

总参军训和兵种部审定通过 军队院校外语教学系列教材

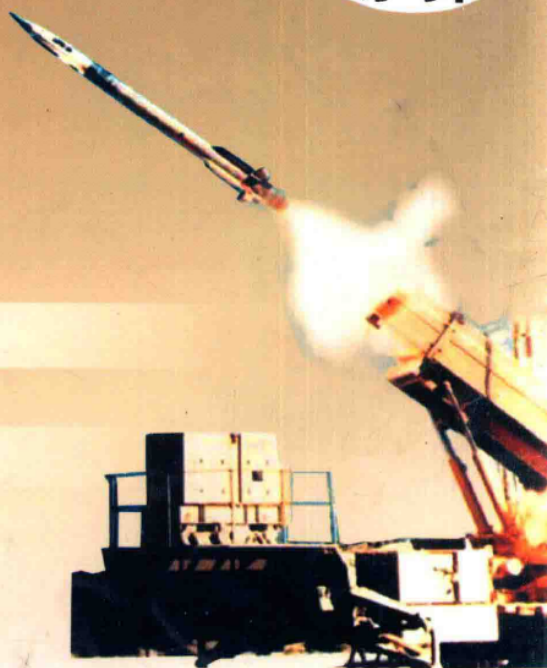


主编 杨作祥

Military English

军事英语

导弹



解放军外语音像出版社

PLA Foreign Languages Audio-Video Press

# 军 事 英 语

Military English

(导 弹)

主 编：杨作祥

副主编：姜 薇 姚 湘

编 者：李凤丽 邢媛圆 杨正新 白 晔

袁长普 尹清山 任培楠

解放军外语音像出版社

PLA Foreign Languages Audio-Video Press

军事英语（导弹） / 《军事英语》（导弹） / 主编 杨作祥

洛阳：解放军外语音像出版社，2006.1

ISBN 7-89994-605-0

I. 军... II. 杨... III. 教材

## 书 名：军事英语（导弹）

---

责任编辑：赵小江

封面设计：陈 琳

装帧设计：尚小倩

版式设计：李 晓

出版发行：解放军外语音像出版社出版发行

社 址：河南省洛阳市涧西区广文路2号

邮 编：471003

电 话：0379-64541129 军 线：0438-43659

印 刷：解放军外国语学院印刷厂

开 本：787×1092mm 1/16

字 数：300千字

印 张：16

版 次：2006年1月第1版

印 次：2006年6月第2次印刷

版 号：ISBN 7-89994-605-0

定 价：24.80元

# 前 言

随着科学技术的日新月异，科研成果不断运用到军事领域，一场新的军事变革正在全球蓬勃兴起。作为我军的重要军种之一——第二炮兵，其在国家发展战略和安全战略中的独特地位和重大使命也日益凸显。为适应国防现代化的需要和二炮建设的需要，培养高素质的军事人才和工程技术人员，提高和加强其外语素质是不能忽视的。为此，要保证在校学员英语四年学习不断线，有机地将“大学英语”学习阶段和“专业英语”学习阶段相衔接，让学员的英语知识和技能更上一个台阶，更好地将英语作为交际工具和及时了解外国导弹技术发展动态的重要手段，我们编写了这本《军事英语》（导弹）教材。

本教材比较全面地介绍了外军该军种和导弹的常识，主要包括：导弹概述、战略和战术导弹、弹道导弹、巡航导弹、雷达火控系统、空空导弹、空中导弹防御、美国战略司令部、俄罗斯战略火箭军、印度导弹现状、导弹竞赛、导弹的未来发展等诸方面。全书共十二个单元，适用于专业学习阶段的军校学员和有一定英语基础的其他人员。

