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Development of U.S. Air Force Intercontinental Ballistic Missile Weapon Systems

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The history of the development of U.S. Air Force intercontinental ballistic missiles is briefly discussed. Emphasis is placed on the technical challenges and the achievements made by the intercontinental ballistic missile team over the past 56 years. The discussion covers all important subsystems in the construction of an intercontinental ballistic missile, that is, rocket propulsion, missile basing, guidance/control, and reentry systems. One of the most remarkable accomplishments of the program is its actual service life, which has far exceeded the original design requirements and goals. The intercontinental ballistic missile program has been one of the most successful programs in the history of the Department of Defense. Besides achieving its nuclear deterrence mission and helping the United States win the Cold War, the intercontinental ballistic missile program also made pivotal contributions in the early stages of the space race with the former Soviet Union. Technologies developed by the intercontinental ballistic missile program have also contributed to nonmilitary and scientific application. Notable examples are miniaturized, high-speed computer chips, composite materials, and high-temperature thermal protection systems.

Introduction

AFTER World War II, it was realized in the United States that mating two war-developed technologies, the atomic bomb and the German V-2 guided ballistic missile, could completely revolutionize weaponry and strategic warfare. To achieve this capability, the U.S. government initiated the intercontinental ballistic missile (ICBM) effort in 1946 with studies and research by Consolidated–Vultee (later Convair Division of General Dynamics Corp.) in stabilization and guidance for a missile with a 1500–5000 mile range.[1–4] Initially, the U.S. Department of Defense (DOD) position was that the ICBM possibility merited only a small, leisurely research program. It was not a program to guarantee that an ICBM would be achieved at the earliest possible date. However, the Atomic Energy Commission's Bikini Island tests in 1952 and 1953 provided a major breakthrough in nuclear warhead technology. About the same time, Charles Draper at the Massachusetts Institute of Technology (MIT) Instrumentation Laboratories achieved significant improvements in missile guidance accuracy. The expectation of a lighter warhead and more accurate missile guidance vastly improved the prospect for an ICBM. Then, in the fall of 1953, U.S. military intelligence concluded that the former Soviet Union had a several-year head start over the United States and was well along in the development of an ICBM. A surprise strike by a large fleet of Soviet ICBMs carrying nuclear bombs could destroy the United States in half an hour. This news caused great alarm and triggered a major shift in the nation's security plans and priorities. The DOD initiated a crash effort to counter this serious threat. Major developments were put in place to upgrade our strategic offensive and defensive nuclear forces, elements of which were assigned to each of the three services. The U.S. Army was responsible for land-based intermediate range ballistic missiles (IRBMs), for example, Jupiter, and antiballistic Missiles (ABMs), for example, Nike and Zeus; the U.S. Navy was responsible for submarine launch ballistic missiles (SLBMs), for example, Polaris and Poseidon; and the U.S. Air Force was responsible for ICBMs, for example, Atlas, Titan, Thor, and Minuteman, in addition to the strategic bomber forces. This paper focuses on the U.S. Air Force ICBM program. However, many of the technology development needs were common across the services, and all programs benefited significantly from cross fertilization.

This major shift in U.S. defense strategy in 1953 essentially set the future course of military strategy and also laid the foundation for the nation's space program. The follow-on ICBM program became the largest technical development ever attempted by the U.S. military, even exceeding in assigned resources the wartime Manhattan Project to develop the atomic bomb.

For an ICBM to have military utility, several key technical problems had to be solved. In 1953, these problems seemed to be close to insoluble. To begin, the technology then available for guiding an ICBM was so inaccurate that a target 5000 miles away would be missed by 20–30 miles or more. The gyroscope, accelerometer, and radar involved in the guidance and control of a missile and the transmission of information about its operation during a flight had to be enhanced by a factor of 10 or more over the proven art in accuracy, range, strength, lightness, reliability, and speed of response. Although an H bomb would pack great explosive power and do considerable damage even if it detonated far off its target, the early H bombs were extremely heavy and bulky. Furthermore, in 1953, there was virtually no reliable scientific knowledge on hypersonic aerodynamics and the related thermal heating issues. For instance, the enormous heat generated by the payload during its streaking reentry into the atmosphere would damage the bomb unless it was protected from the heat by a thick blanket of thermal protection material. Such a covering would add even more weight. Hence, it appeared that rocket engines of gigantic size would be required to boost the heavy reentry vehicle into space.

Many interrelated technical disciplines were involved in the ICBM designs. In each engineering field, technical breakthroughs were needed if the ICBM was to become a reality in a short period of time. It was evident in the early 1950s that a business as usual approach would not produce a successful ICBM program. Fortunately, a new management approach was recognized at the outset of the program by the U.S. officials. The approach eventually created a new management scheme, which today we call system engineering. Another important strategy identified was parallel and competitive development for some high-risk subsystems as discussed in the following section.

New Management Approach

In 1953, at the prodding of Trevor Gardner, then the Special Assistant to the Secretary of the Air Force, a Strategic Missile Evaluation Committee was established. Chaired by Princeton University Professor John Von Neumann, the committee assessed the ICBM program in light of the new atomic technology.[1–3] Among the 11

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