PRC MISSILE AND SPACE FORCES

Since its beginning, the PRC's ballistic missile and space program has received considerable foreign expertise and technology. This support has helped the PRC become a major ballistic missile and space power. The PRC has received considerable assistance from Russia (and previously from the Soviet Union) and the United States, as well as from other nations such as France and Germany.

From 1956 to 1960, the Soviet Union was the major supplier of ballistic missile technology and knowledge to the PRC. The Sino-Soviet split in 1960 ended this cooperation. Today, however, Russia is a major supplier of space launch technology to the PRC. This assistance could be expanded to help the PRC in its efforts to develop road-mobile ICBMs, which would provide the PLA with more confidence in the survivability of its retaliatory nuclear force.

Technology and knowledge acquired from the United States has also assisted the PRC's missile and space programs, although this assistance was never officially sanctioned. Qian Xuesen was a Chinese citizen who was trained in the United States and who worked on classified programs including the Titan ICBM program. After being accused of spying for the PRC in the 1950s, Qian was permitted to return to the PRC, where he became the "father" of the PRC's ballistic missile and space programs. The illegal acquisition of U.S. technology for the PLA's ballistic missiles and space programs has continued aggressively during the past two decades, up to the present day.

The PRC has stolen design information on the United States' most advanced thermonuclear weapons, elements of which could be emulated by the PRC in its next generation ICBMs.

The PRC has stolen U.S. missile guidance technology that has direct applicability to the PLA's ballistic missiles.

Assistance from U.S. companies has improved the reliability of the PRC's military and civilian rockets, and the transfer of some of these improvements to its ballistic missiles is possible.

Western nations, including the United States, Germany, and France, have provided significant support to the PRC's satellite programs. German companies provide the communications package for the PRC's DFH-3 communications satellites. U.S.-manufactured radiation-hardened chips are also used on the PRC's meteorological satellites, used for both military and civilian purposes, to increase the on-orbit life of the satellites.

The PRC is a major ballistic missile proliferator. While the PRC agreed in 1991 to abide by the Missile Technology Control Regime, the PRC transferred complete ballistic missile systems to Pakistan in 1992, and has provided other nations with ballistic missiles production-related technologies. The PRC has not agreed to the MTCR's revised limits on transfers of ballistic missile components.

The PRC has transferred ballistic missile technology to Iran, Pakistan, North Korea, Saudi Arabia, Libya, and other countries.

PRC MISSILE AND SPACE FORCES

Introduction

"By the next century, as high-tech space technology develops, the deployment of space-based weapons systems will be bound to make 'mastery of space' and 'mastery of outer space' prerequisites for naval victory."

PLA Navy Senior Colonel
Shen Zhongchang

In 1956, advisors from the Soviet Union convinced the leadership of the People's Republic of China (PRC) to include ballistic missile development in the PRC's Twelve Year Plan for the Development of Science and Technology (1956-1967). Having just fought a war against the United States in Korea and having come face-to-face with U.S. military supremacy, the PRC decided that combining long-range ballistic missiles and nuclear weapons offered its best chance to build weapons capable of neutralizing the United States' and the Soviet Union's formidable advantage.

Since that time, the PRC has embarked on an extensive ballistic missile and space program.

From its beginning in the 1950s, the PRC has also adapted its ballistic missile program into a major international space program. Since its first space launch in 1971, the PRC has developed ten variations of rockets that have allowed it to place 44 satellites into orbit.

Today, the PRC is embarked on a modernization plan for its ballistic missile and space forces. This expansion includes the exploitation of space-based military recon-

Since their origin, the PRC missile and space programs have been tied together. The PRC can apply the same system refinements and modifications to both its rockets and ICBMs.

naissance and communications satellites and space-based weapons.[1] In addition, the PRC has set for itself the goal of putting men in space this year.

This chapter provides an analysis of the PRC's missile and space forces, and the impact that Western technology has had on those forces. It details the PRC's ballistic missile forces; its space forces, including its rockets and satellites; and the interaction between the two groups.

This chapter also serves as an introduction to the capabilities of the PRC's missile and space programs, and the degree to which foreign assistance and technology may affect the course of their future development.

This chapter is derived from an extensive chapter in the Select Committee's classified Report, much of which, due to national security concerns, cannot be reproduced here.

The PLA's Ballistic Missile Forces

Development of the PLA's Ballistic Missile Forces

The early development of the PLA's indigenous ballistic missile programs was marked by Soviet assistance, and by the guidance of a Chinese citizen who had returned to the PRC after working on the U.S. Titan intercontinental ballistic missile (ICBM) program.[2]

The Soviet Union's Contribution to the PLA's Ballistic Missile Force

The PRC received its first ballistic missiles in 1956, with the acquisition of two Soviet R-1 missiles. These were copies of the German cryogenic liquid-propellant V-2 missiles used in World War II. The PRC quickly acquired more advanced missiles in the form of the R-2 in 1957. The R-2 had considerable technical improvements over the R-1, including a greater range and a larger payload, as well as the use of storable liquid propellants.

In addition to the ballistic missiles themselves, the Soviet Union provided the PRC with blueprints for the R-2 missiles, and with advisors to assist in the PRC's development of a copy of the R-2. With this Soviet technical assistance, the PRC was able to produce and deploy these missiles.

During this period, PRC engineers and students received training at the Moscow Aviation Institute (MAI). While at MAI, these students were trained in aeronautical engineering, and acquired experience with more advanced Soviet missiles such as the SS-3 and the SS-4. In many instances, the information gained about more advanced Soviet missiles came when the students made copies of restricted notes, and quizzed their professors about the Soviet missiles.

In 1960, the Sino-Soviet split ended all cooperation, including missile cooperation, between the PRC and the Soviet Union. This left the PRC to continue its missile programs on its own, using the know-how it had gained from the Soviet Union, and the expertise of its American-trained scientists.

The Role of Qian Xuesen in the Development Of the PRC's Ballistic Missile and Space Programs

The PRC's ballistic missile and space programs received substantial assistance during their early development from Qian Xuesen (also known as Tsien Hsue-Shen), a Chinese citizen who was trained in the United States and had worked on classified U.S. missile programs, including the Titan intercontinental ballistic missile program.

Qian Xuesen became instrumental in the PRC's ballistic missiles program, where he is known as the "father of China's ballistic missile force." A biography of Qian published in the PRC states that he "made significant contributions to the rapid development of Chinese rockets [and] missiles, as well as space flight."[3]

Born in Shanghai in 1911, Qian left China in 1935 during the Japanese occupation. He received his Masters degree from the Massachusetts Institute of Technology (MIT) and his Ph.D. from the California Institute of Technology (Cal Tech). At Cal Tech, Qian worked as a member of the rocket research group of the Guggenheim Aeronautical Laboratory, and at the Jet Propulsion Laboratory (JPL).

While at the Guggenheim Aeronautical Laboratory he made "pioneering contributions" to aviation engineering theory in the areas of supersonic and transonic aerodynamics, as well as thin shell stability theory for ballistic missile structures.[4]

Qian Xuesen is known as the "father of the PRC's ballistic missile force." Once a Colonel in the U.S. Army Air Force, Qian eventually worked on America's Titan ICBM (*right*) before returning to the PRC in the early 1950s amid charges that he was a PRC spy. Qian later helped design the PLA's nuclear-armed CSS-4 ICBMs that are currently targeted at the U.S.

At JPL, Qian was recognized as one of the world's foremost experts on jet propulsion. During this time, he worked on Private A, which was the first solid propellant missile that performed successfully in the United States.[5]

Based on his rocket work at Cal Tech, Qian was recruited to join the U.S. Army Air Force in the development of its long-range missile programs.[6] Commissioned a Colonel in the U.S. Army Air Force,[7] he eventually began working on the Titan intercontinental ballistic missile.[8]

During the 1950s, allegations arose that Qian was spying for the PRC.[9] He lost his security clearances and was removed from work on U.S. ballistic missiles.[10] The allegations that he was spying for the PRC are presumed to be true.

Qian was invited back to the PRC and, after negotiations between the U.S. Government and the PRC, Qian was allowed to return to the PRC in 1955. Four other Chinese members of Qian's Titan design team also returned with him to the PRC.[11]

There were additional allegations that Qian attempted to ship classified documents to the PRC before he left in 1955.[12]

Once back in the PRC, Qian became the leading figure in the PRC's ballistic missile effort.[13] Qian and his associates were able to apply the knowledge they gained from working on U.S. ballistic missile programs to the PRC's ballistic missile programs.

Qian became the chief project manager in all of the PRC's ballistic missile programs, and was the lead designer of the CSS-4 intercontinental ballistic missile. The CSS-4 is the nuclear-armed ICBM currently targeted on the United States. (All but two of the PRC's approximately 20 CSS-4 ICBMs have been deployed during the 1990s.)

Qian was also the first director of the PRC's Fifth Academy, which was responsible for aeronautics and missile development research.[14] Today, the Fifth Academy is known as the China Aerospace Corporation (CASC), and its current Director is PRC Minister Liu Jiyuan.[15]

Qian was also instrumental in the development of the PRC's space program. In 1958, he began presenting his concepts for a satellite to the Communist Party leadership. In 1962, Qian began training PRC scientists in the design and development of satellites. The satellite, which would become known as the Dong Fang Hong-1, was launched on April 24, 1970. Qian was personally commended by Mao Zedong and other PRC leaders for his contributions to the design and launch of the satellite.[16]

The CCP leadership awarded Qian the honorary rank of Lieutenant General in the People's Liberation Army. It is a rank commensurate with his place as a senior scientist in the PRC's ballistic missile program.[17]

In 1991, President Jiang Zemin provided Qian with the "State Scientist of Outstanding Contribution" award, which is the highest honor a scientist in the PRC can achieve.[18]

Development of the PLA's Intermediate- and Short-Range Ballistic Missiles

The PRC began developing three ballistic missiles in the early 1960s. The first two, which would become known in the West as the CSS-2 and CSS-3, showed strong Soviet design influences, especially in the guidance and propulsion subsystems. The

PRC Ballistic Missiles

U.S. Designator	CSS-2	CSS-3	CSS-4	CSS-5/ JL-1	CSS-6	CSS-X-7	CSS-8	DF-31	JL-2
PRC Designator	DF-3	DF-4	DF-5	DF-21	DF-15	DF-11	8610	DF-31	JL-2
Range (in miles)	1,926	3,417	7,457	1,119	373	186	143	4,871	4,871
Propellant Type	Liquid	Liquid	Liquid	Solid	Solid	Solid	Solid/ Liquid	Solid	Solid

The PRC began developing its ballistic missile system in the early 1960s. The first missile, the CSS-2, showed strong Soviet design influences. Launched from mobile launchers, it has a range of up to 1,926 miles. The CSS-3 was the PRC's first intercontinental range missile, but with a range of 3,417 miles it cannot reach the United States. The CSS-4 is the PRC's main ICBM threat against the U.S. With a range in excess of 7,457 miles, it can hit most of the U.S. During the 1990s, the PRC has deployed approximately 20 CSS-4s in silos, most of which are targeted at the U.S. An improved version of the CSS-4, known as the CSS-4 Mod 2, could allow the PRC to deploy multiple warheads.

third missile, which would become known as the CSS-4, uses advanced gyroscopes for increased accuracy. The chart on the previous page illustrates current and future PRC ballistic missile systems.

The **CSS-2** mobile missile is designated by the PLA as the Deng Feng 3 (that is, **East Wind 3**). It has evolved into a 1,700- to 1,900-mile range single-stage liquid-propellant ballistic missile. The PLA deploys CSS-2 ballistic missiles on mobile launchers. The PRC sold several dozen of these CSS-2 missiles, armed with conventional warheads, to Saudi Arabia in 1988.

Associated Press

The CSS-2, manufactured in the early 1960s, was among the PRC's first ballistic missiles. It showed strong Soviet design influences, especially in the guidance and propulsion subsystems.

The **CSS-3** (PLA designation DF-4, or **East Wind 4**) was the PRC's first missile with "intercontinental" range. The CSS-3 is a two-stage liquid-propellant intercontinental ballistic missile. It has a range of more than 3,400 miles,[19] but is considered a "limited range" ICBM because it cannot reach the United States. It uses the medium-range CSS-2 as its first stage. Targets for the PLA's CSS-3 missiles could include:

- **India**
- **Russia**
- **The U.S. Naval Facility at Diego Garcia**
- **The U.S. Air Force Base at Guam**

The CSS-3 missiles are based in silos, and in mountainside tunnels where they are rolled out and erected for launch.[20] The CSS-3 missile has been deployed by the PLA since 1980.[21]

The PLA's Current "East Wind" Intercontinental Ballistic Missiles

The **CSS-4** (PLA designation DF-5, or **East Wind 5**) is currently the PRC's main ICBM nuclear threat against the United States.