本教材的每个单元围绕一个主题选编课文，主课文一篇，篇幅在 1,300 ~ 1,600 词，同时为加大信息量，配有副课文 1-2 篇，篇幅在 2,000 ~ 3,000 词。每篇课文后列有生词表，并带有注释，对文中出现的较复杂的句子及语言的难点、疑点和背景知识做补充说明。为巩固学员对课文内容和军事术语的掌握，每个单元后安排了练习，包括阅读理解、问题回答、英汉术语互译以及段落翻译等。

该书所精选的文章均源于国外当代军事英语报刊杂志。在选文时，我们主要考虑到以下三点：一是课文要行文流畅，语言规范，具有可读性；二是知识性强，趣味性浓，具有较浓厚的现代气息；三是每单元的课文适合做精度和泛读教材使用，这样既能提高学员的理解能力和军语的实际运用能力，又能拓宽其知识面。

由于我们的水平有限，书中难免存在疏漏和差错，诚望同行和读者们不吝指正。

编 者

2006 年 1 月

---

# Contents

<b>Unit 1</b>	An Overview of Guided Missile .....	1
<b>Unit 2</b>	Strategic and Tactical Missile .....	22
<b>Unit 3</b>	Ballistic Missile Proliferation .....	33
<b>Unit 4</b>	Future Cruise Missile's Features .....	53
<b>Unit 5</b>	Active Phased Array Multifunction Radars Go Live for Missile Firings .....	74
<b>Unit 6</b>	AGM-114 Hellfire and Longbow Hellfire .....	94
<b>Unit 7</b>	Russia Sets the Pace in Air-to-Air Missiles .....	112
<b>Unit 8</b>	AMD Systems Rise to the Challenge .....	132
<b>Unit 9</b>	The US Strategic Command and Russia Strategic Rocket Forces .....	152
<b>Unit 10</b>	India's Missiles .....	168
<b>Unit 11</b>	Missile Race .....	197
<b>Unit 12</b>	Hypersonics: A New Age Dawn .....	219
<b>Appendix</b>	.....	237

# Unit One

## Text

### An Overview of Guided Missile

**内容提要** 制导导弹指的是飞行过程可被控制，并可以改变飞行路线的军用火箭。为了提高导弹的精确性及杀伤力，精确制导导弹是导弹发展的一个必然趋势。从德国制造出的 V1 火箭开始，制导导弹就成为各国重点发展的项目。本文将对制导导弹的基本角色和其制导系统进行概述。

A guided missile is a military rocket that can be directed in flight to change its flight path. In typical usage the term “*missile*” refers to guided rockets, and “*rockets*” to unguided ones. The differences between the two may be fairly minor other than the guidance system.

The first missiles to be used operationally were a series of German missiles of WWII. Most famous of these are the V1 and V2, both of which used a simple mechanical autopilot to keep the missile flying along a pre-chosen route. Less well known were a series of anti-shipping and anti-aircraft missiles, typically based on a simple radio control system directed by the operator<sup>1</sup>.

German systems tended to be based on liquid fuel rocket engines, typically derived from Hellmuth Walter's hydrogen peroxide based systems. These were impractical for general use, notably due to the danger of handling the corrosive fuel, and almost all post-war research turned to the simpler solid fuel designs. In addition the quality and ability of various electronic systems improved dramatically in the immediate post-war era, allowing a number of more advanced automatic guidance systems to be introduced. By the 1950s almost every “major power” had a series of missile development programs underway, generally divided into a number of basic classifications.

## ***Basic Roles***

### **Ballistic Missiles**

After the boost-stage ballistic missiles follow a trajectory mainly determined by ballistics, and the guidance is for relatively small deviations from that. The V2 had demonstrated that a ballistic missile could deliver a warhead to a target city with no possibility of interception, and the introduction of nuclear weapons meant it could do useful damage when it arrived. The accuracy of these systems was fairly poor, but post-war development by most military forces improved the basic inertial platform concept to the point where it could be used as the guidance system on ICBMs flying thousands of miles. Today the ballistic missile represents the only strategic deterrent in most military forces; the USAF continued support of manned bombers is considered by most to be entirely political in nature.

