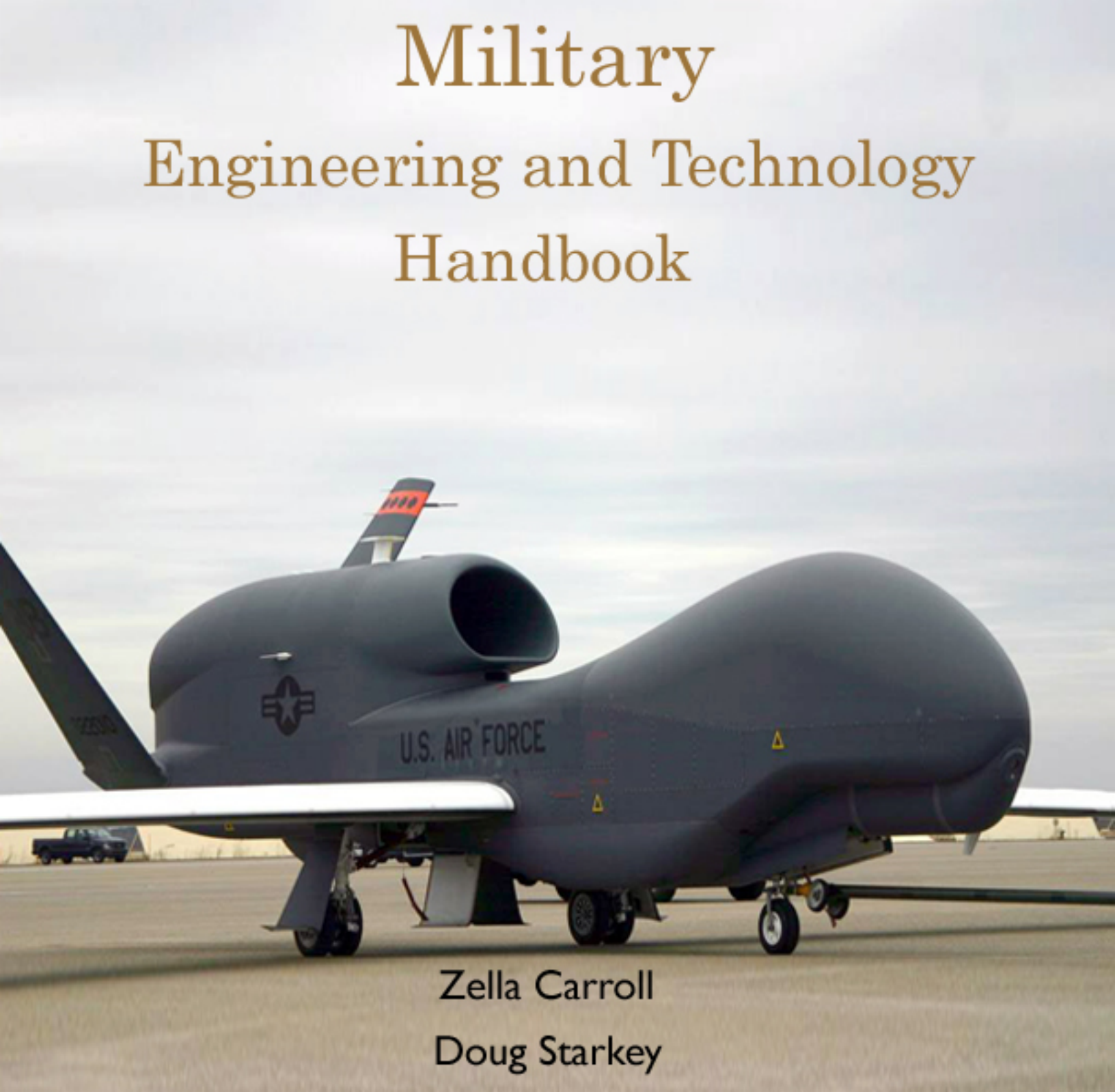
Military Engineering and Technology Handbook



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Chapter 1

Combat Engineering

U.S. Army Combat Engineers place satchel charges and detonating cord, preparatory to demolishing a railway bridge during the Korean War, 30 July 1950

Mobile field-deployable bridge (EFA) of the engineers of the French Army

Combat engineering is a combat arms role that falls within the scope of military engineering. It involves using the knowledge, tools and techniques of engineering by troops in peace and war, but specifically in combat. A combat engineer, in many armies also called **pioneer** or sapper, is a military specialist in using the tools and techniques of engineering under combat conditions, who may perform any of a variety of tasks.

Such tasks typically include constructing/breaching trenches, tank traps and other fortifications, bunker construction, bridge and road construction or destruction, laying or clearing landmines and general engineering tasks under fire. More generally speaking, the combat engineer's tasks involve facilitating movement and support of friendly forces while impeding that of the enemy.

Usually, a combat engineer is also trained as an infantry rifleman, and combat engineer elements often have a secondary role fighting as formed infantry. Beyond self-defense, combat engineers, infantry and assault troopers from Armored Corps units are generally the only troops that engage in the assault while dismounted. This role is limited by a lack of organic fire support (such as that obtained by Infantry units from their mortars), however combat engineers typically do have extensive anti-armored capability in their infantry fighting role.

Terminology

A general combat engineer is often called a *Pioneer* or *Sapper* (the word itself is derived from the French and British armies, and refers to the origin of combat engineering). In some armies the term *Pioneer* or *Sapper* is a term that indicates a specific military rank and level of training. While the officers of a combat engineering unit will generally be professionally-certified civil or mechanical engineers, the non-commissioned members are generally not.

Relevant terminology includes:

- **Sapper** is a term that is used for soldiers in the United States, British, Canadian, New Zealand and Australian armies that have specialized combat engineer training.
- In the Israeli Defence Forces, Sapper 07 (סלפ 07) is a rank denoting a combat engineer who has graduated basic general engineering training.
- In the Finnish army, ***pioneeri*** is the private equivalent rank in the army for a soldier who has completed the basic combat engineering training. Naval engineers retain the rank *matruusi* but bear the *pioneeri* insignia on their sleeves.
- In the British, Canadian and Australian armies, an **assault pioneer** is an infantry soldier with some limited combat engineer training in clearing obstacles during assaults and light engineering duties. Until recently assault pioneers were responsible for the operation of flamethrowers.
- The term **field engineer** is generally used to refer to specialists with training as mechanics or technicians.
- The term **military engineer** encompasses both combat engineers and construction engineers. In some armies the two are allocated to different Corps, such as the former Soviet Army. Geomatics, or surveying and cartography is another area that sometimes is integrated into military engineering, and in other cases is a separate responsibility, as was formerly the case in the Australian Army.

The design and development of military equipment is generally not the province of the military engineer, although they can be involved in such design engineering when the technology in question has a military engineering application.

History

"Combat Engineering" is a relatively modern term, but the concept can trace itself back to early integration of military engineering capability directly into fighting formations.

By the 18th century, regiments of foot (infantry) in the British, French, Prussian and other armies included pioneer detachments. In peacetime these specialists constituted the regimental tradesmen, constructing and repairing buildings, transport wagons, etc. On active service they moved at the head of marching columns with axes, shovels and pickaxes clearing obstacles or building bridges to open the way for the bulk of the regiment to move through difficult terrain. The modern Royal Welch Fusiliers and French Foreign Legion still maintain pioneer sections who march at the front of ceremonial parades, carrying chromium plated tools intended for show only. Other historic distinctions include long work aprons and the right to wear beards.

At the end of World War I, the standoff in the Western Front caused the Imperial German Army to gather experienced and particularly skilled soldiers to form "Assault Teams" which would break through the Allied trenches. With enhanced training and special weapons (such as flamethrowers), these squads obtained some success, but too late to change the outcome of the war. In early WWII, however, the Wehrmacht "Pioniere" battalions proved their efficiency in both attack and defense, somewhat inspiring other

armies to develop their own combat engineers battalions. Notably, the attack on Fort Eben-Emael in Belgium was conducted by Luftwaffe glider-deployed combat engineers.

The need to defeat the German defensive positions of the "Atlantic wall" as part of the amphibious landings in Normandy in 1944 led to the development of specialist combat engineer vehicles. These, collectively known as Hobart's Funnies, included a specific vehicle to carry combat engineers, the Churchill AVRE. These and other dedicated assault vehicles were organised into the specialised 79th Armoured Division and deployed during Operation Overlord - 'D-Day'.

During the 20th century, combat engineers gained vast knowledge and experience in explosives. They are tasked with planting bombs, landmines and dynamite.

Modern combat engineering still retains the Roman role of building field fortifications, road paving and the breaching of terrain obstacles. A notable combat engineer task was, for example, the breaching of the Suez Canal during the Yom Kippur War.

Role, practices and techniques

The combat engineering role includes practices and techniques of camouflage, reconnaissance, communication methods and enhancement of survival by other troops. Combat engineering also includes construction of roads, bridges, field fortifications and obstacles. In their role, combat engineers use a wide variety of engineer hand and power tools. They are also responsible for construction rigging, use of explosives and causing demolitions, camouflage, field fortifications, obstacle clearance and construction, assault of fortifications, bridge erection, use of assault boats in water obstacle crossings, expedient road and helipad construction, general construction, engineer route and road reconnaissance, and erecting communication installations. All these role activities and technologies are divided into several areas of combat engineering:

- Mobility
  - Clearing terrain obstacles
  - Overcoming trenches and ditches
  - Opening routes for armored fighting vehicles
  - Constructing roads and bridges
- Counter mobility
  - Planting landmines
  - Digging trenches and ditches
  - Demolishing roads and bridges
- Explosive material handling
  - Clearing landmine fields
- Assault
  - Opening routes during assault
  - Demolishing enemy structures (using bulldozers or explosive charges).
- Defense
  - Building fortifications
  - Building outposts
  - Building fences
- Defense against NBC weapon threats

- Planting landmines
- Accurate demolitions

Equipment and vehicles

Combat engineering employes a wide range of transportation vehicles and equipment, and uses weapons unique to the engineers, including those used in land mine warfare.

Equipment

IED detonator in Iraq

Basic combat engineering tools include safe use of: Driving and Chopping tools (hammers, mauls, sledges, screwdriver and bit, chopping tools); Cutting and Smoothing tools (saws, chisels, planes, files and rasps, brush-cutting tools, miscellaneous cutting tools); Drilling, Boring and Countersinking tools; Measuring, Levelling and Layout tools (rules, tapes, marking tools, levels and plumb bobs, squares); Gripping, Prying and Twisting tools (pliers, wrenches, bars); Holding, Raising and Grinding tools (vises, clamps, jacks, grinders and oilstones); Timber Handling and Climbing tools; Digging

tools (shovels, posthole diggers, picks and mattocks); Portable Power tools and Trailer-mounted tools (electric tool trailer and generator, portable power tools); Miscellaneous tools.

Vehicles

Armoured front loader

German Army combat engineer vehicle *Dachs*

This EBG combat engineering vehicle is used by the engineers of the French Army for a variety of missions

Obstacle breaching

For obstacle breaching, including minefields, the combat engineers use a variety of vehicles, explosive devices and plastic explosives including:

- Mine breaching devices
  - Dozer blade
  - Mine rollers
  - Bangalore Torpedo
  - Antipersonnel Obstacle Breaching System
  - Mine-clearing line charge (MICLIC)
- EOD robots
- Explosives, mines and bombs
- Field-deployable bridges
  - (ex: French EFA), Bailey bridge

Specific corps

The combat engineer role is a key one in all armed forces of the World, and invariably found either closely integrated into the force structure, or even into the combat units of the national troops.

Denmark

The Danish military engineering corps is almost entirely organized into one regiment, simply named "Ingeniørregimentet" ("The Engineering Regiment"). The core of the Danish combat engineers are the so-called armored engineers. These units usually work in separated squads, each under the command of an infantry company, and equipped with an M113. Their roles are combat demolition, minefield clearing, basic minelaying and EOR. They are also extensively trained as infantry, to support the ordinary troops in combat. Besides these units, the regiment has the different workfields of combat engineers (construction, EOD, CBRN) spread out over different companies.

Israel

IDF Caterpillar D9 with the Combat Engineering Corps flag.
Armored bulldozers are standard combat engineering tools, as they can perform construction, destruction and EOD missions under heavy fire.

In the Israeli Defence Forces the combat engineers are organized under the Combat Engineering Corps (Hebrew: חיל ההנדסה הקרבית). In addition to IEC sappers, each infantry brigade has an engineer company trained with basic engineering and EOD skills. IEC sappers are often attached to other units (such as armored divisions or infantry) in order to help them breach obstacles and handle explosive threats. The IEC operates advance engineering tools such as the IDF Caterpillar D9 armored bulldozer, IDF Puma armored CEV, Armoured vehicle-launched bridges, armored engineering vehicles, EOD robots and electromagnetic mine-detectors. Their main role is enabling Israeli forces to advance (breach the enemy's obstacles), stop the enemy's movement, handle explosives and perform construction and destruction missions under fire. The Israeli engineering corps is also responsible for counter-NBC warfare (i.e. defending troops against unconventional weapon and clean infected areas). The IEC has a special unit, called **Yahalom** (in Hebrew it means "Diamond" but also abbreviation of "Engineering Unit for Special Operations") which handles EOD, commando, engineering recon, advance robotics, tunnel warfare, maritime breaching, counter-NBC and other classified tasks.

The Israeli combat engineer Corps motto is "Rishonim Tamid" Hebrew: ראשונים תמיד, meaning "Always first".

Soviet Union/Russia

Soviet engineers were typically armed with the RPO-A Shmel (Bumblebee) rocket launcher to destroy fortifications.

United States

The motto of the US Army Corps of Engineers is "ESSAYONS," from French "Let *us* try." In the United States Army, the four tasks of combat engineer units are mobility, countermobility, survivability, and general engineering.

- **Mobility**: improving your own force's ability to move around the battlefield. Combat engineers typically support this role through reduction of enemy obstacles which include point and row minefields, anti-tank ditches, wire obstacles, concrete and metal anti-vehicle barriers and wall and door breaching in urban terrain. Mechanized combat engineer units also have armored vehicles capable of laying short bridges for limited gap-crossing.
- **Countermobility**: building obstacles to prevent the enemy from moving around the battlefield. Destroying bridges, blocking roads, creating airstrips, digging trenches, etc. Can also include planting landmines and anti-handling devices when authorized and directed to do so. Explosive Ordnance Disposal units in the U.S. Army employ ordnance personnel.
- **Survivability**: building structures which enable one's own soldiers to survive on the battlefield. Examples include trenches, bunkers, shelters, and armored vehicle fighting positions.
- **General Engineering**: general engineering sustains military forces in the theater through the performance of facility construction and repair, and through acquisition, maintenance, and disposal of real property.

Historical

FM 5-5	11 October 1943	Engineer Field Manual, Engineer Troops
FM 5-5 C-1	31 March 1944	CHANGES No. 1} FM 5-5, 11 October 1943 is changed as follows:
FM 5-5 C-2	10 May 1944	CHANGES No. 2} FM 5-5, 11 October 1943 is changed as follows:
FM 5-5 C-3	5 July 1944	CHANGES No. 3} FM 5-5, 11 October 1943 is changed as follows:
FM 5-5 C-4	11 October 1944	CHANGES No. 4} FM 5-5, 11 October 1943 is changed as follows:

FM 5-5 C-5	28 December 1944	CHANGES No. 5} FM 5-5, 11 October 1943 is changed as follows:
FM 5-5,C1..C5		I. Engineer Units with *Army Air Forces* II. Engineer Units with *Army Service Forces* i. port repair ship ii. port construction and repair group iii. special brigade III. Engineer Units, SERVICE, with *Army Ground Forces* IV. Engineer units, COMBAT, with *Army Ground Forces* i. airborne battalion ii. combat battalion iii. light ponton company iv. heavy ponton battalion v. treadway bridge company

Chapter 2

Military Engineering Vehicle

The **EBG** combat engineering vehicle, based on the AMX 30 tank, is used by the engineers of the French Army for a variety of missions.

BAT-M engineering vehicle of Russia and the former Soviet Union

Military engineering vehicles are vehicles built for military engineering work on the battlefield or for the transportation of combat engineers. These vehicles can range from civilian equipment to purpose built military vehicles.

Types of military engineering vehicles

Civilian and militarized heavy equipment

USMC Caterpillar D9 armored bulldozer. The civilian tractor is fitted with an armor kit, produced by Israel Military Industries.

Military engineering can employ a wide variety of heavy equipment in the same or similar ways to how this equipment is used outside the military. Bulldozers, cranes, graders, excavators, dump trucks, loaders, and backhoes all see extensive use by military engineers.

Military engineers may also use civilian heavy equipment which was modified for military applications. Typically, this involves adding armour for protection from battlefield hazards such as artillery, unexploded ordnance, mines, and small arms fire. Often this protection is provided by armour plates and steel jackets. Some examples of armoured civilian heavy equipment are the IDF Caterpillar D9, American D7 TPK, Canadian D6 armoured bulldozer, cranes, graders, excavators, and M35 2-1/2 ton cargo truck.

Militarized heavy equipment may also take on the form of traditional civilian equipment designed and built to unique military specifications. These vehicles typically sacrifice some depth of capability from civilian models in order to gain greater speed and independence from prime movers. Examples of this type of vehicle include high speed backhoes such as the Australian Army's High Mobility Engineering Vehicle (HMEV) from Thales or the Canadian Army's Multi-Purpose Engineer Vehicle (MPEV) from Arva.

Armoured engineering vehicle

PiPz Dachs AEV of the German Army (2008)

Polish Army MID Bizon-S

Typically based on the platform of a main battle tank, these vehicles go by different names depending upon the country of use or manufacture. In the US the term "combat engineer vehicle (CEV)" is used, in the UK the term "Armoured Vehicle Royal Engineers (AVRE)" is used, while in Canada and other commonwealth nations the term "armoured engineer vehicle (AEV)" is used. There is no set template for what such a vehicle will look like, yet likely features include a large dozer blade or mine ploughs, a large calibre demolition cannon, augers, winches, excavator arms and cranes or lifting booms.

These vehicles are designed to directly conduct obstacle breaching operations and to conduct other earth-moving and engineering work on the battlefield.

Good examples of this type of vehicle include the UK Trojan AVRE, the Russian IMR, and the US M728 Combat Engineer Vehicle.

It should be noted that while the term "armoured engineer vehicle" is used specifically to describe these multi-purpose tank based engineering vehicles, that term is also used more generically in British and Commonwealth militaries to describe all heavy tank based engineering vehicles used in the support of mechanized forces. Thus, "armoured engineer vehicle" used generically would refer to AEV, AVLB, Assault Breachers, and so on.

Armoured earth mover

Lighter and less multi-functional than the AEVs described above, these vehicles are designed to conduct earth-moving work on the battlefield. These vehicles have greater high speed mobility than traditional heavy equipment and are protected against the effects

of blast and fragmentation. Good examples are the American M9 ACE and the UK FV180 Combat Engineer Tractor.

Breaching vehicle

These vehicles are equipped with mechanical or other means for the breaching of man made obstacles. Common types of breaching vehicles include mechanical flails, mine plough vehicles, and mine roller vehicles. In some cases, these vehicles will also mount Mine-clearing line charges. Breaching vehicles may be either converted armoured fighting vehicles or purpose built vehicles. In larger militaries, converted AFV are likely to be used as *assault breachers* while the breached obstacle is still covered by enemy observation and fire, and then purpose built breaching vehicles will create additional lanes for following forces.

Good examples of breaching vehicles include the USMC M1 Assault Breacher Vehicle, the UK Aardvark JSFU, and the Singaporean Trailblazer

Bridging vehicles

U.S Army M104 Wolverine Heavy Assault Bridge

Several types of military bridging vehicles have existed through the years. The most notable are the various armoured vehicle-launched bridge (AVLB). An AVLB is

typically a modified tank hull converted to carry a bridge into battle in order to support crossing ditches, small waterways, or other gap obstacles.

Another type of bridging vehicle is the truck launched bridge. Possibly the most notorious such vehicle was the former Soviet TMM bridging truck that could carry and launch a 10 meter bridge that could be daisy-chained with other TMM bridges to cross larger obstacles. More recent developments have seen the conversion of AVLB and truck launched bridge with launching systems that can be mounted on either tank or truck for bridges that are capable of supporting heavy main battle tanks.

Earlier examples of bridging vehicles include a type in which a converted tank hull is the bridge. On these vehicles, the hull deck comprises the main portion of the tread way while ramps extend from the front and rear of the vehicle to allow other climb over the vehicle and cross obstacles. A notable example of this type of armoured bridging vehicle was the Churchill Ark used by the Allies in the Second World War.

Combat engineer section carriers

Another type of CEVs are armoured fighting vehicles which are used to transport sappers (combat engineers) and can be fitted with a bulldozer's blade and other mine-breaching devices. They are often used as APCs because of their carrying ability and heavy protection. They are usually armed with machine guns and grenade launchers and usually tracked to provide enough tractive force to push blades and rakes. Some examples are the U.S. M113 APC, IDF Puma, Nagmachon, Husky, and U.S. M1132 ESV (a Stryker variant).

Military ferries and amphibious crossing vehicles

This field-deployable apparatus, known as EFA, used by the engineers of the French Army, may either be used as a bridge (deployed in a series), or as a ferry

One of the major tasks of military engineering is crossing major rivers. Several military engineering vehicles have been developed in various nations to achieve this task. One of the more common types is the amphibious ferry such as the M3 Amphibious Rig. These

vehicles are self-propelled on land, they can transform into raft type ferries when in the water, and often multiple vehicles can connect to form larger rafts or floating bridges. Other types of military ferries, such as the Soviet *Plavayushij Transportyor - Srednyj*, are able to load while still on land and transport other vehicles cross country and over water.

In addition to amphibious crossing vehicles, military engineers may also employ several types of boats. Military assault boats are small boats propelled by oars or an outboard motor and used to ferry dismounted infantry across water.

Tank based combat engineering vehicles

Churchill "Bobbin", a rolled roadsurface that could be laid for following vehicles to cross loose sand

Most CEVs are armoured fighting vehicles that may be based on a tank chassis and have special attachments in order to breach obstacles. Such attachments may include dozer

blades, mine rollers, cranes etc. An example of an engineering vehicle of this kind is a bridgelaying tank, which replaces the turret with a segmented hydraulic bridge.

The Hobart's Funnies of the Second World War were a wide variety of armoured vehicles for combat engineering tasks. They were allocated to the initial beachhead assaults by the British and Commonwealth forces in the D-Day landings

Churchill tank

The British Churchill tank because of its good cross-country performance and capacious interior with side hatches became the most adapted with modifications, the base unit being the AVRE carrying a large demolition gun.

M4 Sherman

M4 with 105 mm howitzer and a dozer blade.

- **Dozer**: The bulldozer blade was a valuable battlefield tool on the WWII M4 Sherman tank. A 1943 field modification added the hydraulic dozer blade from a Caterpillar D8 to a Sherman. The later M1 dozer blade was standardized to fit any Sherman with VVSS suspension and the M1A1 would fit the wider HVSS. Some M4s made for the Engineer Corps had the blades fitted permanently and the turrets removed. In the early stages of the 1944 Battle of Normandy before the

Culin Cutter, breaking through the Bocage hedgerows relied heavily on Sherman dozers.

- **M4 Doozit**: Engineer Corps' Sherman dozer with demolition charge on wooden platform and T40 *Whizbang* rocket launcher.

- **Bridgelayer**: The US field-converted a few M4 in Italy with A-frame-supported bridge and heavy rear counter-weight to make the Mobile Assault Bridge. British developments for Shermans included the fascine (used by 79th Armoured Division), Crib, Twaby Ark, Octopus, Plymouth (Bailey Bridge), and AVRE (SBG bridge).

- **Mine-Clearing**: British conversions included the Sherman Crab. The US developed an extensive array of experimental types:
    - **T15/E1/E2**: Series of mine resistant Shermans based on the T14 kit. Cancelled at war's end.
    - **Mine Exploder T1E1 Roller** (*Earthworm*): Three sets of 6 discs made from armor plate.
    - **Mine Exploder T1E2 Roller**: Two forward units with 7 discs only. Experimental.
    - **Mine Exploder T1E3/M1 Roller** (*Aunt Jemima*): Two forward units with five 10' discs. Most widely used T1 variant, adopted as the M1. (picture)
    - **Mine Exploder T1E4 Roller**: 16 discs.
    - **Mine Exploder T1E5 Roller**: T1E3/M1 w/ smaller wheels. Experimental.
    - **Mine Exploder T1E6 Roller**: T1E3/M1 w/ serrated edged discs. Experimental
    - **Mine Exploder T2 Flail**: British Crab I mine flail.
    - **Mine Exploder T3 Flail**: Based on British Scorpion flail. Development stopped in 1943.
        - **Mine Exploder T3E1 Flail**: T3 w/ longer arms and sand filled rotor. Cancelled.
        - **Mine Exploder T3E2 Flail**: E1 variant, rotor replaced with steel drum of larger diameter. Development terminated at war's end.
    - **Mine Exploder T4**: British Crab II mine flail.
    - **Mine Exploder T7**: Frame with small rollers with two discs each. Abandoned.
    - **Mine Exploder T8** (*Johnny Walker*): Steel plungers on a pivot frame designed to pound on the ground. Vehicle steering was adversely affected.
    - **Mine Exploder T9**: 6' Roller. Difficult to maneuver.
        - **Mine Exploder T9E1**: Lightened version, but proved unsatisfactory because it failed to explode all mines.
    - **Mine Exploder T10**: Remote control unit designed to be controlled by the following tank. Cancelled.
    - **Mine Exploder T11**: Six forward firing mortars to set off mines. Experimental.

- **Mine Exploder T12**: 23 forward firing mortars. Apparently effective, but cancelled.
- **Mine Exploder T14**: Direct modification to a Sherman tank, upgraded belly armor and reinforced tracks. Cancelled.
- **Mine Excavator T4**: Plough device. Developed during 1942, but abandoned.
- **Mine Excavator T5/E1/E2**: T4 variant w/ v-shaped plough. E1/E2 was a further improvement.
- **Mine Excavator T5E3**: T5E1/E2 rigged to the hydraulic lift mechanism from the M1 dozer kit to control depth.
- **Mine Excavator T6**: Based on the v-shape/T5, unable to control depth.
- **Mine Excavator T2/E1/E2**: Based on the T4/T5's, but rigged to the hydraulic lift mechanism from the M1 dozer kit to control depth.

M60

A remotely controlled Panther armored mine clearing vehicle leads a column down a road in Bosnia and Herzegovina, May 16, 1996.

- **M60A1 AVLB** - Armored Vehicle Launched Bridge, 60-foot (18 m) scissors bridge on M60A1 chassis.

- **M60 AVLM** - Armored Vehicle Launched MICLIC (Mine-Clearing Line Charge), modified M60 AVLB with up to 2 MICLIC mounted over the rear of the vehicle.
- **M60 Panther** - M60 modified into a remotely controlled mine clearing tank. The turret is removed with the turret ring sealed, and the front of the vehicle is fitted with mine rollers.
- **M728 CEV** - M60A1-based Combat Engineer Vehicle fitted with a folding A-frame crane and winch attached to the front of the turret, and an M135 165mm demolition gun. Commonly fitted with the D7 bulldozer blade, or a mine-clearing equipment.
    - **M728A1** - Upgraded version of the M728 CEV.

M1

Grizzly Combat Mobility Vehicle (CMV)

- M1 Grizzly Combat Mobility Vehicle (CMV)
- M1 Panther II Remote Controlled Mine Clearing Vehicle
- M104 Wolverine Heavy Assault Bridge
- M1 Assault Breacher Vehicle (USMC)

Leopard 1

- Biber (Beaver) armoured vehicle launched bridge
- Pionierpanzer 1
- Pionierpanzer 2 Dachs (Badger) armoured engineer vehicle

Leopard 2

- Panzerschnellbrücke 2 (Bridge layer)
- Pionierpanzer 3 Kodiak

T-55/54

MTU-12 bridgelayer

MTU-20 bridgelayer

IMR combat engineering vehicle

- **T-54 Dozer** - T-54 fitted with bulldozer blades for clearing soil, obstacles and snow.
- **ALT-55** - Bulldozer version of the T-55 with large flat-plate superstructure, angular concave dozer blade on front and prominent hydraulic rams for dozer blade.
- **T-55** hull fitted with an excavator body and armoured cab.
- **T-55 MARRS** - Fitted with a Vickers armoured recovery vehicle kit. It has a large flat-plate turret with slightly chamfered sides, vertical rear and very chmfered front and a large A-frame crane on the front of the turret. The crane has cylindrical winch rope feer between legs of crane. A dozer blade is fitted to the hull front.
- **MT-55** or **MTU-55** (*Tankoviy Mostoukladchik*) - Soviet designator for Czechoslovakian MT-55A bridge-layer tank with scissors bridge.
- **MTU-12** (*Tankoviy Mostoukladchik*)- Bridge-layer tank with 12 m single span bridge that can carry 50 tonnes. The system entered service in 1955; today only a very small number remains in service. Combat weight: 34 tonnes.
- **MTU-20 (Ob'yekt 602)** (*Tankoviy Mostoukladchik*) - The MTU-20 consists of a twin-treadway superstructure mounted on a modified T-54 tank chassis. Each treadway is made up of a box-type aluminum girder with a folding ramp attached to both ends to save space in the travel position. Because of that the vehicle with the bridge on board is only 11.6 m long, but the over all span length is 20 m. This is an increase of about 62% over that of the older MTU-1. The bridge is launched by the cantilever method. First the ramps are lowered and fully extended before the treadways are forward with the full load of the bridge resting on the forward support plate during launch. The span is moved out over the launching girder until the far end reaches the far bank. Next the near end is lowered onto the near bank. This method of launching gives the bridgelayer a low silhouette which makes it less vulnerable to detection and destruction.
    - **MTU-20** based on the T-55 chassis.
- **BTS-1** (*Bronetankoviy Tyagach Sredniy* - Medium Armoured Tractor) - This is basically a turretless T-54A with a stowage basket.
    - **BTS-1M** - improved or remanufactured BTS-1.
- **BTS-2 (Ob'yekt 9)** (*Bronetankoviy Tyagach Sredniy* - Medium Armoured Tractor) - BTS-1 upgraded with a hoist and a small folding crane with a capacity of 3,000 kg. It was developed on the T-54 hull in 1951; series production started in 1955. The prototype Ob.9 had a commander's cupola with DShK 1938/46 machine gun, but the production model has a square commander's hatch, opening to the right. Combat weight: 32 tons. Only a very small number remains in service.
- **BTS-3** (*Bronetankoviy Tyagach Sredniy* - Medium Armoured Tractor) - JVBT-55A in service with the Soviet Army.
- **BTS-4** (*Bronetankoviy Tyagach Sredniy* - Medium Armoured Tractor) - Similar to BTS-2 but with snorkel. In the West generally known as **T-54T**. There are many different models, based on the T-44, T-54, T-55 and T-62.
- **BTS-4B** - Dozer blade equipped armoured recovery vehicle converted from the early -odd-shaped turret versions of the T-54.