The CSS-4 program began in the 1960s. It was originally envisioned that the missile would use liquid oxygen and kerosene propellants, similar to those used in the Soviet R-7 (SS-6) missile and in the U.S. Atlas. In the early 1960s, however, the program transitioned into the use of storable propellant.

Progress in the CSS-4 program was slowed by the Great Leap Forward in 1963 and the Cultural Revolution from 1966-1976, which compounded the technical challenges of developing an ICBM. The CSS-4's development program continued to progress over the next 20 years.

The PRC first attempted a flight test of the CSS-4 in the 1970s. Following several flight test failures, the PRC continued its development of the CSS-4 through its development of the Long March 2 rocket. Of the next nine Long March 2 launches from 1973 through 1978, five were successful.

The CSS-4 uses nitrogen tetroxide (NTO) as the oxidizer and a lightweight, aluminum-copper alloy airframe. It is equipped with four YF-20 engines in its first stage, and a single YF-20 engine in its second stage. Unlike previous PRC missiles that use jet vanes in the exhaust for steering control, the CSS-4 uses steerable exhaust nozzles for control. It has been reported to the Select Committee that the CSS-4 uses a gimbaled guidance system for control.[22]

Starting in 1981, the PRC began deploying CSS-4 missiles in silos. Only two operational missiles were deployed in the 1980s, on what the PRC called "trial operational deployments."

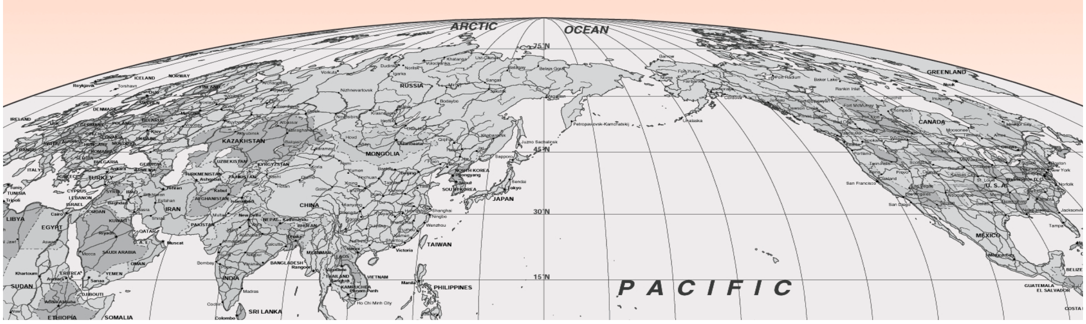
The CSS-4 is the nuclear-armed ICBM currently targeted at the United States. Of the approximately 20 of these ICBMs in the PLA arsenal, all but two were deployed during the 1990s, and most are targeted at the United States.

During the 1990s, the PRC has deployed a total of approximately 20 CSS-4 ICBMs in silos, most of which are targeted on the United States. The Select Committee judges that despite the 1998 announcement that the PRC and the U.S. would no longer target each other with nuclear weapons, the PRC's missiles remain targeted at the United States.

Approximate Distances to Selected Targets in the U.S. and Europe Within Range of the PRC's CSS-4 ICBM

(Distances measured using Great Circle arcs from latitude 35.09N, longitude 112.37E, the area in which PRC CSS-4 silos are reportedly located)

CITY	DISTANCE IN MILES
Anchorage	4,392
Honolulu	5,370
Seattle	5,788
Los Angeles	6,641
Chicago	6,982
Detroit	7,006
Boston	7,096
St. Louis	7,151
New York	7,200
Washington, D.C.	7,301
Dallas	7,613
Moscow	3,707
London	5,216
Paris	5,244



Today, the CSS-4 has a range in excess of 7,400 miles. The PRC has begun deploying an improved version of the CSS-4, known as the **CSS-4 Mod 2**.[23] The Mod 2 has improved range capabilities over the CSS-4. The additional range may provide the PRC with greater confidence that the missile will reach long distance targets such as Washington, D.C., although this and other U.S. cities are already within the range of the CSS-4.

This improved range may also translate into an improved throw-weight that could allow the PRC to deploy multiple warheads on the CSS-4 Mod 2, rather than the single warheads that are currently carried on the CSS-4.

The PLA's Future "East Wind" Intercontinental Ballistic Missiles

Missiles in silos are vulnerable to attack because their precise location can be known in advance. Concerns about the survivability of its silo-based CSS-4 ballistic missile forces have led the PLA to begin a modernization program that includes the development of road-mobile, solid-propellant ballistic missiles.

The use of a solid-propellant missile in place of the liquid-fueled CSS-4 will permit the PRC to launch its missiles with shorter notice. That is because the liquid fuel for the current CSS-4 must be stored separately from the missile until launch. Then, prior to launch, the CSS-4 missile must be fueled.

Substitution of a mobile missile for the silo-based CSS-4 will make it possible to hide the missile's location, thus protecting it from attack.

The PLA is currently developing two road-mobile intercontinental ballistic missile systems. It also has under development a submarine-launched ballistic missile. The Select Committee judges that within 15 years, this modernization program could result in the deployment of a PLA intercontinental ballistic missile force consisting of up to 100 ICBMs.

The PRC's planned new mobile intercontinental ballistic missiles, and its planned new submarine-launched intercontinental ballistic missiles, require smaller warheads than the large, heavy, 1950s-era warheads developed for the PRC's current silo-based missiles. Because U.S. thermonuclear warheads are significantly smaller, they are capable of use on mobile missiles and submarine-launched missiles. The Select Committee judges that the PRC will exploit elements of the stolen U.S. thermonuclear warhead design information on these new ICBMs.

If any of the PRC's planned missiles were to carry multiple warheads, or if the CSS-4 were modified to carry multiple warheads, then a fairing (that is, a covering for the missiles in the nose cone) could be required. See the chapter entitled *Satellite Launches in the PRC: Hughes* for a discussion of the PRC's acquisition of fairing technology from the United States.

The aggressive development of a MIRV system by the PRC could permit the deployment of upwards of 1,000 thermonuclear warheads on ICBMs by 2015. See the chapter entitled *PRC Theft of Thermonuclear Warhead Design Information* for information on the PRC's development of nuclear warheads that may exploit elements of U.S. thermonuclear weapons design information.

The first of the three new intercontinental ballistic missiles that are being developed by the PRC is the **DF-31** (or **East Wind 31**). It is estimated that the DF-31 will be a three-stage, mobile, solid-propellant ballistic missile. It will be deployed on a mobile erector-launcher.

The DF-31's 5,000-mile range will allow it to hit all of Hawaii and Alaska and parts of the state of Washington, but not other parts of the continental United States.[24] Due to its limited intercontinental range, the DF-31 is most likely intended as the replacement for the PRC's aging CSS-3 force, rather than for the longer range CSS-4 ICBM.

The DF-31 missile may be tested this year. Given a successful flight program, the DF-31 could be ready for deployment as early as 2002.

The collapse of the Soviet Union has changed the PRC's strategic outlook, prompting the development of extended range missiles. To this end, the PRC is planning an even longer-range, mobile ICBM to add to its already deployed CSS-4 missiles. This new missile is believed to have a range of more than 7,500 miles, allowing the PRC to target almost all of the United States. These missiles can be deployed anywhere within the PRC, making them significantly more survivable.

The **JL-2** (Julang 2, or **Great Wave 2**) is a submarine-launched version of the DF-31. It is believed to have an even longer range, and will be carried on the PLA Navy's Type 094-class submarine. 16 JL-2 missiles will be carried on each submarine.[25]

The JL-2's 7,500 mile range will allow it to be launched from the PRC's territorial waters and to strike targets throughout the United States.[26]

This range would allow a significant change in the operation and tactics of the PRC's nuclear-powered ballistic missile submarines. Instead of venturing into the open ocean to attack the United States, the Type 094-class submarines could remain near PRC waters, protected by the PLA Navy and Air Force.

Additionally, if the JL-2 were to employ a shroud to protect its warhead as do the majority of submarine-launched ballistic missiles today, this would be the first use of a shroud or fairing on a PRC missile.

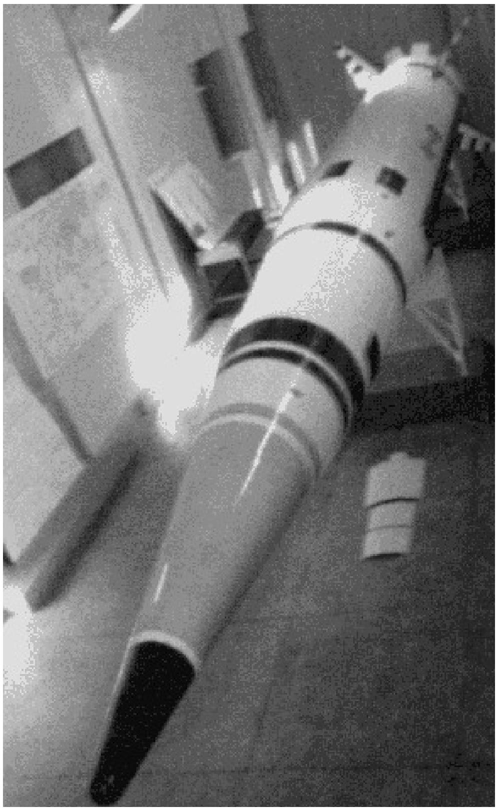
The PRC's Medium- and Short-Range Ballistic Missiles

The PRC is also deploying, or developing for future deployment, a series of short- and medium-range ballistic missiles, including both liquid- and solid-propellant technologies. Some are armed with conventional warheads and others with nuclear warheads. These missiles present a threat to U.S. forces deployed in the region, and to U.S. allies and friends in the region.

The PRC's short- and medium-range ballistic missiles include the CSS-6 short-range ballistic missile, the CSS-X-7 short-range ballistic missile, and the CSS-5 medium-range ballistic missile. The PRC is also developing new versions of its short-range ballistic missiles, and may produce these systems in larger quantities than earlier-generation PRC ballistic missiles.

The PLA's CSS-6 (DF-15 or East Wind 15; also known as the M-9) is an advanced, solid-propellant, short-range ballistic missile that uses 1990s technology. It has a range of 375 miles. It is a road-mobile missile, launched from a transporter-erector-launcher. The CSS-6 may be fitted with nuclear warheads or with an enhanced radiation weapon (neutron bomb).

Janes Defense Group



The CSS-6 ballistic missile is an advanced, solid-propellant short-range weapon that uses 1990s technology. It may be fitted with either strategic nuclear warheads or neutron bomb warheads. The majority of the PLA's CSS-6 missiles are deployed adjacent to Taiwan.

According to published reports, the majority of the PRC's CSS-6 missiles are deployed adjacent to Taiwan.

The PRC may attempt various means to improve the CSS-6's accuracy. The PRC claims to be planning to use the Global Positioning System (GPS) on its "M" missiles, which likely include the CSS-6, CSS-X-7, and other short-range ballistic missiles.

On two recent occasions, the PRC has launched a number of CSS-6 missiles towards Taiwan as a means of political intimidation. In July 1995, the PRC fired CSS-6 missiles to a location north of Taiwan in an attempt to influence Taiwan's parliamentary elections. In March 1996, the PRC again launched CSS-6 missiles to areas north and south of Taiwan's two major ports in an effort to influence its presidential elections.

The PRC is also developing the **CSS-X-7** (DF-11 or **East Wind 11**; also known as the M-11) short-range ballistic missile. The CSS-X-7 is a mobile, 185-mile range solid-propellant ballistic missile that is launched from a transporter-erector-launcher. This missile has been exported to Pakistan. The main advantage of the CSS-X-7 over the CSS-6 is its ability to carry a larger payload.

The CSS-5 (DF-21, or East Wind 21) medium-range ballistic missile is now deployed by the PRC. The CSS-5 is a road-mobile, solid-propellant ballistic missile with a range of 1,100 miles. The CSS-5 is assessed to carry a nuclear warhead payload. An improved version, known as the **CSS-5 Mod 2**, is under development in the PRC. The range of these missiles, if fitted with a conventional warhead, would be sufficient to hit targets in Japan.

The CSS-5 has also been developed in a submarine-launched ballistic missile version. The Western designation of this missile is **CSS-NX-3**; its PLA designation is **JL-1** (Julang 1, or **Great Wave 1**). This missile is assessed to have a range of 1,200 miles. Missiles of this type will be launched from the PLA Navy *Xia*-class nuclear-powered ballistic missile submarine.