### **Cruise Missiles**

The V1 had been successfully intercepted during the war, but this did not make the cruise missile concept entirely useless. After the war the U.S. deployed a small number of nuclear-armed cruise missiles in Germany, but these were considered to be of limited usefulness. Continued research into much longer ranged and faster versions led to the U.S.'s Navaho missile, and its Soviet counterparts, the Burya and Buran. However, these were rendered largely useless by the ICBM, and none were used operationally. Instead, shorter-range developments have become widely used as highly accurate attack systems, such as the U.S. Tomahawk missile.

### **Anti-shipping Missiles**

Another major German missile development project was the anti-shipping class, intended to stop any attempt at a cross-channel invasion. However, the British were able to render their systems useless by jamming their radios, and missiles with wire guidance were not ready by D-Day. After the war the anti-shipping class slowly developed, and became a major class in the 1960s with the introduction of the low-flying turbojet powered cruise missiles known as "sea-skimmers". These became famous during the Falklands War when Argentine Exocet missiles sank several Royal Navy ships<sup>2</sup>.

### **Anti-aircraft Missiles**

By early 1944 U.S. and British bombers were flying essentially unhindered

over the German heartland, and the Luftwaffe became desperate to get some sort of useful ground-based anti-aircraft system into operation. Several systems were under development, but none had reached operational status before the war's end. The U.S. Navy also started missile research to deal with the Kamikaze threat. By 1950 systems based on this early research started to reach operational service, including the U.S. Army's Nike Ajax, the Navy's "3T's" (Talos, Terrier, Tartar), and soon followed by the Soviet SA-1 and SA-2 and French and British systems.

### **Air-to-air Missiles**

German experience in WWII demonstrated that destroying a large aircraft was quite difficult, and they had invested considerable effort into air-to-air missile systems to do this. While their research never reached fruition, the U.S. Navy and USAF used their superior electronics to deliver a number of such designs in the early 1950s, most famous being the Navy's AIM-9 Sidewinder and USAF's AIM-4 Falcon. These systems have continued to advance, and modern air warfare consists almost entirely of missile firing.

### **Anti-tank Missiles**

By the end of WWII, all forces had widely introduced unguided rockets using HEAT warheads as their major anti-tank weapon. However, these had a limited useful range of a 100m or so, and the Germans were looking to extend this with the use of a missile using wire guidance, the X-7. After the war this became a major design class in the later 1950s, and by the 1960s had developed into practically the only non-tank anti-tank system in general use.

### **Anti-ballistic Missiles**

Like most missiles, the Arrow missile and MIM-104 Patriot for defense against short-range missiles carry explosives.

However, in the case of a large closing speed, just a collision is sufficient to destroy the target. See Missile Defense Agency for the following systems being developed:

- Kinetic Energy Interceptor (KEI) – a fast and agile Raytheon-built interceptor used to track incoming missile threats, and destroy them with a non-explosive kinetic energy warhead;
- Aegis Ballistic Missiles Defense System (Aegis BMD)—a SM-3 missile



with Lightweight Exo-Atmospheric Projectile (LEAP) Kinetic Warhead (KW).

### **Anti-satellite Weapon (ASAT)**

Also the proposed Brilliant Pebbles defense system would use collisions without explosives.

## ***Guidance Systems***

Missile guidance systems generally fall into a number of basic classes, each one associated with a particular role. Modern electronics has allowed systems to be mixed on a single airframe, dramatically increasing the capabilities of the missiles.

### **Inertial Guidance**

Inertial guidance systems (INS) use a series of gyroscopes to detect acceleration, and electronics integrate the acceleration to solve for the current location. Early mechanical systems were fairly inaccurate, but continued development allowed for dramatic improvements, and the introduction of the ring laser gyro improved that even more. Today's INS systems offer accuracies of less than 100m at intercontinental ranges, allowing shorter range systems to attack point targets like buildings. INS systems are often combined with other systems to allow the missile to fly to the target system, and then the terminal guidance system takes over for "fine tuning".