    - **BTS-4BM** - Experimental version of the BTS-4B with the capacity to winch over the front of the vehicle.
- **IMR (Ob'yekt 616)** (*Inzhenernaya Mashina Razgrazhdeniya*) - Combat engineer vehicle. It's a T-55 that had its turret replaced with a hydraulically-operated 2t crane. The crane can also be fitted with a small bucket or a pair of pincer type grabs for removing trees and other obstacles. A hydraulically-operated dozer blade mounts to the front of the hull; it can be used in a straight or V-configuration only. The IMR was developed in 1969 and entered service five years later.
- **SPK-12G** (*Samokhodniy Pod'yomniy Kran*) - Heavy crane mounted on T-55 chassis. Only two were built.
- **BMR-2** (*Boyevaya Mashina Razminirovaniya*) - Mine clearing tank based on T-55 chassis. This vehicle has no turret but a fixed superstructure, armed with an NSVT machine gun. It is fitted with a KMT-7 mine clearing set and entered service around 1987 during the war in Afghanistan.
    - Improved version of BMR-2 that has been seen fitted with a wide variety of mine roller designs.

T-64

- **BAT-2** – Fast combat engineering vehicle with the engine, lower hull and "small roadwheels" suspension of the T-64. The 40-ton tractor sports a very large, all axis adjustable V-shaped hydraulic dozer blade at the front, a single soil ripper spike at the rear and a 2-ton crane on the top. The crew compartment holds 8 persons (driver, commander, radio operators plus a five-man sapper squad for dismounted tasks). The highly capable BAT-2 was designed to replace the old T-54/AT-T based BAT-M, but Warsaw Pact allies received only small numbers due to its high price and the old and new vehicles served alongside during the late Cold War.

T-72

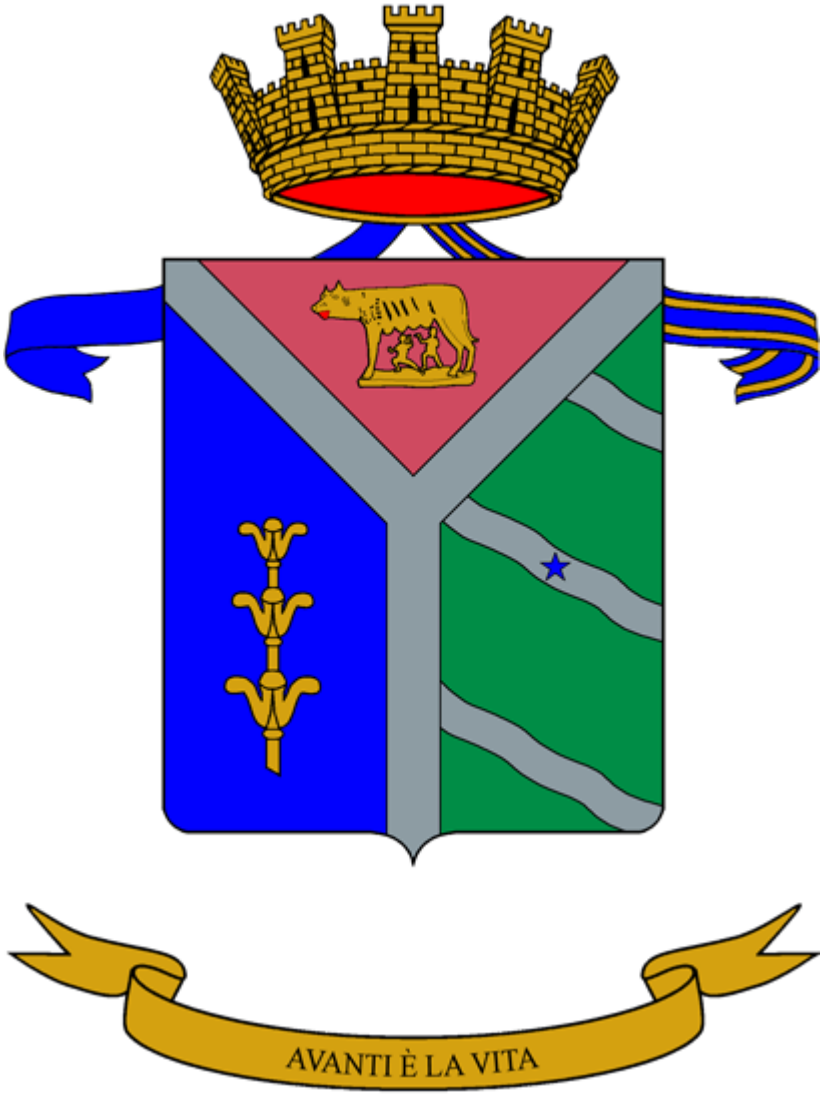
- **IMR-2** (*Inzhenernaya Mashina Razgrashdeniya*) - Combat engineering vehicle (CEV). It has a telescoping crane arm which can lift between 5 and 11 metric tons and utilizes a pincers for uprooting trees. Pivoted at the front of the vehicle is a dozer blade that can be used in a V-configuration or as a straight dozer blade. When not required it is raised clear of the ground. On the vehicle's rear, a mine-clearing system is mounted.
    - **IMR-2M1** - Simplified model without the mine-clearing system. Entered service in 1987.
    - **IMR-2M2** - Improved version that is better suited for operations in dangerous situations, for example in contaminated areas. It entered service in 1990 and has a modified crane arm with bucket instead off the pincers.
    - **IMR-2MA** - Latest version with bigger operator's cabin armed with a 12.7 mm machine gun NSV.
        - **Klin-1** - Remote controlled IMR-2.

- **MTU-72 (Ob'yekt 632)** (*Tankovyj Mostoukladchik*) - bridge layer based on T-72 chassis. The overall layout and operating method of the system are similar to those of the MTU-20 and MTU bridgelayers. The bridge, when laid, has an overall length of 20 meters. The bridge has a maximum capacity of 50,000 kg, is 3.3 meters wide, and can span a gap of 18 m. By itself, the bridge weighs 6400 kg. The time required to lay the bridge is 3 minutes, and 8 minutes for retrieval.
- **BLP 72** (*Brückenlegepanzer*) - The East-German army had plans to develop a new bridgelayer tank that should have been ready for series production from 1987 but after several difficulties the project was canceled.

Chapter 3

Sapper

The pionier sappers ("*sapeurs*") of the French Foreign Legion traditionally sport large beards, wear leather aprons and gloves and carry axes.



8° Reggimento Genio Guastatori Paracadutisti "Folgore"

A **sapper** or **combat engineer** is a combatant soldier who performs a wide variety of combat engineering duties, typically including, but not limited to, bridge-building, laying or clearing minefields, demolitions, field defences, general construction and building, as well as road and airfield construction and repair. He is also trained to serve as an infantryman when needed in both defensive and offensive operations and is fully involved in modern counter-insurgency operations. A sapper's tasks have, throughout history, including modern day counter-insurgency operations, been devoted to the mission-critical tasks involving facilitating movement and logistics of allied forces and impeding that of enemies. This active combatant career field is normally limited to males in most countries due to legislation.

The term "sapper" is used in British Army, Polish Army or Commonwealth nations' military services. In the United States Army and United States Air Force, the term *sapper*

leader has been instituted to indicate combat engineers who meet additional professional qualifications that demonstrate a certain level of proficiency and accomplishment as a small unit leader of combat engineers. An ordinary engineer who has completed his training is called a pioneer. The German Army uses the term *Pionier*, while *sapeur* is used in the French Army, and *guastatore* (more precisely defined as an **assault engineer**) in the Italian Army.

Historical origin

Sapper

Soldiers of No 2 Field Company, Bombay Sappers and Miners on duty in China in 1900. The mule carries the tools required for field engineering tasks.

A sapper, in the sense first used by the Assyrian Army in the early 7th Century BC, was one who excavated trenches under defensive fire to advance a besieging army's position in relation to the works of an attacked fortification, which was referred to as sapping the enemy fortifications.

Saps were excavated by brigades of trained sappers or instructed troops. When an army was defending a fortress with cannon, they had an obvious height and therefore range advantage over the attacker's own guns. The attacking army's artillery had to be brought forward, under fire, so as to facilitate effective counter-battery fire.

This was achieved by digging what the French termed a '**Sappe**'. Using techniques developed and perfected by Vauban, the *sapeurs* (sappers) began the trench at such an angle so as to avoid enemy fire 'enfilading' (passing directly along) the sappe. As they pressed forward, a position was prepared from which cannon could suppress the defenders on the bastions. The sappers would then change the course of their trench, zig-zagging their way toward the fortress wall.

Each leg brought the attacker's artillery closer and closer until (hopefully) the besieged cannon would be sufficiently suppressed for the attackers to breach the walls with their artillery. Broadly speaking, sappers were originally experts at demolishing or otherwise overcoming or bypassing fortification systems.

Miner

The fort of Ghazni which fell as a result of mining by a mixed contingent of the Bombay and Bengal Sappers during the First Afghan War on 23rd July 1839.

An additional term applied to sappers of the British Indian Army was 'miner'. The native engineer corps were referred to as 'sappers and miners', as for example, the Royal Bombay Sappers and Miners. The term arose from a task done by sappers to further the battle after saps were dug. The saps permitted cannon to be brought into firing range of the besieged fort and its cannon, but often the cannon themselves were unable to breach the fort walls. The engineers would dig a tunnel from the forward-most sap up to and under the fort wall, then place a charge of gunpowder and ignite it, causing a tremendous explosion which would destroy the wall and permit attacking infantry to close with the enemy. This was dangerous work, often lethal to the sappers, and was vehemently

resisted by the besieged enemy. Since the two tasks went hand in hand and were done by the same troops, native Indian engineer corps came to be called 'sappers and miners'.

Specific usage

Commonwealth of Nations

Sapper (abbreviated Spr) is the Royal Engineers' equivalent of Private. This is also the case within the Indian Army Corps of Engineers, Canadian Military Engineers, Royal Australian Engineers, South African Army Engineer Formation and Royal New Zealand Engineers. The term Sapper was introduced in 1856 when the Corps of Royal Sappers and Miners was amalgamated with the officer Corps of Royal Engineers to form the Corps of Royal Engineers.

Indian Army

The term 'Sappers', in addition to the connotation of rank of engineer private, is used collectively to informally refer to the Engineer Corps as a whole and also forms part of the informal names of the three combat engineer groups, viz. Madras Sappers, Bengal Sappers and the Bombay Sappers. Each of these groups consist of about twenty battalion-sized engineer regiments and additional company-sized minor engineer units. The three Sapper groups are descended from the Sapper and Miner groups of the East India Company and later the British Indian Army of the British Raj.

Israel Defence Forces

In the Israel Defence Forces a sapper (in Hebrew: סלפ, palas) is the military profession of a combat soldier who went through basic combat engineering training. Most of the sappers are soldiers of the Combat Engineering Corps, but there are also infantry sappers, who are part of the infantry brigades and are organized in Engineering companies called ן"החלפ (Palchahan). These companies are integral part of the infantry brigades. Combat engineering corps sappers are arranged in battalions.

Each sapper goes through high level infantry training, which qualifies him as Rifleman 07 (יאבור 07). Combat engineering sappers are qualified as Sapper 06 (סלפ 06). They are skilled in infantry combat, basic sabotage, landmine planting and demining, use of explosives, breaching and opening routes, trench warfare, and operating the IDF Puma combat engineering vehicle (CEV). Combat engineering commanders are qualified as Sapper 08 while combat engineering officers are qualified as Sapper 11. Both go through additional advance training to gain the skills needed for high level sapper profession.

France

Sapeurs-pompiers de Paris (Paris Fire Brigade)

In France, the civil firefighters and the military firefighters of the Paris Fire Brigade and other town or country brigades are called "sappers-firemen" (*sapeurs-pompiers*, SP): the first fire company created by Napoléon I was a military sappers company. Apart from this, the sappers are the combat engineers.

The sappers were very common in the French army and in other European armies during the Napoleonic era but progressively disappeared in the 19th century, except in the French Foreign Legion, which retains a sapper unit.

In the French Army, since the 18th century, every grenadier battalion had a small unit of sappers. They had the mission to advance, under the enemy's fire, in order to destroy with their axes the obstacles drawn by the enemy and to clear the way for the rest of the infantry. The danger of such missions and their short life expectancies, allowed them certain privileges, such as the authorization to wear beards. In addition to their beards and axes, they traditionally wear leather aprons and gloves.

The current pioneer unit of the Legion reintroduced the symbols of the Napoleonic sappers: the beard, the axe, the leather apron, the crossed-axes insignia and the leather

gloves. If the parades of the Legion are opened by this unit, it is to commemorate the traditional role of the sappers "opening the way" for the troops.

United States Army

US Combat Engineer setting a charge in World War II

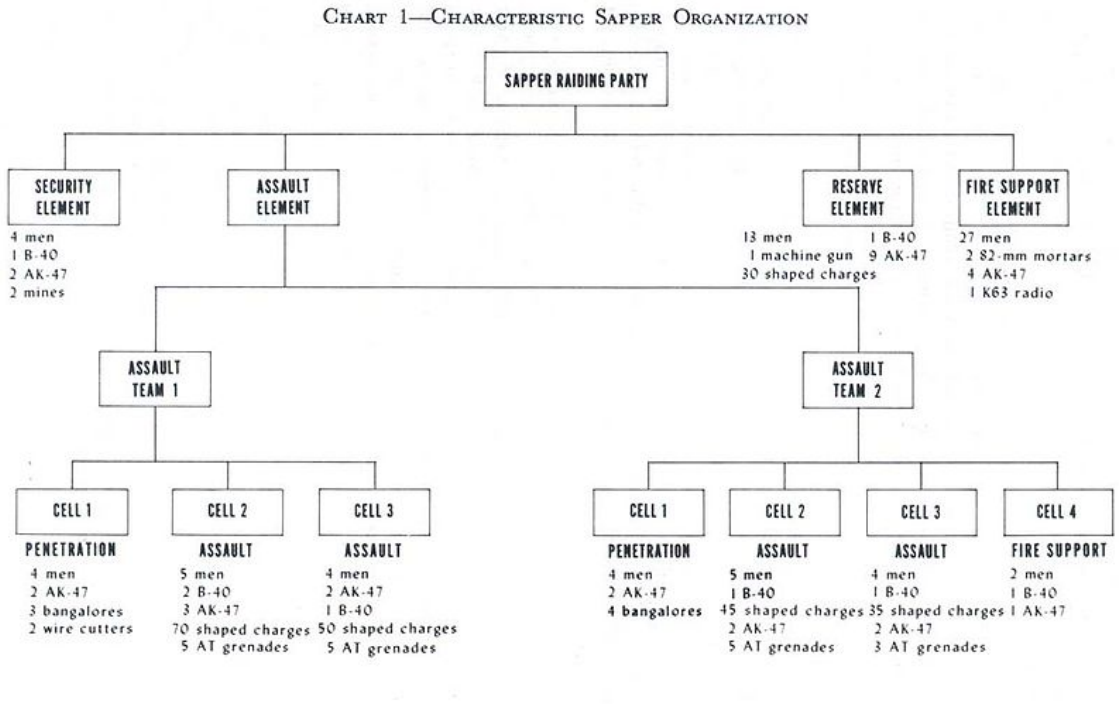
In the U.S. Army, sappers are combat engineers who support the front-line infantry, and they have fought in every war in American history. For example, after the Battle of Yorktown, General Washington cited Louis Lebèque Duportail, the U.S. Army's first Chief of Engineers, for conduct which afforded "brilliant proofs of his military genius."

Designation as a sapper nowadays is earned as an additional proficiency. The U.S. Army authorizes four skill tabs for permanent wear above the unit patch on the left shoulder (Army Regulation 670-1 Chapter 29-13, Sub-Paragraph f). Along with the Sapper Tab, the Special Forces Tab and the Ranger Tab identify soldiers who have passed a demanding course of military instruction and demonstrated their competence in particular specialities and skills. The Sapper Tab ranks below the Special Forces Tab and the Ranger Tab, so the three tabs are worn in that order of precedence from highest to lowest.

To wear the Sapper Tab, a soldier must complete the *Sapper Leader Course* (SLC) which is operated by the U.S. Army Engineer School at Fort Leonard Wood, Missouri. The Sapper Leader Course is a 28-day course designed to train joint-service leaders in small unit tactics, leadership skills, and tactics required to perform as part of a combined arms team. The course is open to enlisted soldiers in the grades of E-4 (P) (in the Army,

specialist on the list for promotion to sergeant, E-5) and above, cadets, and officers O-3 (Army, captain) and below. Students can come from any combat or combat support branch of the service, but priority is given to engineering, cavalry, and infantry soldiers.

PAVN and Viet Cong



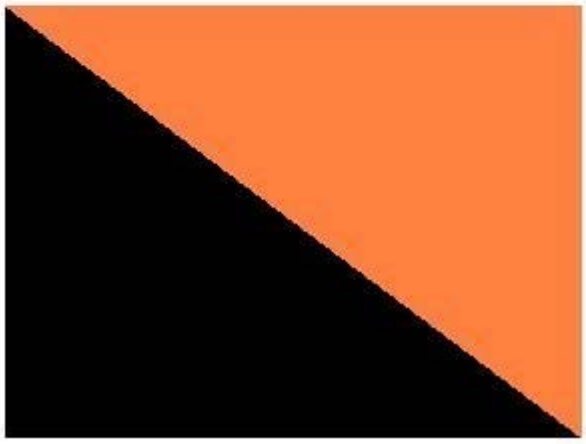
Sapper formation- PAVN/Viet Cong

PAVN (People's Army of Vietnam) and Viet Cong sappers, as they were called by US forces, are better described as commando units. The Vietnamese term "đặc công" can be literally translated as "special task". Thousands of specially trained elite fighters served in the PAVN and Viet Cong commando/sapper units which were organized as independent formations. While not always successful due to lack of appropriate personal weapon types for combat and assault like other special forces, at times they inflicted heavy damage against their enemies. They have been armed with various types of bombs, mines, explosive charges, grenades and even steel-pellet mines which were much more devastating than the U.S M18 Claymore and are still the main weapons of the Dac cong. These elite units served as raiders against American/ARVN troops, and infiltrated spearheads during the final Ho Chi Minh Campaign in 1975 – where they seized key road and bridge assets, destroyed installations, attacked command and control nodes located deep inside enemy territory, and otherwise helped the PAVN's rapid mobile forces advance. A typical PAVN/VC Dac cong organization is shown in the diagram. The raiding force was usually grouped into assault teams, each broken down into several 3–5 man assault cells. Overall, there were generally 4 operational echelons.

Chapter 4

Combat Engineering Corps

Israeli Engineering Corps



Israeli Combat Engineering Corps symbols

Active	1947 - today
Country	Israel
Branch	GOC Army Headquarters
Type	Combat Engineering
Role	Combat Engineering, EOD, counter-NBC
Part of	Israel Defense Forces

Nickname	"Muhandesim", "Palasim", "Ksoofim"
Motto	"Rishonim Tamid" ("Always First"), "Rishonim BaHazit" ("First in the Front"), "Lech Beyekvot Haksufim" ("Follow the Silver ones")
Colors	Silver berets
March	"Handasa Kravit Theme"
Mascot	"BobCat" lynx
Engagements	All of Israel's wars, notable are: Suez War; Yom Kippur War (Operation Abirey Lev - breaching the Suez Canal); Second Intifada (Battle of Jenin), Second Lebanon War, Operation Cast Lead
Decorations	Israel Defense Prize
Commanders	
Current commander	Brigadier General Moshe Sheli
Notable commanders	Emmanuel Shachar, Elchanan Klein, Avishay Katz, Shimon Daniel

The Israeli **Combat Engineering Corps** (Hebrew: חיל ההנדסה הקרבית, *Heil HaHandasa HaKravit*) is the combat engineering forces of the Israel Defense Forces.

The Combat Engineering Corps beret's color is grey and their symbol features a sword on a defensive tower with a blast halo on the background. The Combat Engineering Corps mottos are *"Always First" (דימת מינושאר Rishonim Tamid)* and the unofficial *"The hard - we shall do today, the impossible - we shall do tomorrow"*.

Their roles include mobility assurance, road breaching, defense and fortifications, counter-mobility of enemy forces, construction and destruction under fire, sabotage, explosives, bomb disposal, counter-NBC and special engineering missions.

In addition to Combat Engineering Corps sappers, each infantry brigade has an engineering company trained with basic engineering and EOD (Explosive Ordnance Disposal) skills (called וה"חלפ). Combat Engineering Corps sappers and heavy equipment operators are often attached to other units (such as armored or infantry brigades) in order to help them breach through obstacles and handle explosive threats.

Roles

Beside extensive training in basic combat engineering, Combat Engineering Corps are specialized and go through advanced training in their profession. The professions are:

- **Sapper:** trained with all the basic engineering skills and also trained at high infantry level (יאבור 07). Their main role is to breach through terrain obstacles (natural and artificial), breach through minefields and enable ground forces to advance in the battle field. They are trained to supply close combat support for both armored fighting vehicles and infantry. Some of them are trained in driving the Combat Engineering Corps standard CEV: the IDF Puma. They professional ranks after advance training are Rifleman 07 (יאבור 07) and Sapper 06 (סלפ 06).
- **Engineering Vehicles Operator** (EVO): less combatant but nonetheless important, these soldiers are skilled in the operation of heavy mechanical equipment and engineering vehicles such as heavy bulldozers, excavators, cranes, tractors and mine-breaching devices. EVO units are called ה"מצ (*Tzama*) in Hebrew, acronym of *Tziyud Mechani Handasi* (Mechanical Engineering Equipment). They professional ranks are Rifleman 05 (יאבור 05) and EVO Operator 07 (ה"מצ ליעפמ 07).
    - **Bulldozer Operators:** belong to the EVO, these soldiers are operating the IDF Caterpillar D9 armored bulldozers, including under heavy fire. Their roles are versatile and differ according to the units whom they are attached. The D9 operators perform construction, destruction, breaching and EOD missions while assisting to tanks, infantry and even special forces during battle.
- **NBC Disposal:** called "purifiers", they are expert in handling nuclear, biological and chemical threats.
- **EOD experts:** the Explosive Ordnance Disposal are experts in detonating explosives without damage and bomb disposal. Among their equipment you can find the Barrett M82A1 and remote-control EOD robots with shotguns and

mechanic-arms. The EOD are the military equivalent of the police's bomb squad. In the IDF, they are a part of the elite Engineering unit Yahalom.

- **Demolition experts:** they are specially trained in blowing up things in the most accurate and effective way. They explode things ranging from cellular phones and doorlocks up to tanks and large buildings. In the IDF, the demolition experts are united in Sayeret Yael of Yahalom (Sayeret is the Israeli name for SF elite unit) and therefore gain high infantry training as well.
- **Fortification experts:** assigned on designing and overseeing the construction of bases, outposts, bridges and fortifications. Construction itself is usually done by the EVOs.
- **Counter-Tunnels experts:** established in 2003 by the late Captain Aviv Hakani, these Combat Engineering Corps soldiers are expert in finding smuggling tunnels and weapon caches, and demolishing them. They operated in Rafah during the al-Aqsa Intifada and received recommendation of honor for their activity. After 2004 APC incident the Rafah tunnel team was united with the Combat Engineering Corps elite unit Yahalom and was renamed Sayeret Samur ("Samur" means "Weasel" in Hebrew).

IDF Puma.
Puma is a heavy armed engineering vehicle, used to transfer Combat Engineering Corps through minefields or a hostile urban terrain.

IDF Caterpillar D9.
Armored bulldozers are standard combat engineering tools, as they can perform construction, destruction and EOD missions under heavy fire.

RemoTec ANDROS EOD robot.

Armoured front loader.

Units

- Combat Engineering Battalions
  - Asaf 601 חסא
  - HaMachatz 605 ץחמה
  - Lahav 603 בהל
- Command's Engineering Units
  - North
  - Center
  - South
- Special Engineering Vehicles (TZAMA צמ"ה) units
  - Knights of Steel הדלפה יריבא - Tzama Gaza
  - Wild Cats רבה ילותח - Tzama Yeuda and Shomron
  - Beit Hilel לֹלה תיב - Tzama North
- Yahalom - special engineering unit להי"ם
  - Sayeret Yael - engineering commando
  - SAP - EOD and bomb disposal
  - SAMUR - counter-tunnels
  - Hevzek - Robotics
- Counter-NBC and purifiers
  - Counter-NBC battalion 76
  - Yanshuf - NBC training center
- Military Engineering School (Bahad 14) 14 ד"הב - תיאבצ הסדנהל רפסה תיב

History

Founding of the corps

The Israeli Combat Engineering Corps are based upon the sabotage unit of the Palmach and the tractors operators units of the Israeli War of Independence. In the first years, the Combat Engineering Corps drew their soldiers mainly from Jews who served in the British Royal Engineers.

The Combat Engineering Corps have record of great professional achievements and breaking-through decorations. The Engineering Corps' most famous operation is the breaching of the Suez Canal in Yom Kippur War.

In the Israeli wars

In the Israeli War of Independence, the Combat Engineering Corps blasted bridges over the Jordan River and the streams of the southern Coastal plain in order to stop the advance of the Arab armored forces into the Israeli civilian rear. The Combat Engineering Corps also helped in breaching the "Burma Road" into the then besieged Jerusalem.

"Road of Heroism" memorial for the fallen soldiers of the Israeli Engineering Corps, near Hulda forest, at Burma Road, Israel.

In the 1956 Sinai war the Combat Engineering Corps destroyed the Egyptian military infrastructure in the Sinai Peninsula and were awarded with a battalion recommendation of honor (TZALASH).

In the 1967 Six Day War the Combat Engineering Corps stormed the Jordanian fortifications, which were the walls of the Old City of Jerusalem. After the Israelis annexed the entire Old City, the Combat Engineering Corps removed landmines planted in the city by the Jordanians. This was the first war in which Caterpillar D9 bulldozers were employed by the Combat Engineering Corps.

After the war, the Combat Engineering Corps helped to build a fortification line of defense along the Suez Canal and was awarded the Israel Security Prize in 1969. The Israeli Engineering Corps were the first corps to ever win such an award.

In the 1973 Yom Kippur War the Combat Engineering Corps battalions attached to Ariel Sharon's armored Brigade breached the Suez Canal and built bridges over it in "Operation Knights of Heart" while carrying tanks and paratroopers across the canal with Gillois amphibious tank-carriers. This effort enabled Sharon and Avraam "Bren" Adan's armored divisions to pass the canal and surround the 3rd Egyptian Army, forcing it to surrender. The bridging of the canal is regarded by many as the turning point of the war in the southern front. On the northern front, a Combat Engineering Corps Caterpillar D9 bulldozer was the first ever motorized vehicle to reach the peak of the Hermon.

In the Operation Peace for Galilee the Combat Engineering Corps worked intensively to open routes to Israeli forces. Their duties also included the disarming landmines and IEDs as well as building fortifications and outposts.

In the 1991 Gulf War, the NBC purifiers of the Combat Engineering Corps were on a "code red" alert for disarming Iraqi Scud missiles, armed with non-conventional warheads.

The October 2000 Lebanon abduction

"Timsach" (crocodile) Gillois amphibious tank-carrier

On October 7, 2000 three Israeli combat engineering soldiers were kidnapped by Hezbollah from the Shebaa Farms, in the Golan Heights. The soldiers, Beni Avraham, Adi Avitan and Omar Sawaed, suffered fatal injuries during their abduction. Their bodies were retrieved in 2004 at a prisoner swap deal with Hezbollah.

A series of accusations were made against the United Nations Interim Force in Lebanon (UNIFIL) by press and partisan web sites for having cooperated with the abduction. Those accusations stem from a video, whose existence was originally denied by U.N. officials, recorded by Indian peacekeepers one day after the abduction. The video, which the U.N. agreed to provide to Israeli officials in June 2001 with civilian faces blurred, showed abandoned vehicles with fake U.N. license plates and uniforms, and Hezbollah supporters intercepting U.N. efforts to retrieve the vehicles. A U.N. investigation also found no evidence to support accusations of peacekeepers involvement in the abduction. Although the bereaved families met with Kofi Annan, they refused to accept the UN version. On September 2004, the bereaved families announced their intention to sue the UN, Hezbollah, Iran, Syria and Lebanon for their parts in the abduction.

The al-Aqsa Intifada

IDF **D9**L, which won the Battle of Jenin 2002 during Operation Defensive Shield. The armored Caterpillar D9 bulldozers were cited by military experts as a key factor in keeping IDF casualties low.

During the al-Aqsa Intifada, which erupted in September 2000, the Combat Engineering Corps were employed to disarm many Palestinian IED explosive charges and booby traps. In many cases, the Combat Engineering Corps also detonated explosive belts captured on Palestinian suicide bombers. The Combat Engineering Corps also dynamited Palestinian houses, bomb labs and smuggling tunnels.

However, the Combat Engineering Corps were most known for operating the armored IDF Caterpillar D9 bulldozers, which are cited by many Israelis and military experts as a key factor in keeping IDF casualties low and successfully fighting terrorism. On the other side, for Palestinians, the bulldozers became a nightmare, as they bulldozed many Palestinian buildings and shrubbery, and were almost impervious to Palestinian attacks. The Combat Engineering Corps bulldozers' operators unit received an honor of recommendation for its activity in Jenin during Operation Defensive Shield.