While the *Xia* submarines were completed in 1981, the PRC has yet to deploy the CSS-NX-3 missile.[27] Due to the missile's 1,000-mile range, the CSS-NX-3 is best suited for theater targets, although it could threaten the U.S. if the PRC chose to deploy it in open-ocean operations.

The PRC has also developed the **CSS-8** (8610) short-range ballistic missile. The CSS-8 is derived from the Soviet SA-2 surface-to-air missile. The PRC has sold the missile to Iran.

The PRC's CSS-NX-3 ballistic missile will be launched from the PLA Navy's Xia-class submarines (*above*). With a range of more than 1,000 miles, the ballistic missile could threaten the U.S. if the PRC chose to deploy it in open-ocean operations. The CSS-NX-3 is best suited for theater targets.


AV
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The PRC has stolen American guidance technology used on a variety of U.S. military hardware, including the F-15 (*above, left*), F-16 (*below, left*), and F-117 "stealth" aircraft (*above*).

Stolen U.S. Technology Used on PRC Ballistic Missiles

The PRC has stolen U.S. missile guidance technology that has direct applicability to the PLA's ballistic missiles and rockets. The stolen guidance technology is used on a variety of U.S. missiles and military aircraft:

- **The 90-mile range U.S. Army Tactical Missile System**
- **The U.S. Navy's Stand-off Land Attack Missile-Extended Range (SLAM-ER)**
- **The U.S. Navy F-14 fighter jet**
- **The U.S. Air Force F-15 fighter jet**
- **The U.S. Air Force F-16 fighter jet**
- **The U.S. Air Force F-117 fighter jet**

The PRC's Strategic Forces Doctrine

Following the detonation of its first nuclear weapon in 1964, the PRC publicly declared that it would never use nuclear weapons first against the homeland of a nuclear power or a non-nuclear nation. The PRC pointedly does not include Taiwan in this formulation. The PRC's announced strategic doctrine is based on the concept of "limited deterrence," which is defined as the ability to inflict unacceptable damage on an enemy in a retaliatory strike.[28]

The PRC's currently deployed ICBMs are so-called "city busters": that is, they are useful for targeting entire cities or large military bases, rather than smaller, hardened targets such as U.S. ICBM silos. The intercontinental-range CSS-4s are deployed in their silos without warheads and without propellants during day-to-day operations.[29]

Strategic doctrine, however, can change, and the PRC's movement towards a nuclear missile force of several kinds of mobile, long-range ballistic missiles will allow it to include a range of options in its nuclear force doctrine. The acknowledged high accuracy of U.S. ballistic missiles, as well as the large number of increasingly accurate Russian missiles, may have left the PRC unsatisfied with the vulnerability of its silo-based forces. The PRC's new mobile missiles will be difficult to locate once they have been dispersed from their garrisons, giving them far better protection from attack. These new, mobile, long-range missiles can also be launched on much shorter notice than the PRC's current force, due to their planned use of solid propellants.

Because they will be much more difficult to locate and destroy than the PRC's current silo-based ICBM force, these new mobile ICBMs will present a more credible threat against the U. S. in the event a crisis develops over a regional conflict in East Asia.

According to the Commission to Assess the Ballistic Missile Threat to the United States:

> *In a crisis in which the U. S. confronts China's conventional and nuclear forces at the regional level, China's modernized strategic nuclear ballistic missile force would pose a credible threat against the United States.*

Deterring the U. S. can be important to China's ability to use force to achieve its goal of being the preeminent power in East Asia.

China demonstrated a willingness to use ballistic missiles in the Taiwan crisis of 1995/96.

The question of a senior Chinese official — was the U. S. willing to trade Los Angeles for Taiwan — suggests their understanding of the linkage between China's regional and strategic ballistic missile capabilities.[30]

The deployment of the PRC's new nuclear-powered ballistic missile submarine could also lead to a shift in PRC doctrine, as these submarines will likely be deployed with their nuclear warheads already mated to the missiles. The long range of the JL-2 submarine-launched intercontinental ballistic missile will allow the PRC to conduct patrols close to its base, and under the protective cover of the PLA Navy and Air Force. This would provide the PLA submarine fleet with a more survivable nuclear force.

The fact that these new nuclear weapons will be far more survivable than the PRC's current silo-based forces could signal a major shift in the PRC's current nuclear strategy and doctrine.

The PRC might allow the first use of nuclear weapons on its own territory, which the PRC views as including Taiwan.

The PRC has tested an enhanced radiation weapon (neutron bomb) that minimizes blast effects, while maximizing human casualties. The PRC probably originally developed the neutron bomb for use on its own territory against invading Soviet forces. Similarly, the neutron bomb would be useful in a conflict with Taiwan, since the PRC undoubtedly would intend to occupy the territory it was attacking. The PRC may have plans to deploy neutron bombs.

These enhancements to the PRC's nuclear forces, together with its expanding economic capabilities, present the PRC with additional options for changes in its strategic doctrine. The PRC's growing economy, for instance, could allow it to produce and deploy more missiles than earlier planned. Additionally, the Select Committee judges that if the PRC made a decision to do so, it could build multiple warheads for its ballistic missiles.

Moreover, the PRC's concerns about the vulnerability of its nuclear weapons could lead the PRC to develop an early warning system in order to support a launch-on-warning posture.

The secretive nature of the Chinese Communist Party's Central Military Commission, as well as the PLA's other decision-making bodies, means that changes in PRC nuclear force doctrine may not be apparent.

Clearly, the PRC views its conventional ballistic missile forces as potential weapons for use during regional conflicts. This strategy was implied by the PRC in the course of its CSS-6 short-range ballistic missile exercises during the March 1996 presidential elections in Taiwan. During the exercise, the PRC launched four CSS-6 ballistic missiles towards points north and south of Taiwan's major ports.

The PRC's Opposition to U.S. Missile Defenses

Statements by PRC Government officials make it clear that the PRC is opposed to the development of either theater or national missile defense systems that could counter Beijing's nuclear forces.

If the PRC were intent upon overwhelming these defenses, there are several options it could take in an attempt to preserve the offensive capability of its missile forces.

One of the PRC's responses could be to expand the size of its ballistic missile force, to increase the chances that some of its nuclear weapons overcome a nation's defenses. This would be an expensive option requiring the PRC to invest in the production of significant additional missiles and infrastructure.

A cheaper response to U.S. missile defenses for the PRC could be the development of penetration aids (PENAIDS) for its ballistic missiles. These PENAIDS could include:

- **Decoys** that create multiple radar targets, which must be tracked until discrimination of the actual nuclear warhead can be accomplished. Simple decoys are effective during exoatmospheric flight of the nuclear warhead, but burn up during reentry into the atmosphere.

- **Chaff** consisting of aluminum strips that are designed to reflect radar beams, thereby confusing a radar as to the location of the PLA warhead.

- **Jammers** used to jam the radar system during the flight of the PLA nuclear warhead.

- **Radar absorbing materials,** which can also be used to reduce the radar cross section of the PLA nuclear warhead.

- **The PLA nuclear warhead itself could be reoriented** to present the lowest radar cross section.[31]

The PRC is expected to pursue one or more PENAIDs in connection with its new nuclear missiles.

Given the PRC's aggressive opposition to missile defenses, the Select Committee judges that the PRC is collecting information about U.S. missile defense systems in order to help its development of PENAIDS.

Another option for countering U.S. missile defenses would be the development of a maneuvering reentry vehicle (MARV). The maneuvering capability could be used to complicate hit-to-kill or conventional warhead ballistic missile defense systems.

The PRC could also develop multiple independently-targetable reentry vehicles (MIRVs) or multiple reentry vehicle (MRV) platforms. This would effectively increase the size of the PLA's nuclear force without the full expense required to deploy additional missiles. The PRC's theft from the United States of design information for the W-88 miniaturized nuclear warhead makes it possible that existing or future PLA missiles, which might have been too small in diameter to carry multiple warheads, could now do so.

Furthermore, existing PLA missiles, including the CSS-4 Mod 2, could be capable of carrying the new, smaller warheads in a MIRV or MRV configuration. Within a short period of time after a decision to proceed, the PRC has the ability to deploy missiles with multiple reentry vehicles (MIRVs or MRVs). The PRC has demonstrated similar concepts and technologies in the Smart Dispenser that it developed to place multiple Iridium satellites into orbit. The Select Committee did not, however, review sufficient evidence to permit a judgment whether the PRC will in the future decide to deploy a MIRV or MRV system.

THE IRIDIUM SMART DISPENSER CONTROVERSY

In May 1998, allegations were made that Motorola had provided the PRC with technology that would allow it to build a multiple, independently targetable reentry vehicle (MIRV) missile-dispensing platform. The allegations were that the Smart Dispenser used by the PRC to place two Iridium communications satellites into orbit would provide the PRC with technology that would be directly applicable to MIRV dispensing.[32]

The Smart Dispenser is an on-orbit maneuvering stage with its own independent guidance system. The Select Committee has determined that Motorola did not provide the PRC with information on how to design the Smart Dispenser; rather, the PRC built the Smart Dispenser indigenously to Motorola's specifications. However, the Select Committee's independent technical expert noted that the PRC has demonstrated all of the techniques that are required for developing a MIRV bus, and that the PRC could develop a MIRV dispensing platform within a short period of time after making a decision to proceed.

The PRC's Acquisition of Foreign Ballistic Missile Technology

The PRC constantly searches for technology for its ballistic missile programs. Any technology or know-how that the PRC can acquire from foreign sources will save the PRC time and money in the development of its future weapons systems.

The prospect of ballistic missile and nuclear weapons cooperation between Russia and the PRC would be especially troubling because of the advanced technical capabilities of the Russian strategic nuclear forces. Thus far, Russia has been the only nation to deploy a mobile intercontinental ballistic missile force. These missiles include the road-mobile solid-propellant SS-25 ICBM and the rail-mobile SS-24 ICBM. Any cooperation in the area of solid-propellant mobile missiles would clearly benefit the PRC's new road-mobile ICBM programs.

Additionally, the Russians have advanced guidance and control capabilities. Assistance in the guidance and control field could help the PRC improve the accuracy of its current and future missile forces.

Furthermore, the Russians have the ability to mass-produce large, solid-propellant missiles. The manufacturing capabilities for these missiles could help the PRC produce large numbers of its next generation ICBMs. Russia's use of advanced solid-propellant materials could benefit the PRC's ICBM and submarine-launched ballistic missile programs, allowing them to build lightweight, longer-range ballistic missiles.

The Russian designer of the SS-X-27 has claimed that the missile's advanced penetration capabilities will allow it to defeat any nation's ballistic missile defenses.[33] While the validity of such a statement cannot be judged against a U.S. national missile defense system that is not yet deployed, or even finally designed, Russia's provision of these presumably advanced penetration technologies to the PRC could assist PRC efforts to counter a U.S. national missile defense system.

While the Select Committee has no evidence that the Russians or any other nation of the former Soviet Union have provided the PRC with complete ballistic missiles or missile subsystems, there have been reported instances of the PRC approaching Russia and Ukraine about acquiring SS-18 and SS-25 intercontinental ballistic missiles. Reportedly, the PRC was turned down.[34]

The PRC's Indigenous Ballistic Missile Design Capabilities

The PRC is judged to have a fairly sophisticated capability to design ballistic missiles and rockets. This assessment is based on the fact that the PRC is able to develop missiles and rockets that are capable of delivering large payloads to their intended destination with reasonable accuracy and reliability. However, these design capabilities are not in all cases as sophisticated as those of Western nations.

The Select Committee's independent technical expert noted that while PRC scientists and engineers may have a textbook understanding of problems, there is a difference between a textbook understanding and the application of this knowledge to specific problems. Interactions with U.S. and foreign scientists and engineers, therefor, could assist the PRC engineers and scientists in overcoming these limitations.

PRC Missile Proliferation

The PRC is one of the world's leading proliferators of complete ballistic missile systems, as well as missile components.

Despite the fact that, in 1991, the PRC agreed to adhere to the April 1987 Missile Technology Control Regime (MTCR) guidelines that call for restraint on the sale of missiles capable of delivering a 225-pound payload to 185 miles, the PRC has sold complete ballistic missile systems or missile components to a number of countries, including but not limited to Iran, Pakistan, and Saudi Arabia.[35]

In 1993, the MTCR States issued new expanded guidelines that called for a "strong presumption to deny" both sales of complete missile systems and sales of components that could be used in ballistic missile systems. Furthermore, the new guidelines call for restrictions on transfers of missiles that can deliver a weapons of mass destruction payload to 185 miles.[36] However, the PRC has accepted neither these revised guidelines, nor the annex on the transfer of components and other commodities such as propellants and test equipment.[37]

Notwithstanding the PRC's purported adherence to the MTCR Category I restrictions, the PRC has provided, or is providing, assistance to the missile and space programs of Iran, North Korea, Pakistan, Saudi Arabia, and other countries. The PRC also continues to offer Category II missile components for sale to international customers. In addition, the PRC has provided assistance to the nuclear programs of Iran and Pakistan.