### **MCLOS**

Almost all German systems used manual command to line-of-sight, or MCLOS, in which the missile was directed via either radio control by an operator watching both the missile and the target. MCLOS relies on there being a high speed differential between the missile and the target; otherwise manually calculating "lead" becomes difficult. In the case of glide bombs missiles against ships or the supersonic Wasserfall against slow-moving B-17 bombers this system worked fine, but as speeds increased MCLOS was quickly rendered useless for most roles.

### **SACLOS**

SACLOS, semi-automatic command to line-of-sight, is a modification of MCLOS systems, in which the operator tracks only the target, and electronics

calculate the needed “lead”. Commands are then sent to the missile as before, either over radio control or wire guidance. SACLOS dramatically reduces the operator workload, typically to simply keeping a piece of equipment pointed at the target. SACLOS is the most common form of guidance against ground targets such as tanks and bunkers.

### **Active Radar Homing**

Active radar systems mount a small radar unit in the missile and use it to track targets, typically the “largest return”. Radar resolution is based on the size of the antenna, so in a smaller missile these systems are useful for attacking only large targets, ships or large bombers for instance. Active radar systems remain in widespread use in anti-shiping missiles, and in “fire and forget” air-to-air missile systems such as AMRAAM and R-77.

### **Semi-active Radar Homing**

SARH systems combine a radar receiver on the missile with a radar broadcaster located “elsewhere”. Since the missile is typically being launched after the target was detected using a powerful radar system, it makes sense to use that same radar system to track the target, thereby avoiding problems with resolution or power. SARH is by far the most common “all weather” guidance solution for anti-aircraft systems, both ground and air launched.

### **Contrast Seeker**

Contrast seekers use a television camera, typically black and white, to image a field of view in front of the missile, which is presented to the operator. When launched, the electronics in the missile look for the spot on the image where the contrast changes the fastest, both vertically and horizontally, and then attempts to keep that spot at a constant location in its view. Contrast seekers have been used for air-to-ground missiles, including the famous AGM-65 Maverick, because most ground targets can be distinguished only by visual means. However, they rely on there being strong contrast changes to track, and even traditional camouflage can render them unable to “lock on”.

## Words and Expressions in the Text

- autopilot *n.* 自动驾驶仪  
hydrogen peroxide *n.* [化]过氧化氢  
automatic *adj.* 自动的, 无意识的, 机械的  
ballistic *adj.* 弹道的, 弹道学的  
trajectory *n.* 轨道, 弹道  
demonstrate *vt.* 示范, 证明, 论证  
warhead *n.* 弹头  
inertial *adj.* 不活泼的, 惯性的  
deterrent *n.* 威慑  
cruise *vi. & n.* 巡航  
intercept *vt.* 中途阻止, 截取  
version *n.* 形式, 种类; 变形, 变体  
counterpart *n.* 副本; 配对物  
render *vt.* 致使  
turbojet *n.* 涡轮喷气飞机  
unhindered *adj.* 不受妨碍的, 不受阻碍的  
fruition *n.* 成就, 实现  
patriot *n.* 爱国者  
explosive *adj.* 爆炸的 *n.* 爆炸物, 炸药  
collision *n.* 碰撞, 冲突  
aegis *n.* [希神]羊皮盾, 保护, 庇护  
airframe *n.* 机身  
gyroscope *n.* 陀螺仪  
inaccurate *adj.* 不准确的  
gyro *n.* [海][空]陀螺仪  
terminal *n.* 终点站, 终端  
supersonic *adj.* 超音波的; 超声波  
resolution *n.* 辨析率, 解析度  
widespread *adj.* 广泛的, 普遍的  
vertically *adv.* 垂直地  
horizontally *adv.* 地平地, 水平地  
camouflage *v.* 伪装 *n.* 伪装  
warhead *n.* 弹头  
cruise missile 巡航导弹  
strategic deterrence 战略威慑  
operational status 作战状态  
wire guidance 有线制导  
anti-ballistic 反弹道的  
Kinetic Energy Interceptor 动能拦截导弹  
anti-satellite weapon 反卫星武器  
inertial guidance 惯性制导  
active radar homing 主动雷达导航  
fine tuning 精调谐, 微调  
manual command to line-of-sight 瞄准线指令  
terminal guidance system 末段制导系统  
anti-shipping *adj.* 反舰艇的  
radio control system *n.* 无线电操纵系统  
jam *v.* 干扰 (电波信号)