Bulldozers were also massively employed in Rafah to counter terrorist smuggling tunnels. Human Rights Watch published a report criticizing the extensive destruction of Palestinian houses in the southern Gaza strip, and said it was unlawful, claiming that Israel uses the Palestinian smuggling tunnels as a pretext to create a "buffer zone" along the Gaza-Egypt border. In Rafah, the Combat Engineering Corps formed a special unit, designated for searching and destroying smuggling tunnels, it is called SAMUR and now belongs to Yaalom. They also received an honor of recommendation, for their conduct. Until the Disengagement plan, the Combat Engineering 603 battalion's Reconnaissance platoon (ר"סחמ) held a record of over 70 terrorists killed in 2004-2005 on the border between the Gaza Strip and Israel. They received an honor of recommendation for this achievement.

Second Lebanon War

The Combat Engineering Corps took significant part in the Second Lebanon War that erupted in 2006 after Hizbullah attacked IDF patrol, abducted two soldiers and killed another 8 with anti-tank missiles and IED that hit the rescuers.

On July 16 combat engineering forces from Asaf battalion were the first to enter Lebanon. Their mission was to clear IEDs, open safe routes to ground forces and demolish Hizbullah infrastructures. Yahalom bomb disposal experts and IDF Caterpillar D9 bulldozers cleared most of Hizbullah's IEDs. During the war, a D9 went over a 500 kg belly charge IED but survived without taking significant damage.

During the war, combat engineers used bulldozers and explosives to destroy Hizbullah outposts, bunkers, warehouses and HQs - mainly along the border. The works intensified as the war reached near end, and indeed the borderline was cleared in time.

Combat engineers also rescued damaged tanks, often under fire.

Two combat engineers were awarded with Medal of Distinguished Service and other two awarded a recommendation of honor from the General Chief of Staff. Many other awarded with recommendation of honor from less senior commanders.

Operation Cast Lead

During the Gaza War (2008-2009) codenamed "Operation Cast Lead" by the IDF, combat engineering forces were the first to enter the Gaza Strip to clear IEDs, booby traps and open safe routes to armor and infantry.

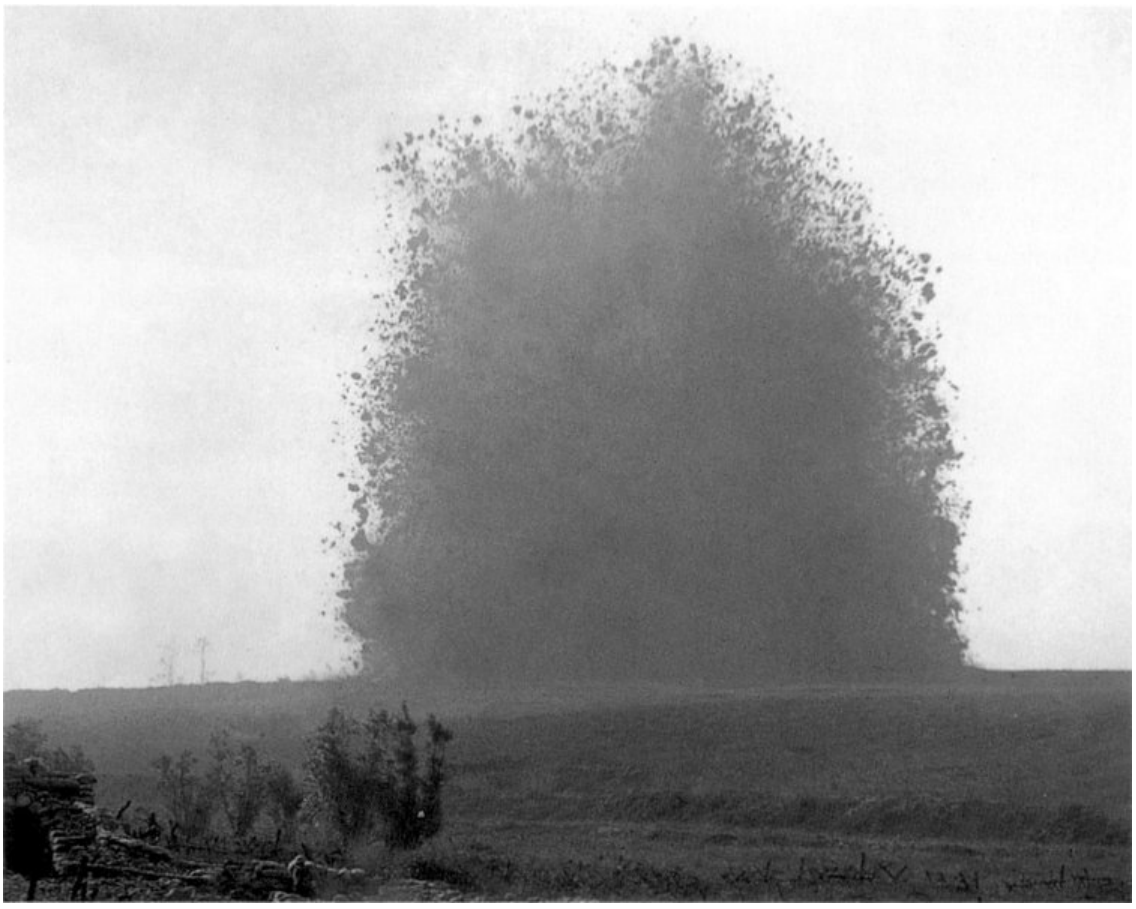
Many booby traps, rigged structures and tunnels were present in the Gaza Strip as part of Hamas efforts to preper to the Gaza war. These were often concealed in civilian structures, and were even found in schools and mosques. However, most of the Palestinian booby traps were successfully countered by the IDF Combat Engineering Corps bomb disposal experts (part of Yahalom Special Engineering Unit) which dismentaled the bombs and armored D9 bulldozers which detonated bombs and booby traps while sustaining no damage from the explosions. IDF Caterpillar D9R and unmanned "Raam HaShachar" D9N armored bulldozers which opened route in dangerous areas have taken a lot of IEDs, landmines, explosive charges and RPG hits, but no crewmen were killed. However, a Yahalom bomb disposal expert was killed after entering a house and encountering a suicide bomber. He was the only fatality of the Combat Engineering Corps during the war.

Beside of neutralizing Hamas IEDs and traps, combat engineering forces demolished Hamas infrastructure and other structures which used as outpost, shooting positions, traps, cover for tunnels, HQs or a warehouses. The head officer of the Combat Engineering Corps (נהק"ר) estimated that about 600 buildings were bulldozed or exploded by his troops.

The war upgraded the Combat Engineering Corps' status and reputation within the IDF and in the Israeli public. This was manifested in increased number of conscripts who chose the Combat Engineering Corps as their first priority in their draft preferation questionnaire ("Manila הלינמ" - a form in which the conscript chooses in what unit he would like to serve, the IDF tries to fulfill his request as much as possible). On the August 2010 draft, there were 1.1 conscripts who chose Combat Engineering as first priority over each slot.

Chapter 5

Mining (Military)



Explosion of the mine beneath Hawthorn Ridge Redoubt on the Western Front during World War I (July 1 1916). Photo by Ernest Brooks

Mining, **landmining** or **undermining** is a siege method which has been used since antiquity against a walled city, fortress, castle or other strongly-held and fortified military position.

In antiquity

The Greek historian Polybius, in his *Histories*, gives a graphic account of mining and counter mining at the Roman siege of Ambracia:

> The Aetolians [...] offered a gallant resistance to the assault of the siege artillery and [the Romans], therefore, in despair had recourse to mines and underground tunnels. Having safely secured the central one of their three works, and carefully concealed the shaft with wattle screens, they erected in front of it a covered walk or stoa about two hundred feet long, parallel with the wall; and beginning digging from that, they carried it on unceasingly day and night, working in relays. For a considerable number of days the besieged did not discover them carrying the earth away through the shaft; but when the heap of earth thus brought out became too high to be concealed from those inside the city, the commanders of the besieged garrison set to work vigorously digging a trench inside, parallel to the wall and to the stoa which faced the towers. When the trench was made to the required depth, they next placed in a row along the side of the trench nearest the wall a number of brazen vessels made very thin; and, as they walked along the bottom of the trench past these, they listened for the noise of the digging outside. Having marked the spot indicated by any of these brazen vessels, which were extraordinarily sensitive and vibrated to the sound outside, they began digging from within, at right angles to the trench, another underground tunnel leading under the wall, so calculated as to exactly hit the enemy's tunnel. This was soon accomplished, for the Romans had not only brought their mine up to the wall, but had under-pinned a considerable length of it on either side of their mine; and thus the two parties found themselves face to face.

According to Polybius, this was the first time poison gas was used.

Another extraordinary usage of siege-mining in the ancient Greece, where during Philip V of Macedon's siege of the little town of Prinassos, according to Polybius,"the ground around the town were extremely rocky and hard, making any siege-mining virtually impossible. However, Philip ordered his soldiers during the cover of night collect earth from elsewhere and throw it all down at the fake tunnel's entrance, making it look like the macedonians were almost finished completing the tunnels. Eventually, when Philip V announced that large parts of the town-walls were undermined the citizens surrendered without delay.

Mining was a siege method used in ancient China from at least the Warring States (481–221 BC) period forward. When enemies attempted to dig tunnels under walls for mining or entry into the city, the defenders used large bellows (the type the Chinese commonly used in heating up the blast furnace for smelting cast iron) to pump smoke into the tunnels in order to suffocate the intruders.

In the Middle Ages

In warfare during the Middle Ages, a "mine" was a tunnel dug to bring down castles and other fortifications. The technique was used when the fortification was not built on solid rock, and was developed as a response to stone built castles that could not be burned like earlier-style wooden forts. A tunnel would be excavated under the outer defenses either to provide access into the fortification or to collapse the walls. These tunnels would normally be supported by temporary wooden props as the digging progressed. Once the excavation was complete, the wall or tower being undermined would be collapsed by filling the excavation with combustible material that, when lit, would burn away the props leaving the structure above unsupported and thus liable to collapse. Later, explosives were used for greater effect.

A tactic related to mining is sapping the wall, where engineers would dig at the base of a wall with crowbars and picks. Peter of les Vaux-de-Cernay recounts how at the battle of Carcassonne, during the Albigensian Crusade, "after the top of the wall had been somewhat weakened by bombardment from petraries, our engineers succeeded with great difficulty in bringing a four-wheeled wagon, covered in oxhides, close to the wall, from which they set to work to sap the wall"

As in the siege of Carcassonne, defenders worked to prevent sapping by dumping anything they had down on attackers who tried to dig under the wall. Successful sapping usually ended the battle since either the defenders would no longer be able to defend and surrender, or the attackers would simply charge in and engage the defenders in close combat.

There were several methods to resist under mining. Often the siting of a castle could be such as to make mining difficult. The walls of a castle could be constructed either on solid rock or on sandy or water logged land making it difficult to dig mines. A very deep ditch or moat could be constructed in front of the walls, as was done at Pembroke Castle, or even artificial lakes as was done at Kenilworth Castle. This makes it more difficult to dig a mine and even if a breach is made the ditch or moat makes exploiting the breach difficult. The defenders could also dig counter mines. From these they could then either dig into the attackers' tunnels and sortie into them to either kill the miners or to set fire to the pit-props to collapse the attackers' tunnel. Alternatively they could under mine the attackers' tunnels and create a camouflet to collapse the attackers' tunnels. Finally if the walls were breached they could either place obstacles in the breach for example a chevaux de frise to hinder a forlorn hope, or construct a coupure. The great concentric ringed fortresses like Beaumaris Castle on Anglesey were designed in such a way that the inner walls were ready built coupures so that if an attacker succeeded in breaching the outer walls would have left them in a killing field between the lower outer walls and the higher inner walls.

In the American Civil War

During the Siege of Vicksburg in 1863 Union troops led by General Ulysses S. Grant tunnelled under the Confederate trenches and detonated the mine beneath the 3rd Louisiana Redan on June 25, 1863. The following assault led by General John A. Logan gained a foothold in the Confederate trenches where the crater was formed but the attackers were eventually forced to withdraw.

A more famous instance occurred during the Siege of Petersburg, Union troops dug a tunnel under the Confederate lines at Elliott's Salient and packed its end with vast amounts of gunpowder. When set off, the resulting explosion killed about 300 soldiers. It might have been decisive if not for the faulty Union tactic of storming into, rather than around, the resulting crater, allowing the defenders to shoot down onto attackers unable to climb the steep crater sides. The combat was accordingly known as the Battle of the Crater. (The horror of this engagement was portrayed in the Charles Frazier novel and subsequent Anthony Minghella movie *Cold Mountain*.)

In modern warfare

Contractors manually clear a mine field on Bagram Airfield, Afghanistan in 2007

Mining saw a brief resurgence as a military tactic during the First World War when army engineers attempted to break the stalemate of trench warfare by tunneling under no man's land and laying large quantities of explosives beneath the enemy's trench. As in siege warfare, mining was possible due to the static nature of the fighting.

A notable example was the Battle of Messines, when 450 tonnes of high explosive were placed in 21 mines after about two years of sapping. Approximately 10,000 German troops were killed when 19 of the mines were simultaneously detonated. One of the explosive caches exploded years later. The 21st cache was never found and there are still several tonnes of high explosive buried somewhere in the Belgian countryside.

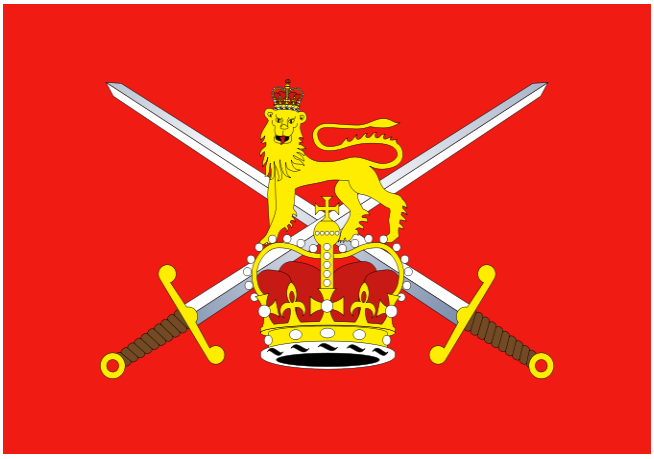
Another example is recorded in Louis Trenker's *Berge in Flammen*. Whole mountain peaks in the Alps, such as Col di Lana, Lagazuoi and Marmolata, were exploded during the mountain war.

Because troop movements in World War II were too fluid, and tunneling too slow, mining proved not to be worth the investment of effort in that conflict.

Chapter 6

Royal Engineers

British Army Arms and Services



Combat Arms

Royal Armoured Corps

Infantry

- Guards Division
- Scottish Division
- King's Division
- Queen's Division
- Prince of Wales' Division
- Royal Irish Regiment
- Parachute Regiment
- Royal Gurkha Rifles
- The Rifles
- Special Air Service

Army Air Corps

Combat Support Arms

Royal Artillery

Royal Engineers

Royal Corps of Signals

Intelligence Corps

Combat Services

Royal Army Chaplains Department

Royal Logistic Corps

Army Medical Services

- Royal Army Medical Corps
- Royal Army Dental Corps
- Royal Army Veterinary Corps
- Queen Alexandra's Royal Army Nursing Corps

Royal Electrical and Mechanical Engineers

Adjutant General's Corps

- Educational and Training Services Branch
- Army Legal Services Branch
- Royal Military Police
- Military Provost Staff Corps

Small Arms School Corps

Royal Army Physical Training Corps

General Service Corps

Corps of Army Music

The **Corps of Royal Engineers**, usually just called the **Royal Engineers** (**RE**), and commonly known as the **Sappers**, is one of the corps of the British Army. It provides military engineering and other technical support to the British Armed Forces. It is headed by the Chief Royal Engineer.

The Regimental Headquarters and the Royal School of Military Engineering are in Chatham in Kent, England. The corps is divided into several regiments, barracked at various places in the United Kingdom of Great Britain and Northern Ireland and Germany.

History

Cap Badge of the Corps of Royal Engineers

Royal Engineers recruitment poster

Corps of Royal Engineers Cypher

The Royal Engineers trace their origins back to the military engineers brought to England by William the Conqueror, specifically Bishop Gundulf of Rochester Cathedral, a talented military engineer, and claim over 900 years of unbroken service to the crown. Engineers have always served in the armies of the Crown; however, the origins of the modern corps, along with those of the Royal Artillery, lie in the Board of Ordnance established in the 15th century. In 1717, the Board established a **Corps of Engineers**, consisting entirely of commissioned officers. The manual work was done by the **Artificer Companies**, made up of contracted civilian artisans and labourers. In 1782, a **Soldier Artificer Company** was established for service in Gibraltar, and this was the first instance of non-commissioned military engineers. In 1787, the Corps of Engineers was granted the *Royal* prefix and adopted its current name and in the same year a **Corps of Royal Military Artificers** was formed, consisting of non-commissioned officers and privates, to be officered by the RE. Ten years later the Gibraltar company, which had remained separate, was absorbed and in 1812 the name was changed to the **Corps of Royal Sappers and Miners**.

In 1855 the Board of Ordnance was abolished and authority over the Royal Engineers, Royal Sappers and Miners and Royal Artillery was transferred to the Commander-in-Chief of the Forces, thus uniting them with the rest of the Army. The following year, the Royal Engineers and Royal Sappers and Miners became a unified corps as the **Corps of Royal Engineers**. In 1862 the corps also absorbed the British officers and men of the engineer corps of the East India Company.

In 1911 the Corps formed its Air Battalion, the first flying unit of the British Armed Forces. The Air Battalion was the forerunner of the Royal Flying Corps and Royal Air Force.

In 1915, in response to German mining of British trenches under the then static siege conditions of World War One, the corps formed its own tunnelling companies. Manned by experienced coal miners from across the country, they operated with great success

until 1917, when after the fixed positions broke, they built built deep dugouts such as the Vampire dugout to protect troops from heavy shelling.

The Corps has no battle honours, but its motto is *Ubique Quo Fas et Gloria Ducunt*. This translates to "Everywhere Where Right and Glory Lead" and is often seen shortened to simply "Ubique" although the full motto should always be used for tradional, heraldic or historical purposes. The motto was granted by King William IV in 1832, signifying that the Corps had seen action in all the major conflicts of the British Army and almost all of the minor ones as well. The Royal Engineers Museum of Military Engineering is in Gillingham in Kent.

A point of some pride to the Sappers is that their name takes the form Corps of Royal Engineers rather than, for example, Royal Engineer Corps. The distinction, they say, is that every Sapper is Royal in his own right, rather than simply being a member of a Royal Corps (such as the Royal Corps of Signals or the Royal Regiment of Artillery).

Before the Second World War, Royal Engineers recruits were required to be at least 5 feet 4 inches tall (5 feet 2 inches for the Mounted Branch). They initially enlisted for six years with the colours and a further six years with the reserve or four years and eight years. Unlike most corps and regiments, in which the upper age limit was 25, men could enlist in the Royal Engineers up to 30 years of age. They trained at the Royal Engineers Depot in Chatham or the RE Mounted Depot at Aldershot.

Honourable Conquests and Historical Construction

Britain having acquired an Empire, it fell to the Royal Engineers to conduct some of the most significant 'civil' engineering schemes around the world. Some examples of great works of the era of empire can be found in A.J. Smithers' book; 'Honourable Conquests':

Royal Albert Hall

The Royal Albert Hall, designed by Captain Francis Fowke RE.

The Royal Albert Hall is one of the UK's most treasured and distinctive buildings, recognisable the world over. Since its opening by Queen Victoria in 1871, the world's leading artists from every kind of performance genre have appeared on its stage. Each year it hosts more than 350 performances including classical concerts, rock and pop, ballet and opera, tennis, award ceremonies, school and community events, charity performances and lavish banquets.

The Hall was designed by Captain Francis Fowke and Major-General Henry Y.D. Scott of the Royal Engineers and built by Lucas Brothers. The designers were heavily influenced by ancient amphitheatres, but had also been exposed to the ideas of Gottfried Semper while he was working at the South Kensington Museum.

Indian Infrastructure

Much of the infrastructure of India, still enjoyed today, was created by engineers of the three presidencies armies and the Royal Engineers. Lieutenant (later General Sir) Arthur Thomas Cotton (1803–99), Madras Engineers, was responsible for the design and construction of the great irrigation works on the river Cauvery, which watered the rice corps of Tanjore and Trichinopoly districts in the late 1820s. In 1838 he designed and built sea defences for Vizagapatam. He masterminded the Godavery Delta project where 720,000 acres (2,900 km^2) of land were irrigated and 500 miles (800 km) of land to the

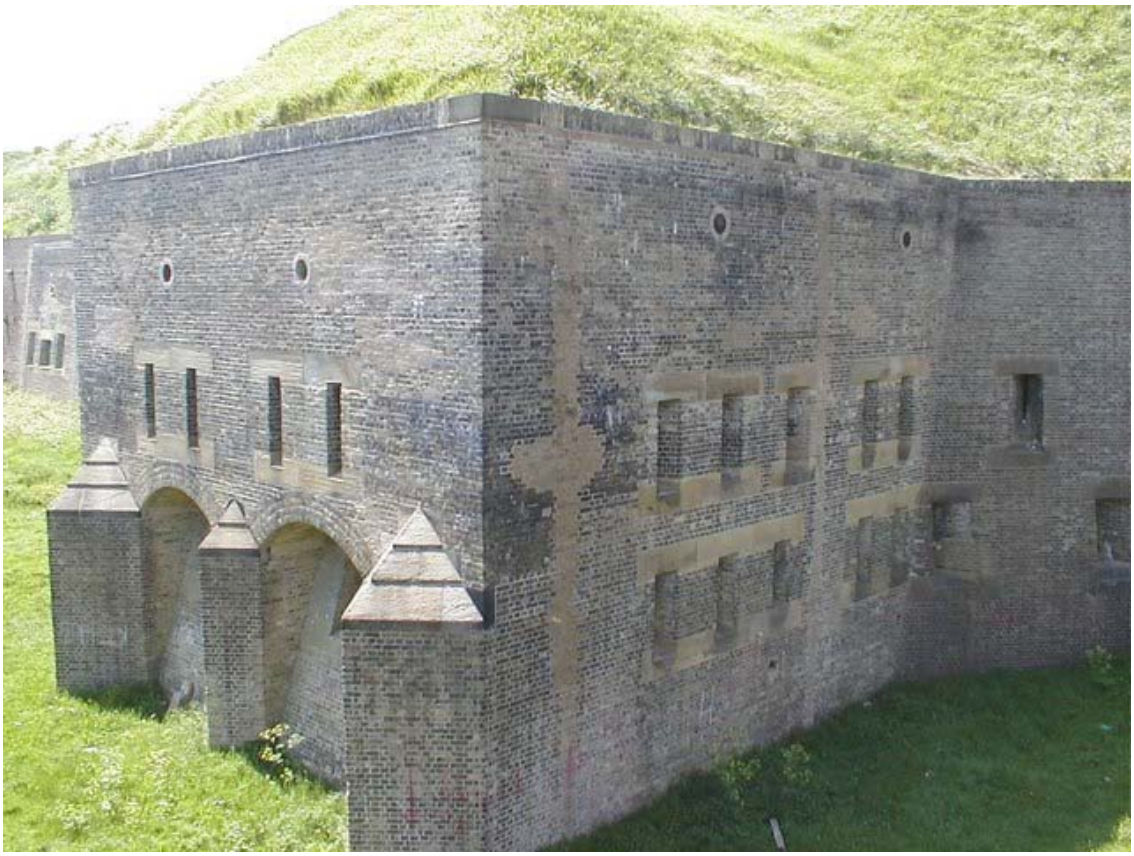
port of Cocanada was made navigable in the 1840s. Such regard for his lasting legacy was shown when in 1983, the Indian Government erected a statue in his memory.

Other irrigation and canal projects included the Ganges Canal, where Colonel Sir Colin Scott-Moncrieff (1836–1916) acted as the Chief Engineer and made modifications to the original work. Scott-Moncrieff went on to become Under Secretary of State Public Works, Egypt where he restored the Nile barrage and irrigation works of Lower Egypt.

Rideau Canal

The construction of the Rideau Canal was proposed shortly after the War of 1812, when there remained a persistent threat of attack by the United States on the British colony of Upper Canada. The initial purpose of the Rideau Canal was military, as it was intended to provide a secure supply and communications route between Montreal and the British naval base in Kingston, Ontario. Westward from Montreal, travel would proceed along the Ottawa River to Bytown (now Ottawa), then southwest via the canal to Kingston and out into Lake Ontario. The objective was to bypass the stretch of the St. Lawrence River bordering New York State, a route which would have left British supply ships vulnerable to attack or a blockade of the St. Lawrence. The construction of the canal was supervised by Lieutenant-Colonel John By of the Royal Engineers. In 2007 it was inscribed as a UNESCO World Heritage Site recognizing it as a work of human creative genius. The Rideau Canal was recognized as the best preserved example of a slack water canal in North America demonstrating the use of European slackwater technology in North America on a large scale. Lt. Denison was one of the junior Royal Engineers who worked under Lt. Colonel John By, RE on the Rideau Canal in Upper Canada (1826–1832). Of note, Denison carried out experiments under the direction of Lt. Col. By to determine the strength, for construction purposes of the old growth Canadian timber in the vicinity of Bytown. His findings were published by the Institution of Civil Engineers in England who bestowed upon him the prestigious Telford Medal.

Dovers' Western Heights



Drop Redoubt.

The Western Heights of Dover are one of the most impressive fortifications in Britain. They comprise a series of forts, strong points and ditches, designed to protect the country from invasion. They were created to augment the existing defences and protect the key port of Dover from both seaward and landward attack. First given earthworks in 1779 against the planned invasion that year, the high ground west of Dover, England, now called Dover Western Heights, was properly fortified in 1804 when Lieutenant-Colonel William Twiss was instructed to modernise the existing defences. This was part of a huge programme of fortification in response to Napoleon's planned invasion of the United Kingdom. To assist with the movement of troops between Dover Castle and the town defences Twiss made his case for building the Grand Shaft in the cliff:

'...the new barracks.....are little more than 300 yards horizontally from the beach.....and about 180 feet (55 m) above high-water mark, but in order to communicate with them from the centre of town, on horseback the distance is nearly a mile and a half and to walk it about three-quarters of a mile, and all the roads unavoidably pass over ground more than 100 feet (30 m) above the barracks, besides the footpaths are so steep and chalky that a number of accidents will unavoidably happen during the wet weather and more especially after floods. I am therefore induced to recommend the construction of a shaft,

with a triple staircase....the chief objective of which is the convenience and safety of troops....and may eventually be useful in sending reinforcements to troops or in affording them a secure retreat.'

Twiss' plan was approved and building went ahead. The shaft was to be 26 feet (7.9 m) in diameter, 140 feet (43 m) deep with a 180 feet (55 m) gallery connecting the bottom of the shaft to Snargate Street, and all for under an estimated £4000. The plan entailed building two brick-lined shafts, one inside the other. In the outer would be built a triple staircase, the inner acting as a light well with 'windows' cut in its outer wall to illuminate the staircases. Apparently, by March 1805 only 40 feet (12 m) of the connecting gallery was left to dig and it is probable that the project was completed by 1807.

Pentonville Prison

Two Acts of Parliament allowed for the building of Pentonville Prison for the detention of convicts sentenced to imprisonment or awaiting transportation. Construction started on 10 April 1840 and was completed in 1842. The cost was £84,186 12s 2d.Captain (later Major General Sir) Joshua Jebb designed Pentonville Prison, introducing new concepts such as single cells with good heating, ventilation and sanitation.

Boundary Commissions

Although mapping by what became the Ordnance Survey was borne out of military necessity it was soon realised that accurate maps could be also used for civic purposes.The lessons learnt from this first boundary commission were put to good use around the world where members of the Corps have determined boundaries on behalf of the British as well as foreign governments; some notable boundary commissions include:

- 1839 - Canada-United States
- 1858 - Canada-United States (Captain (later General Sir) John Hawkins RE)
- 1856 and 1857 - Russo-Turkish (Lieutenant Colonel (later Sir) Edward Stanton RE)
- 1857 - Russo-Turkish (Colonel (later Field Marshall Sir) John Simmons RE)
- 1878 - The Bulgarian
- 1880 - Græco-Turkish (Major (later Major General Sir) John Ardagh RE)
- 1884 - Russo-Afghan (Captain (later Colonel Sir) Thomas Holdich RE)
- 1894 - India-Afghanistan (Captain (later Colonel Sir) Thomas Holdich RE)
- 1902 - Chile-Argentine (Colonel Sir Delme Radcliffe RE)
- 1911 - Peru-Bolivia (Major AJ Woodroffe RE)

Much of this work continues to this day. The reform of the voting franchise brought about by the Reform Act (1832), demanded that boundary commissions were set up. Lieutenants Dawson and Thomas Drummond (1797–1839), Royal Engineers were employed to gather the statistical information upon which the Bill was founded, as well as determining the boundaries and districts of boroughs. It was said that the fate of numerous boroughs fell victim to the heliostat and the Drummond light, the instrument

that Drummond invented whilst surveying in Ireland. (In 1835 he resigned his commission on his appointment as Under Secretary of State for Ireland).

Abney Level

A Topographic Abney Level is an instrument used in surveying which consists of a fixed sighting tube, a movable spirit level that is connected to a pointing arm, and a protractor scale. The Topographic Abney Level is an easy to use, relatively inexpensive, and when used correctly an accurate surveying tool. The Abney level was invented by Sir William de Wiveleslie Abney (Born 24 Jul 1843 Died 3 Dec 1920) who was a Royal Engineer, an English astronomer and chemist best known for his pioneering of color photography and color vision. Sir Abney invented this instrument under the employment of the Royal School of Military Engineering in Chatham, England in the 1870s.

H.M. Dockyards

Slip 7 at Chatham Dockyard, designed by Col. G Greene RE.

Slip 3 at Chatham Dockyard, designed and built by the Corps.

In 1873, Captain Henry Brandreth RE was appointed Director of the Department of Architecture and Civil Engineering, later the Admiralty Works Department. Following this appointment many Royal Engineer officers superintended engineering works at Naval Dockyards across the world.

Early in the 19th century, cast, wrought and corrugated iron came to be used in dockyard buildings, replacing wood as the material for frames and cladding. The experience of the Corps made them experts in the use of these new materials.