Iran

During the 1990s, the PRC sold Iran significant numbers of 90-mile range CSS-8 ballistic missiles, along with associated support equipment. In addition, PRC companies provided Iran with ballistic missile production technology. The PRC also reportedly sold Iran guidance components,[38] and more recently telemetry equipment,

Eight Versions of the Long March in Use Today by the PRC

Since 1970 the PRC has launched 12 different versions of the Long March rocket. The eight rockets depicted above, plus one not shown, are in use today. Three new versions of the rocket are said to be in development.

The PRC's early efforts were aided by technology and knowledge transferred from the Soviet Union.

From that beginning, the PRC has developed a comprehensive space program that includes a family of rockets, numerous satellites, and a telemetry, tracking, and control network. These efforts have paid off, as the PRC is now a major space power. It offers international launch services and is working on placing men in space.

The PRC's first satellite launch occurred on April 24, 1970, using a CSS-3 intercontinental ballistic missile. The ICBM was modified by adding a third stage, which was used to place the satellite into orbit. This new rocket was named the **Long March 1**.

The 380-pound satellite it carried was named Dong Fang Hong-1 (East Is Red 1). The satellite orbited for approximately 26 days, transmitting to Earth the song "The East is Red." [45]

After the PRC's second successful launch of a satellite on March 3, 1971, again using the modified CSS-3 ICBM, the PRC set out to launch heavier payloads into orbit. For this purpose, the PRC turned to the longer-range, more powerful CSS-4 ICBM. This rocket was named the **Long March 2**.

The first three launches of the Long March 2 rocket, from 1973 through 1974, were failures. Finally, on July 26, 1975, the PRC successfully launched the **Long March 2C** and placed its third satellite into orbit.

During the balance of the 1970s, the PRC launched nearly a dozen satellites on the Long March 2, many of which undoubtedly were for military purposes. Nearly half of these launches were unsuccessful, however, resulting in the destruction of many payloads.

The Long March 2 and its derivatives are the main rockets used by the PRC today, in both its military and civilian space programs. Because the Long March 2 was derived directly from the CSS-4 intercontinental ballistic missile, the two share much in common. The Long March 2 rocket and the CSS-4 ICBM use the same airframe structure, the same cluster of four YF-20 engines (known as the YF-21) in the first stage, and the same single YF-22 engine combined with the YF-23 vernier engines that form the YF-24 in the second stage.[46] However, unlike the CSS-4, the Long March 2 was modified to deliver payloads to orbit rather than a nuclear weapon to a target.

In order to meet space launch requirements for heavier payloads and higher orbits, the PRC improved the performance of the Long March rocket. Among other changes, the PRC increased the amount of propellant the rocket could carry, improved the performance of the first and second stage engines, added new cryogenic liquid-propellant third stage engines, and attached additional boosters that were strapped on to the basic rocket. These changes led to the development of three new modifications to the Long March rocket.

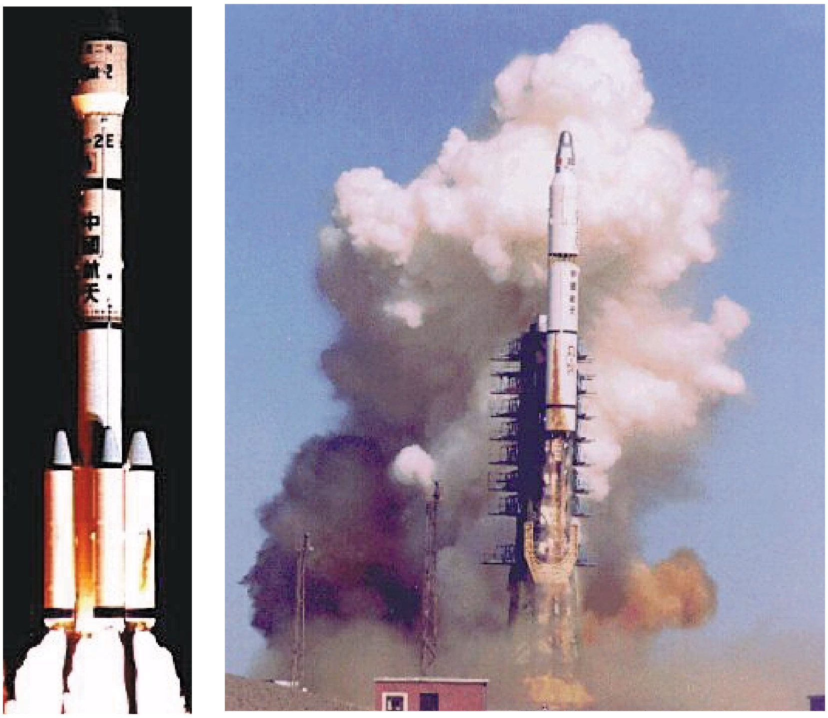
The **Long March 3** was developed in 1977 to meet the requirements for launching communications satellites into geosynchronous orbit. It was the PRC's first rocket built for this purpose.[47] The Long March 3 uses the same first and second stages as the Long March 2C, except that aerodynamic fins are added to the base of the first stage.[48] It also uses the same YF-21 and YF-24 engines.[49] The main change from the Long March 2C is the addition of a restartable, cryogenic liquid-propellant third stage.[50] This stage is designed to boost the payload into a geostationary transfer orbit.

The **Long March 4** was developed by the PRC in the late 1970s to launch meteorological satellites for military and civilian purposes into sun-synchronous orbits. The new rocket used improved first and second stage engines, and a first stage that was 13 feet longer than the standard Long March 2 first stage.[51]

When the PRC announced in 1986 that is was entering the commercial satellite launch market, it decided to develop a rocket that could provide heavy-lift capabilities to low earth orbit. However, the PRC's operational rockets at the time were exceptionally limited in their ability to place payloads in this orbit. The Long March 2C, for example, could only place a 1,350-pound payload into low earth orbit.[52] In comparison, the U.S. Delta 3925 rocket could place 2,140 pounds into low earth orbit. The U.S. space shuttle could transport 15,400 pounds into low earth orbit.[53]

Moreover, the majority of commercial payloads at the time were for geosynchronous satellites.[54] But to place heavy payloads into geosynchronous orbit requires a third stage, which the Long March 2C still lacked, or a satellite perigee kick motor.

To meet the geosynchronous payload lift requirement, the PRC developed the **Long March 2E** rocket, which was first launched successfully in 1992. The Long March 2E uses a stretched version of the Long March 2C first and second stages, increasing the amount of propellant carried, which increases the burn-time of the engines. [55] The Long March 2E also uses improved versions of the YF-20 engines used on the Long March 2C. Known as the YF-20B, these engines offer improved thrust.[56] The Long March 2E also uses four strap-on liquid-propellant boosters. These boosters are attached to the rocket's first stage. Each booster is fitted with a YF-20B engine.



The Long March 2E (*far left*), carrying Hughes satellites, crashed in 1992 and 1995. In the aftermath of those crashes, Hughes engineers worked with the PRC to improve the rocket's fairing, which had twice ripped apart under launch conditions. The Long March 2E uses a stretched version of the Long March 2C (*left*), increasing the burn-time of the engines and adding four boosters.

To permit the Long March 2E to place a satellite into geosynchronous orbit, the PRC mated the satellite payload with a perigee kick motor, which acted as a third stage. Because there was no indigenous PRC kick motor, however, foreign launch customers had to use Western-manufactured kick motors. This required a separate export license. The PRC later developed its own family of kick motors, allowing customers to choose between Western- or PRC-manufactured versions.

Finally, the Long March 2E employs an enlarged "hammerhead" fairing to protect the satellite payloads, which exceed the upper stage's diameter. The Long March 2E can place 5,450 pounds into low earth orbit and 2,140 pounds into geosynchronous transfer orbit.[57]

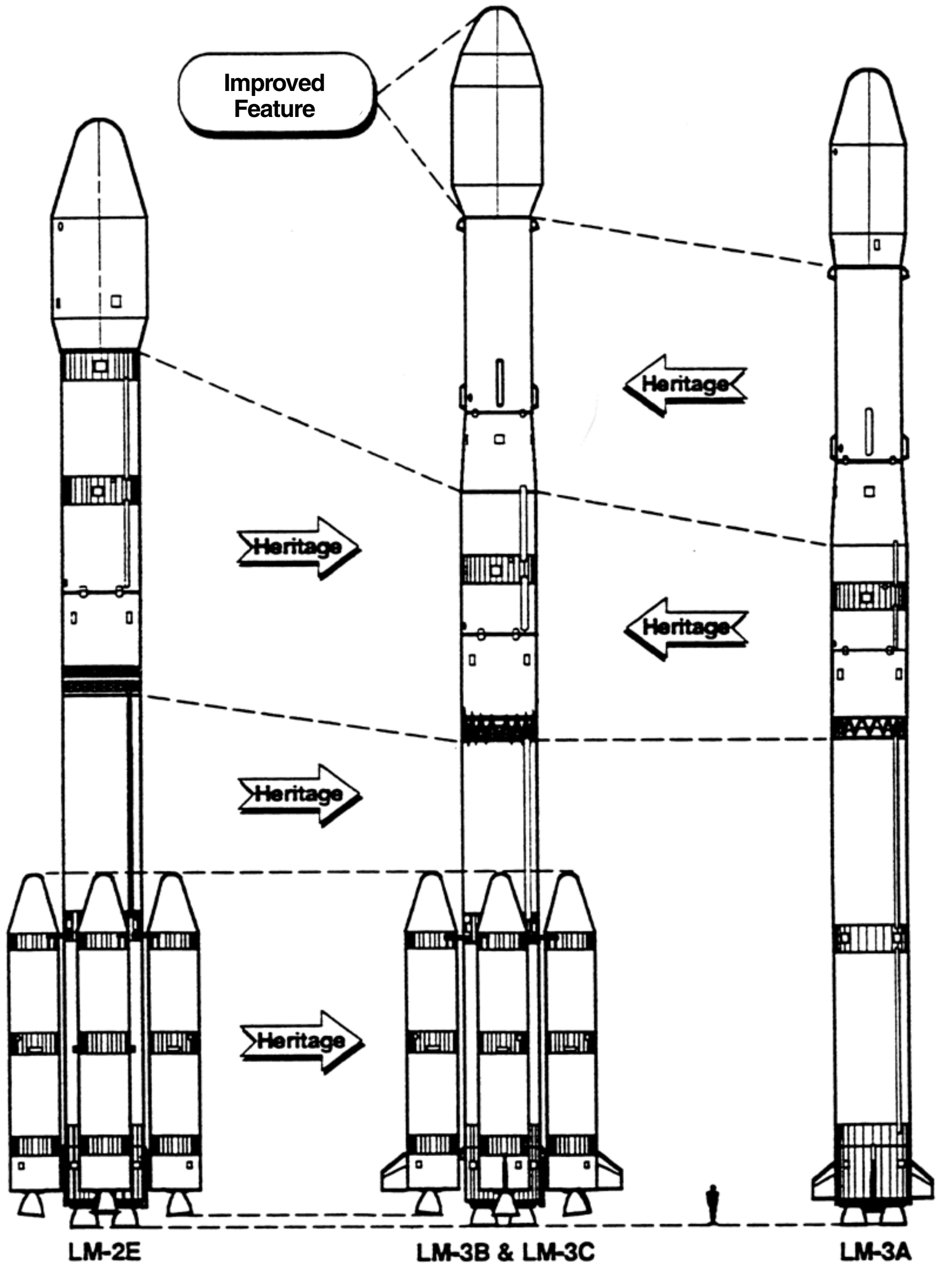
The Long March 2E has suffered a series of in-flight failures (see table overleaf). The December 1992 and January 1995 failures resulted in the destruction of two Hughes-manufactured satellites. The results of the failure analyses conducted by Hughes as a result of these launch failures are discussed in the chapter entitled *Satellite Launches in the PRC: Hughes*.