## Notes

1. Less well known were a series of anti-shipping and anti-aircraft missiles,

typically based on a simple radio control system directed by the operator. 这是个倒装句，真正的主语是“a series of anti-shipping and anti-aircraft missiles”。

2. These became famous during the Falklands War when Argentine Exocet missiles sank several Royal Navy ships.

The Falklands War or the Malvinas War (Spanish: Guerra de las Malvinas), was an armed conflict between Argentina and the United Kingdom over the Falkland Islands (Spanish: Islas Malvinas) between March and June 1982. Though surprised by an Argentine attack on the South Atlantic islands, Britain mustered a naval task force to engage the Argentine navy and airforce, landed Royal Marines and after heavy combat eventually prevailed and the islands remained in British hands, in accordance with the wishes of the inhabitants. The sovereignty issues remain contested. In Argentina, the conclusion of the war led to the downfall of the military junta.

The Exocet is a French-built anti-ship missile made in various versions capable of being launched from surface ships and boats, submarines and airplanes. It has been extensively used in combat from the 1980s onwards. The name comes from a French word for flying fish.

3. Other terms and abbreviations:

ICBMS: Intercontinental Ballistic Missile System 洲际弹道(式)导弹系统

D-Day (第二次世界大战中)盟国在西欧登陆日, 即 1944 年 6 月 6 日。

Royal Navy *n.* (英国)皇家海军

Kamikaze *n.* <日> (第二次世界大战期间日本空军敢死队)神风对队员, 此种战术之飞机或驾驶员

HEAT: High-Explosive Anti-Tank (Projective) 反坦克高爆(弹)

INS: Inertial Navigation System 惯性导航系统

MCLOS: Manual Control to Line of Sight 瞄准线指令

## Exercises

### I. Reading Comprehension

1. V1 and V2 \_\_\_\_\_.
- A. are anti-shipping missiles.
  - B. are anti-aircraft missiles.
  - C. can fly along a pre-chosen route.

- D. are based on a simple radio control system
2. German systems liquid fuel rocket engines were impractical for general use, mainly because \_\_\_\_\_.  
A. liquid fuel is too expensive.  
B. the liquid fuel is corrosive.  
C. liquid fuel is difficult to get.  
D. liquid fuel is dangerous to handle.
3. Which of the following statements is correct? \_\_\_\_\_.  
A. A ballistic missile could deliver a warhead to a target city with less possibility of interception.  
B. The USAF's continued support of ballistic missiles is considered by most to be entirely political in nature.  
C. After the World War II, the U.S. deployed a small number of nuclear-armed ballistic missiles in Germany.  
D. Cruise missile became a major class in the 1960s.
4. The anti-aircraft system \_\_\_\_\_.  
A. was to stop British bombers in the world war II.  
B. never reached operational status.  
C. used superior electronics.  
D. were wire guided.
5. Which of the following statements is NOT correct? \_\_\_\_\_.  
A. Inertial guidance systems are often combined with other systems to allow the missile to fly to the target system.  
B. The missile in MCLOS was directed via either radio control by an operator watching both the missile and the target.  
C. SACLOS is the most common form of guidance against ground targets such as tanks and bunkers.  
D. Active radar systems mount a big radar unit in the missile and use it to track targets.