Chatham Dockyard

Chatham being the home of the Corps, meant that the Royal Engineers and the Dockyard had a close relationship since Captain Brandreth's appointment. At the Chatham Dockyard, Captain Thomas Mould RE designed the iron roof trusses for the covered slips, 4, 5 and 6. Slip 7 was designed by Colonel Godfrey Greene RE on his move to the Corps from the Bengal Sappers & Miners. In 1886 Major Henry Pilkington RE was appointed Superintendent of Engineering at the Dockyard, moving on to Director of Engineering at the Admiralty in 1890 and Engineer-in-Chief of Naval Loan Works, where he was responsible for the extension of all major Dockyards at home and abroad. It was under his supervision that the Royal Naval Hospital, Chatham, was built in 1905.

Trades

All members of the Royal Engineers are trained combat engineers and all sappers (privates) and non-commissioned officers also have another trade. Women are eligible for all Royal Engineer specialities.

ME - Fabricator in Iraq

ME - Armoured operating an AVRE in Canada

All Sappers train as Military Engineer - Combat. Sappers then qualify one of the following additional trades:

- Military Engineer - Armoured Crewman
- Military Engineer - Bricklayer and Concretor
- Military Engineer - Bomb Disposal
- Military Engineer - Building and Structural Finisher
- Military Engineer - Carpenter and Joiner
- Military Engineer - Command, Communications and Information Systems Specialist
- Military Engineer - Construction Materials Technician
- Military Engineer - Draughtsman (Design)
- Military Engineer - Draughtsman (Electrical and Mechanical)
- Military Engineer - Driver
- Military Engineer - Electrician
- Military Engineer - Fabricator (Welder)
- Military Engineer - Fitter (Air Conditioning and Refrigeration)
- Military Engineer - Fitter (General)
- Military Engineer - Geographical Technician
- Military Engineer - Heating and Plumbing
- Military Engineer - Plant Operator Mechanic
- Military Engineer - Resources Specialist
- Military Engineer - Surveyor (Engineering)

- Military Engineer - Surveyor (Topographical)

Later, sappers can specialise in further trades and specialities, including:

- Counter Terrorist Advanced Search
- Explosive Ordinance Disposal
- Amphibious Engineer
- Clerk of Works (Construction)
- Clerk of Works (Electrical)
- Clerk of Works (Mechanical)
- Commando Engineer
- Army Diver
- Military Plant Foreman
- Parachute Engineer
- Regimental Signals Instructor

Senior NCOs who have passed the appropriate Clerk of Works course can be commissioned as Garrison Engineers (Construction, Electrical or Mechanical).

Units

The Royal Engineers comprises units of both the Regular Army and the Territorial Army. There is also a higher engineer formation:

Theatre Troops

Combat Engineers prepare a bridge for demolition in Malaya.

Royal Engineers' Surveyors in Europe

Combat Engineers of 20 Field Squadron, 36 Engineer Regiment practice landmine clearance.

- 8 Force Engineer Brigade
  - 12 (Air Support) Engineer Group (25, 39, 529 Specialist Teams (STRE)RE)
  - 29 (Land Support) Engineer Group (33 and 101 (V) Regiments)
  - 170 (Infrastructure Support) Engineer Group (previously Military Works Force)
    - HQ Works Group
      - Royal Engineers Specialist Advisory Team (RESAT)
      - Technical Information Centre Royal Engineers
    - 62 Works Group (Water utilities, water development and well drilling)
      - 506 STRE (Water Infrastructure) (Volunteers)
      - 519 STRE (Works)
      - 523 STRE (Works)
      - 521 STRE (Water Development)
    - 63 Works Group (Electrical power generation and distribution)
      - 504 STRE (Power Infrastructure) (Volunteers)
      - 518 STRE (Works)
      - 528 STRE (Power)

        - 535 STRE (Works)
    - 64 Works Group (Fuels, fuel production and distribution)
        - 516 STRE (Fuels)
        - 524 STRE (Works)
        - 527 STRE (Works)
    - 65 (Volunteers) Works Group (Civilian infrastructure, railway and ports infrastructure)
        - STRE
        - STRE
        - STRE
        - STRE
        - STRE
    - 66 Works Group (Air Support and geotechnical engineering)
        - 510 STRE (Volunteers)
        - 517 STRE (Works)
        - 522 STRE (Works)
        - 530 STRE (Materials)
    - 67 Works Group
        - 502 STRE (Works)
        - 505 STRE (Works)

Regiments

Armoured Vehicle Royal Engineers, Bobin, on D Day

RE Plant Operators construct foundations for a new bridge in Workington after floods

Sappers launching a Logistic Support Bridge at Workington in order to reduce effects of collapsed bridges

An AVLB and Armoured Engineer Squadron in Canada

Royal Engineers Bomb Disposal Team, from 33 Engineer Regiment (EOD) in Coventry.

RE Rigid Raider Crew working with HMS Dasher of the Royal Navy Cyprus Squadron off Cyprus.

TROJAN AVRE with Full Width Mine Plough and Fascine.

- 21 Engineer Regiment
  - 7 Headquarters and Support Squadron
  - 1 Armoured Engineer Squadron
  - 4 Armoured Engineer Squadron
  - 73 Armoured Engineer Squadron

- 22 Engineer Regiment
  - 6 Headquarters and Support Squadron
  - 3 Armoured Engineer Squadron
  - 5 Armoured Engineer Squadron
  - 52 Armoured Engineer Squadron (2008)

- 23 Engineer Regiment (Air Assault) - part of 16 Air Assault Brigade
  - 12 (Nova Scotia) Headquarters and Support Squadron (Air Assault)
  - 9 Parachute Squadron
  - 51 Parachute Squadron
  - 299 Para Field Squadron (V) [Wakefield/Hull/Gateshead]

- 24 Commando Engineer Regiment - (Attached to 3 Commando Brigade, Royal Marines).(based at Chivenor)

    - 54 Commando Headquarters and Support Squadron
    - 56 Commando Field Squadron
    - 59 Commando Squadron
    - 131 Commando Squadron (TA)

NB: As part of the restructuring of the armed forces in 2004, it was announced that the engineering support for 3 Commando Brigade would be increased to a full regiment, with 24 (Commando) Engineer Regiment to be formed.

- 25 Engineer Regiment
    - 43 Headquarters and Support Squadron (Air Support)
    - 34 Field Squadron (Air Support)
    - 53 Field Squadron (Air Support)

- 26 Engineer Regiment
    - 38 Headquarters and Support Squadron
    - 8 Armoured Engineer Squadron
    - 30 Armoured Engineer Squadron
    - 33 Armoured Engineer Squadron (2008)

- 28 Engineer Regiment
    - 64 Headquarters and Support Squadron
    - 23 Amphibious Engineer Squadron + 412 Troop(Volunteers) TA
    - 42 Field Squadron
    - 45 Field Support Squadron
    - 65 Field Support Squadron

- 32 Engineer Regiment
    - 2 Headquarters and Support Squadron
    - 26 Armoured Engineer Squadron
    - 31 Armoured Engineer Squadron
    - 39 Armoured Engineer Squadron

- 33 Engineer Regiment (Explosive Ordnance Disposal) [Hybrid Regiment with Regular & Territorial Army Squadrons]
    - 49 Field Squadron (EOD)
    - 58 Field Squadron (EOD)
    - 61 Field Squadron (EOD)
    - 217 (London) Field Squadron (EOD)(V) {Holloway}

- 101 (City of London) Engineer Regiment (Explosive Ordnance Disposal) [Hybrid Regiment with Regular & Territorial Army Squadrons]
    - 22 Headquarters and Support Squadron (EOD)
    - 17 Field Squadron (EOD)
    - 21 Field Squadron (EOD)
    - 221 Field Squadron (EOD)(V) {Rochester/Catford}

    - 579 Field Squadron (EOD)(V) {Tunbridge Wells}

- 35 Engineer Regiment
    - 44 Headquarters and Support Squadron
    - 29 Armoured Engineer Squadron
    - 37 Armoured Engineer Squadron
    - 77 Armoured Engineer Squadron

- 36 Engineer Regiment (Search)
    - 50 Headquarters and Support Squadron (Search)
    - 20 Field Squadron (Search)
    - 69 Gurkha Field Squadron (Search), Queen's Gurkha Engineers
    - 70 Gurkha Field Support Squadron (Search), Queen's Gurkha Engineers

- 38 Engineer Regiment
    - 32 Headquarters and Support Squadron
    - 11 Field Squadron
    - 15 Field Support Squadron
    - 25 Field Squadron

- 39 Engineer Regiment
    - 60 Headquarters and Support Squadron (Air Support)
    - 10 Field Squadron (Air Support) based at RAF Leeming
    - 48 Field Squadron (Air Support)

- 42 Engineer Regiment (Geographic)
    - 13 Geographic Squadron
    - 14 Geographic Squadron (based in Munchengladbach)
    - 16 Geographic Support Squadron

- 62 Cyprus Support Squadron Royal Engineers (British Forces Cyprus)

The Royal School of Military Engineering

HQ Royal School of Military Engineering.

The Royal School of Military Engineering is the British Army's Centre of Excellence for Military Engineering, Explosive Ordnance Disposal (EOD), and counter terrorist search training. Located on several sites in Chatham, Kent, Camberley in Surrey and Bicester in Oxfordshire the Royal School of Military Engineering offers superb training facilities for the full range of Royal Engineer skills.

The RSME was founded by Major (later General Sir) Charles Pasley, as the **Royal Engineer Establishment** in 1812. It was renamed the **School of Military Engineering** in 1868 and granted the "Royal" prefix in 1962.

- Royal School of Military Engineering
  - Combat Engineer School
    - 3 Royal School of Military Engineering Regiment
      - 55 Training Squadron Royal Engineers
      - 57 Training Squadron Royal Engineers
      - 63 Training Support Squadron Royal Engineers
    - Battlefield Engineering Wing
      - United Kingdom Mine Information and Training Centre
    - Communication Information Systems Wing
  - Construction Engineer School
    - 1 Royal School of Military Engineering Regiment
      - 24 Training Squadron Royal Engineers
      - 36 Training Squadron Royal Engineers
    - Command Wing

        - Civil Engineering Wing
        - Electrical and Mechanical Wing
    - Defence Explosive Munitions and Search School (formally Defence EOD School and the National Search Centre)
    - Defence Animal Centre
    - Royal School of Military Survey (until 1 April 2006)

- 28 Training Squadron, Army Training Regiment Bassingbourn

- Diving Training Unit (Army), (DTU(A))

- Band of the Corps of Royal Engineers

Territorial Army

Royal Monmouthshire RE (Militia) Capbadge.

- Royal Monmouthshire Royal Engineers (Militia)
    - 100 Field Squadron [Cwmbran/Bristol/Cardiff]
    - 101 Headquarters Troop [Monmouth]
    - 108 (Welsh) Field Squadron [Swansea/Gorseinion]
    - 225 Field Squadron [Birmingham]
    - The Jersey Field Squadron [St Helier]

- 71 Engineer Regiment (Volunteers) (Air Support)
    - 102 (Clyde) Field Squadron (Air Support) [Paisley/Barnsford Bridge]
    - 124 Field Squadron (Cumbernauld)
    - 236 Field Squadron [Elgin]
    - Headquarters Troop RAF Leuchars
    - 10 Orkney Field Troop [Orkney Islands]

- 72 Engineer Regiment (Volunteers) Close Support
    - 103 (Tyne Electrical Engineers) Field Squadron (Air Support) [Newcastle/Sunderland(2Tp)]
    - 106 (West Riding) Field Squadron [Sheffield/Bradford]

- 73 Engineer Regiment (Volunteers) (Air Support)

    - 129 Headquarters and Support Squadron [Nottingham]
    - 350 Field Squadron (Air Support) [Nottingham]
    - 575 (Sherwood Foresters) Field Squadron (Air Support) [Chesterfield]

- 75 Engineer Regiment (Volunteers) (Field)
    - 107 (Lancashire and Cheshire) Field Squadron [Birkenhead]
    - 125 (Staffordshire) Field Support Squadron [Stoke-on-Trent]
    - 202 Field Support Squadron [Manchester]

- 101 (City of London) Engineer Regiment (EOD) [Hybrid Regiment - Regular & TA]
    - 221 Field Squadron (EOD)(V) [Rochester/Catford]
    - 579 Field Squadron (EOD)(V) [Tunbridge Wells]

- 33 Engineer Regiment (EOD) [Hybrid Regiment - Regular & TA]
    - 217 (London) Field Squadron (EOD) [Holloway]

- 131 Independent Commando Squadron Royal Engineers (Volunteers) [London/Bath/Plymouth/Birmingham] ' formed 24 Commando Regiment Royal Engineers in early 2007

- 135 Independent Geographic Squadron Royal Engineers (Volunteers) [Ewell]

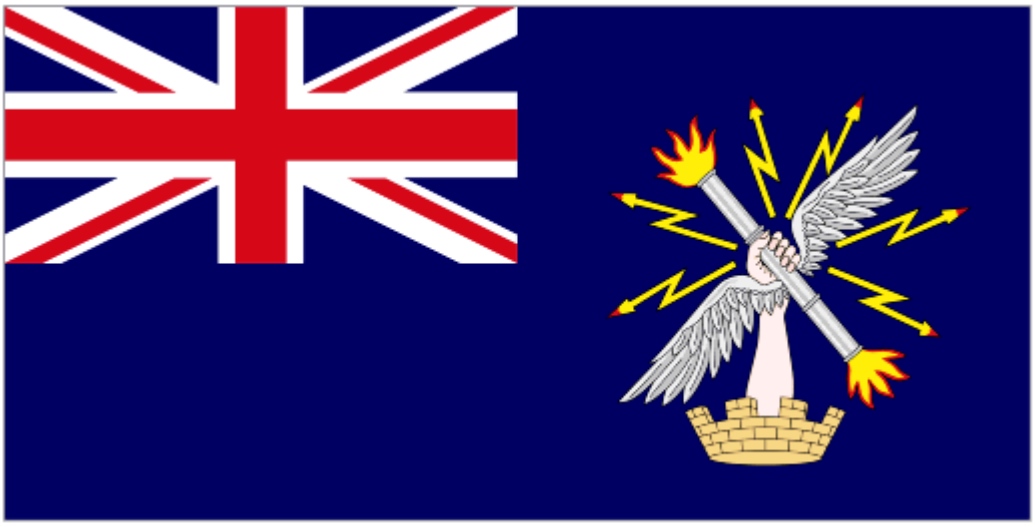
- Engineer and Logistic Staff Corps (Volunteers)

- 170 (Infrastructure Support) Engineer Group (previously Military Works Force)
    - 62 Works Group [Regular]
        - 506 STRE (Water Infrastructure)
    - 63 Works Group [Regular]
        - 504 STRE (Power Infrastructure)
    - 64 Works Group [Regular]
        - 503 STRE (Fuels Infrastructure)
    - 65 Works Group
        - 507 STRE (Railway Infrastructure)
        - 509 STRE (Ports Infrastructure)
        - 508 STRE (Works)
        - 525 STRE (Works)
        - 526 STRE (Works)

- 591 Independent Field Squadron
    - Is the only Royal Engineer TA Unit in Northern Ireland.

Corps' Ensign

Camp Gate Flag of the Royal Engineers



Royal Engineers' Ensign

The Royal Engineers, Ports Section, operated harbours and ports for the army and used mainly specialised vessels such as tugs and dredgers. Although the former Submarine Mining Service badge had been incorporated into their Ensign, which was been designated 'Royal Engineers' after Submarine Mining was transferred to the Admiralty in 1904, the badge was made obsolete in 1909. However at the beginning of the 1914-1918 War, Inland Water Transport (IWT), previously part of the War Department Fleet, was transferred to the Royal Engineers and in 1915 the old Submarine Mining/Royal Engineers badge was reintroduced with pattern again sealed (L of C 17226).

IWT ran barges on rivers and canals up to the front line in France. Later their responsibilities were extended, and by 1916 they were also operating ships and train

ferries across the Channel from a purpose built port at Richborough. IWT vessels were also in East Africa, and Mesopotamia (Iraq) where they moved supplies on the Tigris and Euphrates from Basra to Baghdad; by 1918 over 1600 vessels were there, mainly chartered or requisitioned. IWT was disbanded in 1924, but revived in 1939. During the 1939-1945 War IWT was active in North Africa, India, British Malaya, Burma, Iraq, Normandy, Belgium, and the Netherlands.

In November 1942 the Director of Transportation asked whether the flag issued to Royal Engineers small craft was correct. He seems to have been concerned with the form of the thunder-bolt. The original 1806 crest from which the badge was derived; "Out of a mural crown a dexter hand holding a thunderbolt all proper", had been changed in 1823 to "Out of a mural crown, argent, a dexter cubit arm the hand grasping a thunderbolt, winged and in flames, proper". Sir Gerald W. Wollaston, Inspector of Regimental Colours, wrote "thunderbolts are always subject to treatment", and in a later letter, "Wings and lightning should emanate from the body of the thunder-bolt of which they are a constituent part. In the badge the wings seem to float behind the hand. A thunder-bolt is a winged body (of no very definite formation perhaps) from which emanate flashes of lightning."

Ensigns with the revised badge were made in two sizes, 6' x 3' and 3' x 1.5', (183/ 91/ 46 cm). Small numbers were ordered in 1943 and early 1944, probably for training units, but in June orders were placed for 2,514 six feet ensigns and 1,982 three feet ensigns, for operational service.

After the war the army continued to have two separate water-borne transport organisations, Royal Engineers (Transport Services) operating ports and bulk movement in bases and on lines of communication, and Royal Army Service Corps responsible for intercommunication and distribution movements. In July 1965 the Royal Army Service Corps Fleet (civilian and military) and the Royal Engineers Fleet (Port Squadrons & Inland Water Transport) merged to form the Royal Corps of Transport Fleet.

The Royal Engineers ensign was later flown on boats of the RE Berlin Squadron and at the Royal Engineers Diving Training Wing at Gunwharf, Portsmouth. It presumably disappeared in 1996, when all Service diving moved to the Joint Service Defence Diving School on Hornsea Island, Portsmouth, it made a brief reappearance on one of the landing- craft beached at Arromanches during the 60th anniversary of D-Day celebrations and was flown by both 37 and 29 Armoured Engineer Squadrons on boats conducting anti-rocket patrols in the rivers and marshes of Southern Iraq in 2009.

Bishop Gundulf, Rochester and King's Engineers

Rochester Castle from across the Medway. Engraving from image by G.F. Sargent c1836.

Rochester Cathedral from the West

Bishop Gundulf, a monk from the Abbey of Bec in Normandy came to England in 1070 as Archbishop Lafranc's assistant at Canterbury. His talent for architecture had been spotted by King William I and was put to good use in Rochester where he was sent as Bishop in 1077. Almost immediately the King appointed him to supervise the construction of the White Tower, now part of the Tower of London in 1778. Under William Rufus he also undertook building work on Rochester Castle. Having served three Kings of England and earning 'the favour of then all' Gundulf is accepted as the first "King's Engineer". Gundulf died in 1108 and his statue adorns the West door of Rochester Cathedral.

Because of his military engineering talent, Bishop Gundulf is regarded as the 'father of the Corps of Royal Engineers'. The Corps claims a line of Kings' Engineers pre-dating the Engineers of the Board of Ordnance,1414, and the formal founding of the Corps in 1716, all the way back to Gundulf. This shared heritage and the close proximity to the Cathedral of the Royal School of Military Engineering in Brompton, Medway means the Corps of Royal Engineers and Rochester Cathedral maintain strong links to this day, including holding the Corps' annual veterans and remembrance services at the Cathedral.

There are over 25 memorials to individual Officers and Soldiers of the Corps of Royal Engineers and a number of memorials representing members of the Corps that have given their lives in the discharge of their duty, including many stained glass windows presented by the Corps. The interior wall surrounding the West Door (the main entrance) is entirely given over to a mosaic memorial to the Corps' dead from campaigns of the Victorian era, including previous forays into Afghanistan.

The Institution of Royal Engineers (InstRE)

The Institution Badge, taken from the Corps' Cypher

The **Institution of Royal Engineers (InstRE)**, the professional institution of the **Corps of Royal Engineers**, was established in 1875 and in 1923 it was granted its Royal Charter by King George V. The Institution is co-located with the Royal Engineers

Museum, within the grounds of the Royal School of Military Engineering at Brompton in Chatham, Kent.

The Institution Today

The present objectives of the Institution are to promote and advance the science of military engineering and to promote the military efficiency of the Corps of Royal Engineers. In pursuit of these objects the Institution provides a forum for debate through its sponsorship of joint professional meetings; the publication of articles in its Journal; the maintenance of a Museum and Library for the Corps' heritage and archive collection; and the administration of prize funds, a memorials fund and a scholarship fund.

Members of the InstRE are awarded the post-nominal letters MInstRE. The Institution is a licensed member of the Engineering Council and was granted permission to award Engineering Technician (EngTech) status in 2007. In 2010 the institution was granted the ability to award Incorporated Engineer (IEng) and Chartered Engineer (CEng) status to suitably experienced and qualified Military Engineers who are members of the Institution.

There are several categories of membership:

- **Fellowship (FInstRE)** of the Institution is conferred on members of note by the Council. This is a personal honour and is not conferred on the holder of an office as such.
- **Membership (MInstRE)** of the Institution is open to serving and retired officers, warrant officers, senior and junior NCOs, both Regular and Territorial, of the Corps of Royal Engineers, and to those who are of similar rank in the engineer arm of the land forces of Commonwealth countries, and such other friendly nations as the Council of the Institution shall determine.
- **Honorary Members (HonMInstRE)** are elected by the Council. This is a personal honour and is not conferred on the holder of an office as such. Members of the Royal Engineers are not eligible for election as Honorary Members.
- **Honorary Associate Membership** is reserved for the Chief Engineers of the armed forces of friendly nations and others who by their appointment hold an office with whom the Institution have an affiliation.
- **Associate Membership** is no longer offered. In the streamlining of membership existing Associate Members were granted permission to become full members on application.

The Institution currently publishes a journal, less formal magazine and supports a number of books and papers:

- **Royal Engineers Journal** is published tri-annually and contains articles that have some military engineering connection. The first Journal was published in August 1870. The idea for the publication was proposed at the Corps Meeting of May 1870 by Major R Harrison and seconded By Captain R Home, who became its

first editor. (The Journal eventually superseded the Professional Papers, which were started by Lieutenant WT Denison in 1837 and continued to be published until 1918).

- **Royal Engineers List** is a list of all serving and retired officers and warrant officers. The first list was published in 1876 as part of the Journal, in 1905 it became a separate publication.

- **History of the Corps of Royal Engineers** is currently in its 11th volume. The first two volumes were written by Major General Whitworth Porter and published in 1889.

- **The Sapper** is a monthly magazine for all ranks first published in August 1895. It was originally proposed by three Corporals; Piggott, Avis and Beaumont and was taken up by Engineer Clerk Sergeant SW Hirst. The first few editions were published at the School of Military Engineering (SME) Printing School. Today, past issues of The Sapper Magazine can be viewed, free, online.

The Institution, in line with the aims of the Engineering Council supports Continuous Professional Development of all serving members of the Corps. The Corps manages CPD through the Royal Engineers Continuous Personal Development (RE-CPD) Team. The RE CPD Team is still managed and funded by the Royal Engineers Vocational Education & Training Trust (REVETT). The Trust is a registered Charity (number 1068709) largely funded through the Learning & Skills Council but also has access to limited Ministry of Defence funding.

Based in Chatham at the Royal School of Military Engineering, the RE CPD Team is the driving force behind most RE CPD activity and is directly involved in many qualifications schemes. The Team supports the provision of qualifications & training in many of the skills areas associated with military engineering, including construction, civil, electrical and mechanical engineering, surveying, cartography and telecommunications.

History of the Institution

The Ravelin Building at the Royal School of Military Engineering, Chatham, is now home to the Institution and Corps Museum.

The expansion of the British Empire during the 1860s, and in particular the absorption of the officer engineer elements from the former East India Company Army into the **Corps of Royal Engineers** in 1862 created the need and wish for further opportunities for the officers to study technical issues to better enable them to met the challenges of their work. This led to the suggestion of a **Royal Engineer Institute**, to house a technical library and a Museum.

In 1869 a Royal Commission on Military Education was set up to investigate education within the armed services. In 1871 a proposal to build accommodate for both the Institute and parts of the **School of Military Engineering** was laid before the Commission. The proposal was accepted and construction began on the building. It was designed by Lieutenant (later Sir) Montague Ommanney, Royal Engineers in 1872, who went on to become King of Arms of the Order of St Michael and St George, the herald of the Order of St Michael and St George. The Institute Building was completed at the end of 1873, since the Institutions move the building has become the Headquarters of the Royal School of Military Engineering.

In 1875 a report on the proposed founding of an Institute was submitted to the Commander-in -Chief and the Secretary of State for War, who approved it. Thereafter the Institute came into being when it was accepted at the Corps Meeting in May 1875.

It was initially called the 'Royal Engineer Institute', but in 1882 an 's' was added to the name 'Engineer' in all Corps Associations, so the Institute became the 'Royal Engineers Institute'. The title was again changed to the 'Institution of Royal Engineers' (InstRE) in 1923 when it was incorporated by Royal Charter.

Captain VG Clayton, Royal Engineers, acted as a temporary Secretary until Major WH Collins, Royal Engineers, was appointed Secretary in August 1875, but soon resigned and the position was taken over by Captain RH Vetch, Royal Engineers, in July 1876. He held the post until January 1884 and laid the foundations on which the Secretary's duties grew and continued until the First World War (1914–18).

In 1910, owing to a shortage of Royal Engineer Officers, permission to employ an officer in the post of Secretary on the active list was withdrawn, but a Government grant was secured to cover the salary of the Secretary who was to be elected from officers on the reserve or retired lists.

The home of the Institute was the Institute Building at Chatham although in 1887 a committee was appointed to consider the question of the provision of premises in London. In 1984 the Institution moved into the Ravelin Building to be co-located with the Corps museum and other 'regimental' activities.

The Royal Engineers' Association

The Royal Engineers Association was formed under the conditions of a Deed of Declaration of Trust by the amalgamation of the original Royal Engineers Association and the Royal Engineers Benevolent Fund Ltd on 19 November 1968. The original Royal Engineers Association was founded in 1912 under the name of The Royal Engineers Old Comrades Association. Its name was changed to the Royal Engineers Association in 1952. The Royal Engineers Benevolent Fund Ltd was originally established as the RE Charitable Fund in 1868. It was incorporated as a Friendly Society on 29 January 1925 and changed its name to the RE Benevolent Fund on 23 July 1943.

The Aims of The Association are to promote and support the Corps among members of the Association in the following ways:

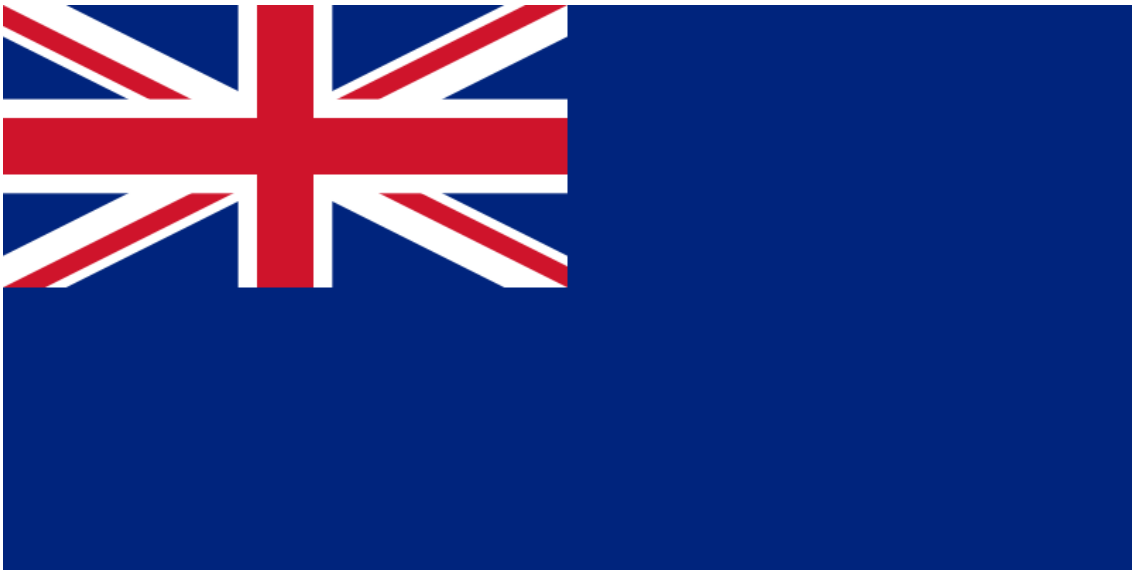
- By fostering esprit de corps and a spirit of comradeship and service.
- By maintaining an awareness of Corps traditions.
- By acting as a link between serving and retired members of the Corps.
- To provide financial and other assistance to serving and former members of the Corps, their wives, widows and dependants who are in need through poverty.
- To make grants, within Association guidelines, to the Army Benevolent Fund and to other charities which further the objectives of the Association.

The Association is organised into a Headquarters, Groups and Branches. The Association Headquarters are located at the Royal School of Military Engineering at Brompton, Chatham. Group Headquarters are located geographically to supervise and organise

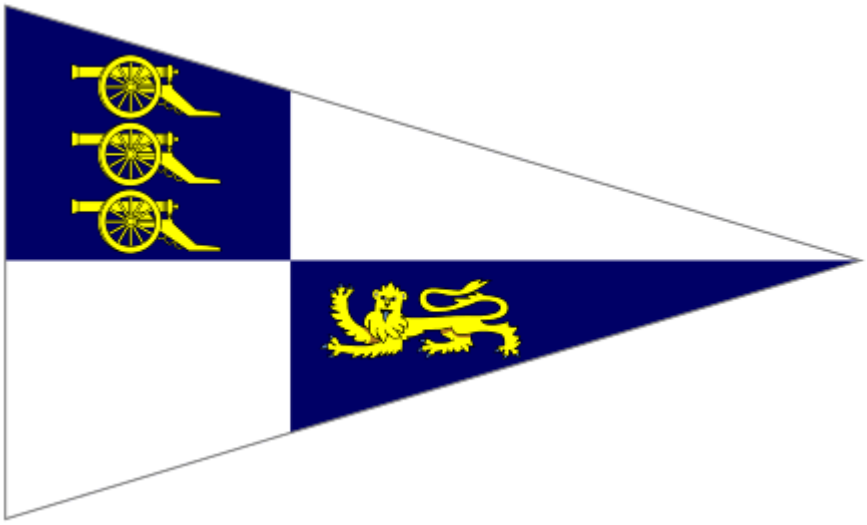
Branches. Branches are established in towns, districts or units of the Corps and are administered by their elected Branch officials. There are also a growing number of National Branches which relate to various activities within the Corps. Currently these are:

- Bomb Disposal,
- Military Survey,
- Armoured Engineers,
- Radio,
- Junior Leaders,
- Airborne Engineers,
- Amphibious Engineers,
- Commando Engineers,
- Plant,
- Postal and Courier (RE).