Launch History of the PRC's Long March 2E[58]

LAUNCH DATE	SATELLITE	MANUFACTURER	OWNER	RESULTS
Jul. 16, 1990	Dummy AUSSAT Satellite and Badr-1	PRC	Dummy AUSSAT Satellite – PRC Badr-1 – Pakistan	Perigee kick motor failed in the Dummy AUSSAT Satellite Badr-1 achieved orbit
Aug. 31, 1992	Optus-B1	Hughes	Optus (Australia)	Success
Dec. 21, 1992	Optus-B2	Hughes	Optus (Australia)	Failure-fairing collapse
Aug. 24, 1994	Optus-B3	Hughes	Optus (Australia)	Success
Jan. 25, 1995	Apstar-2	Hughes	Asia-Pacific Telecommunications (PRC-controlled)	Failure-fairing collapse
Nov. 28, 1995	Asiasat-2	Lockheed-Martin	Asiasat (Hong Kong)	Success
Dec. 28, 1995	Echostar-1	Lockheed-Martin	Echostar Inc. (U.S.)	Success

Two years after the first successful launch of the Long March 2E, the PRC successfully launched the **Long March 3A**, a cheaper, higher performance rocket that would better meet both its military and commercial geosynchronous launch requirements. The Long March 3A was the first of a family of **Long March 3A**, **3B** and **3C** rockets.

The Long March 3A family of rockets uses a strengthened Long March 3 first stage. In the case of the Long March 3B and 3C, this permits the mounting of additional strap-on boosters. The Long March 3A, 3B, and 3C rockets also use a new, lighter weight, and cheaper inertial measurement unit. Furthermore, these rockets employ large "hammerhead" fairings to protect their satellite payloads. The failure analysis of the Long March 3B launch, carrying the Intelsat 708 satellite manufactured by Loral, is discussed in the chapter of this Report entitled *Satellite Launches in the PRC: Loral*.



This illustration shows the design evolution of the Long March 3B and 3C from the LM 2E and LM 3A. The LM 3B incorporates the strap-on boosters from the LM 2E and the third stage from the LM 3A.

Launch History of the Long March 3B Rocket[59]

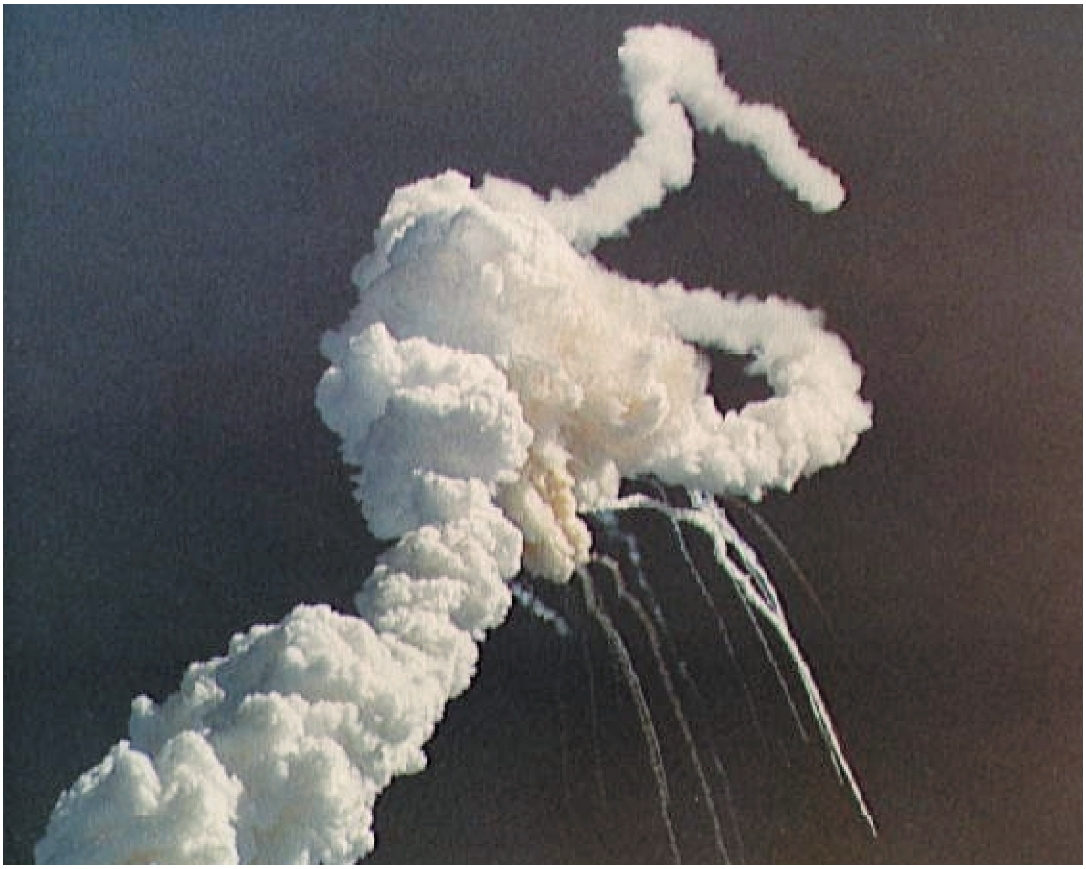
LAUNCH DATE	SATELLITE	MANUFACTURER	OWNER	RESULTS
Feb. 14, 1996	Intelsat 708	Loral	Intelsat	Failure
Aug. 19, 1997	Agila	Loral	Mabuhay Philippines Satellite Company	Success
Oct.16, 1997	Apstar-2R	Loral	APT (PRC-controlled)	Success
May 30, 1998	ChinaStar 1	Lockheed-Martin	China Oriental Telecom Satellite Co. (PRC-controlled)	Success
July 18, 1998	SinoSat	Aerospatial	Sino Satellite Communications Co. (PRC-controlled)	Success

The PRC's Commercial Space Launch Program

The PRC's entry into the commercial space launch market coincided with a dark period for the U.S. launch industry that included the 1985 and 1986 launch failures of several Delta and Titan expendable rockets, and the 1986 explosion of the Space Shuttle *Challenger*. At the time of the *Challenger* accident, the U.S. space launch industry was in the midst of a plan to phase out all expendable rockets in favor of the Space Shuttle, which was projected to be more economical.[60] But that plan was cancelled with the *Challenger* explosion. Instead, the United States imposed a hiatus in shuttle launches until September 1988, and a permanent decision that the Space Shuttle would not be used to launch commercial payloads.[61]

The lack of available U.S. commercial space launch capacity forced satellite manufacturers to seek alternative launch providers. The Soviet Union had the capacity to launch commercial satellites, but U.S. policy would not support the launching of U.S.-manufactured satellites on Soviet rockets. The European consortium of Arianespace had no extra capacity. This left the PRC as the only alternative for launching geosynchronous communications satellites.

In 1987, the United States viewed the PRC as a counterbalance to Soviet military power in Asia. Accordingly, the "Green Line" policy had been adopted to per-



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mit some technology transfers to the PRC, while limiting transfers of technologies that could improve the PLA's ballistic missile and anti-submarine warfare capabilities.[62] In 1988, President Reagan agreed to allow the PRC to launch U.S.-manufactured satellites on the condition that the PRC sign three bilateral agreements with the U.S. on competitive pricing, liability, and the protection of U.S. technology. [63]

The PRC's first success in the commercial market occurred in 1987. In that year, Matra of France contracted with the PRC to place a scientific payload in orbit, using a Long March 2C rocket. These French scientific experiments were launched on August 5, 1987 aboard a PLA military photo-reconnaissance satellite. The recoverable capsules of the PLA's reconnaissance satellites made them an ideal platform for microgravity experiments.[64]

The PRC's first commercial launch of a U.S.-manufactured communications satellite occurred on April 7, 1990. The Asiasat — a Hughes HS 376 model satellite — was launched into orbit aboard a Long March 3 rocket.[65]

From that point, in addition to their military launch schedule, the PRC has attempted 28 launches of Western-manufactured satellites.[66] Of these satellites, 27 were U.S-manufactured: only the French-manufactured Sinosat, launched successfully on July 18, 1998, was produced by a non-U.S. manufacturer.[67] Twenty-three of the PRC's attempts to launch U.S. satellites were successful. Four have ended in failure.[68] These four failures are detailed below.

PRC Commercial Launch Failures

SATELLITE	LAUNCH DATE	ROCKET	FAILURE MODE
Optus B2	Dec. 21, 1992	Long March 2E	Fairing collapse
Apstar-2	Jan. 25, 1995	Long March 2E	Fairing collapse
Intelsat 708	Feb. 15, 1996	Long March 3B	Inertial measurement unit malfunction
Chinasat 7	Aug. 18, 1996	Long March 3	Third stage malfunction

Recently, the PRC has made an effort to sell low-earth orbit satellite launches:

- **The PRC has entered into contracts with Motorola for the launch of Iridium satellites**, including a contract to launch replacement satellites. Iridium satellites have been successfully launched six times on the Long March 2C/SD (that is, the Long March 2C with a "Smart Dispenser" (SD) stage added). The "Smart Dispenser" allows the PRC to launch two Iridium satellites into orbit at a time.

- **The PRC has pursued a contract with Loral for the launch of Globalstar satellites**. The PRC offered a version of its Long March 2E equipped with a "Top Stage" (TS) that would dispense twelve Globalstar satellites. While Loral had originally contracted for a launch on the Long March 2E/TS, it cancelled that contract following the crash of the Long March 3B in February 1996.

The PRC's Future Space Launch Capabilities

The PRC also recognizes the importance of space in future conflicts, for purposes that include both command and control, and military reconnaissance. The PRC is believed to be developing a new, larger rocket that will be able to carry larger payloads into orbit.

PRC papers have discussed the use of cryogenic liquid propellant engines for this future rocket. One of the engines the PRC could use is the RD-120. The PRC is known to have acquired at least one of these engines from Russian during the 1990s.[69] The RD-120 is a liquid oxygen/kerosene engine that is used on the second stage of the Zenit rocket, which is used on the multinational Sea Launch program.

Difficulties with the development of the new engines for this rocket may have prompted the PRC to focus, in the nearer term, on the proposed Long March 2E(A) and Long March 3B(A) versions of the Long March rocket that will utilize improved strap-on boosters to achieve greater payload-to-orbit capability. It should be noted that these are the two systems that were the subject of the failure review investigations in which Loral and Hughes participated. See the chapters *Satellite Launches in the PRC: Hughes and Loral* for a detailed discussion of how these failure reviews assisted the PRC.

PRC Space Weapons

The PRC is believed to be developing space-based and ground-based anti-satellite laser weapons. Such weapons would be of exceptional value for the control of space and information. The Select Committee judges that the PRC is moving toward the deployment of such weapons.

Based on the significant level of PRC-Russian cooperation on weapons development, it is possible that the PRC will be able to use nuclear reactors to pump lasers with pulse energies high enough to destroy satellites.

In addition, Russian cooperation could help the PRC to develop an advanced radar system using lasers to track and image satellites.

The Select Committee judges that the PRC has the technical capability to develop direct ascent anti-satellite weapons. The CSS-2 could be modified for use in this role. This would be similar to the approach taken by the Soviets with their SS-9 ASAT system.

The PRC's Manned Space Program

The PRC has conducted research since the 1950s, including biological and life support research, on placing astronauts into orbit. Pursuant to its 921 Project, the PRC's plans since the 1980s have included concepts for Space Shuttle-like spacecraft, recoverable capsules, and a space station.[70]

In 1996, two PRC astronauts began training at the Gagarin Cosmonaut Training Center, Star City, Russia. The PRC appears set to launch these two astronauts into space sometime this year to mark the fiftieth anniversary of Communist rule in China.

For its manned space program, the PRC will use Soyuz capsules purchased during Yeltsin's visit to the PRC in April 1996. A Soyuz capsule will be carried on top of the Long March 2E, using a payload shroud (that is, a fairing) equipped with a launch escape system. (See the chapter *Satellite Launches in the PRC: Hughes* for a discussion of fairing improvements to the Long March 2E.)

If the PRC is successful in placing men in orbit, it will be only the third nation, after Russia and the United States, to have done this.

The PRC's Communications Satellite Programs

Since the beginning of its domestic communications satellite programs, the PRC has suffered a string of problems with the performance of its communications satellites, as well as the rockets designed to place those satellites into orbit.

During the mid-to-late 1980s, the PRC was able to place four of its communications satellites into geosynchronous orbit. Today, however, the PRC has only one active domestically-manufactured telecommunications satellite on orbit. This satellite has reportedly suffered on-orbit problems that may have reduced its capabilities.[71]

The PRC's inability to place reliable communications satellites (COMSATs) into orbit has created serious gaps in the PRC's satellite communications capabilities, both for civilian and military purposes. The PRC has addressed the greatest part of its satellite communications requirement by leasing communications channels on Western-manufactured communications satellites.