## II. Decide whether the following statements are true or false

1. German systems tended to be based on solid fuel rocket engines. (      )
2. Today the cruise missile represents the only strategic deterrence in most military

forces. ( )

3. The anti-shiping class was another major German missile development project, intended to stop any attempt at a cross-channel invasion. ( )
4. By the end of WWII all forces had widely introduced guided rockets using HEAT warheads as their major anti-tank weapon. ( )
5. Early mechanical systems of INS were fairly inaccurate, but continued development allowed for dramatic improvements, and the introduction of the ring laser gyro improved that even more. ( )

### III. Translate the following terms or phrases from English into Chinese and vice versa

- |                       |                               |
|-----------------------|-------------------------------|
| 1. ballistic missiles | 2. nuclear weapons            |
| 3. cruise missiles    | 4. strategic deterrence       |
| 5. anti-shiping       | 6. anti-aircraft              |
| 7. operational status | 8. air-to-air missile systems |
| 9. 反弹道                | 10. 动能拦截导弹                    |
| 11. 导弹制导系统            | 12. 惯性制导                      |
| 13. 主动雷达导航            | 14. 伪装                        |

### IV. Match the following English military terms to their Chinese equivalents

- |                             |                |
|-----------------------------|----------------|
| 1. HEAT                     | 1. 末段制导系统      |
| 2. MCLOS                    | 2. 空对空导弹       |
| 3. INS                      | 3. 惯性导航系统      |
| 4. terminal guidance system | 4. 反舰艇的        |
| 5. D-Day                    | 5. 反坦克高爆(弹)    |
| 6. inertial platform        | 6. 弹道飞弹        |
| 7. ICBMS                    | 7. 洲际弹道(式)导弹系统 |
| 8. ballistic missile n.     | 8. 惯性平台        |
| 9. anti-shiping adj.        | 9. 二战盟国在西欧登陆日  |
| 10. air-to-air missile      | 10. 瞄准线指令      |

### V. Translation the following passage into Chinese

Another major German missile development project was the anti-shiping

class, intended to stop any attempt at a cross-channel invasion. However, the British were able to render their systems useless by jamming their radios, and missiles with wire guidance were not ready by D-Day. After the war the anti-shipping class slowly developed, and became a major class in the 1960s with the introduction of the low-flying turbojet powered cruise missiles known as “sea-skimmers”. These became famous during the Falklands War when Argentine Exocet missiles sank several Royal Navy ships.

## Supplementary Reading

### Passage I

#### Guided Missiles (I)

Guided Missiles, self-propelled aerial projectiles, usually containing conventional or nuclear explosives, guided in flight towards a target either by remote control or by internal mechanisms. Guided missiles vary widely in size and type, ranging from large strategic ballistic missiles with nuclear warheads to small, portable rockets carried by foot soldiers. Although most are military weapons with explosive warheads, others may carry scientific instruments for gathering information within or above the Earth’s atmosphere.

Guided missiles consist of three separate systems: power source, guidance and control mechanism, and warhead or payload. Power sources normally are either self-contained rocket motors or air-breathing jet engines, but may also be airfoils or outside booster charges from ramp or tube launchers. The type of guidance and control system employed depends on the type of missile and the nature of the target. Inertial guidance systems sense the position of the flight path in relation to a fixed target; other guidance systems use a variety of more active sensors to help direct the missile towards a moving objective. Payloads are generally warheads designed for specific missions, from piercing armour plate to destroying entire urban areas.

Not all missiles require guidance systems. Very short range missiles – artillery

and sounding rockets (which may carry scientific instruments for collecting information within or above the Earth's atmosphere) – with ranges of up to about 90 km (56 mi), and efficient aerodynamics and high acceleration, can be delivered onto their targets with such accuracy that they do not require guidance. The range of more sophisticated systems can be increased to about 140 km (87 mi), although guidance is provided if great accuracy is required. The U.S. Lance surface-to-surface missile with a range of about 120 km (74 mi), for example, was provided with guidance. At greater ranges, drag, wind, and drift spoil the accuracy of even the best-designed missile; the designers then have to rely on guidance for acceptable accuracy.