Royal Engineers' Yacht Club



Un-defaced Blue Ensign flown by members of the REYC.



REYC Burgee.

Watermanship being one of the many skills required of the Sapper led to the formation of a sailing club in 1812 and later to the development of cutter rowing teams.

In 1899 the General Officer Commanding Thames and Medway, the Royal Engineer General Sir Charles Warren (1840–1927) presented a challenge shield for a championship cutter race on the River Medway against the Royal Navy. The Sapper teams were drawn from members of the Submarine Mining School, but when the service was disbanded in 1905, the tradition of cutter rowing was continued by the fieldwork squads.

The club developed and became the Royal Engineer Yacht Club in 1846, making it one of the most senior yacht clubs in the United Kingdom. The REYC continues to this day, operating three club yachts and competing on behalf of the Corps at races around the world. The club is one of the oldest sports clubs in the British Army.

Members of the REYC, as one of the oldest clubs in the UK, are permitted to apply for permission to fly an Un-defaced Blue Ensign along with the REYC Burgee which is formed from cannons and lions of the shield of the coat of arms of the Board of Ordnance.

The Royal Engineers A.F.C.: The first combination team (late 1860s to mid 1870s)

Sir Frederick Wall (who was the secretary of the Football Association from 1895–1934) states in his biography that the early combination game was first used by the Royal Engineers A.F.C. in the early 1870s, in particular prior to their 1873 tour of Nottingham, Derby and Sheffield . Wall states that the "Sappers moved in unison" and showed the "advantages of combination over the old style of individualism". He goes on to state that they were the first "to show the value of combination in Sheffield and Nottingham. Wall

attended and regularly refers to the 1872 international match in his account (see below) and speaks very highly of many Scottish teams and players he does not attribute the combination game to either of these. The Engineers were also capable of dribbling the ball, for example one 1868 match reports states "Lieut Morris got off and dribbling the ball quite round his opponents, brought it in front of the goal and a kick from Lieut Dorward scored the first goal for the Royal Engineers".

The Royal Engineers: the first passing side. The team that reached the first FA Cup final

Royal Engineers in 1868

By early 1868 a contemporary match report states "For the R.E.s Lieuts Campbell, Johnon and chambers attracted especial attention by their clever play"

Royal Engineers in 1869

As early as 1869 the Royal Engineers football club is documented in a contemporary match report as having "worked well together" and "had learned the secret of football success - backing up". In this match failure of the opposite team was attributed to "a painful want of cooperation" against the Engineers.

Royal Engineers in 1870

Another contemporary match report clearly shows that by 1870, ball passing was a feature of the Engineers style: "Lieut. Creswell, who having brought it up the side then kicked it into the middle to another of his side, who kicked it through the posts the minute before time was called"

Royal Engineers in 1871

Although brief, contemporary match reports confirm that passing was a regular feature of the Engineers' style. For example in a match of February 1871 against Crystal Palace it is noted that "Lieut Mitchell made a fine run down the left, passing the ball to Lieu. Rich, who had run up the centre, and who pinced another [goal]" The Engineers used their team playing style with effect against the Wanderers FC, a side considered as early as 1870 to be the MCC of football. In a match of March 1871 against Wanderers their victory was due to "irreproachable organisation" and in particular that both their attacks and their backing up were both "so well organised" In November 1871 similar passing tactics are described in a contemporary account of a game against the Wanderers in which two goals were scored through tactical passing: "Betts, however, soon seized his opportunity, and by a brilliant run down the left wing turned the ball judiciously to Currie, who as judiciously sent it flying through the strangers' goal in first rate style" Later in the match it is reported that "Lieut G Barker, turning the ball to Lieut Renny-Tailyour who planted it between the posts" "Turning" the ball clearly points to the short pass.

Royal Engineers in 1872

There is evidence that opponents sometimes adjusted their playing style to counteract the organisation and passing of the Engineers. For example in February 1872 against Westminster school a brief contemporary match report states that: "The school captain took the precaution of strengthening his backs, deputizing HDS Vidal to cooperate with Rawson and Jackson and so well did these three play in concert... they succeeded in defying the... RE forwards" What is most notable about this report is that it confirms that the Royal Engineers "played beautifully together" That the engineers were the first side to break the trend of dribbling is shown in a contemporary account of their victory against Crystal Palace in early 1872. This said that: "very little dribbling was displayed"

Summary of the Royal Engineers early playing style

The evidence above contains detailed descriptions of passing that are lacking in reports of the 1872 Glasgow international. For example, in a lengthy account the Scotsman newspaper makes no mention of passing or combination by the Scottish team and specifically describes the Scottish attacks in terms of dribbling: "The Scotch now came away with a great rush, Leckie and others dribbling the ball so smartly that the English lines were closely besieged and the ball was soon behind" and "Weir now had a splendid run for Scotland into the heart of his opponents' territory." Although the Scottish team are

acknowledged to have worked better together during the first half, this contemporary account acknowledges that in the second half England played similarly: "During the first half of the game the English team did not work so well together, but in the second half they left nothing to be desired in this respect." The Scotsman concludes that the difference in styles in the first half is the advantage the Queens' Park players had "through knowing each others' play" as all came from the same club. Unlike the 1872 Glasgow international - which was drawn - the contemporary evidence above shows that the Engineers' team playing style benefited their team play by winning games. Similarly, the 5th March 1872 match between Wanderers and Queens park contains no evidence of ball passing

The early accounts cited above all confirm that the Engineers were the first club to play a passing game of cooperation and organisation with both their forwards and their defence. Although they could also play rough - as would be expected for an army team - The Engineers are the first side to be considered to play the football "beautifully". All of these developments clearly occurred before and independent of the 1872 match between England and Scotland (Queen's Park FC). It is probable that Queen's Park FC observed the Engineers' passing game during one of their visits to England to participate in the 1871–72 FA Cup. Undoubtedly, their representatives in London were well aware of the Sheffield and Engineers' style.

Rugby

The Army were represented in the very first international by two members of the Royal Engineers, both playing for England, Lieutenant Charles Arthur Crompton RE and Lieutenant CW Sherrard RE.

Successor units

Several units have been formed from the Royal Engineers.

- The Air Battalion Royal Engineers (formed 1911) was the precursor of the Royal Flying Corps (formed 1912) which evolved into the Royal Air Force in 1918.
- The Telegraph Battalion Royal Engineers became the Royal Engineers Signals Service, which in turn became the independent Royal Corps of Signals in 1920.
- The Royal Engineers were responsible for railway and inland waterway transport, port operations and movement control until 1965, when these functions were transferred to the new Royal Corps of Transport.
- In 1908, the Army Postal Corps (formed in 1882) and the Royal Engineers Telegraph Reserve (formed in 1884) amalgamated to form the Royal Engineers Postal Section. This later became the Army Postal and Courier Service and remained part of the RE until the formation of the Royal Logistic Corps in 1993 - see (British Forces Post Office).

The Royal Engineers from just after the Second World War until the early 1970s also had 4 Plant Troops located in the United Kingdom which were RE reinforced Plant &

Engineering troops attached to various Home Commands. The Command Plant Troops were initially set up in the late 40s to clear up the beach defences around the coast and remove the minefields and were equipped with Armoured Bulldozers. In the 1950s once all this work was complete they took responsibility of maintaining and building all Army Ranges and various civil works in support of the civilian population and in support of civilian organisations in the event of natural disasters and crises such as the Torrey Canyon disaster where the Southern Command Plant Troop was deployed to the West Country to clean up the mess on the beaches caused by the large volume of oil that floated ashore. The 4 Command Plant Troops were based in various locations across the United Kingdom with Southern Commend Plant Troop initially based in Tidworth, then Perham Down in Wiltshire and eventually Longmoor in Hampshire. The Midlands Plant Squadron was based in Walsall and the Northern Command plant troop was based in Ripon. The other command plant troop was based in Scotland. In Germany there was an Entire Engineering group based in Willich near Düsseldorf called the Military Civilian Plant & Engineering group that had a similar large scale Engineering, Plant and Support role for British Army of the Rhine. Each Command Plant Troop was commanded by an RE Major supported by a Military Plant Foreman.

In 1969, it was decided to amalgamate all of the Command Plant Troops into one large Squadron which had 4 troops, an HQ Troop and a large REME Attachment to it and the Squadron - 66 Plant Squadron became the largest squadron in the entire Royal Engineers, in terms of Plant Engineering and Equipment as well as staff. Its last home was in Longmoor Hampshire - Engineer Stores Depot attached to Longmoor Military Camp, which was also home to a Field Support Squadron. Longmoor Military Railway was from 1901 until the late 1960s the preserve of the Royal Engineers but subsequently Royal Corps of Transport and eventually Royal Logistic Corps Railway Training Centre. Its role also changed with a much wider role to support Military operations throughout NATO.

In late 1976 a Mr Trotter in Parliament asked the Secretary of State for Defence which units, apart from 66 Plant Squadron Royal Engineers, are specialists in heavy plant; whether he still intends to disband this squadron; if so, what unit will take its place; and what will be the reduction in the engineers' heavy plant capacity.

In answer to Mr Trotter 's question Mr. Robert C. Brown replied ...There is no directly comparable regular unit containing a similar concentration of specialist plant expertise, but specialist capability exists in parts of various regular field and base units in the United Kingdom, BAOR and elsewhere. In addition, there are two TAVR plant squadrons. As a consequence of the Defence Review, 66 Plant Squadron, Royal Engineers will disband by early 1978, but most of its heavy equipment will be taken over by other engineer units notably in the TAVR. As a result, there will be some reduction in the capacity of the Royal Engineers to plan and conduct major projects in peacetime.

Equipment

- Chieftain Armoured Vehicle Royal Engineer (ChAVRE)

- Chieftain Armoured Vehicle Layer Bridge (ChAVLB)

These are being replaced by 66 Armoured Support Vehicles ;

- **TROJAN** is a minefield breaching vehicle. It prepares routes, mark safe routes using an Obstacle Marking System, breach complex obstacles and provide short dry and wet gap crossing utilising its excavator arm, earth moving blade and a midi fascine. It will plough through minefields, build trenches and dig defensive ditches

- **TITAN** will carry and lay the current range of In-Service Close Support bridges laying them faster, and in a wider variety of terrain conditions, than previous equipment. TITAN can lay a bridge over a 26 metre gap in two minutes, making it the fastest Support Vehicle in the world at this task. This gives commanders a potential battle winning edge and allows them to choose from a more flexible range of armoured vehicles.

Both vehicles which weigh over 60 tonnes and are capable of speeds of up to 56 km/h, are designed to mount and tow the current range of in-service Royal Engineer equipment (PYTHON, AVRE Trailer, Track/Full Width Mineploughs and earth moving blades). They have purpose designed hulls, will incorporate Special to Role equipment and have major assemblies common to the Challenger 2 Main Battle Tank.

Order of precedence

Preceded by:		Succeeded by:
Royal Regiment of Artillery	**Order of Precedence**	**Royal Corps of Signals**

Decorations

Victoria Cross

Victoria Cross and Bar

The following Royal Engineers have been awarded the Victoria Cross (VC), the highest and most prestigious award for gallantry in the face of the enemy that can be awarded to British and Commonwealth forces.

Rorke's Drift, 22 - 23 January 1879, a battle fought under the command of Lt. John Chard, RE. Eleven Victoria Crosses were won during the battle, including one by Chard. Painting by Alphonse de Neuville

- Tom Edwin Adlam, 1916, Thiepval, France
- Adam Archibald, 1918, Ors, France
- Fenton John Aylmer, 1891, Nilt Fort, India
- Mark Sever Bell, 1874, Battle Of Ordashu, Ashanti (now Ghana)
- John Rouse Merriott Chard, 1879, Rorke's Drift, South Africa
- Brett Mackay Cloutman, 1918, Pont-Sur-Sambre, France
- Clifford Coffin, 1917, Westhoek, Belgium
- James Morris Colquhoun Colvin, 1897, Mohmand Valley, India
- James Lennox Dawson, 1915, Hohenzollern Redoubt, France
- Robert James Thomas Digby-Jones, 1900, Ladysmith, South Africa
- Thomas Frank Durrant, 1942, St. Nazaire, France
- Howard Craufurd Elphinstone, 1855, Sevastopol, Crimea
- George de Cardonnel Elmsall Findlay, 1918, Catillon, France
- Gerald Graham, 1855, Sevastopol, Crimea
- William Hackett, 1916, Givenchy, France
- Reginald Clare Hart, 1879, Bazar Valley, Afghanistan
- Lanoe Hawker, 1915 {While serving with the RFC}
- Charles Alfred Jarvis, 1914, Jemappes, Belgium
- Frederick Henry Johnson, 1915, Hill 70, France

- William Henry Johnston, 1914, Missy, France
- Frank Howard Kirby, 1900, Delagoa Bay Railway, South Africa
- Cecil Leonard Knox, 1918, Tugny, France
- Edward Pemberton Leach, 1879, Maidanah, Afghanistan
- Peter Leitch, 1855, Sevastopol, Crimea
- William James Lendrim, 1855, Sevastopol, Crimea
- Wilbraham Oates Lennox, 1854, Sevastopol, Crimea
- Henry MacDonald, 1855, Sevastopol, Crimea
- James John McLeod INNES, 1859, Sultanpore, India
- Cyril Gordon Martin, 1915, Spanbroek Molen, Belgium
- James McPhie, 1918, Aubencheul-Au-Bac, France
- Philip Neame, 1914, Neuve Chapelle, France
- John Perie, 1855, Sevastopol, Crimea
- Claude Raymond, 1945, Talaku, Burma (now Myanmar)
- John Ross, 1855, Sevastopol, Crimea
- Michael Sleavon, 1858, Jhansi, India
- Arnold Horace Santo Waters, 1918, Ors, France
- Thomas Colclough Watson, 1897, Mamund Valley, India
- Theodore Wright, 1914, Mons, Belgium

Chapter 7

Military Engineer

Polish military engineers during humanitarian aid after the 2005 Pakistan earthquake.

A **military engineer** is a soldier whose occupation involves military engineering. According to NATO, "Military Engineering is that engineer activity undertaken, regardless of component or service, to shape the physical operating environment." Military Engineering incorporates support to maneuvre and to the force as a whole, including military engineering functions such as engineer support to Force Protection, Counter - Improvised Explosive Devices, Environmental Protection, Engineer Intelligence and Military Search. Military Engineering does not encompass the activities

undertaken by those 'engineers' who maintain, repair and operate vehicles, vessels, aircraft, weapon systems and equipment."

The military engineer is primarily responsible for the design and construction of offensive, defensive, and logistical structures for warfare. Other duties include the layout, placement, maintenance and dismantling of defensive minefields and the clearing of enemy minefields and the construction and destruction of bridges. In some cases an engineer may be required to destroy something that that same engineer designed and constructed. In many armies the military engineers are also called pioneers or sappers. There are also many modern armies that use the term combat engineer to describe the military engineer well forward in battle and under fire. *For more modern aspects of military engineering and tools of the combat engineering corps, see combat engineering.* The construction, management and maintenance of infrastructure is another responsibility associated with the military engineer.

Terminology

The term engineering is derived from the word engineer, which itself dates back to 1325, when an engine'er (literally, one who operates an engine) was originally referred to "a constructor of military engines." In this context, now obsolete, an "engine" referred to a military machine, i. e., a mechanical contraption used in war (for example, a catapult).

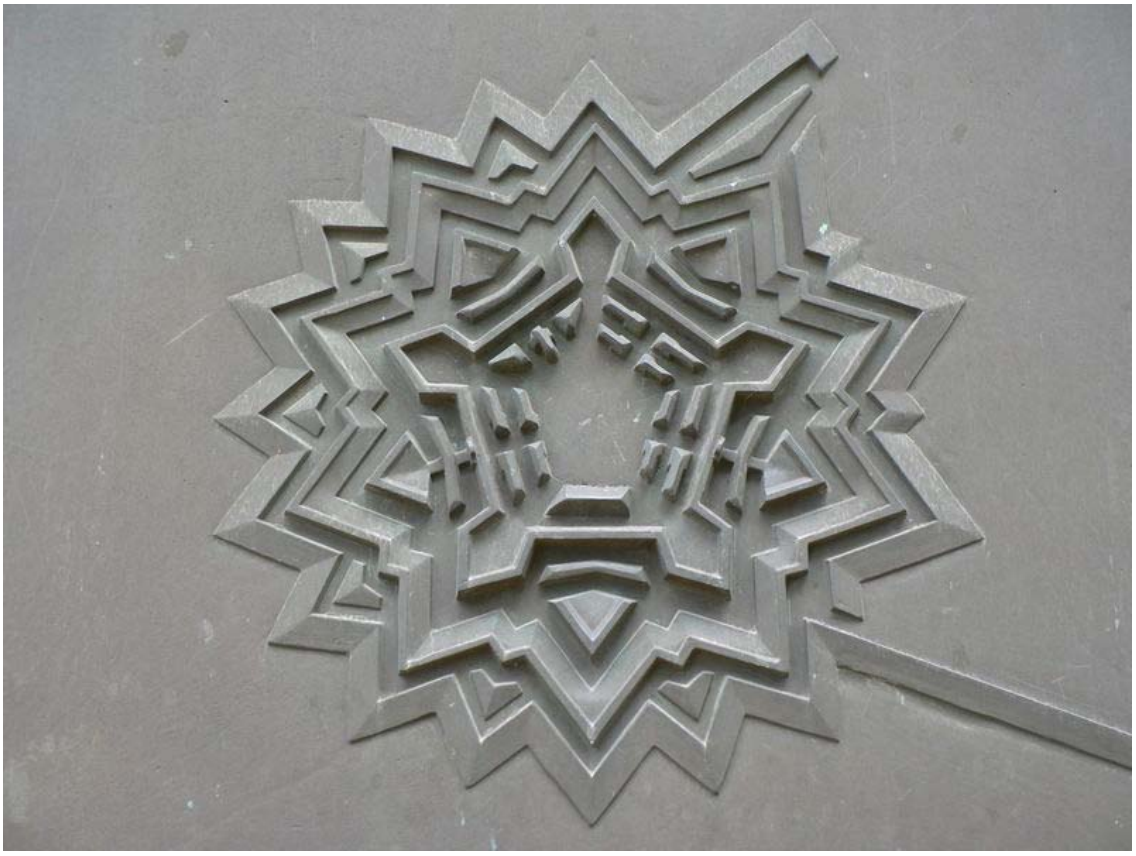
Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specializing in the construction of such non-military projects and those involved in the older discipline. As the prevalence of civil engineering outstripped engineering in a military context and the number of disciplines expanded, the original military meaning of the word "engineering" is now largely obsolete. In its place, the term "military engineering" has come to be used.

History

Perhaps the first civilization to have a dedicated force of military engineering specialists were the Romans, whose army contained a dedicated corps of military engineers known as *architecti*. Roman military engineering was pre-eminent amongst its contemporaries, and the scale of certain military engineering feats, such as the construction of a double-wall of fortifications 30 miles (48 km) long in total (both walls combined total) in just six weeks to completely encircle the besieged city of Alesia in 52 B.C. Such military engineering feats would have been completely new, and probably bewildering and demoralizing, to the Gallic defenders. The best known of these Roman army engineers due to his writings surviving is Vitruvius.

In ancient times, military engineers were responsible for siege warfare and building field fortifications, temporary camps and roads. The most notable engineers of ancient times were the Romans and Chinese, who constructed huge siege-machines (catapults, battering rams and siege towers) and were responsible for constructing fortified wooden camps and

paved roads for their legions. Many of these Roman roads are still in use two thousand years later.



Relief map of the Citadel of Lille, designed in 1668 by Vauban, the foremost military engineer of his age.

In the Middle Ages military engineering focused on siege warfare. They planned castles and fortresses. When laying siege, they planned and oversaw efforts to penetrate castle defences. When castles served a military purpose, one of the tasks of the sappers was to weaken the bases of walls to enable them to be breached before means of thwarting these activities were devised. Broadly speaking, sappers were experts at demolishing or otherwise overcoming or bypassing fortification systems.

With the 14th century development of gunpowder, new siege engines in the form of cannons appeared. Initially military engineers were responsible for maintaining and operating these new weapons just as had been the case with previous siege engines. In England, the challenge of managing the new technology resulted in the creation of the Office of Ordnance around 1370 in order to administer the cannons, armaments and castles of the kingdom. Both military engineers and artillery formed the body of this organization and served together until the office's predecessor, the Board of Ordnance was disbanded in 1855.

In comparison to older weapons, the cannon was significantly more effective against traditional medieval fortifications. Military engineering significantly revised the way fortifications were built in order to be better protected from enemy direct and plunging shot. The new fortifications were also intended to increase the ability of defenders to bring fire onto attacking enemies. Fort construction proliferated in 16th century Europe based on the trace italienne design.

The dawn of the internal combustion engine marked the beginning of a very significant change for military engineering. With the arrival of the automobile at the end of the 19th century and heavier than air flight at the start of the 20th century, military engineers would absorbe a major new role to support the movement and deployment of these systems in war.

Defensive

Defensive fortifications are designed to prevent intrusion into the inner works by siege infantry. For minor defensive locations these may only consist of simple walls and ditches. The design principle is to slow down the advance of attackers to where they can be destroyed by defenders from sheltered positions. Most large fortifications are not a single structure but rather a concentric series of fortifications of increasing strength. Fortified cities would typically include an inner "old town"' within walls. Should the city be attacked, those residing outside the walls would enter the inner city. Within this would be a redoubt, or citadel, to which defenders could retreat should the walls or gates be breached.

The placement of mines to create minefields and their maintenance and disassembly is another defensive task.

When the defender must retreat it is often desirable to destroy anything that may be of use to the enemy, particularly bridges, as their destruction can slow the advance of the attackers. The retreating forces may also leave booby traps for enemy soldiers, even though these often wreak their havoc upon non-combatant civilians.

Famous military engineers

- Mozi
- Gundulf of Rochester - Considered father of the UK's Corps of Royal Engineers
- John Chard, Royal Engineers, who won the Victoria Cross 1n 1879 for his actions and leadership during the defence of Rorkes Drift
- Henri Alexis Brialmont
- Menno van Coehoorn
- Giovanni Fontana
- Leslie Groves
- John Rosworm
- Pierre Charles L'Enfant
- Charles Pasley - Founder of the UK's Royal School of Military Engineering
- Vauban
- Marc René, marquis de Montalembert
- Charles George Gordon
- Francis Fowke - Royal Engineer designer of the Royal Albert Hall
- Paul R. Smith
- Vitruvius
- Tadeusz Kościuszko.
- Leonardo da Vinci
- Zahid Ali Akbar Khan
- Robert E. Lee
- Herman Haupt
- Douglas MacArthur
- Tommy Franks
- George Washington - Surveyor

Multinational military engineering institutions

The NATO Military Engineering Center of Excellence (MilEng CoE) is co-located with the German Army Military Engineer School in Ingolstadt. Prior to becoming a NATO CoE, the institute was known as the Euro NATO Training Engineer Centre (ENTEC) and it was located in Munich. As ENTEC, the institute was mandated to conduct military engineer interoperability training for participating nations. As the MilEng CoE, the institute's mandate has expanded to include doctrine and NATO standardization agreements (STANAGs) related to military engineering.

Chapter 8

Westland Lynx

Lynx / Super Lynx

Lynx HAS3 of the Black Cats (Royal Navy) display team

Role	Helicopter
National origin	United Kingdom
Manufacturer	Westland Helicopters AgustaWestland
First flight	21 March 1971
Introduced	1978
Status	Active service
Primary users	British Army Royal Navy French Navy German Navy
Produced	1978-present
Variants	AgustaWestland AW159 Westland 30

The **Westland Lynx** is a British multi-purpose military helicopter designed and built by Westland Helicopters at its factory in Yeovil. Originally intended as a utility craft for both civil and naval usage, military interest led to the development of both battlefield and naval variants, which went into operational usage in 1977 and were later adopted by the armed forces of over a dozen nations, where it primarily serves in the battlefield utility, anti-armour, search and rescue and anti-submarine warfare roles. In 1986 a specially modified Lynx set the current Fédération Aéronautique Internationale's official airspeed record for helicopters. The helicopter is now produced and marketed by AgustaWestland.

Development

The initial design (then known as the Westland WG.13) was started in the mid-1960s as a replacement for the Westland Scout and Wasp, and a more advanced alternative to the UH-1 Iroquois. As part of the Anglo-French helicopter agreement signed in February 1967, the French company Aérospatiale were given a work share in the manufacturing programme. Aérospatiale received 30% of production with Westland performing the remainder. It was intended that France would buy Lynxes for its Navy and as an armed reconnaissance helicopter for the French Army, with the United Kingdom in return buying Aérospatiale Gazelles and Pumas for its armed forces. The French Army cancelled its requirement for Lynxes in October 1969.

The original Lynx design was powered by two Rolls-Royce Gem 2 turboshaft engines, and used many components derived from the Scout and Wasp. However, the rotor was new, being of a semi-rigid design with honeycomb sandwich blades. The first Lynx prototype took its maiden flight on 21 March 1971.

XX153 which broke the Helicopter speed record in 1972

In 1972, a Lynx broke the world speed record over 15 and 25 km by flying at 321.74 km/h (199.92 mph). It also set a new 100 km closed circuit record shortly afterwards, flying at 318.504 km/h (197.91 mph).

Over 100 Lynxes were ordered by the British Army as the **Lynx AH.1** (*A*rmy *H*elicopter Mark 1) for different roles, such as transport, armed escort, anti-tank warfare (with eight TOW missiles), reconnaissance and evacuation. The Army has fitted a Marconi Elliot AFCS system onto the Lynx for automatic stabilisation on three axis. Deliveries of production Lynxes began in 1977.

An improved Lynx AH.1 with Gem 41-1 or Gem 42 engines and an uprated transmission was referred to as the **Lynx AH.5**; only five were built for evaluation purposes. The AH.5 led to the **Lynx AH.7**, which added a new tail rotor derived from that of the Westland 30, a reinforced airframe, improved avionics and defensive aids. These received further upgrades in service, including British Experimental Rotor Programme (BERP) rotor blades.

The initial naval variant of the Lynx, known as the **Lynx HAS.2** in British service, or **Lynx Mk.2(FN)** in French service, differed from the Lynx AH.1 in being equipped with a tricycle undercarriage and a deck restraint systems, folding main rotor blades, an emergency floatation system and a nose-mounted radar. An improved Lynx for the Royal Navy, the **Lynx HAS.3**, had Gem 42-1 Mark 204 engines, an uprated transmission, a new floatation system and an Orange Crop ESM system. The Lynx HAS.3 also received various other updates in service. A similar upgrade to the French Lynx was known as the **Lynx Mk.4(FN)**. Many different export variants based on the Lynx HAS.2 and HAS.3 were sold to other air arms.

In 1986, the former company demonstrator Lynx, registered *G-LYNX*, was specially modified with Gem 60 engines and BERP rotor blades. On 11 August 1986 the helicopter was piloted by Trevor Egginton when it set an absolute speed record for helicopters over a 15 and 25 km course by reaching 400.87 km/h (249.09 mph); an official record it currently holds.

Lynx-3

Announced in 1984, the **Lynx-3** was an enhanced Lynx development, with a stretched fuselage, a redesigned tailboom and tail surfaces, Gem 60-3/1 engines and a new wheeled tricycle undercarriage. The Lynx-3 also included BERP rotor blades, and increased fuel capacity. Both Army and Naval variants were proposed. The project was ended in 1987 due to insufficient orders. Only one Army Lynx-3 prototype was built.

Super Lynx and Battlefield Lynx

ZD252 a Royal Navy Lynx HMA8 about to land

A development of the Lynx AH.7 with the wheeled undercarriage of the Lynx-3 was marketed by Westland as the **Battlefield Lynx** in the late 1980s. The prototype first flew in November 1989 and deliveries began in 1991. This variant entered British Army service as the **Lynx AH.9**.

In the early 1990s, Westland incorporated some of the technology from the Naval Lynx-3 design into a less-radical **Super Lynx**. This featured BERP rotor blades, the Westland 30-derived tail rotor, Gem 42 engines, a new under-nose 360-degree radar installation and an optional nose-mounted electro-optical sensor turret. Royal Navy Lynx HAS.3s upgraded to Super Lynx standard were known in service as the **Lynx HMA.8**, and several export customers ordered new-build or upgraded Super Lynxes. Later, Westland offered the **Super Lynx 200** with LHTEC CTS800 engines and the **Super Lynx 300**, which also had a new cockpit and avionics derived from the AgustaWestland EH101. Both of these models have achieved several export sales.

Future Lynx/Lynx Wildcat

The British Army and Royal Navy Lynx fleets are due to be upgraded to a new common advanced Lynx variant based on the Super Lynx 300, with a new tailboom, undercarriage, cockpit, avionics and sensors. Initially referred to as the Future Lynx, this type has since been renamed by AgustaWestland as the AW159 Lynx Wildcat.

Design

The Lynx is a multi-purpose helicopter design with a side by side cockpit for pilot and observer. It features a large sliding crew door on each side giving access to the cabin which can be used to accommodate up to nine equipped troops dependent on seating configuration, or alternatively radio equipment when used in the command post role or surplus fuel for long journeys. Its twin Rolls Royce Gem turboshaft engines power a four-blade semi-rigid main rotor system. The Lynx is an agile helicopter, capable of performing loops and rolls.