The PRC first began developing its own communications satellites in the early 1970s, based on Western technology. All of these satellites were designed by the China Academy of Space Technology (CAST) for military purposes. They have all been operated by China Satellite Launch and Tracking Control General (CLTC), which is subordinate to COSTIND.[72]

The PRC's inability to design and produce advanced communications satellites has also led it to seek Western components and technology for its domestic communications satellite industry. The Select Committee judges that the use of Western technology cut in half the time required for the PRC to progress from an experimental communications satellite to the advanced DFH-3 satellites, which were first launched in 1994.

The following table shows a chronology of the PRC's history of launching PRC communications satellites.

History of the PRC's Domestic Communications Satellite Launches

PRC SATELLITE	DATE	PRC ROCKET	RESULT
DFH-2	Jan. 29, 1984	Long March 3	Rocket Failure
DFH-2	Apr. 8, 1984	Long March 3	Success
DFH-2	Feb. 1, 1986	Long March 3	Success
DFH-2A	Mar. 7, 1988	Long March 3	Success
DFH-2A	Dec. 22, 1988	Long March 3	Success
DFH-2A	Feb. 4, 1990	Long March 3	Success
DFH-2A	Dec. 28, 1991	Long March 3	Rocket Failure
DFH-3	Nov. 29, 1994	Long March 3A	Satellite Failure
DFH-3	May 11, 1997	Long March 3A	Satellite Problem

The PRC's first generation communications satellite was the **DFH-2** (Dong Fang Hong-2, or **East Is Red 2**). These satellites were designed to provide the PRC with test experience. The satellite design was similar to that used on the Hughes HS376 satellites, employing a spin-stabilized body and a de-spun horn antenna.

The first attempt to launch a DFH-2 satellite, in January 1984, was not successful due to the failure of the Long March 3 rocket that was to carry it into orbit. The second launch attempt on April 8, 1984 successfully placed a communications satellite into orbit. A third DFH-2 satellite was launched on February 1, 1986. This satellite provided communications services until it reached the end of its service life.

In 1988, the PRC launched an improved version of this satellite, known as the **DFH-2A**. The new satellite used the same spin-stabilized body, this time equipped with an improved antenna array that increased the number of communications channels available.

These satellites were able to handle five television channels and 3,000 phone calls simultaneously. The first three of these satellites were named "Chinasats" by the

Janes Defense Group

The DFH-3 (East Is Red 3) is the PRC's most modern communications satellite. It is useful for military communications.

PRC, and were successfully launched twice in 1988 and once in 1990. A fourth DFH-2A satellite launch in 1990 was unsuccessful, when the failure of the rocket's third-stage engine left the satellite stranded in an incorrect orbit.

The PRC's third generation communications satellites, known as the **DFH-3**, are the PRC's most modern communication satellites. The DFH-3 is useful for military communications. These satellites have three-axis stabilized bodies, 24 C-band transponders and are designed to have an 8-year on-orbit life. Due to the increased weight of these satellites as compared to the DFH-2A, the DFH-3 satellites are launched on the more capable Long March 3A rocket.

The first launch of the DFH-3 satellite on November 29, 1994 was unsuccessful when the satellite failed to attain the proper orbit, rendering it useless for its intended communications function.

The PRC's second attempt to launch a DFH-3 satellite on May 11, 1997 successfully placed the satellite into a geosynchronous orbit at 125 degrees east longitude.[73] The PRC, however, reportedly may have suffered problems with the satellite.[74]

The PRC's Use of Foreign Components on Communications Satellites

The PRC's limited communications satellite construction capabilities led it from the first to seek Western manufacturers for reliable components. Even the PRC's most modern communications satellite, the DFH-3, which was first successfully launched in 1997, contains a large number of Western components:

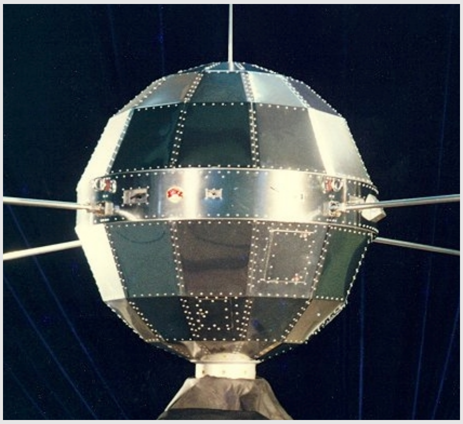
- **The DFH-3 is reported to use a control processor built by Matra-Marconi**[75]
- **Messerschmitt Boelkow Blohm (MBB) provided the DFH-3 solar panel substrates** to the China Academy of Space Technology (CAST), and CAST-produced solar cells were mounted on them. The solar panel assemblies were then returned to MBB for assembly into deployable solar arrays[76]
- **Daimler Chrysler Aerospace Group provided the DFH-3's antenna assembly,** consisting of a deployable dual gridded reflector, feed and interconnecting structure[77]

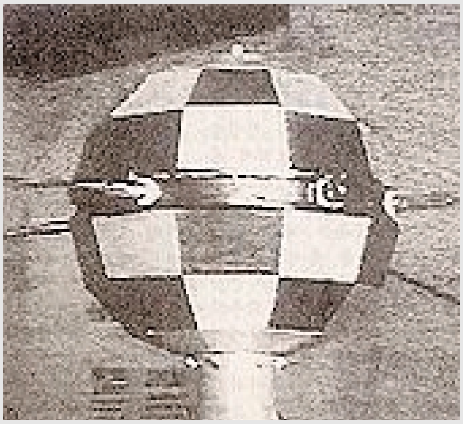
- **Officine Galileo provided the Infrared Earth sensor to determine pitch/roll in geosynchronous orbit**[78]
- **The DFH-3's payload test equipment, according to 1993 reports, consisted of five racks and consoles with 80% U.S. (Hewlett Packard) and German equipment**
- **The equipment racks for the test equipment were provided by Germany's Ant Corporation**[79]

PRC SATELLITE TECHNOLOGY ASSISTANCE AND NORTH KOREA

The PRC, through the China Academy of Space Technology (CAST), provides complete satellites and technology to other nations.

On August 31, 1998, North Korea launched a three stage Taepo Dong-1 ballistic missile. The North Koreans claim to have launched their first satellite, known as Kwangmyongsong No. 1 (Bright Star 1), on this Taepo Dong-1 missile. Comparing the picture of the Kwangmyongsong No. 1 satellite released by North Korea with that of the PRC's Dong Fang Hong 1 satellite (*below*), the two bear a striking resemblance.





Several U.S. companies have also marketed their communications satellite technologies to the PRC. Loral, for example, offered the PRC a direct broadcast satellite (DBS) capability in 1996 using either a Loral-produced satellite bus or the DFH-3 series satellite bus.[80] A 1995 Memorandum of Agreement between Loral and China Aerospace Corporation offered the PRC direct broadcast satellites, regional mobile satellite services systems, and the joint development of an advanced high capacity communications satellite. Under this agreement, Loral would provide design and technical support, while the final integration of the satellite was to have occurred in Germany or the PRC.[81]

Hughes and Loral competed for the Asia-Pacific Mobile Telecommunications (APMT) satellite, and Hughes was awarded the contract. APMT is a Singapore-based, PRC-controlled consortium. At least 51% of APMT is owned by PRC Government agencies, including China Aerospace Corporation, the China Academy of Launch Vehicle Technology, China Satellite Launch and Tracking Control General, and Chinasat, a subsidiary of the PRC Ministry of Post and Telecommunications.[82] See the *Asia-Pacific Mobile Telecommunications Satellite* section of this chapter, below.

The PRC's Reliance on Western Communications Satellites

Due to the failures of the PRC's rockets, and of its satellites, the PRC has become dependent on Western-manufactured communications satellites.

The PRC's dependency began as the early DFH-2A satellites reached the end of their on-orbit lives, while the fourth DFH-2A satellite failed to reach orbit. This created a gap in the PRC's satellite communications capabilities. As a result, the PRC was forced to look to foreign communications satellite manufacturers for supplemental capacity.

In December 1992, the PRC purchased Spacenet 1 on-orbit from GTE to replace its aging DFH-2A/1 and DFH-2A/2 satellites. The PRC renamed it "ChinaSat-5." This satellite was to provide supplemental capabilities until the PRC's first DFH-3 satellite was launched in 1994.

The failure of the PRC's first DFH-3 satellite to reach orbit, and the imminent expiration of the useful life of ChinaSat-5, forced the PRC to purchase a Hughes HS-376 satellite to provide additional communications channels. But this satellite launch in August 1996, aboard a Long March 3 rocket, was also a failure. The third stage left the satellite stranded in an unusable orbit.[83]

The second DFH-3 satellite that the PRC launched in May 1997 reportedly has now developed on-orbit problems.[84]

These failures have left the PRC dependent on Western-manufactured satellites, which it purchases through multinational consortia in which the PRC maintains a controlling interest. These include the Asia Pacific Satellite Telecommunications Co., and China Orient Telecomm Satellite Co, Ltd. Satellites acquired by the PRC in this way include the Apstar-1, Apstar-1A, Apstar-2R, and ChinaStar-1.

It is likely that these failures have made the PLA dependent on Western communications satellites as well.

PRC Use of Very Small Aperture Terminals (VSATs)

The PRC has acquired Western-manufactured very small aperture terminals (VSATs) that could be used for military satellite communications.

VSATs are small satellite communications antennas used to transmit voice, data, video, fax, and computer-to-computer communications between multiple users. One VSAT terminal can be used to transmit communications from multiple users to different recipients via communications satellites.

The small size of VSAT terminals allows easy transportation between different locations and assembly in remote areas. These VSAT networks could improve the PLA's military command and control capabilities, by allowing mobile, reliable communications virtually anywhere.

The majority of VSAT terminals in use today in the PRC are U.S. manufactured. Hughes is by far the largest provider of VSAT networks to the PRC. The other significant U.S. supplier is Scientific Atlantic. Other providers include NEC of Japan and Spar of Canada.[85]

The PLA's Reconnaissance Satellite Program

The PLA has developed a photo reconnaissance satellite, known as the **FSW** (for Fanhui Shi Weixing, or **Recoverable Test Satellite**). The current version of the Recoverable Test Satellite uses a recoverable capsule similar in concept to those used in the early U.S. Corona program. This PLA reconnaissance satellite provides the PRC with the ability to photograph U.S. military installations.

The first version of the satellite was successfully launched on November 26, 1975, using a Long March 2C rocket. After three days in orbit, the satellite capsule reentered and was successfully recovered by the PRC. Subsequent redesigns of the FSW-1 satellites allowed the PRC to increase its on-orbit life to five days before reentry. The PRC launched fifteen FSW-1 satellites, the last occurring in October 1993.[86]

The PRC's current, enhanced version of this satellite is known as the **FSW-2**. The FSW-2 is larger than the FSW-1 and has a longer on-orbit life. The FSW-2 military reconnaissance satellite has been launched three times since 1992.[87] The most recent launch occurred in October 1996.

The PRC has also offered the FSW satellites as microgravity research platforms — that is, scientific experiments are mounted on the military reconnaissance satellite itself. The commercial proceeds from such "piggy back" launches may in turn be used to subsidize the efforts of PRC entities. Starting in 1987, several FSW satellites have carried microgravity experiments for commercial customers, including France and Germany.[88]

The PRC has also announced that it is going to deploy a new, more capable military reconnaissance satellite.

CBERS: A PROTOTYPE OF THE PRC'S ACQUISITION OF WESTERN TECHNOLOGY

The CBERS-1 satellite program is an open program that has received considerable publicity. The Select Committee judges that the PRC is interested in promoting Western interest in this presumably civil satellite because it offers a means of acquiring technology that could be useful for future military reconnaissance satellites.

CBERS stands for the China-Brazil Earth Resources Satellite. The CBERS-1 satellite is a joint venture with Brazil for the development of a remote imaging satellite that will include a variety of Western technologies.

The CBERS remote imagery satellite is designed to include wide field imagery, a charge-coupled device (CCD) camera from the United States manufactured by Fairchild, and an infrared multispectral camera. The satellite is designed to provide global coverage at a variety of spatial resolutions and spectral bands to meet a range of commercial needs.

The CBERS-1 satellite, if successfully completed and deployed, will be able to image any location on the Earth within three days in the visible region, and 26 days in the infrared region.

The PRC's Other Military Satellite Programs

The PRC has developed and deployed a variety of other satellites for military purposes since its first launches in the 1970s.

It has been reported that the PRC may have developed a series of electronic intelligence (ELINT) satellites in the early 1970s.[89] These satellites would have been useful for collecting data on Soviet defense, among other purposes.

The PRC has also developed two different types of meteorological satellites for military and civil purposes, known as **Feng Yun (Wind and Cloud)**.