Some 90 countries have artillery rockets with ranges of up to 40 km (25 mi); about 40 countries have missiles with ranges of more than 40 km (25 mi); 12 countries have ballistic missiles able to deliver major payloads over ranges greater than 600 km (387 mi); and 9 countries have missiles with ranges greater than 1,500 km (930 mi), of which China, Russia, and the U.S. have intercontinental ballistic missiles (ICBM<sup>1</sup>) with ranges greater than 5,500 km.

## Warheads

Military guided missiles carry either high-explosive or chemical, biological, or nuclear warheads. Short-range tactical missiles employ high-explosive charges that produce damage through their force of impact and blast or through fragmentation. Anti-tank missiles, for example, normally depend on a concentrated blast effect to penetrate or splinter armour; warheads used against less protected targets such as aircraft rely more on fragmentation to produce the greatest damage.

Nuclear warheads are weapons of mass destruction carried primarily by an ICBM. To enhance the effectiveness of these long-range delivery systems, several types of warheads were developed in the 1970s. The multiple independently targeted re-entry vehicle dispatches several nuclear warheads from a single missile while in flight; the rocket-powered manoeuvrable alternative-target re-entry vehicle enables an individual warhead to change course as it falls. The Soviet-built fractional orbit bombardment system (FOBS) allows missiles or warheads to remain in Earth orbit before beginning their descent. FOBS gave the Union of Soviet Socialist Republics (USSR) the ability to launch a mass attack against the United States from any direction rather than just depending on a ballistic pathway arching over the North Pole.



The 1993 START<sup>2</sup> II arms control agreement banned all ICBMs with MIRV<sup>3</sup> but was never ratified by the U.S. and Russia. It also attempted to limit submarine-launched ballistic missiles and called for the elimination of all multiple-warhead land-based missiles. However, during their November 2001 summit meeting in Washington, D.C., Presidents George W. Bush and Vladimir Putin agreed to attempt to make progress again in reductions in strategic nuclear forces. Bush announced that the U.S. would unilaterally reduce the number of its operationally deployed strategic nuclear warheads to between 1,700 and 2,200 over the next ten years, substantially below the 3,500-warhead limit in the START II Treaty. Putin announced that the Russians would reduce the number of their operationally deployed strategic nuclear warheads to 1,500, but he did not say over what period of time this would be done.

Nuclear warheads are also used in several U.S. air defence missiles with the intention of breaking up mass bomber formations. Most large tactical missiles are designed to carry nuclear warheads to destroy military concentrations on or behind the battlefield. In the 1980s, Soviet airborne or shipboard nuclear-tipped cruise missiles posed a threat to U.S. Navy carrier task forces. A new type of nuclear weapon, the first to be added to the U.S. arsenal since 1989, is being deployed by the United States. The weapons laboratory at Los Alamos has created the B61 "Mod 11", an earth-penetrating warhead designed to destroy underground command and control installations.

## ***Guidance and Control***

Missiles are guided towards targets by remote control or by internal guidance mechanisms. Remote-control missiles are linked to a human or mechanical target locator through trailing wires, wireless radio, laser, or some other type of signal system. Internal guidance mechanisms have optical, radar, infrared, or some other type of sensor that can detect heat, light, or electronic emissions from the target. Most missiles have some type of movable fins or airfoil that can be used to direct the course of the missile towards the target while in flight.

The inertial guidance systems of ballistic missiles are more complex. Missile velocity, pitch, yaw, and roll are sensed by internal gyroscopes and accelerometers, and course corrections are made mechanically by slightly altering the thrust of the rocket exhaust by means of movable vanes or deflectors. In larger rockets, small external jets are also used to alter direction.