Operational history

A Lynx HAS.3 of HMS *Cardiff* in March 1982 prior to the Falklands War practising search and rescue.

A French Navy *Lynx* helicopter taking off from the Ouragan

The Lynx Mk.2(FN) entered service with the French Navy's Aviation navale in 1979. In British service, the Lynx is used by the Army Air Corps (AAC) and the Fleet Air Arm (FAA). The Lynx AH.1 entered service with the AAC in 1979, followed by the Lynx HAS.2 with the FAA in 1981. The FAA Lynx fleet was upgraded to Lynx HAS.3 standard during the 1980s, and again to Lynx HMA.8 standard in the 1990s. Most Army Lynx were later upgraded to Lynx AH.7 standard.

As of 2009, the AAC operate the Lynx AH.7 and AH.9 as utility helicopters. Army owned Lynx AH.7 and AH.9 are also in service with the FAA where they operate as attack/utility helicopters in support of the Royal Marines. Lynx HAS.3 and HMA.8 operate as anti-submarine warfare and maritime attack helicopters equipped with the Stingray torpedo, Sea Skua anti-ship missile and depth charge for Royal Navy warships. HAS.3 and HMA.8 are also capable of anti-trafficking and anti-piracy roles when carrying boarding parties and when fitted with the FN Herstal M3M pintle mounted heavy machine gun.

The Lynx's most prominent combat role was operating the Sea Skua to devastating effect against the Iraqi Navy during the 1991 Gulf War. The Lynx also saw service with British Army forces during that conflict. The HAS.2 naval ASW variant had already taken part in combat operations in British service during the Falklands War in 1982. Although none were shot down, three were lost aboard vessels hit in Argentine air attacks, two from iron bombs on HMS *Coventry* and HMS *Ardent*, and one to Exocets on MV *Atlantic Conveyor*.

It was used during Operation Barras to rescue 11 British soldiers in Sierra Leone on 10 September 2000.

The most recent wartime mission for the Lynx was during the invasion of Iraq in 2003. It has also seen extensive service during peacekeeping operations and exercises, and it is standard equipment for most Royal Navy surface combatants when they deploy.

A British Lynx from 847 Naval Air Squadron was shot down over Basra, Iraq on 6 May 2006. The helicopter was downed by a surface-to-air missile (using a Man Portable Air Defence System). The Lynx crashed into a house and burst into flames, killing all five on board, including the Commanding Officer of 847 NAS. A riot followed with locals celebrating the downing of the helicopter and surrounding the crash site as British troops rushed to the scene. This was the first British helicopter and only the second British aircraft downed (the first was an RAF Hercules) due to enemy fire in the war. A flight of either AAC or RM Lynx AH.7s are based at Basra Air Station under command of the Joint Helicopter Force (Iraq) on a rotational basis, but are restricted operationally during the summer months due to the very high daytime temperatures which affect lifting capacity and endurance dramatically.

The Super Lynx has been used extensively by the Portuguese Navy in Operation Ocean Shield. It operates from NRP Alvares Cabral and has been fitted with a FN M3M 12.7mm machine gun.

Variants

Land-based variants

Army Air Corps Lynx AH.7 at RIAT 2010

A British Army Lynx AH 7 in Bosnia during Operation Joint Endeavor - Peace Implementation Force (IFOR), 7 May 1996

Westland WG.13
: Prototype, first flight 21 March 1971. Thirteen prototypes built.

Lynx AH.1
: Initial production version for the British Army Air Corps, powered by 671 kW (900 hp) Gem 2 engines, with first production example flying 11 February 1977, and deliveries continuing until February 1984, with 113 built. Used for a variety of tasks, including tactical transport, armed escort, anti-tank warfare (60 were equipped with eight TOW missiles as **Lynx AH.1 (TOW)** from 1981), reconnaissance and casualty evacuation.

Lynx AH.1GT
: Interim conversion of the AH.1 to partial AH.7 standard for the Army Air Corps with uprated engines and revised tail rotor.

Lynx HT.1
: Planned training version for Royal Air Force. Cancelled.

Lynx AH.5
: Upgraded version for the Army Air Corps, with 835 kW (1,120 shp) Gem 41-1 engines and uprated gearbox. Three built as **AH.5 (Interim)** as Trials aircraft for MoD. Eight ordered as AH.5s for Army Air Corps, of which only two built as AH.5s, with remaining six completed as AH.7s. Four were later upgraded to AH.7 standard and one was retained for trials work as an **AH.5X**.

Lynx AH.6

Proposed version for the Royal Marines with undercarriage, folding tail and deck harpoon of Naval Lynx. Not built.

Lynx AH.7

Further upgraded version for the Army Air Corps, with Gem 41-1 engines and uprated gearbox of AH.5 and new, larger, composite tail rotor. Later refitted with BERP type rotor blades. Twelve new build, with 107 Lynx AH.1s converted. A small number also used by the Fleet Air Arm in support of the Royal Marines. Now replaced by the WAH-64 Apache as the main attack helicopter.

Lynx AH.7(DAS)

AH.7 with Defensive Aids Subsystem.

Lynx AH.9 (*"Battlefield Lynx"*)

Utility version for Army Air Corps, based on AH.7, but with wheeled undercarriage and further upgraded gearbox. Sixteen new-built plus eight converted from AH.7s.

Lynx AH.9A

AH.9 with uprated LHTEC CTS800-4N 1,015 kW (1,362 shp) engines. 22 are to be upgraded.

Naval variants

Royal Navy Lynx HAS.3(ICE(S)) supporting an Antarctic research base

Lynx HAS.2 / Mk.2(FN)

Initial production version for the Royal Navy (HAS.2) and the French Navy (Mk.2(FN)), powered by Gem 2 engines and with wheeled undercarriage, folding rotors and tail and deck harpoon. HAS.2 equipped with British Sea Spray radar, with Mk.2(FN) having French radar and dipping sonar. When it is used in the anti-submarine role, it can carry two torpedoes or depth charges. For anti-surface warfare, it is equipped with either four Sea Skua missiles (Royal Navy) or four AS.12 missiles (French Navy). 60 built for Royal Navy, and 26 for France.

Lynx HAS.3

Improved version of HAS.2 powered by Gem 42-1 engines and with upgraded gearbox. Thirty built from new, with deliveries starting in March 1982 and all remaining HAS.2s (53 aircraft) converted to HAS.3 standards.

Lynx HAS.3S

Improved version of the HAS.3 for the Royal Navy fitted with secure radio systems.

Lynx HAS.3GM

Modified helicopters for the Royal Navy, for service in the Persian Gulf, with improved electronic warfare equipment, revised IFF and provision for Forward looking infrared (FLIR) under fuselage. Originally deployed for 1990-91 Gulf War. Designated HAS.3S/GM when fitted with secure radios. (GM denotes **G**ulf **M**odification).

Lynx HAS.3ICE

HAS.3 modified for Antarctic service aboard ice patrol ship HMS *Endurance*. Designated HAS.3SICE when fitted with secure radios.

Lynx HAS.3CTS

HAS.3 upgraded with avionics system proposed for HMA.8. Seven converted as test beds.

Lynx Mk.4(FN)

Upgraded version for the Aéronavale, with Gem 42-1 engines. Fourteen built.

Lynx HMA.8

Upgraded maritime attack version based on Super Lynx 100. Gem 42-200 engines, BERP type main rotors and larger tail rotor of AH.7. Fitted with FLIR in turret above nose, with radar moved to radome below nose.

Lynx HMA.8(DSP)

Digital **S**ignal **P**rocessor.

Lynx HMA.8(DAS)

Defensive **A**ids **S**ubsystem. (DSP aircraft modified).

Lynx HMA.8(SRU)

SATURN (**S**econd-generation **A**nti-jam **T**actical **U**HF **R**adio for **N**ATO) **R**adio **U**pgrade. (DAS aircraft modified. Incorporates SIFF (**S**uccessor to **IFF**)).

Lynx HMA.8(CMP) see note below

Combined **M**ods **P**rogramme. (SRU aircraft modified with improved comms and defensive systems).

Note: At the time of writing, all HMA.8 aircraft have been upgraded to DAS standard, all but one of those have been upgraded to SRU standard. All SRU aircraft have been modified to CMP standard and as such HMA.8(CMP) aircraft

have since been re-designated back to HMA.8(SRU). All Lynx HAS.8 will eventually be at the CMP/SRU standard. The first CMP entered service in late 2008.

Export variants

A boarding team rappel onto their ship from a Brazilian Navy Super Lynx Mk.21A

Lynx Mk.90B landing on Royal Danish Navy THETIS-class

Lynx of the German Navy

Cockpit of a Lynx of the German Navy

Super Lynx of the Brazilian Navy

Lynx Mk.21
: Export version of the HAS.2 for the Brazilian Navy. Brazilian navy designation **SAH-11**. Nine delivered.

Super Lynx Mk.21A
: Version of the Super Lynx (based on HAS.Mk.8) for the Brazilian navy, with Gem 42 engines and 360° traverse Seaspray 3000 radar under nose. Nine new build helicopters plus upgrades of remaining five original Mk.21s.

Lynx Mk.22
: Unbuilt export version for the Egyptian Navy.

Lynx Mk.23
: Export version of the HAS.2 for the Argentine Navy. Two built. Grounded due to British embargo on spares following Falklands War. Single surviving helicopter later sold to Denmark.

Lynx Mk.24
: Unbuilt export utility version for the Iraqi army.

Lynx Mk.25
: Export version of the HAS.2 for the Royal Netherlands Navy. Designated **UH-14A** in Dutch service. Used for utility and SAR roles.

Lynx Mk.26
: Unbuilt export armed version for the Iraqi army.

Lynx Mk.27
: Export version for the Royal Netherlands Navy with 836 kW (1,120 kW) Gem 4 engines. Equipped for ASW missions with dipping sonar. Designated **SH-14B** in Dutch service. 10 built.

Lynx Mk.28
: Export version of the AH.1 for the Qatar Police. Three built.

Lynx Mk.64
: Export version of the Super Lynx for the South African Air Force.

Lynx Mk.80
: Export version for the Royal Danish Navy based on the HAS.3 but with non-folding tail. Eight built.

Lynx Mk.81
: Upgraded ASW version for the Royal Netherlands Navy, powered by Gem 41 engines with no sonar but fitted with towed Magnetic anomaly detector. Designated **SH-14C** in Dutch service, and mainly used for training and utility purposes. Eight built.

SH-14D
: UH-14A/SH-14B/SH-14C Lynx upgraded to a common standard by the Royal Netherlands Navy under the STAMOL programme with Gem 42 engines, provision for dipping sonar and FLIR. 22 upgraded.

Lynx Mk.82
: Unbuilt export version for the Egyptian army.

Lynx Mk.83
: Unbuilt export version for the Saudi Arabian army.

Lynx Mk 84
: Unbuilt export version for the Qatar army.

Lynx Mk 85
: Unbuilt export version for the United Arab Emirates army.

Lynx Mk.86
: Export SAR version of the HAS.2 for the Royal Norwegian Air Force.

Lynx Mk.87
: Embargoed export version for the Argentine navy. Two completed and sold to Denmark as Mk.90 other six not built

Lynx Mk.88
: Export version for the German Navy with Gem 42 engines, and dipping sonar. Nineteen built. **Super Lynx Mk.88A** is an upgraded version with Gem 42 engines, under-nose radome with 360°traverse radar and FLIR above nose. Seven new build helicopters plus conversion of Mk.88s.

Lynx Mk.89
: Export version of HAS.3 for the Nigerian navy. Three built.

Lynx Mk.90
: Export version for the Royal Danish Navy, modified from embargoed Argentine Mk.87s. Lynx Mk.90A is the upgraded version. The Lynx Mk.90 and Mk.90A were upgraded to Super Lynx standard and designated Mk.90B.

Lynx Mk.95
: Version of Super Lynx for the Portuguese Navy, with Bendix radar in undernose radome, dipping sonar but no FLIR. Three new build plus two converted ex-Royal Navy HAS.3s.

Super Lynx Mk.99
: Version of Super Lynx for the South Korean Navy, with Seaspray 3 radar in undernose radome, dipping sonar, and FLIR, for anti-submarine and anti-ship operations. Twelve were built. Super Lynx Mk.99A is the upgraded version with improved rotor, with a further 13 built. Hulls were produced in the United Kingdom while South Korea supplied domestic ISTAR, electro-optical, electronic warfare, and fire-control systems, as well as flight control actuators and undercarriage.

Super Lynx Mk.100
: Super Lynx for the Royal Malaysian Navy, with 990 kW (1,327 hp) CTS-800-4N engines. Six built.

Super Lynx Mk.110
: Super Lynx 300 for Thai Navy. Four ordered.

Super Lynx Mk.120
: Export version for the Royal Air Force of Oman. 16 built.

Super Lynx Mk.130
: Export version for the Algerian Navy. Four ordered.

Super Lynx 300
: Advanced Super Lynx with CTS-800-4N engines.

Projects

Lynx HT.3
: Proposed training version for the Royal Air Force, not built.

Lynx-3
: Enhanced Lynx variant with Westland 30 tail boom and rotor, Gem 60 engines, new wheeled tricycle undercarriage and MIL-STD-1553 databus. Only one prototype built (serial/registration *ZE477* / G-17-24) in 1984.

Battlefield Lynx
: Proposed export version of Lynx AH.9.

Battlefield Lynx 800
: Proposed export version of Lynx AH.9 with LHTEC T800 engines, the project was suspended in 1992. One demonstrator helicopter was built and flight tested.

Lynx ACH
: Proposed **A**dvanced **C**ompound **H**elicopter technology demonstrator, partly funded by the Ministry of Defence. Announced in May 1998, the ACH was planned to be powered by RTM322 engines with variable area exhaust nozzles and a gearbox from the Westland 30-200, have wings attached at cabin roof level and BERP rotor blades. It was predicted to fly approximately 50% faster than a standard Lynx.

Derivatives

Westland 30
: medium helicopter based on the Lynx, using some dynamic systems with a new, enlarged fuselage for up to 22 passengers.

AgustaWestland AW159 Lynx Wildcat
: a development of the Super Lynx with two LHTEC CTS800 engines; previously known as the **Future Lynx**.

NOTES: AH = Army Helicopter, HAS = Helicopter, Anti-Submarine, HMA = Helicopter, Maritime Attack, IFF = Identification Friend or Foe, (GM) = Gulf Modification, (S) = Secure speech radio, and SIFF = Successor to IFF.

Operators

Lynx of Royal Danish Navy

Lynx of the Portuguese Navy

Westland Super Lynx Mk-21A Brazilian Navy

Military operators

Algeria

- Algerian Air Force: Super Lynx 4 Mk.300 (to be delivered in 2010)

Argentina

- Argentine Navy: The Argentine Naval Aviation ordered ten Mk.23s but only two were delivered before the outbreak of the Falklands War and the ensuing arms embargo imposed by the British. To make up for the undelivered aircraft, the Argentines ordered the Eurocopter Fennec. The two delivered helicopters in addition to the undelivered helicopters were later sold to the Danish Navy and Brazilian Navy.

Brazil

- Brazilian Navy: 12 Lynx Mk.21A

Denmark

- Royal Danish Air Force: 8 Super Lynx Mk.90Bs used for various missions. These were originally operated by the Royal Danish Navy until January 2011.

 France

- French Navy: 31 Lynx HAS.4

 Germany

- German Navy: 22 Sea Lynx Mk.88A

 Malaysia

- Royal Malaysian Navy: 6 Super Lynx Mk.100

 Netherlands

- Royal Netherlands Navy: 20 Super Lynx SH-14D. Originally received 6 search and rescue (UH-14A/Mk.25) and 18 anti-submarine warfare models (SH-14B/Mk.27 and SH-14C/Mk.81), which have all been upgraded to SH-14D standard for both SAR and ASW duties.
    - Dutch Naval Aviation Service

 Nigeria

- Nigerian Navy: 3 Lynx Mk.89 (One caught fire and was destroyed) - used for anti-submarine warfare. Retired from service.

 Norway

- Royal Norwegian Air Force: 6 Lynx Mk.86 - operated on on behalf of the Norwegian Coast Guard. 337 Skvadron operates from the Nordkapp Class cutters.

 Oman

- Royal Air Force of Oman: 15 Super Lynx Mk.120

 Pakistan

- Pakistan Navy - Pakistan Naval Air Arm: 3 Lynx Mk.3 - used for anti-ship / anti-submarine / transport duties. These aircraft have been retired from service since 2003.

 Portugal

- Portuguese Navy 5 Lynx Mk.95 - operated from the *"Vasco da Gama class frigates"*.

South Africa

- South African Air Force: 4 Super Lynx Mk.64. Operates from the South African Navy Valour class frigates.

British Army Air Corps AH.7 at RIAT 2010

South Korea

- Republic of Korea Navy: 12 Super Lynx Mk.99 and 13 Super Lynx Mk.99A. Used for anti-submarine and surface warfare.

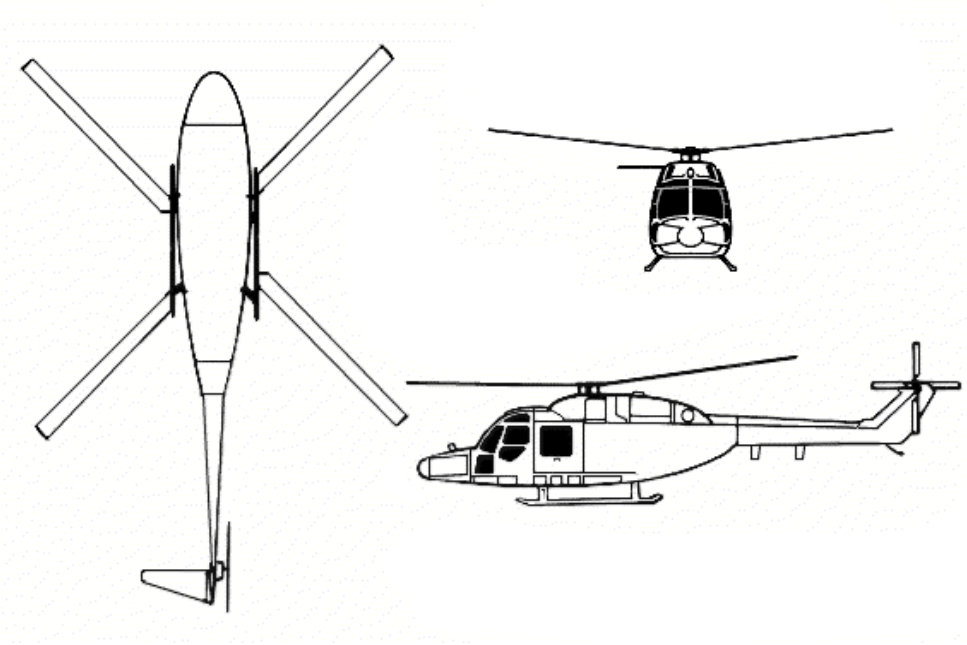
Thailand

- Royal Thai Navy had 2 Super Lynx 300s in use in January 2010. Operated by 203 Squadron at U-Tapao RTNS, Chonburi Province, Thailand.

United Kingdom

- British Army - Army Air Corps: 120 Lynx AH.1/5/7/9.
- Royal Navy - Fleet Air Arm: 80 Lynx HAS.2/3/HMA8.

Specifications (Super Lynx Series 100)



General characteristics

- **Crew:** 2 or 3
- **Payload:** 737 kg
- **Length:** 15.241 m (50 ft)
- **Rotor diameter:** 12.80 m (42 ft)
- **Height:** 3.734 m for mk7; 3.785 m for mk9 (12.25 ft for mk7; 12.41 ft for mk9)
- **Disc area:** 128.71 m² (1,385 ft²)
- **Empty weight:** 3,291 kg (7,255 lb)
- **Max takeoff weight:** 5,330 kg (11,750 lb)
- **Powerplant:** 2× Rolls-Royce Gem turboshaft, 835 kW (1,120 shp) each

Performance

- **Maximum speed:** 324 km/h (201 mph)
- **Range:** 528 km (328 miles) with standard tanks

Armament

- Naval: 2 x torpedoes *or* 4x Sea Skua missiles *or* 2 x depth charges.
- Attack: 2 x 20mm cannons, 2 x 70mm rocket pods CRV7, 8 x TOW ATGM
- General: 7.62mm General Purpose Machine Guns (AH.7 and AH.9), Browning AN/M3M .50 calibre heavy machine gun (HAS.3 and HMA.8)

Chapter 9

Military Robot

Soviet TT-26 teletank, February 1940

Military robots are autonomous robots or remote-controlled devices designed for military applications.

Such systems are currently being researched by a number of militaries.

History

British soldiers with captured German Goliath remote-controlled demolition vehicles (Battle of Normandy, 1944)

Armed Predator drone

Broadly defined, military robots date back to World War II and the Cold War in the form of the German Goliath tracked mines and the Soviet teletanks. The MQ-1 Predator drone was when "CIA officers began to see the first practical returns on their decade-old fantasy of using aerial robots to collect intelligence".

The use of robots in warfare, although traditionally a topic for science fiction, is being researched as a possible future means of fighting wars. Already several military robots have been developed by various armies.

Some believe the future of modern warfare will be fought by automated weapons systems. The U.S. Military is investing heavily in research and development towards testing and deploying increasingly automated systems. The most prominent system currently in use is the unmanned aerial vehicle (IAI Pioneer & RQ-1 Predator) which can be armed with Air-to-ground missiles and remotely operated from a command center in reconnaissance roles. DARPA has hosted competitions in 2004 & 2005 to involve private companies and universities to develop unmanned ground vehicles to navigate through rough terrain in the Mojave Desert for a final prize of $2 Million. The field of artillery has also seen some promising research with an experimental weapons system named "Dragon Fire II" which automates the loading and ballistics calculations required for accurate predicted fire, providing a 12 second response time to artillery support requests. However, weapons of warfare have one limitation in becoming fully autonomous: there remain intervention points which requires human input to ensure that targets are not within restricted fire areas as defined by Geneva Conventions for the laws of war.

There have been some developments towards developing autonomous fighter jets and bombers. The use of autonomous fighters and bombers to destroy enemy targets is especially promising because of the lack of training required for robotic pilots, autonomous planes are capable of performing maneuvers which couldn't otherwise be

done with human pilots (due to high amount of G-Force), plane designs don't require a life support system, and a loss of a plane doesn't mean a loss of a pilot. However, the largest draw back to robotics is their inability to accommodate for non-standard conditions. Advances in artificial intelligence in the near future may help to rectify this.

Examples

In development

The combat version of the Foster-Miller TALON, SWORDS

XM1219 Armed Robotic Vehicle-Assault-Light (ARV-A-L) based on the MULE Vehicle.

- US Mechatronics has produced a working automated sentry gun and is currently developing it further for commercial and military use.
- MIDARS, a four-wheeled robot outfitted with several cameras, radar, and possibly a firearm, that automatically performs random or preprogrammed patrols around a military base or other government installation. It alerts a human overseer when it detects movement in unauthorized areas, or other programmed conditions. The operator can then instruct the robot to ignore the event, or take over remote control to deal with an intruder, or to get better camera views of an emergency. The robot would also regularly scan radio frequency identification tags (RFID) placed on stored inventory as it passed and report any missing items.
- Tactical Autonomous Combatant (TAC) units, described in Project Alpha study *'Unmanned Effects: Taking the Human out of the Loop'* -
- Autonomous Rotorcraft Sniper System is an experimental robotic weapons system being developed by the U.S. Army since 2005. It consists of a remotely operated sniper rifle attached to an unmanned autonomous helicopter. It is intended for use in urban combat or for several other missions requiring snipers. Flight tests are scheduled to begin in Summer 2009.
- The "Mobile Autonomous Robot Software" research program was started in December 2003 by the Pentagon who purchased 15 Segways in an attempt to

develop more advanced military robots. The program was part of a $26 million Pentagon program to develop software for autonomous systems.

- ARV
- ACER
- ARTS
- BigDog
- Dassault nEUROn
- Dragon Runner
- MATILDA
- MULE
- R-Gator
- Ripsaw MS1
- RAAS
- SUGV
- Syrano
- Train Cable UAV (TCUAV) Is a combination of three concepts: Unmanned aerial vehicle (UAVs), Unmanned ground vehicle (UGVs), Train.
- iRobot Warrior
- Excalibur unmanned aerial vehicle
- Nöbetçi, Turkish Border Patrol Unit

In current use

Foster-Miller TALON SWORDS units equipped with various weaponry

- DRDO Daksh
- Goalkeeper CIWS
- Guardium
- PackBot

- MARCbot
- RQ-9 Predator B
- RQ-1 Predator
- TALON
- Samsung SGR-A1
- Gladiator Tactical Unmanned Ground Vehicle (used by the United States Marine Corps)

Effects and impact

Advantages

Major Kenneth Rose of the US Army's Training and Doctrine Command outlined some of the advantages in robotic technology in warfare: "Machines don't get tired. They don't close their eyes. They don't hide under trees when it rains and they don't talk to their buddies ... A human's attention to detail on guard duty drops dramatically in the first 30 minutes ... Machines know no fear."

Increasing attention is also paid to how to make the robots more autonomous, with a view of eventually allowing them to operate on their own for extended periods of time, possibly behind enemy lines. For such functions, systems like the Energetically Autonomous Tactical Robot are being tried, which is intended to gain its own energy by foraging for plant matter.

Potential risks

In 2009, academics and technical experts attended a conference to discuss the impact of the hypothetical possibility that robots and computers could become self-sufficient and able to make their own decisions. They discussed the possibility and the extent to which computers and robots might be able to acquire any level of autonomy, and to what degree they could use such abilities to possibly pose any threat or hazard. They noted that some robots have acquired various forms of semi-autonomy, including being able to find power sources on their own and being able to independently choose targets to attack with weapons. They also noted that some computer viruses can evade elimination and have achieved "cockroach intelligence." They noted that self-awareness as depicted in science-fiction is probably unlikely, but that there were other potential hazards and pitfalls.

Some experts and academics have questioned the use of robots for military combat, especially when such robots are given some degree of autonomous functions. The US Navy has funded a report which indicates that as military robots become more complex, there should be greater attention to implications of their ability to make autonomous decisions.

XM1216 Small Unmanned Ground Vehicle

Small Unmanned Ground Vehicle	
	
Small Unmanned Ground Vehicle	
Type	Unmanned Ground Vehicle
Place of origin	United States
Specifications	
Weight	29 lbs.

The **Small Unmanned Ground Vehicle** (SUGV) is a Future Combat Systems specific, man packable (< 30 lbs) version of the iRobot's PackBot.

Note the Xbox 360 controller held by the operator

Description

The XM1216 Small Unmanned Ground Vehicle (SUGV) is a lightweight, man portable Unmanned Ground Vehicle (UGV) capable of conducting military operations in urban terrain, tunnels, sewers, and caves. The SUGV aids in the performance of manpower-intensive or high-risk functions (i.e. urban Intelligence, Surveillance, and Reconnaissance (ISR) missions, chemical/Toxic Industrial Chemicals (TIC), Toxic Industrial Materials (TIM), reconnaissance, etc.).

Alternative SUGV controller

Working to minimize Soldiers' exposure directly to hazards, the SUGV's modular design allows multiple payloads to be integrated in a plug-and-play fashion. Weighing less than 30 pounds, it is capable of carrying up to six pounds of payload weight.

The XM1216 can either be remotely manned, or manipulated through use of a Microsoft Xbox 360 gamepad fitted with speciality drivers. This allows full control of the unit, otherwise unavailable through a conventional joystick.

The SUGV is part of Spin Out 1 and has entered evaluation at the Army Evaluation Task Force (AETF). It will be fielded to IBCTs starting in 2011.

A robotics technician assigned to the Bahraini Special Security Force (BSSF) trains soldiers on the SUGV

Chapter 10

Military Communications

Historically, the first **military communications** had the form of sending/receiving simple signals (often hidden or encoded to be unrecognizable for the enemy). Respectively, the first distinctive tactics of military communications were called *Signals*, while units specializing in those tactics received the *Signal Corps* name. Later *Signals* and Signaller became a highly-distinct military occupation dealing rather with general communications methods (similar to those in civil use) than with weapons.

Present-day militaries of an informational society conduct very intense and complicated communicating activities on a daily basis, using modern high-tech telecommunications and computing methods. Only a small part of these activities is immediately related to the combat actions. That's why some prefer the term "military communications".

In 1934, the USSR invented the first military based equipment inside an automotive vehicle.

Modern concepts

Network-centric warfare (NCW) relies on network-oriented methods of communications and control to make existing forces vastly more effective.

Military communications equipment

Many pieces of military communications equipment are built to encrypt and decode transmissions and survive rough treatment in hostile climates. They use many frequencies to send signals to other radios and to satellites.

Military comms are activities, equipments, techniques and tactics used by the Military in some of the most hostile areas of the earth not only geographically but also from the point of view of the conditions of operations and equipment functionality like in battle fields, on land, underwater, air and whatever other conditions one can encounter. Military comms includes Command, Control, Communications and Intelligence which is also

known as the C3I model. The Command here refers to the communication with the Highest Command in the country.

The first military comms tool was the communication automobile designed by the Soviet Union in 1934. The basics of the communications in the beginning was the sending and receiving of signals – which were encoded so that the enemy would not be able to get hold of any top secret communication. Then the advent of distinctive signals which lead to the formation of the Signal Corps, this corp., specialised in tactics of military comms. They evolved into a distinctive occupation where the signaller became a highly technical job where they dealt with all available communications methods including the civil methods.

In today's world where war is to be avoided at all costs the role of the military comms is more intense, complicated, hi-tech, bordering on futuristic with the communication satellites, reconnaissance drones and aircraft. Computers and their varied uses have revolutionised military comms. Fortunately these activities are not only related to action in combat but also gathering intelligence to prevent war.

There are 6 categories of military comms, the alert measurement systems, cryptography, military radio systems, nuclear command control and the signal corps. Another new concept is network-centric warfare.

The alert measurement systems – these are various state of alert or readiness for the armed forces used world over – be it a state of war, terrorism or military attack against a state. They are known by different acronyms or example – DEFCON, INFOCON and REDCON in the US military comms and BIKINI states in the British protocol.