- **The FY-1 series of satellites**, first launched in 1988, are polar-orbiting. The FY-1 satellites have suffered a series of on-orbit failures. The first satellite operated for only 39 days of its one-year planned design life; the second satellite lost attitude control five months into its on-orbit life, was recovered 50 days later, and was again lost due to radiation damage.

- **The FY-2 satellites** were designed to provide meteorological information from geosynchronous orbit. The first satellite of this class, however, was lost due to an explosion during ground processing.[90] The second of this class was launched on June 10, 1997 and was successfully placed into orbit.[91]

While the PLA has, to date, relied on the U.S. Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS) navigation satellites, the PRC has announced plans for its own navigation satellite system, known as the **Twin Star**.

The GPS system of satellites, which provides three-dimensional positioning and timing data throughout the globe, consists of 24 satellites with several on-orbit spares. The Russian GLONASS system is intended to use 21 satellites with three on-orbit spares, but the financial crisis in Russia has reduced the number of operational satellites currently on orbit.

In comparison, the PRC's proposed Twin Star positioning system program, as planned, would utilize two satellites in geosynchronous orbit for positioning, messaging, and timing services.[92] The Twin Star system represents the PRC's attempt to become independent of the United States' GPS and the Russian GLONASS navigation satellites.

The Asia-Pacific Mobile Telecommunications (APMT) Satellite

Hughes is currently designing a geosynchronous communications satellite for a PRC-controlled consortium, Asia-Pacific Mobile Telecommunications, Ltd. (APMT). The stated purpose is to provide regional mobile communications throughout Asia.[93]

Unlike previous communications satellites, however, this satellite uses a very large antenna array, which has raised concerns that the satellite could be used not simply for telecommunications, but also for space-based signals intelligence (SIGINT) collection.

This would give the PRC the capability to eavesdrop electronically on conversations not only in the PRC, but also in neighboring countries. Since the APMT satellite's antenna array is significantly larger than any that has been provided to the PRC by any nation, it is likely that the PRC would seek to exploit the APMT design for a future PRC SIGINT satellite.

Other concerns have been raised about the participation of the son of a PLA general in the program's technical interchange meetings, as described in greater detail later in this chapter.

When Hughes was awarded this contract, PRC entities had at least a 51 percent share in the international consortium that made up APMT. PRC entities involved included China Aerospace Corporation, China Launch and Tracking Control General, Chinasat, a subsidiary of the PRC Ministry of Posts and Telecommunications, and UNICOM, the PRC's second telephone network. Originally, two Singaporean companies, Singapore Telecommunications, Ltd. and Singapore Technologies Telemedia, owned twenty-five percent of APMT.[94] In 1998, however, Singapore Telecommunications pulled out of the APMT project, stating that the project no longer met its business requirements.[95] Thailand is also listed by Hughes as an "other" shareholder in APMT.[96] In 1998, Hughes reported that the shareholders for APMT included:

- **China Aerospace Corporation**
- **China Academy of Launch Vehicle Technology**
- **China Satellite Launch & Tracking Control General**
- **China Communications Systems Co. Limited**
- **China Resources Holdings Co. Ltd (PRC)**
- **Communications Authority of Thailand**

- **Telephone Organization of Thailand**
- **China Telecommunications Broadcast Satellite Corporation**
- **China Asia-Pacific Mobile Telecommunications Satellite Co. Ltd.**
- **Asia-Pacific Mobile Telecommunications (Singapore) Pte. Ltd.**
- **Sunburst Technologies Investments Pte. Ltd. of Singapore**
- **Mitsubishi Corporation of Japan**
- **NTT Mobilecommunications Network Inc. of Japan**
- **Future Hi-Tech Co., Ltd. of Thailand**[97]

In the early 1990s, APMT held a competition among satellite manufacturers for a regional mobile communications satellite system that would use 50,000 small, portable handsets similar to cellular telephones. The system called for a communications satellite in geosynchronous orbit, which would transmit communications between handsets or rout them through "gateways" into the local telephone network.[98] Among the competitors were Hughes and Loral.[99]

Hughes won the APMT contract. In 1996, Hughes requested an export license from the Commerce Department for the APMT satellite.[100] If approved for export, the APMT satellite was to be launched on a Long March 3B rocket from the PRC.[101] Hughes' design proposal, as originally submitted to the Commerce Department, included two HS 601 satellite buses with a 12-year design life. The satellites were to be equipped with a 40 foot L-band antenna.[102] The license was originally approved by the Commerce Department in 1996.[103]

In April 1998, Hughes submitted a second license request to the Commerce Department due to changes in the satellite bus design.[104] Hughes wanted to use the more powerful HS-GEM bus, in place of the HS 601, which would have permitted them to achieve design commonalities and hence production efficiencies with another satellite sale to the United Arab Emirates (UAE). The design change for the UAE satellite was the result of a requirement by Hughes' Thuraya satellite customer, who wanted to reduce the power used by the handsets when transmitting. This required an increase in the sensitivity and power of the satellites and their antenna.[105] The original contract also called for two on-orbit satellites. This was modified to one on-orbit satellite and one spare satellite.[106]

The 40-foot antenna, which uses a truss-like outer ring and mesh reflector surface, is the unique aspect of the APMT satellite design. It has led to concerns that the PRC could use the APMT satellite for signals intelligence collection against a wide spectrum of communications.[107]

The satellite, however, is designed to collect and process only communications in the same bandwidth as is allocated to the handsets.[108] Communications satellite antennas are designed to receive their own frequency and reject all others. To do otherwise would add unnecessary expense and complexity to the satellite.

In an attempt to reduce interference from other satellites using the same frequency bands, the APMT satellite antenna will use "left-hand circular polarization" which gives its signals a unique signature. The satellite will not collect other signals that use right, vertical, horizontal, or no polarization. These factors thus limit the satellite's ability to engage in signals intelligence to the collection of information transmitted by APMT system users. That volume of information, however, would be substantial.

When the handsets in the proposed APMT system are used, even for handset-to-handset conversations that are not bounced off the satellite, copies of the transmissions are downloaded to a central ground station. This capability is typically required of most satellite communications systems. Only Iridium, which uses inter-satellite cross-links, does not downlink its communications to a ground station. This downlink would allow the PRC to monitor the communications of APMT's users across the Asian region.

APMT AND THE ASIAN FINANCIAL CRISIS

The APMT program is one of the few commercial communications satellite programs that has remained strong despite the Asian financial crisis. Projections of an oversupply problem for Asia, and an accompanying plunge in transponder lease rates, appeared before the 1998 recession began. Asian currencies fell, as did demand for new satellite capacity. This oversupply was compounded when India did not pass legislation as expected to open their nation to the direct-to-home satellite market. That failure left some Asian satellites with empty beams aimed at India. Additional questions arose during this time about whether there are sufficient customers for these satellites to earn revenue. The Asian market is flooded with transponder capacity, creating a buyers' market.[109]

At least ten Asia-Pacific region communications satellite programs have been deferred due to the economic crisis.[110] These include the Measat 3, Agila 3, AsiaSat 4, Thaicom 4, LSTAR 1, LSTAR 2, and the M2A communications satellites.[111]

Yet another concern with Hughes' proposed APMT sale is that it could help the PRC learn about the deployment of large antenna structures. This could assist the PRC in the development of future reconnaissance satellites. Mechanisms used to deploy large antenna systems have been protected from PRC scrutiny in the past. Visual access to the satellite, as well as the risk of unauthorized discussion with engineers such as has occurred in the past, could give the PRC access to this sensitive technology for the first time.

The Role of PLA General Shen Rongjun and His Son in APMT

The complex relationship between the Shen family and the Asia-Pacific Mobile Telecommunications (APMT) satellite has raised concerns about the possible use of the satellite for military intelligence purposes, and the possibility that technology discussed in the technical interchange meetings would be transferred to the People's Liberation Army (PLA).[112]

In May 1994, PLA Lieutenant General Shen Rongjun, the Deputy Director of the People's Republic of China Commission of Science, Technology and Industry for National Defense (COSTIND), traveled to the United States and attended several business meetings with Hughes. Gen. Shen's responsibilities at COSTIND included the acquisition of satellite systems for the PRC. During this visit to the United States, General Shen's son, Shen Jun, who was living in Canada at the time, attended a business lunch with his father where he was introduced to Frank Taormina of Hughes. Taormina would later assist Shen Jun in obtaining a job at Hughes.[113]

Shen Jun is the older of two sons born to Gen. Shen. He spent 10 of his early years living at the Taiyun Satellite Launch Center in Shanxi province. Shen Jun received his Bachelor's and Master's degrees in computer science from the Changsha Institute of Technology.[114] The Changsha Institute of Technology is also known as the National Defense University of Science and Technology, and is run by the PLA.

For two years, Shen Jun received training and worked in the field of missiles and satellites under PLA supervision.

Shen Jun began working in North America in 1989 as a research assistant at the University of Waterloo, where he would later receive his Ph.D. in computer science in 1993.[115]

During his lunch meeting with Taormina in 1994, Shen Jun remarked that he was applying for a job with Hughes Canada. Taormina suggested to Shen Jun that he submit his resume to Taormina at Hughes in Los Angeles, where he could probably get a better job. While Shen Jun says he was not certain whether Taormina had a relationship with his father, he assumes that this was so, since Taormina was a Hughes vice president in charge of marketing and commercial business.[116]

Shen Jun was hired at Hughes in August 1994 after interviewing with Steve Hagers, who would become his boss.[117] At the time, a division of Space Systems/Loral was also considering hiring Shen for a position that would have allowed him access to classified information.

Originally, Shen Jun was hired at Hughes as a scientist in the information technology division. His primary duty was to investigate new software systems that were available in the commercial market for potential use by Hughes.[118] However, by June 1995, Shen Jun was transferred into Hughes' business development unit, where Hughes used him to conduct market research, general marketing of satellites in Asia, and, specifically, marketing of the APMT program.[119]

Another of Shen Jun's roles was to act as an interpreter for Hughes. While Hughes acquired a license from the U.S. State Department for Shen Jun to work as an interpreter in late 1996, Shen says he did not attend any of the preliminary design review meetings for APMT.[120] Shen Jun states that he did translate for Hughes during at least one or two meetings in the proposal stage. During this period, Shen Jun had a foreign national badge and did not have access to certain Hughes facilities.[121]

Shen Jun also claims that he did not talk with his father, Gen. Shen Rongjun, on a regular basis and had only discussed the APMT satellite with him on a couple of occasions, and even then only at a very general level. Shen Jun claims he talks infrequently with his father, and that he usually talks with his mother when he talks with his family because his father is busy. Furthermore, Shen Jun claims not to know his father's current occupation since the reorganization of COSTIND. Shen Jun, acknowledges, however, that he has had "very high level" discussions with his father on APMT such as "how is the thing … nothing deep, because it's a sensitive issue."[122]

Gen. Shen Rongjun's interactions with the APMT program are more obviously extensive. General Shen has been an advocate at COSTIND for purchasing Western satellites for the PLA, especially since the PRC's domestic satellites began failing in the early 1990s. Based on his position and responsibilities, Gen. Shen was directly involved in the decision to choose Hughes to work on the APMT program.

Similarities Between the PRC's Ballistic Missile and Rocket Technology

Background

The technologies used in rockets and ballistic missiles are essentially the same, except in the areas of payload and flight profile.[123] The common elements of rockets and ballistic missiles include:

- **Propulsion**
- **Structure**
- **Staging**
- **Guidance and control**

- **Ground support and launch equipment**
- **Systems integration**[124]

These commonalities have led to considerable interaction between rocket and ballistic missile programs. Nations that possess space launch capabilities are considered to have all the essential elements to develop a ballistic missile, and vice versa.

Historically, most rockets have been derived from ballistic missiles. In the United States, for example, the current Titan, Atlas, and Delta rockets were derived from ballistic missiles developed in the 1950s and 1960s. Russia's Start rocket is essentially an SS-25 intercontinental ballistic missile (ICBM) that has been modified with an additional upper stage and a payload fairing in place of its reentry vehicle.[125] Some rockets were even launched from silos, such as the Soviet-era SL-7 and SL-8. These Soviet rockets made use of the SS-4 and SS-5 intermediate-range ballistic missiles, respectively, as first stages.[126]

Since their origin, the PRC missile and space programs have been tied together. Like the space programs in the United States and the Soviet Union, the PRC space program got its early start by modifying ballistic missiles into rockets. These early attempts set a pattern of cooperation that continues today. The interaction can be seen in the overall design of the ballistic missiles and the rockets and in certain subsystems, such as propulsion.

In some areas, however, there are divergences. These divergences will increase in the future as the PRC's rockets and ballistic missiles employ different technologies, such as solid-propellant motors for ICBMs and cryogenic liquid-propellant engines for rockets.

The PRC's first rocket, known as the Long March 1, was a derivative of its limited range CSS-3 ICBM. The PRC launched two satellites aboard the Long March 1: one in 1970, and the second in 1971.

The PRC's CSS-4 ICBM has been the model for all PRC rockets since 1973. The first, the Long March 2A, has evolved into a family of rockets, including the Long March 2C, 2E, and 3; the Long March 3A family; and the Long March 4. The Long March 2C rocket is the most closely related to the CSS-4 ICBM. Indeed, it was derived directly from it. The two vehicles share the same first stage engines, structure, and dimensions.[127]

The PRC has also modified the CSS-3 into a small satellite launch vehicle known as the Long March 1D. The modifications include improvements to the YF-2 engines, a new second stage engine utilizing the YF-40 engines from the Long March 4, and a solid-propellant third stage similar to the apogee kick motor used on the Long March 3. The PRC has yet to use this new rocket for commercial space launches. The Long March 1D has, however, been used for military purposes.

Propulsion Systems

The propulsion system requirements for rockets and ballistic missiles are the same. Liquid-propellant engines or solid-propellant motors can be used on either. Both first and second stage engines are interchangeable between ballistic missiles and rockets. The flight environments that ballistic missiles and rockets pass through are the same, thus allowing their engines to be designed similarly. Traditionally, however, rockets use either additional stages or kick motors to place their payloads into orbit. Strap-on boosters can also be used for both rockets and ballistic missiles.

For its next generation ballistic missiles, the PRC is moving towards solid propellants. This will offer faster reaction times compared to liquid-propellant missiles. Moreover, solid-propellant missiles tend to be lighter weight. Solid propellants are less commonly used for rocket applications, since they provide less boosting power to place large payloads into orbit. Furthermore, the challenge of restarting solid-propellant motors once stopped makes them unattractive for upper stage use. The light weight of solid propellants, however, does make them useful for placing satellites into geosynchronous orbits, because they may be employed as kick motors and also as strap-on boosters on rockets.

The PRC's space program is reported to be moving away from storable liquid-propellant engines to cryogenic liquid-propellant engines. The PRC is reported to be working on a rocket that would use cryogenic liquid-propellant engines for its first and second stages. These engines provide greater boosting power over storable liquid propellants and solid propellants.[128]

Airframes

The airframe structure that forms the aerodynamic shell within which all elements of the rocket and ballistic missile are integrated is the same for both rockets and ballistic missiles.[129]

Ballistic missile and rocket structures must use materials that are lightweight and strong.[130] Lightweight materials are preferred because the smaller the structural fraction of the weight of the missile or rocket, the more weight can be dedicated to payload or range.[131]

The structure must also be strong enough to withstand the aerodynamic loads that affect the missile or rocket during boost and ground handling operations.[132] Because these loads are similar during the boost phase of flight, the structural requirements for ballistic missiles and rockets are the same, placing the same premium on materials, design, and fabrication.[133]

Ballistic Missile and Rocket Stages

The staging mechanisms on ballistic missiles and rockets are the same. In both cases, the purpose of using stages is to carry aloft the smallest amount of weight necessary to accelerate the payload to its target.

By discarding parts of the rocket or missiles that are no longer necessary, including unused propellant, stage separation makes space flight more efficient. For ballistic missiles with low accuracy (for example, "city buster" nuclear weapons as opposed to those designed to hit ICBM silos), the mechanisms for payload separation can be similar to those used on rockets.

Guidance Systems

The guidance and control subsystem of a rocket and of a ballistic missile monitors the flight path and adjusts for the effects of high altitude winds or gravitational attractions. The purpose, in both cases, is to deliver a payload to preselected points, either in orbit or on the earth, at preselected velocities.

The accuracy capabilities of a ballistic missile's guidance system may exceed those required for placing satellites into orbit, but the guidance system for a ballistic missile can be used on a rocket. A rocket guidance system, on the other hand, is not usually designed for the same degree of accuracy as is required for ballistic missiles, and therefore may not be suitable for use in some ballistic missile missions where a high degree of accuracy is required. In most cases, however, a rocket guidance system would be sufficiently accurate for delivering nuclear weapons to large targets such as cities.[134]

Many of the PRC's ballistic missiles and rockets share the same guidance systems.

The Select Committee has learned from Western scientists participating in the failure review following the 1996 Long March 3B crash that the guidance system used on the Long March 2C, Long March 2E, and Long March 3 rockets is also used on the CSS-4 intercontinental ballistic missile.[135]

The strap-down guidance system that is used on the PLA's M-series of ballistic missiles, such as the CSS-6 (also known as the M-9) and CSS-X-7 (also known as the M-11), is also used on the PRC "Smart Dispenser." [136] The PRC has used the Smart Dispenser to dispense two Iridium communications satellites on six different occasions.

The PRC had proposed to Loral to use this same guidance system on the PRC's "Top Stage" dispenser to dispense twelve Globalstar communications satellites from atop a Long March 2E rocket.[137] The PRC marketed the Top Stage to Loral as having a mature guidance system, since its inertial measurement unit had been tested on more than 50 flights of the M-series missiles.[138] After the crash of the Long March 3B carrying Loral's Intelsat 708 payload, however, Loral withdrew from its Globalstar contract with the PRC, and the 12-satellite dispenser was never used.

The Long March 3A, 3B, and 3C rockets use a different inertial measurement unit than do the Long March 2 family of rockets, the Long March 3, and the CSS-4 ICBM. The new guidance system for the Long March 3A, 3B, and 3C was developed in 1985, and is cheaper and lighter than the Long March 2 and Long March 3 guidance system.

The Long March 2 and 3 inertial measurement unit, for example, is so heavy that a crane is required to place it into position in the rocket. The Long March 3A, 3B, and 3C inertial measurement system is sufficiently smaller that it can be manually installed in the rocket.

Comparison of Two Different Inertial Measurement Units Used in Guidance System of Long March Rockets[139]

Features of the Inertial Measurement Unit	Used in the Guidance System of	
	LM 2C/2E/3	LM 3A/3B/3C
Number of Gimbals	3	4
Number of Gyroscopes	3	2
Number of Accelerometers	3	3
Number of Torque Motors for Each Gimbal	2	1
Dimensions (mm)	500 x 600 x 800	300 x 300 x 400
Mass (kg)	140	48
Maiden Flight	1974 on Long March 2C	1994 on Long March 3A
Manufactured by	CALT (LM 2C/2E) CAST (LM 3)	CALT

Additionally, the Long March 2 guidance system and the guidance system for the Long March 3A, 3B, and 3C share almost none of the same components. The Long March 2 guidance system uses a double solder for connectors, whereas the Long March 3B uses a single solder. The Long March 2 guidance system is also a three-axis stabilized platform, whereas the Long March 3B is a four-axis stabilized platform.[140]

A relatively small and lightweight inertial measurement unit would be required for the PRC's next generation of ICBMs. While the Long March 3B inertial measurement unit is capable of being used for that purpose, it is considered an unlikely choice. Nonetheless, the experience that the PRC has gained with the Long March 3B in designing a small and lightweight inertial measurement unit that works will almost certainly benefit its designs of ICBM guidance systems in the future.

Ground Support

Ground support and launch procedures can be the same for rockets and ballistic missiles. The crews that launch ballistic missiles and rockets can be the same (and, indeed, PLA personnel are involved in both rocket and ICBM launches in the PRC).

The ground support equipment, such as the launch tower, the missile stand, the propellant handling equipment, and the transportation trains, can all be the same for rockets and ballistic missiles.

Payload preparation and handling is an area where procedures do differ, since satellites often require a complex checkout sequence before launch which ballistic missile warheads do not.[141]

The various institutes and academies in the PRC involved in the design and production of ballistic missiles also share design and production responsibilities for rockets. The China Academy of Launch Technology (CALT) is responsible for research and development of ballistic missiles and rockets. The Beijing Institute of Control Devices is responsible for both ballistic missile and rocket design. Moreover, all of these academies and institutes are managed within the same organizational hierarchy. These common responsibilities will allow the PRC to gain experience for both their ballistic missile and rocket programs through the launching of Western communications satellites.

The PRC's launch sites are also used for both military and commercial purposes. The Taiyun Satellite Launch Center was originally designed for launches of the CSS-4 ICBM. Today it launches the Long March 2C/SD rocket carrying Iridium satellites and the Long March 4 into polar orbits.[142]

Systems Integration

The system for integrating the propulsion, guidance and control, payload, and structure is the same for rockets and ballistic missiles.[143] Analytical and diagnostic tools, such as structural analysis software, are the same for both and are widely available.[144]

Payload

The payload is the area of most significant potential difference between rockets and ballistic missiles.

Satellites are usually complex, fragile systems that are designed to remain in orbit for fixed periods of time. Satellite payloads usually are not required to withstand the aerodynamic stresses of reentry. Single warheads, on the other hand — including nuclear, chemical, and biological warheads, as well as conventional bombs — are designed to survive the intense stresses of atmospheric reentry.

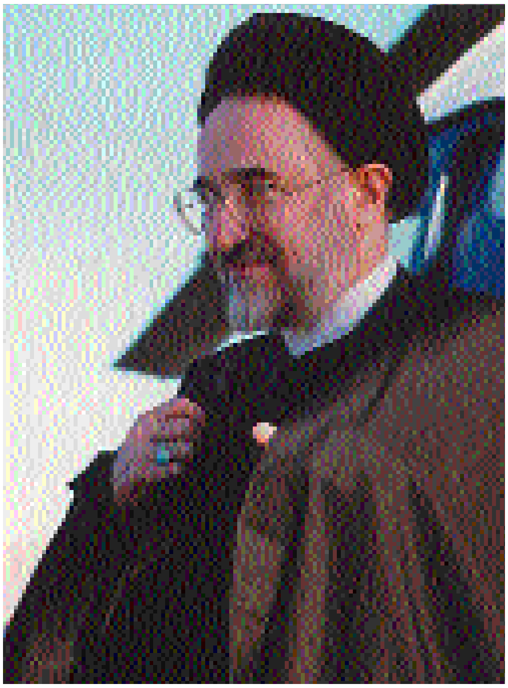
Rockets normally use a fairing to protect the satellite payload from the aerodynamics stresses of launch (although a satellite can be designed, in some instances, to withstand the aerodynamic stresses of launch and therefore would not require a fairing). But in many cases, such as in the deployment of multiple warheads, or submarine launched missiles, ballistic missiles can include a shroud that is similar to a fairing. Both fairings and shrouds are aerodynamic shells that are placed over the payload — satellite or warhead — to reduce drag and aerodynamic stresses during launch.

To place the desired payloads into orbit, rockets generally operate at higher velocities than ballistic missiles. These higher velocities are often attained by high performance third stages, or by kick motors. An ICBM payload, on the other hand, is not intended to achieve orbit around the earth. Rather, the nuclear warhead reentry vehicle is considered to be a rocket whose orbit intersects the earth at the target.

Conclusion

Because of the many commonalities between rockets and ballistic missiles, the PRC can apply the same system refinements and modifications to both its rockets and ICBMs. It is likely that the failure rates of CSS-4 ICBM test flights, and the remedies the PRC adopts to address technical problems with the CSS-4 ICBM, are the same as or similar to those of the Long March series of rockets.

for ballistic missiles.[39] The PRC reportedly is currently providing Iran with solid-propellant missile technology.[40] During the 1980s and 1990s, the PRC has transferred C-802 anti-ship cruise missiles to Iran.[41] The PRC has also provided assistance to Iran's nuclear weapons programs.[42]



During the 1990s, the PRC sold Iran significant numbers of CSS-8 ballistic missiles, along with associated support equipment. The PRC reportedly is currently providing Iran with solid-propellant missile technology.

Pakistan

The PRC has provided Pakistan with a wide range of weapons assistance. The PRC has reportedly supplied Pakistan with CSS-X-7 (or M-11) ballistic missiles, mobile missile launchers, and the facilities necessary to produce M-11 missiles. The PRC has also provided Pakistan with assistance on uranium enrichment, ring magnets, and other technologies useful for Pakistan's nuclear weapons program.[43]

Saudi Arabia

The PRC provided complete CSS-2 missiles to Saudi Arabia in 1987. The conventionally armed missile has a range of 1,500 to 1,800 miles.[44]

The Select Committee's classified Final Report contains additional information on PRC proliferation that the Clinton administration has determined cannot be made public without affecting national security.

The PRC's Military and Civil Space Program

The PRC's military and civilian space launch program began in the 1950s, concurrent with its development of long-range ballistic missiles. At that time, a small research effort was begun at the Chinese Academy of Sciences to develop indigenous space launch and satellite production capabilities.