Cryptography is the study of methods of converting readable messages into guised unreadable information, unless one knows of the methods of decryption. This military comms method ensured that the messages reached the correct hands and eyes or ears. Nowadays digital cash, signatures, digital rights management and intellectual property rights and secure electronic commerce are its new purviews. It is also being used in computing, telecommunications and infrastructure.

There are close to 97 different categories of military comms by radio. To name a few are ACP-131, AN/ARC-164, AN/ARC-5, HWU transmitter, Hallicrafters SX-28, SCR-197, SCR-203, SCR-270 radar, etc.

Mobile User Objective System

The **Mobile User Objective System** is an array of geosynchronous satellites being developed for the United States Department of Defense (DoD) to provide global satellite communications (SATCOM) narrowband (64 kbit/s and below) connectivity for communications use by the United States and allies.

Overview

Installing a MUOS satellite dish in Hawai'i

The Mobile User Objective System (MUOS) is an Ultra High Frequency (UHF) (300 MHz to 3 GHz frequency range) SATCOM system, primarily serving the DoD. The MUOS will replace the legacy UHF Follow-On (UFO) system before that system reaches its end of life to provide users with new capabilities and enhanced mobility, access, capacity, and quality of service. Intended primarily for mobile users (e.g. aerial and maritime platforms, ground vehicles, and dismounted soldiers), MUOS will extend users' voice, data, and video communications beyond their lines-of-sight.

The MUOS operates as a global cellular service provider to support the war fighter with modern cell phone-like capabilities, such as multimedia. It converts a commercial third generation (3G) Wideband Code Division Multiple Access (WCDMA) cellular phone system to a military UHF SATCOM radio system using geosynchronous satellites in place of cell towers. By operating in the UHF frequency band, a lower frequency band than that used by conventional terrestrial cellular networks, the MUOS provides warfighters with the tactical ability to communicate in "disadvantaged" environments, such as heavily forested regions where higher frequency signals would be unacceptably attenuated by the forest canopy. The MUOS constellation will consist of four operational satellites and one on-orbit spare. MUOS will provide military point-to-point and netted communication users with precedence-based and pre-emptive access to voice, data, video, or a mixture of voice and data services that span the globe. Connections may be set up on demand by users in the field, within seconds, and then released just as easily, freeing resources for other users. In alignment with more traditional military communications methods, pre-planned networks can also be established either permanently or per specific schedule using the MUOS' ground-based Network Management Center.

The Navy's Communications Satellite Program Office (PMW 146) of the Program Executive Office (PEO) for Space Systems in San Diego is lead developer for the MUOS Program. Lockheed Martin is the Prime System Contractor and satellite designer for MUOS under U.S Navy Contract N00039-04-C-2009, which was announced September 24, 2004. The cost-plus-incentive-fee-and-award-fee contract award for the MUOS defined a base period-of-performance of seven years valued at $2,110,886,703. The base contract provides for an Initial Operational Capability comprising two satellites with the associated MUOS ground control elements. The contract also defined contract options which, if exercised, would add four years and $1,154,948,927 to the base. Key subcontractors include General Dynamics (Ground Transport architecture), Boeing (Legacy UFO and portions of the WCDMA payload) and Harris (deployable mesh reflectors). The first MUOS satellite was scheduled for launch in late 2009 with on-orbit capability achieved in 2010. This has been delayed to the first launch in Nov 2010 and operational by February 2011. First launch has now been delayed further to December 2011.

Legacy payload

In addition to the cellular MUOS WCDMA payload, a fully capable and separate UFO legacy payload is incorporated into each satellite. The "Legacy" payload extends the useful life of legacy UHF SATCOM terminals and enables a smoother transition to MUOS. The Joint Tactical Radio System (JTRS) is the program of record that will provide the DoD terminals that can communicate with the MUOS WCDMA waveform. MUOS also allows on-the-move users access to shore-based, DoD-exclusive telephone and INTERNET networks of the Defense Information Systems Network (DISN) services via the DoD Teleport and the MUOS ground infrastructure.

MUOS Ground Stations

MUOS ground station in Wahiawā, Hawai'i

The MUOS will include four ground station facilities. Site selections were completed in 2007 with the signing of a Memorandum of Agreement (MOA) between the U.S. navy and the Australia Department of Defence. The four ground stations, each of which serves one of the four active satellites of the MUOS constellation will be located at: Kojarena about 30 km east of Geraldton, Western Australia; Naval Radio Transmitter Facility (NRTF) Niscemi about 70 km from Naval Air Station Sigonella; Catania, Italy; Northwestern Virginia; and the Naval Computer and Telecommunications Area Master Station Pacific, Hawaii.

The Navy's 2007 RDT&E Budget Item Justification for 0303109N Satellite Communications (Space), indicates that MUOS efforts in the period from FY2006-FY2009 will focus on, among other activities, designing, developing, fielding, and testing the MUOS ground segment.

Chapter 11

Military Equipment

Paradummy

British "Rupert" at Merville D-Day Bunker Museum - France

The Paradummy is a device first used in World War II that, used with other artificial paratrooper units, is meant to cause an invasion by air to appear larger than it actually is. Paradummies can also be used to lure enemy troops into staged ambushes.

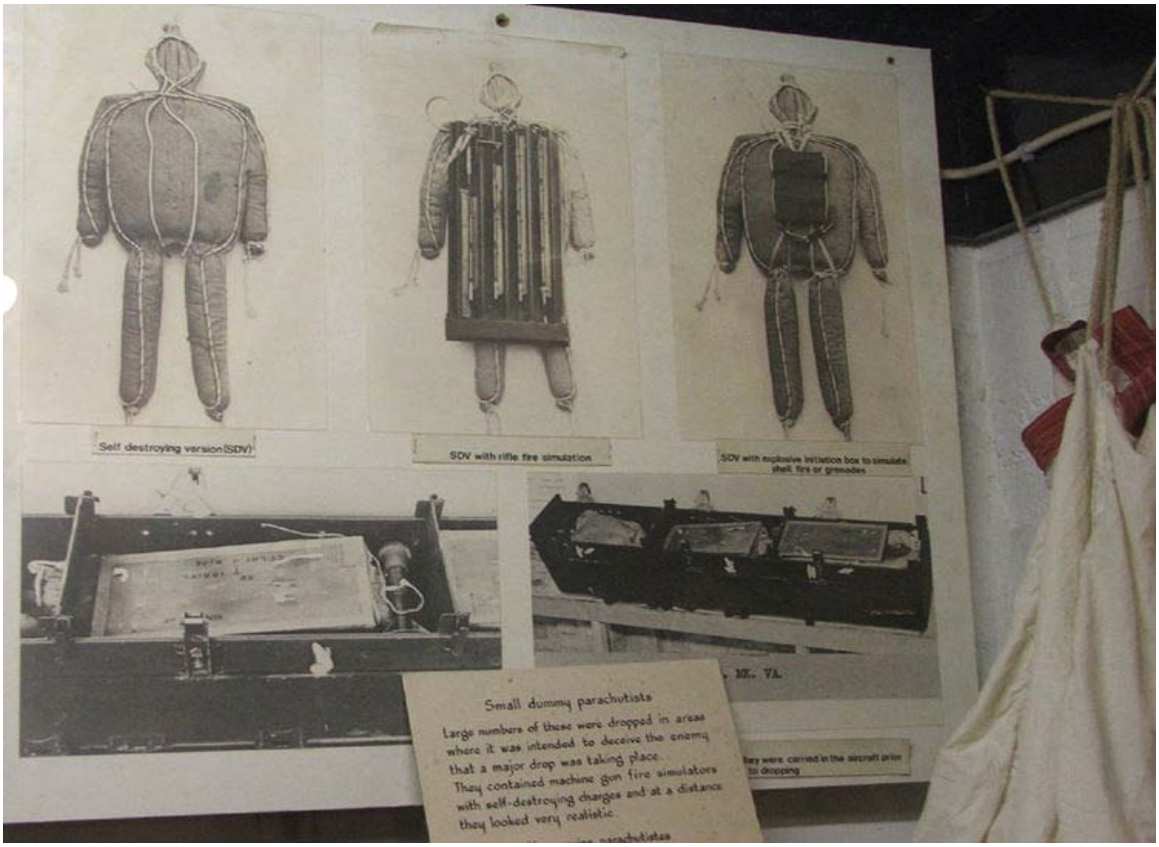
German paradummies

The first known use of paradummies was by the Germans during the Battle of the Netherlands and Belgium in 1940. They used straw-filled puppets that were thrown en masse out of airplanes in order to incite fear and panic among the civilian population. The regular German paratrooper units, the Fallschirmjäger, were actually much smaller in number. In August of the same year, paradummies were also used over Scotland for deceptive purposes. These dummies no longer exist and little is known today about their appearance and other details.

The Luftwaffe's Fallschirmjäger used artificial jumpers in later times as well, such as during the Ardennes Offensive, which started in the middle of December 1944. These dummies were so convincing that some American troops rapidly evacuated their positions. Subsequent clarification confirmed only the landing of dummies, as well as the testimony of isolated German soldiers who were taken captive.

To facilitate an even more realistic depiction of a Paratrooper landing, the Luftwaffe was believed to have experimented with smoke bombs attached to the feet of the dummies as a way of simulating kicked-up dust. These modified dummies, however, were never used.

British paradummies



British "Rupert" at Merville Bunker D-Day Museum - France

The British dummies were assembled in the USA and shipped to Great Britain. The first known use of the puppets was in North Africa in 1940 when they were dropped on Italian troops at the Siwa Oasis. Paradummies were also dropped over Italy during Operation Husky.

In 1942 the Paradummies served as a distraction to the British invasion of Madagascar, which at the time was administered by France's Vichy Government. The dummies used during Operation Ironclad roughly resembled those dropped at night in Normandy on D-Day. Little if anything is known about dummies created before 1942 as they are no longer in existence.

Operation Titanic

The paradummy drop over Normandy Operation Titanic is probably the best known operation of its kind. In the early hours of the morning of June 6, 1944 a force of 40 Hudsons, Halifaxes and Stirlings dropped a total of 500 dummies in four separate locations along the coastal interior. Window, rifle fire simulators and two teams of Special Air Service soldiers carrying recordings of loud battle noise were also dropped to reinforce the deception and divert German troops away from the Allies' actual drop

zones. The dummies were nicknamed *Rupert* and were fabricated with sack cloth/burlap representations of a human figure stuffed with straw or sand and not the highly elaborate and lifelike rubber dummies suggested in some accounts and portrayed in the film *The Longest Day*. They were equipped with an explosive charge that burned away the cloth after landing to prevent the immediate discovery of their true nature. Two Stirling aircraft were lost in the operation and of the six SAS soldiers involved, only two eventually reached safety, the others were captured and remained in German POW camps until the end of the war.

A few of the original dummies are now displayed in war museums. In the 1980s, several more dummies were found in the hangar of an old airfield in Great Britain. They have frequently been offered in auctions and on the Internet.

American paradummies

US "Oscar"/PD-pack at Airborne Museum St. Mere Eglise - France

In 1943, the United States Navy Beach Jumper Unit (a deception unit) conducted tests using parachute dummies made of a non-magnetic metal, probably lead or aluminum. The dummies got their nickname "Oscar" since they resembled Oscar statues. The actor Douglas Fairbanks Jr., who served as a lieutenant in the navy, was directly involved in

the development and design of these dummies. It is believed that he brought the idea with him from Great Britain, where he was stationed for a time. In early March 1943, the test flight with several of these paradummies took place at an airfield near the coast of Chesapeake Bay. The Paradummies were dropped by a TBF Avenger plane over the coast and airfield. Three observation groups standing at various distances shared in writing their impressions with the navy. A few of them had been intentionally left unaware that dummies had been dropped - they were simply told to report on what they saw. The reports stated that the dummies proved defective since they were too small and had no moving parts that might move during the drop which reduced their effectiveness. The observers mostly felt the dummies looked unrealistic.

As a result of this test, the US Navy at Lakehurst developed larger, inflatable dummies made of rubberized material, the so-called PD-Packs. The PD-Packs were used in southern France and the Philippines.

Another use of artificial Paratroopers by Americans in the Second World War took place over New Guinea during a jump of the 503d Infantry Regiment. It is believed these were the rubber dummies. In the 1950s, the US Army further developed the "Oscar" paradummy variation. This development led to an easy-to-transport, foldable dummy whose head and boots were made of plaster. The dummies now also wore realistic fabric uniforms. The new type was used during missions in Korea.

Other uses for paradummies

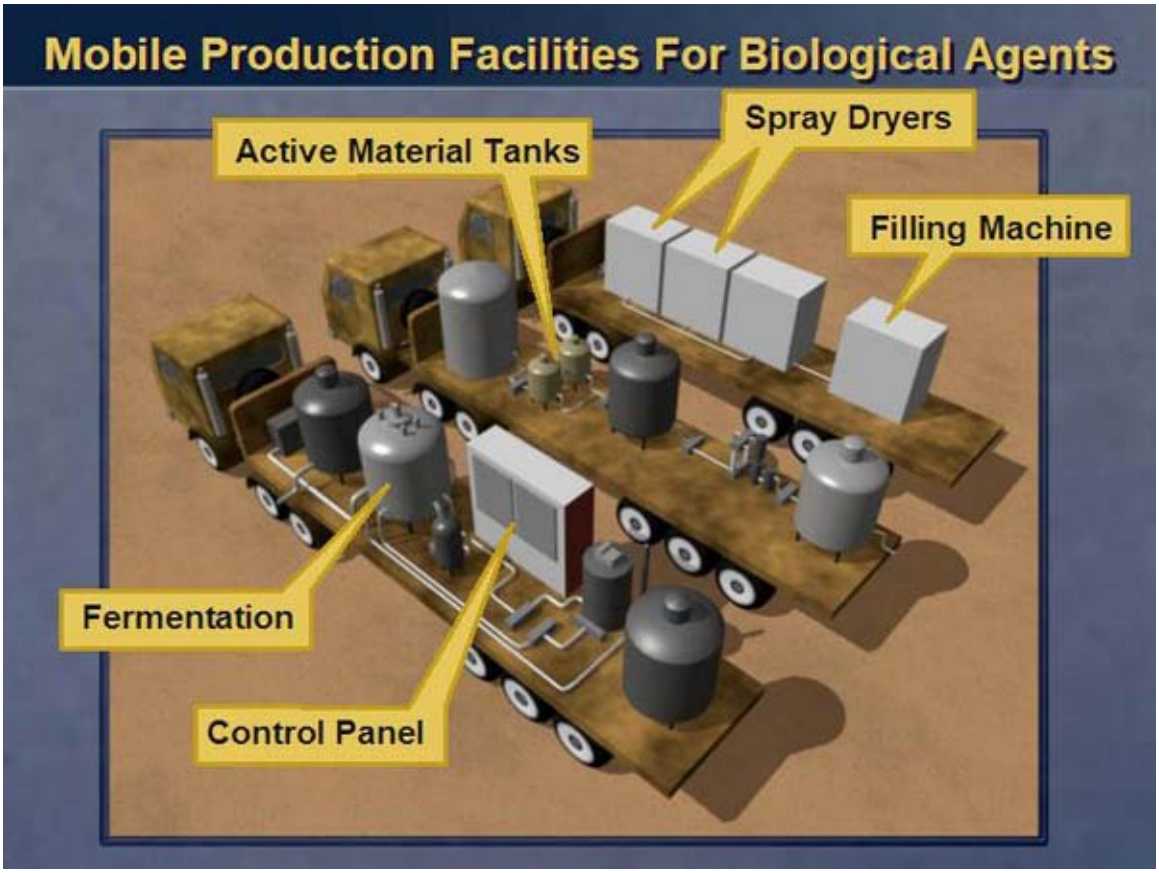
'Movie Prop from the famous 1960s war film "The Longest Day," at Airborne Museum St. Mere Eglise - France

During the Vietnam War, the Americans dropped leftover dummies over Vietcong outposts and in their vicinity. This served to lure the North-Vietnamese into staged ambushes, where they could be attacked with air power. Other covert operations used blocks of ice instead of dummies, which would melt in the hot Vietnamese weather before Communist forces could arrive. The parachutes would be left and found in the drop zones and lead them to believe that American troops were still operating in the area.

The modern American paradummies are made of PVC and look like GI-dummies, but they are larger than the dummies of the 1950s. During the Gulf War, special forces implemented these dummies to distract Iraqi troops. They have also been used in Afghanistan.

The Americans also use paradummies during exercises to simulate larger paratrooper invasions.

Mobile weapons laboratory



Purported Iraqi mobile weapons laboratories

Mobile weapons laboratories are bioreactors and other processing equipment to manufacture and process biological weapons that can be moved from location to location either by train or vehicle.

Iraqi Mobile weapons laboratories

In the run up to the 2003 Invasion of Iraq, the main rationale for the Iraq War was Hussein's Iraq failure to transparently and verifiably cease Weapons of Mass Distruction (WMD - nuclear, biological and chemical weapons) programs, and to destroy all materials relating thereto, as mandated in United Nations Resolution 1441. In February 2003 the then Secretary of State Colin Powell gave a presentation before the United Nations showing a computer generated view of what the laboratories looked like. He said Iraq had as many as 18 mobile facilities for making anthrax and botulinum toxin. "They can produce enough dry, biological agent in a single month to kill thousands upon thousands of people." Powell based the assertion on accounts of at least four Iraqi defectors, including a chemical engineer who supervised one of the facilities and been present during production runs of a biological agent. Following the invasion of Iraq two trailers were found and initially declared as the alleged mobile labs.

Intelligence Sources

In the CIA briefing days before the 2003 United Nations security council presentation Colin Powell knew that all information included in the report had to be solid. "Powell and I were both suspicious because there were no pictures of the mobile labs," Wilkerson, Powell's chief of staff said. Powell demanded multiple sources and the two CIA men present George Tenet, then the CIA director and John E. McLaughlin, then the CIA deputy director claimed to have multiple eye witness accounts and supporting evidence. Wilkerson claims that the two said, "This is it, Mr. Secretary. You can't doubt this one"

The information behind the mobile vehicles had come from the multiple informants but the main and most important one was known as Curveball. Curveball an Iraqi asylum in Germany claimed that after he had graduated top of his chemical engineering class at Baghdad University in 1994 he worked for “Dr. Germ,” British-trained microbiologist Rihab Rashid Taha to led a team that built mobile labs to brew deadly bio WMDwas never actually interviewed by the American intelligence and eventually in May 2004, over a year after the invasion of Iraq, the CIA concluded formally that Curveball's information was fabricated. Furthermore on June 26 2006, the Washington Post reported that "the CIA acknowledged that Curveball was a con artist who drove a taxi in Iraq and spun his engineering knowledge into a fantastic but plausible tale about secret bioweapons factories on wheels."

With information about the mobile labs the Bush administration then went and asked Ahmed Chalabi's Iraqi National Congress (INC) if they knew anything about this "threat". The INC provided an Iraqi defector, Mohammad Harith, who claimed that while working for the Iraqi government he had purchased seven Renault refrigerated trucks to be converted into mobile biological weapons laboratories. The INC used James Woolsey, former director of the CIA, to directly contact Deputy Assistant Defense Secretary Linton Wells, of the Defense Intelligence Agency (DIA), with info about Mohammad Harith's account to avoid any scrutiny by the CIA. Harith's was met by a DIA debriefer who concluded that it "seemed accurate, but much of it appeared embellished" and he

apparently "had been coached on what information to provide." However, the line about Harith being coached was removed and one that he passed a lie detector added and as such became official evidence of mobile bio-labs even being used by Bush in his January 2003 State of the Union message. Later Mohammad Harith like curveball evidence was labeled with a fabricator notice.

A third source, reporting through Defense HUMINT channels and another asylum seeker, claimed that in June 2001 that Iraq had mobile biological weapons laboratories however after the war in Oct 2003 the source recanted his testimony.

A fourth source existed but all information and details regarding the report are still classified.

All the sources depended on the curveball account and where seen as supportive to it. When Tenet called Powell in late summer 2003, seven months after the U.N. speech, he admitted that all of the CIA's claims Powell used in his speech about Iraqi weapons were wrong. "They had hung on for a long time, but finally Tenet called Powell to say, 'We don't have that one, either,' " Wilkerson recalled. "The mobile labs were the last thing to go."

Discovery of Iraqi mobile labs?

May 13, 2003 it was reported that a second suspected mobile weapons lab had been found in Iraq on April 19, 2003.

May 27, 2003 a fact finding mission to Iraq sent its report to Washington unanimously declaring that the trailers had nothing to do with biological weapons. The report was 'shelved'.

May 28, 2003 the Central Intelligence Agency released a report on the supposed mobile weapons labs, stating:-

Despite the lack of confirmatory samples, we nevertheless are confident that this trailer is a mobile BW production plant.

May 29, 2003 President George W Bush declared that they had found the weapons of mass destruction that had been claimed were in Iraq, these were in the form of mobile labs for manufacturing biological weapons.

We found the weapons of mass destruction. We found biological laboratories. You remember when Colin Powell stood up in front of the world, and he said, Iraq has got laboratories, mobile labs to build biological weapons. They're illegal. They're against the United Nations resolutions, and we've so far discovered two. And we'll find more weapons as time goes on. But for those who say we haven't found the banned manufacturing devices or banned weapons, they're wrong, we found them.

May 29, 2003 "We have already found two trailers that both our and the American security services believe were used for the manufacture of chemical and biological weapons." Tony Blair, Flying in to Kuwait for morale boosting trip.

May 29, 2003 "My personal view is we're going to find them, just as we found these two mobile laboratories" Town Hall Meeting with Secretary of Defense Donald Rumsfeld, Infinity-CBS Radio.

June 2, 2003 In the UK Susan Watts broadcasts on the influential BBC2 Newsnight report which includes an anonymous experts (Dr David Kelly) opinion on the Mobile Weapons labs being for biological weapons. Dr Kelly is now only 40% certain the trailers are labs.

"But our source, who is in an excellent position to know, and spoke of being 90% confident these claims are correct on the day the Pentagon showed the trucks to the world, now put that confidence level at just 40%."

June 3, 2003 "But let's remember what we've already found. Secretary Powell on February 5th talked about a mobile, biological weapons capability. That has now been found and this is a weapons laboratory trailers capable of making a lot of agent that -- dry agent, dry biological agent that can kill a lot of people. So we are finding these pieces that were described." Condoleezza Rice, Capital Report, CNBC.

June 3, 2003 "We know that these trailers look exactly like what was described to us by multiple sources as the capabilities for building or for making biological agents. We know that we have from multiple sources who told us that then and sources who have confirmed it now. Now the Iraqis were not stupid about this. They were able to conceal a lot. They've been able to scrub things down. But I think when the whole picture comes out, we will see that this was an active program." Condoleezza Rice, Capital Report, CNBC.

June 5, 2003 "We recently found two mobile biological weapons facilities which were capable of producing biological agents" President G W Bush Talks to Troops in Qatar, White House.

June 5, 2003 Dr David Kelly one of Britains foremost experts on Biological Weapons visited Iraq to examine the trailers and take photographs.

June 7, 2003 Judith Miller reports that some scientists had doubts about the trailers in her piece - "Some experts doubt trailers were germ lab", Judith Miller and William J. Broad, New York Times.

June 8, 2003 The UK's Observer newspaper picks up on the story with their piece "Blow to Blair over 'mobile labs' - Saddam's trucks were for balloons, not germs " Placing more pressure on Prime Minister Tony Blair over the lack of Weapons of Mass Destruction found in Iraq.

June 8, 2003 "Already, we've discovered, uh, uh, trailers, uh, that look remarkably similar to what Colin Powell described in his February 5th speech, biological weapons production facilities." Condoleezza Rice, This Week with George Stephanopolous, ABC.

June 8, 2003 "We are confident that we -- I believe that we will find them. I think that we have already found important clues like the biological weapons laboratories that look surprisingly like what Colin Powell described in his speech." Condoleezza Rice, Meet the Press, NBC.

June 8, 2003 "We have uncovered the mobile vans and we are continuing to search." Colin Powell Remarks at Stakeout Following Fox News Interview, Fox News.

June 8, 2003 "And I think the mobile labs are what I think is a good indication of the kind of thing they are doing." Colin Powell Remarks at Stakeout Following Fox News Interview, Fox News.

June 15, 2003 It was revealed that the trailers discovered were for the production of hydrogen to fill artillery balloons, as the Iraqis had insisted all along. The artillery balloons were used to get detailed weather data to be used to accurately direct artillery shelling. A British scientist and biological weapons expert was quoted "They are not mobile germ warfare laboratories. You could not use them for making biological weapons. They do not even look like them. They are exactly what the Iraqis said they were - facilities for the production of hydrogen gas to fill balloons." It was confirmed later that this expert was Dr David Kelly

June 20, 2003 MP Paul Flynn: "To ask the Prime Minister what assessment has been made of the function of the two vehicles suspected of being biological weapons laboratories that were discovered in Iraq." The UK Prime Minister Tony Blair: "Investigations into their role are continuing."

June 23, 2003 MP Harry Cohen: "Will the Secretary of State consider sending some of the Territorials to look at the mobile labs in the form of two trailers in northern Iraq? A report in The Observer on 15 June said that the system was originally sold by a British company, Marconi, as a command and control system. If any Territorials investigated the trailers, would they find a "Made in Britain" stamp on them? If this is a smoking gun in terms of weapons of mass destruction, why did we apparently sell them? MP Geoff Hoon - I do not think that anyone suggested that this was an example of a smoking gun. It has rightly been suggested that this was a gun and that the mobile laboratories were wholly consistent with the description of mobile laboratories given by Secretary of State Colin Powell in his evidence to the United Nations Security Council. That remains the position as far as coalition forces are concerned."

July 17/18, 2003 Dr David Kelly, a key source for many of the newspaper articles doubting the Mobile weapons labs, is found dead. An inquiry into his death, The Hutton Inquiry, found his death to be suicide.

September 8, 2003

> “The discovery by U.S. forces in Iraq of two mobile 'biological weapons laboratories' was touted by President Bush as clear evidence that Iraq possessed illegal weapons capabilities. However, it now is clear that these so-called labs were nothing more than hydrogen generation units based upon British technology acquired by Iraq in the 1980s, used to fill weather balloons in support of conventional artillery operations, and have absolutely no application for the production of biological agents.”
>
> — Scott Ritter, a former United Nations weapons inspector, wrote in the San Francisco Chronicle on September 8, 2003

Dick Cheney continued to claim trailers were mobile labs

September 14, 2003 "Same on biological weapons--we believe he'd developed the capacity to go mobile with his BW production capability because, again, in reaction to what we had done to him in '91. We had intelligence reporting before the war that there were at least seven of these mobile labs that he had gone out and acquired. We've, since the war, found two of them. They're in our possession today, mobile biological facilities that can be used to produce anthrax or smallpox or whatever else you wanted to use during the course of developing the capacity for an attack." Dick Cheney, Meet the Press, NBC.

January 22, 2004 "In terms of the question what is there now, we know for example that prior to our going in that he had spent time and effort acquiring mobile biological weapons labs, and we're quite confident he did, in fact, have such a program. We've found a couple of semi trailers at this point which we believe were, in fact, part of that program." Dick Cheney, Morning Edition, NPR.

Powell retraction

> “I looked at the four [sources] that [the CIA] gave me for [the mobile bio-labs], and they stood behind them, ... Now it appears not to be the case that it was that solid. At the time I was preparing the presentation, it was presented to me as being solid. April 3, 2004
>
> I feel terrible ... [giving the speech] ... It's a blot. I'm the one who presented it on behalf of the United States to the world, and [it] will always be a part of my record. It was painful. It's painful now." 2005”
>
> — Colin L Powell

Pentagon report

In 2006 a Washington Post article claimed that the Pentagon had produced a secret report in later in 2003 entitled *Final Technical Engineering Exploitation Report on Iraqi*

Suspected Biological Weapons-Associated Trailers that found that the trailers were impractical for biological agent production and almost certainly designed and built for the generation of hydrogen.

Chapter 12

Non-lethal Weapon

Pepper spray demonstration

Non-lethal weapons, also called **less-lethal weapons**, **less-than-lethal weapons**, **non-deadly weapons**, **compliance weapons**, or **pain-inducing weapons** are weapons intended to be less likely to kill a living target than are conventional weapons. These various terms are meant to describe the intended result of applying these technologies, techniques and procedures; accidental, incidental, and correlative casualties are possible and are an understood and accepted risk wherever force is applied. Non-lethal weapons are used in combat situations to limit the escalation of conflict or where employment of

lethal force is prohibited or undesirable or where rules of engagement require minimum casualties or policy restricts the use of conventional force. Non-lethal weapons may be used by conventional military in a range of missions across the force continuum. Non-lethal weapons may also be utilized by military police, by United Nations forces, and by occupation forces for peacekeeping and stability operations. Non-lethal weapons may be used to channelize a battlefield or control the movement of civilian populations or limit civilian access to restricted areas (as they were utilized by the U.S.M.C.'s 1st Marine Expeditionary Force in Somalia in 1995). When used by police forces domestically, similar weapons, tactics, techniques and procedures are often called "less lethal" or "less than lethal" and are employed in riot control, prisoner control, crowd control, refugee control, and self-defense.

Recent history of non-lethal weapons development for military use

Demonstration of the use of Taser gun on US military personnel. The device was originally developed for use by civilian police.

In the past, military and police faced with undesirable escalation of conflict had few acceptable options. Military personnel guarding embassies often found themselves restricted to carrying unloaded weapons. National guards or policing forces charged with quelling riots were able to use only truncheons or similar club-like weapons, or bayonet or saber charges, or fire live ammunition at crowds. In the late 1980s and early 1990s, the Non-lethality Policy Review Group at U.S. Global Strategy Council in Washington and other independent think tanks around the world called for a concerted effort to develop

weapons that were more life-conserving, environmentally friendly, and fiscally responsible than weapons available at that time. The futurists Alvin Toffler and Heidi Toffler reported comprehensively on this phase of the history of non-lethal weapons in their 1993 book, *War and Anti-War*. The U.S. Congress and other governments agreed and began an organized development of non-lethal weapons to provide a range of options between talking and shooting.

Humvee with Active Denial System mounted

Recognizing the need to limit the escalation of force, research and development of a range of non-lethal weapons has since been undertaken internationally by governments and weapons manufacturers to fill the need for such weapons. Some non-lethal weapons may provide more effective riot control than firearms, truncheons or bayonets with less risk of loss of life or serious injury. Before the general availability of early military non-lethal weapons in the mid 1990s, war-fighters had few or no casualty-limiting options for the employment of scalable force and were continually at risk whenever lethal force was prohibited during sensitive missions.

In 2001 the United States Marine Corps revealed its development of a less-than-lethal energy weapon called the Active Denial System, a focused millimeter wave device said to be capable of heating all living matter in the target area rapidly and continuously for the duration of the beam, causing transient intolerable pain but no lasting damage. The skin temperature of a person subjected to this weapon can jump to approximately 130 °F (54 °C) in as little as 2 seconds depending on the skin's starting temperature. The system is nonlethal (the penetration of the millimeter wave beam into human skin is only a few millimeters).

In 2004, author Jon Ronson cited an unclassified military report titled "Non-Lethal Weapons: Terms and References" 21 acoustic weapons were listed, in various stages of development, including the Infrasound ("Very low-frequency sound which can travel long distances and easily penetrate most buildings and vehicles ... biophysical effects are projected to be: nausea, loss of bowels, disorientation, vomiting, potential internal organ damage or death may occur. Superior to ultrasound...)", however no such effects had been achieved as of 2002.

Recent history of non-lethal options for employment by police

Long Range Acoustic device mounted on police vehicle, 2004 Republican National Convention, New York City.

Until the development of non-lethal weapons, police officers around the world had few if any non-lethal options for riot control. Common tactics used by police that were intended to be non-lethal or less lethal included a slowly-advancing wall of men with batons, officers on horses trained to deal with policing situations, or a charge into a riot using the flats of sabers. Other reasonably successful approaches included shotguns with lower-powered cartridges, "salt shells", and ricocheting the shot off of the ground. In the mid 1900s, with the integration of fire-control systems into major cities, police found that high-pressure fire hoses could be effective in dispersing a crowd (the use of water cannons and fire trucks has remained an effective nonlethal tactic to disperse riots). Trained police dogs were also commonly used to scare and disperse rioters and apprehend individuals. In the 1980s the development of the high-tensile plastics Kevlar and Lexan revolutionized personal armor and shields, and led to new tactics for riot squads and other special-purpose teams. Officers could now stand up against violent rioters throwing dangerous projectiles without having to resort to lethal methods to quickly disperse the danger. Coupled with the introduction of effective non-lethal chemical agents such as tear gas and offensive odor canisters, and non-lethal impact rounds such as rubber bullets and "bean bag" flexible baton rounds, riot tactics were modified to rely less on violent response to attacking rioters than on a return to the slowly-advancing wall, with supporting officers firing non-lethal ordnance into the crowd to discourage advance.

Swedish police in riot gear, carrying an extended telescopic baton

Police officers on patrol were traditionally armed with a baton or pistol or both, and non-lethal methods of subduing an attacker centered on hand-fighting techniques such as Jujutsu and baton use. In the 1980s and 1990s officers began deploying non-lethal personal sidearms such as pepper sprays, and eventually electroshock weapons such as Tasers, which were developed for use by police and also found a market in self-defense by private citizens. However, these weapons were developed for non-lethal resolution of a one-on-one conflict.

During the 1990s and early 2000s interest in various other forms of less-than-lethal weapons for military and police use rose. Amongst other factors, the use of less-than-lethal weapons may be legal under international law and treaty in situations where weapons such as aerosol sprays or gases defined as chemical are not. Less-than-lethal weapons are also useful in keeping the peace in the aftermath of violent conflict.

Between the years of 1987-1990 after a 3 year field study by the FBI's Firearm's Training Unit; In 1990 the use of Oleoresin Capsicum was first issued and used by the FBI as the first official law enforcement agency.

Pepper spray training

In the late 1990s and early 2000s police began to adopt a new pepper spray delivery system based on the equipment used in paintballs. A specialized paintball, called a "pepperball", is filled with liquid or powdered capsaicin, the active ingredient in pepper spray, and is propelled by compressed gas using a paintball marker similar to those used for the sport but operating at higher pressure. The impact of the capsule is immediately painful (a pepperball's shell is thicker than a standard paintball and is fired at higher velocity), and it breaks open on impact, dispersing the capsaicin with similar effect to aerosol-delivered pepper spray. However, to be most effective, pepper spray must contact the eyes, nose, or mouth of the target; pepper spray on clothing or tougher skin has a much reduced effect.

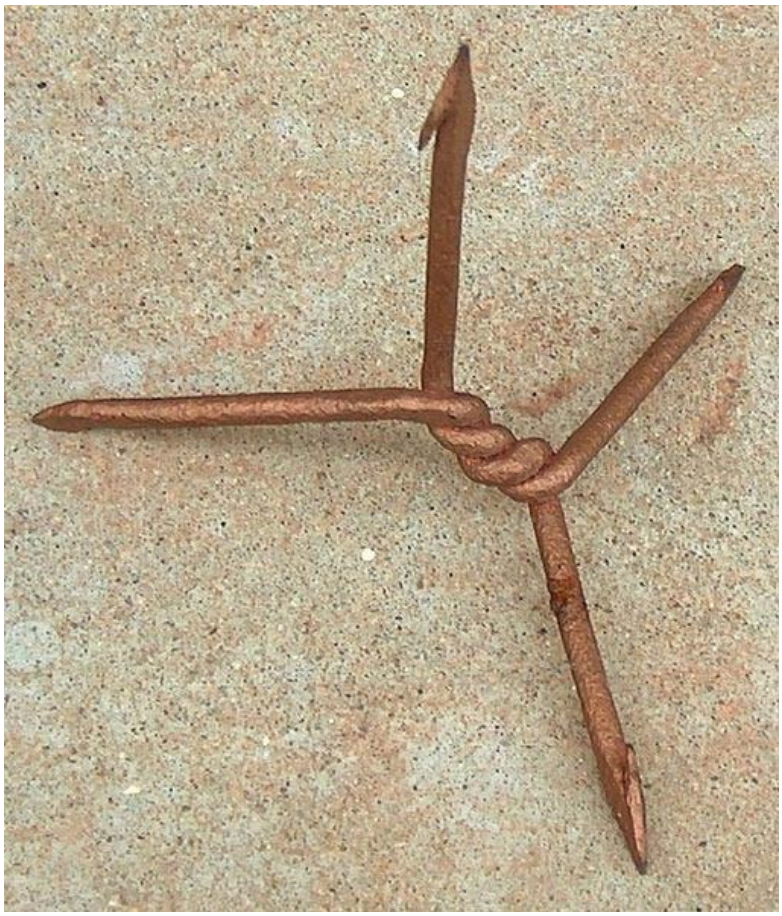
Effects

Non-lethal weapons ability to incapacitate without minimal lasting effects has made them the weapon of choice for use in civilian populations. However, some analysts describe "non-lethal" as a misnomer and instead define them as "less-lethal".

Area denial

Area denial weapons work by either incapacitating or detering the enemy.

Anti-vehicle



Iron caltrops

Vehicle stoppers include a wide range of methods and devices meant to disable a vessel or vehicle to prevent attack by an oncoming vessel or vehicle or to stop that vessel or vehicle for evaluation. Vessel and vehicle stoppers may include kinetic, chemical, or electromagnetic means.

Caltrops

Caltrops are known to have been in use since Roman times and may have been used earlier: the concept was familiar to the 4th century BC Greeks, who used rocks, brush, nets and trees placed in the path of enemy conveyances on land or ensnarement devices hidden under water to achieve the same result: stop the enemy or suspected hostile in his tracks for examination or to prevent or limit incursions. Contemporary caltrops look something like large jacks from the childhood game. Placed in the path of oncoming

wheeled or tracked vehicles, they are meant to foul wheels, destroy tires and tracks, and incapacitate vehicles.

Anti-personnel

Caltrops

Simple rows or clusters of sharpened sticks (nowadays also known as punji sticks), and the use of small caltrops have been a feature of anti-infantry warfare for a long time. However, due to the difficulty of mass-producing them in the pre-modern age, they were rarely used except in the defense of limited areas or chokepoints, especially during sieges, where they were used to help seal breaches. Increasing ease of production still did not prevent these methods from slowly falling out of favor from the late Middle Ages onward.

Caltrops are still sometimes used in modern conflicts, such as during the Korean War, where Chinese troops, often wearing only light shoes, were particularly vulnerable. In modern times, special caltrops are also sometimes used against wheeled vehicles with pneumatic tires. Some South American urban guerrillas as the Tupamaros and Montoneros called them "miguelitos" and used these as a tactic to avoid pursuit after ambushes.

Active Denial System

Increasingly, combat vehicles, such as the urban variant of the Leopard 2 main battle tank, are being fitted with non-lethal weapons. The pictured Humvee has been fitted with the Active Denial System. A dish that projects electromagnetic radiation just powerful enough to penetrate human skin and make the nervous system think the victim is on fire although no physical damage is done. Future combat vehicles such as the American GCV Infantry Fighting Vehicle will incorporate non-lethal weapons.

A water pistol can be filled with ammonia and used against attacking dogs.

Mechanics

Non-lethal weapons are intended to minimize injury or death. While people are occasionally seriously injured or killed by these weapons, fatalities are relatively infrequent. Causes of death from non-lethal weapons are varied and occasionally uncertain. Misplaced or ricocheting shots, pre-existing medical conditions, inadequate user training, repetitive applications and intentional misuse have been implicated in different cases where death has occurred.

As different parts of the body differ in vulnerability, and because people vary in weight and fitness, any weapon powerful enough to incapacitate may be capable of killing under certain circumstances. Thus "non-lethal force" does have some risk of causing death: in this context "non-lethal" means only "not *intended* to kill".

Several groups maintain there is great room for improvement in non-lethal weapons and procedures for their use. Claims for the relative safety of such weapons are usually contingent on their being used "properly." For example, the rubber bullets developed during the 1960s were supposed to be fired at the ground and hit the target only after ricochet, and other non-lethal bullets are designed to be fired at the lower body; they can be lethal if fired directly at the head, as commonly happens.

Ammunition

Rubber bullet fired in Thailand in 2010

Non-lethal rounds are firearm rounds which are designed to incapacitate, but not kill, a target. The rounds rely on the transfer of kinetic energy to accomplish this incapacitation. Rubber bullets, wax bullets, plastic bullets, beanbag rounds, and rubber bullets with electroshock effect (e.g. Taser XREP rounds) are less lethal than conventional metal bullets, and are also propelled at lower speed by using less propellant. "Bean bag" type bullets are sometimes referred to as flexible baton rounds. More recently, high-velocity paintball guns are also used to launch less-lethal rounds, including the FN 303 launcher and PepperBall commercial products. There is also the Variable Velocity Weapon Concept, for which a propulsion energy source may not yet have been clearly established and/or finalized. In any case, all of these technologies apply the same basic mechanism, which is to launch a mass at the target that interacts kinetically.

Explosives

Hand grenades come in several less-lethal varieties, such as "flashbang" (stun) grenades, "sting" grenades with rubber shrapnel, and grenades designed to release chemical irritants (described below).

Gases and sprays

Water

Water cannon during a German demonstration, 2001

Water cannons are commonly used in crowd and riot control, for dispersal or to prevent movement on a particular position. Water-filled rounds for small arms are in experimental stages.

Scent-based weapons

Malodorants produce smells so horrible they cause people to leave the affected area. In 2008 The Israeli Defence Forces have begun using Skunk for crowd control. It is a form of mist sprayed from a water cannon, which leaves a terrible odor of rot or sewage on whatever it touches, and does not wash off easily.

Pepper spray

The active ingredient in pepper spray is oleoresin capsicum (OC), a spicy chemical derived from burning-hot cayenne pepper plants.

An estimate by the International Association of Chiefs of Police suggested at least 113 pepper spray related fatalities had occurred in the United States, mostly from positional

asphyxia, which is caused by airway-restrictive immobilizing holds. Such holds can be exacerbated by the use of pepper spray and the resulting airway inflammation.

Tear gas

The use of chemical weapons such as tear gas (CS) and pepper spray (OC) has come under increasing scrutiny and criticism due to studies showing serious long term side effects. Many police forces are no longer exposing their members to the chemicals during training. Additionally, tear gas and pepper spray are banned in warfare by the international Chemical Weapons Convention.

The journalist Rubén Salazar was killed in Los Angeles in 1970 by an errant CS gas canister during the Chicano riots.

There have been accusations that the use of (inflammable) CS gas canisters during the Waco siege in 1993 contributed to the fire that killed many Branch Davidians.

Mace

Often promoted for self defense, mace is a spray of various formulations, that may include tear gas, pepper spray, and phenacyl chloride (CN).

Psychochemical

Psychochemical weapons are psychoactive drugs, such as BZ, LSD, Kolokol-1, EA-3167, and methamphetamine designed to have a disorienting effect when used during combat or interrogation.

Other chemical agents

Blister agents, including CR gas, are less often used riot control agents. Other irritants include CS gas and nonivamide (PAVA).

Sticky foam

Sticky foam was tried by the U.S. Marine Corps in the peacekeeping Operation United Shield in 1995 with some success, but as a result various complications in its field use were also discovered.

Electroshock weapons

Electroshock weapons are incapacitant weapons used for subduing a person by administering electric shock aimed at disrupting superficial muscle functions. One type is a conductive energy device (CED), an electroshock gun popularly known by the brand name "Taser", which fires projectiles that administer the shock through a thin, flexible

wire. Other electroshock weapons such as stun guns, stun batons, and electroshock belts administer an electric shock by direct contact.

Directed energy weapons

Directed energy weapons are weapons that emit energy in an aimed direction without the means of a projectile. They are non-lethal and can immobilize people as well as machines (e.g. vehicles). Directed energy weapons include electromagnetic weapons, (including laser weapons), particle beam weapons, and sonic weapons.

Safety and legal status

In the United States of America, the University of Texas-Austin Institute for Advanced Technology (IAT) conducts basic research to advance electrodynamics and hypervelocity physics related to electromagnetic weapons. Although generally considered 'non-lethal weapons', electromagnetic weapons do pose health threats to humans. In fact, "non-lethal weapons can sometimes be deadly."

United States Department of Defense policy explicitly states that **non-lethal weapons** "shall not be required to have a zero probability of producing fatalities or permanent injuries." Although a Human Effects Advisory Panel was established in 1998 to provide independent assessment on human effects, data, and models for the use of 'non-lethal weapons' on the general population, the TECOM Technology Symposium in 1997 concluded on non-lethal weapons: "Determining the target effects on personnel is the greatest challenge to the testing community," primarily because "the potential of injury and death severely limits human tests." However, "directed energy weapons that target the central nervous system and cause neurophysiological disorders" may violate the Convention on Certain Conventional Weapons of 1980. And weapons that go beyond non-lethal intentions and cause "superfluous injury or unnecessary suffering" could violate the Protocol I to the Geneva Conventions of 1977." Safety and evaluation of the physical and psychological effects of the long-term or repetitive uses of the pain-inducing non-lethal weapons on humans have not been well understood or studied in any great details. Any such studies require explicit consent of all participants so as not to violate the UN Convention against torture and other cruelties.

Allegations of torture

Both pepper spray and electroshock weapons have been misused in so-called "pain compliance" techniques against people attempting to practice nonviolent civil disobedience. For instance, pepper spray has been swabbed directly into the eyes of protesters who were being held immobile with their eyelids forcibly pulled back. Amnesty International in 1997 released a report titled *USA: Police use of pepper spray is tantamount to torture.* The repetitive use of pain-inducing non-lethal weapons on a human may be considered cruel, if not torture by itself. Such use is likely to be considered abusive or in violation of the 1984 United Nations Convention against torture and other cruelties.

Terrorism concerns

Alleged Taser made to look like a cell phone

Loren Thompson, chief operating officer of the Lexington Institute in Virginia states that: "The relevant (electromagnetic weapon) technology is well within the grasp of some countries and transnational terrorist groups", and further states that U.S. hardware is susceptible to microwave and other directed-energy weapons.

Suitable materials and tools to create electromagnetic weapons are commonly available. "The threat of electromagnetic bomb proliferation is very real."

Also, electroshock weapons can be easily made DIY. Reports have been made of people making Tasers from cell phones and other electrical devices.

Chapter 13

Command & Control

Command and control, or **C2**, in a military organization can be defined as the exercise of authority and direction by a properly designated commanding officer over assigned and attached forces in the accomplishment of the mission.

Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

Commanding officers are assisted in executing these tasks by specialized staff officers and enlisted personnel. These *military staff* are a group of officers and enlisted personnel that provides a bi-directional flow of information between a commanding officer and subordinate military units.

The purpose of a military staff is mainly that of providing accurate, timely information which by category represents information on which command decisions are based. The key application is that of decisions that effectively manage unit resources. While information flow toward the commander is a priority, information that is useful or contingent in nature is communicated to lower staffs and units.

Derivative terms

There is a plethora of derivative terms which emphasise different aspects, uses and sub-domains of C2. They include:

- C2I - Command, Control & Intelligence
- C2I - Command, Control & Information (A less common usage)
- C2ISR - C2I plus Surveillance and Reconnaissance
- C2ISTAR - C2 plus ISTAR (Intelligence, Surveillance, Target Acquisition, and Reconnaissance)
- C3 - Command, Control & Communication (Human activity focus)
- C3 - Command, Control & Communications (Technology focus)

- C3I - 4 possibilities; the most common is Command, Control, Communications & Intelligence
- C3ISTAR - C3 plus ISTAR
- C3ISREW - C2ISR plus Communications plus Electronic Warfare (Technology focus)
- C4, C4I, C4ISR, C4ISTAR, C4ISREW - plus Computers (Technology focus) or Computing (Human activity focus)
- C5I - Command, Control, Communications, Computers, Combat systems and Intelligence

and others.

Command and Control Centers

A **Command and Control Center** is typically a secure room or building in a government, military or prison facility that operates as the agency's dispatch center, surveillance monitoring center, coordination office and alarm monitoring center all in one. Command and control centers are operated by a government or municipal agency.

Various branches of the U.S Military such as the U.S Coast Guard and Navy have command and control centers. They are also common in many large correctional facilities.

A command and control center that is used by a military unit in a deployed location is usually called a **command post**. A warship has a Combat Information Center for tactical control of the ship's resources, but commanding a fleet or joint operation requires additional space for commanders and staff plus C4I facilities provided on a Flagship (eg Aircraft Carriers), sometimes a Command ship or upgraded logistics ship such as USS Coronado (AGF-11).

Battlespace

Battlespace is a term used to signify a unified military strategy to integrate and combine armed forces for the military theatre of operations, including air, information, land, sea, and space to achieve military goals. It includes the environment, factors, and conditions that must be understood to successfully apply combat power, protect the force, or complete the mission. This includes enemy and friendly armed forces, infrastructure, weather, terrain, and the electromagnetic spectrum within the operational areas and areas of interest.

Concept

Battlespace awareness

Battlespace awareness (BA), is a practice of military philosophy that is used as a valuable asset by joint -component and -force commanders, to predict courses of action before employing troops into a prescribed area of operation (AO). It utilizes the intelligence preparation asset to assist the commander in being 'aware' of recent, current, and near term events in his battlespace.

It is based around its knowledge and understanding obtained by the an intelligence, surveillance, and reconnaissance (ISR) system. It is another methodical concept used to gain information about the operational area—the environment, factors, and conditions, including the status of friendly and adversary forces, neutrals and noncombatants, weather and terrain—that enables timely, relevant, comprehensive and accurate assessments. It has became an effective concept for conventional and unconventional operations in successfully projecting, or protecting, a military force, and/or complete its mission.

Battlespace digitization

Battlespace digitization is designed to improve military operational effectiveness by integrating weapons platforms, sensor networks, ubiquitous command and control (UC2), intelligence, and network-centric operations. This military doctrine reflects that in the future, military operations will be merged into joint operations rather than take place in separate battlespaces under the domain of individual armed services.

Battlespace intelligence preparation

Intelligence preparation

Intelligence preparation of the battlespace (IPB) is an analytical methodology employed to reduce uncertainties concerning the enemy, environment, and terrain for all types of operations. Intelligence preparation of the battlespace builds an extensive database for each potential area in which a unit may be required to operate.

The database is then analyzed in detail to determine the impact of the enemy, environment and terrain on operations and presents it in graphic form. Intelligence preparation of the battlespace is a continuing process.

Joint intelligence preparation

Joint intelligence preparation of the battlespace (JIPB) is the analytical process used by joint intelligence organizations to produce intelligence assessments, estimates and other intelligence products in support of the joint force commander's decision making process. It is a continuous process that includes defining the total battlespace environment;

describing the battlespace's effects; evaluating the adversary; and determining and describing adversary potential courses of action.

The process is used to analyze the aerial, terrestrial, maritime/littoral, spatial, electromagnetic, cyberspace, and human dimensions of the environment and to determine an opponent's capabilities to operate in each. JPIB products are used by the joint force and component command staffs in preparing their estimates and are also applied during the analysis and selection of friendly courses of action.

Battlespace measures

Maneuver control

Maneuver control measures are the basic preliminary step in effective clearance of fire support (e.g. artillery, Naval gunfire, and close air support), marked by imaginary boundary lines used by commanders to designate the geographical area for which a particular unit is tactically responsible. It is usually established on identifiable terrain to help aid in hasty referencing for better lateral advantage in the science of fire support, normally orchestrated by a higher echelon of the general staff, mainly the operations staff sections

They are normally designated along terrain features easily recognizable on the ground. An important point on maneuver control graphics: staffs must be knowledgeable regarding the different maneuver control measures and their impact on clearance of fires. For instance, boundaries are both restrictive and permissive; corridors are restrictive, while routes, axis, and directions of attack are neither.

It should be reminded of the effect on clearance of fires if subordinate maneuver units are not given zones or sectors (i.e. no boundaries established). Since boundaries serve as both permissive and restrictive measures, the decision not to employ them has profound effects upon timely clearance of fires at the lowest possible level.

The higher echelon may coordinate all clearance of fires short of the Coordinated Fire Line (CFL), a very time-intensive process. It allows the unit to maneuver successfully and to swiftly and efficiently engage targets. It requires coordination and clearance only within that organization.

They affect fire support in two ways:

- **Restrictive**—Restrictive control that is established in conjunction with a host nation to preclude damage or destruction to a national asset, population center, or religious structure. Its key role are for protection an of an element of tactical importance, such as a fuel storage area.
    - Restrictive fire area (RFA) is an area with specific restrictions and in which fires that exceed those restrictions will not be delivered without

coordination with the establishing headquarters, or higher echelon; occasionly, it may be established to operate independently.
    - No-fire area (NFA) is a designated area which no fire support may be delivered for fires or effects. When the establishing headquarters allows fires on a mission-by-mission basis. When a friendly force is engaged by an enemy located within the NFA and the commander returns fire to defend his forces. The amount of return fire should not exceed that sufficient to protect the force and continue the mission.

- **Permissive**—Permissive control that gives the maneuver commander the liberty to announce and engage fire support at his will, unless it otherwise is restricted by a higher echelon. Most cases, a commander will deny the use of Fire Support Coordinating Measures (FSCM).
    - There are free-fire areas (FFA) which fire support can commense without additional coordination with the establishing headquarters. Normally, it is established on identifiable terrain by division or higher headquarters.

Battlespace shaping

Battlespace shaping is a concept involved in the practice of maneuver warfare that are used for shaping a situation on the battlefield, gaining the military advantage for the commander. It forecasts the elimination of the enemy's capability by fighting in a coherent manner before deploying determine-sized forces.

Fog of war

The **fog of war** is a term used to describe the uncertainty in situation awareness experienced by participants in military operations. The term seeks to capture the uncertainty regarding own capability, adversary capability, and adversary intent during an engagement, operation, or campaign. The term is ascribed to the Prussian military analyst Carl von Clausewitz, who wrote:
"The great uncertainty of all data in war is a peculiar difficulty, because all action must, to a certain extent, be planned in a mere twilight, which in addition not infrequently — like the effect of a fog or moonshine — gives to things exaggerated dimensions and unnatural appearance."

Levels

The nature of the ambiguity described as the fog of war varies according to the level at which participants are engaged:

Grand strategic

Ambiguity is related to the political intent, capabilities and logistical strengths of an adversary. Sources of information include diplomatic intelligence, secret (or special)

intelligence, strategic modeling and data derived from open source intelligence. Affected participants seek to understand intent of and political motivations. Outcomes at this level may encompass military action but are more concerned with **socio-political and economic outcomes** from which it might cascade if left unattended.

Military strategic

Militarily, the ambiguity experienced at this level relates to the structure, strength, capability, and disposition of own and adversary offensive and defensive assets. Own-force ambiguity can be caused by failure to report material deficiencies or an unwillingness to escalate concerns, leading to an optimistic view of own capabilities. Adversary ambiguity may be a result of inaccurate intelligence, sources being subverted or deceived, or adversary intelligence presenting a superior picture allowing one's decision cycle to be compromised. In addition, if unanticipated situations occur they can hamper the execution of long term planning.

Operational

Within the operational theatre the commander undertakes tasks as directed by the Military Strategic level, ambiguity continues to relate to adversary capability and intent but is coupled with own directive ambiguity, the commander not having the full sight of the strategic imperative. As operational tempo increases at this level the ambiguity experienced by the commander is susceptible to delays in communication of the tactical situation and the ebb and flow of own force, and adversary force interaction. The commander seeks to penetrate the fog of war through significant use of reconnaissance assets and a comprehensive Joint Operational Picture.

Tactical

Ambiguity stems from several factors at the tactical level, both by deliberate means by the enemy (including active deception and/or electronic attack on communications and sensors) as well as factors inherent to battle resulting in lack of comprehension by commanders as to the tactical environment, the logistic status of their own units, how they are interacting with each other, or their intentions. This lack of comprehension can stem from many factors, individually or in combination, such as poor reconnaissance; inaccurate intelligence; or faulty communication. The tempo of decision making at the tactical level is much greater than at other levels, increasing the risk of escalating ambiguity as assumptions build and resources are allocated based on those assumptions.

Experience

The practical experience of the *fog of war* is most easily demonstrated in the tactical battlespace. It may include military commanders' incomplete or inaccurate intelligence regard their enemy's numbers, disposition, capabilities, and intent, regarding features of the battlefield, and even including incomplete knowledge of the state of their own forces. Fog of war is caused by the limits of reconnaissance, by the enemy's feints and

disinformation, by delays in receiving intelligence and difficulties passing orders, and by the difficult task of forming a cogent picture from a very large (or very small) amount of diverse data.

When a force engages in battle and the urgency for good intelligence increases, so does the fog of war and chaos of the battlefield, while military units become preoccupied with fighting or are lost (either destroyed by enemy fire or literally lose their way), reconnaissance and liaison elements become unavailable, and sometimes while real fog and smoke obscure vision. Much of the modern military's technological efforts, under the rubric of command and control seek to reduce the fog of war. Although even the most advanced technology cannot completely eliminate it, military theorists continue to develop ways to reduce it.

Simulations and games

Fog of war in a computer game. Black tiles represent unknown terrain. Darkened ones have been explored, but are not currently observed by the player.

Fog of war in the computer game Battle for Wesnoth. The grey areas are outside the unit's vision range.

Abstract and military board games sometimes try to capture the effect of the fog of war by hiding the identity of playing pieces, by keeping them face down or turned away from the opposing player (as in *Stratego*) or covered (as in *Squad Leader*). Other games, such as the *Kriegspiel* chess-variant, playing pieces are hidden from the opponent by tracking them on paper or by using a duplicate, hidden game board.

Solitaire games also by their nature attempt to recreate fog of war using random dice rolls, card draws, or flowcharts to determine events, for example *Ambush!*. Complex double-blind miniatures wargames, including cloth model training exercises for military commanders, may make use of two identical maps or model landscapes, one or more referees providing limited intelligence to the opposing sides, participants in the roles of sub-unit leaders, and the use of radio sets or intercoms.

The term "fog of war" has become jargon in military and adventure video and computer games, in the more limited sense of enemy units or characters being hidden from the player. Often this is done by obscuring sections of the map already explored by the player with a grey fog whenever they do not have a unit in that area to report on what is there. The player can still view the terrain but not any enemy units on it. One early use of fog of

war was the 1978 game *Tanktics* designed by Chris Crawford, which was criticized for its fog of war system detracting from the fun of the game. Crawford later noted that "...when the games get too realistic, they lose their appeal."

Two of the most successful Blizzard franchises, *Warcraft* and *StarCraft*, also use a similar fog of war which only reveals terrain features and enemy units through a player's reconnaissance. Without a unit actively observing, previously revealed areas of the map are subject to a shroud through which only terrain is visible, but not changes in enemy units or bases. *Star Wars: Galactic Battlegrounds* is another example of a game that uses this technique to make the game more realistic. EA Games' (formerly Westwood Studios') franchise *Command & Conquer* has incorporated a similar fog of war through the series, as has Activision's *Dark Reign*. Similarly, in the classic Empire computer game, a player can only observe an enemy unit if it is in the vicinity of one of the players units or cities. In some games, such as *Command & Conquer: Red Alert 2*, it is possible for the player to artificially recreate a fog of war against his opponent. In turn-based strategy games of the Advance Wars, Field Commander and Fire Emblem series, "Fog of War" literally refers to a fog which shrouds the most part of a map, but merely as a form of in-game handicap, but in Fire Emblem "fog of war" is simply coined as 'fog' due to its medieval style. Sid Meier's turn-based franchise *Civilization* and its spin-off *Alpha Centauri* obscure parts of the map not occupied by the player or allies until the advent of orbital flight is reached by the player. Real-Time Strategy game *Rome: Total War* and all games after it have a cheat function, "toggle_fow", which allows the player to see everything that is happening all over the map.

By extension, "Fog of War" is also used to describe the limited view distance of many first person shooters, where unlimited view is considered either bad for gameplay or, more often, because of technical limitations, in that a Fog of War allows for the rendering of a smaller part of the game area. This, however, is often referred to as one's "line of sight". In the *Commands & Colors* series of boardgames, designed by Richard Borg, the fog of war is simulated by a deck of cards from which the players can pick their actions. Different sides of the battle usually have a different number of cards (each one describing a possible action) and players have to choose which card to use. It often happens that the best action imaginable in that moment is impossible to do because the player does not have a useful card for it. This is to simulate the difficulty of in-battle communication in the heat of the moment.