Managing Manhattan:
A Case Study in Complex Project Management

By Lieutenant Colonel Bryan J. Baldwin (Retired)

The Manhattan Project, the U.S.-led secret program to develop the atomic bomb, established the blueprint for the collaboration between the military, academia, and industry. In a span of just more than 3 years, the Manhattan Project transformed a complex scientific theory into the most destructive weapon system the world had ever known. On 16 July 1945, the force of the first atomic explosion shocked even the team of scientists working on the Manhattan Project and forever changed the global security environment. This crowning achievement in American ingenuity highlights how U.S. Army Corps of Engineers leaders leveraged complex problem-solving and risk management skills to attain extraordinary results.

Quantum Revolution

The early 20th-Century revolution in quantum mechanics provided the scientific framework for developing atomic fission. Danish physicist Niels H. D. Bohr, synthesizing existing research by Ernest Rutherford and Max K. E. L. Planck, developed the first modern model of the atom, launching a period of rapid expansion in the field of atomic physics.[1] In 1938, two German physicists stunned the scientific community by unexpectedly discovering atomic fission. Albert Einstein recognized the importance of this discovery and wrote a cautionary letter to President Franklin D. Roosevelt, highlighting the implications were Nazi Germany able to weaponize the science; Einstein cautioned that "This new phenomenon would also lead to the construction of bombs, and it is conceivable—though much less certain—that extremely powerful bombs of a new type may thus be constructed."[2] He advised Roosevelt to establish a scientific research program regarding the technology and to secure a supply chain of uranium ore.[3] Einstein's revelations jolted the President into action; and in 1939, he commissioned a committee to study uranium.

The Unlikely Pair, Brigadier General Leslie Groves and Dr. J. Robert Oppenheimer (Photograph courtesy of the U.S. Department of Energy)

The Advisory Committee on Uranium served as the focal point for U.S. government research into atomic fission, sponsoring the research of scientists Enrico Fermi and Leo Szilard at the University of Chicago, Illinois. In 1941, President Roosevelt also created the Office of Scientific Research and Development to mobilize American science for the purposes of war and appointed Vannevar Bush to lead the effort.[4] That same year, a parallel British effort resulted in the publication of the MAUD report.[5] This pivotal study, based upon research conducted by scientists Niels H. D. Bohr, Otto R. Frisch, and Rudolf E. Peierls, not only contained conceptual plans for developing an atomic bomb, but also concluded that ". . . it is quite conceivable that Germany is, in fact, developing this weapon."[6] The prospect of a Nazi atomic weapon was a clarion call for the national security community, and plans were developed to not only defeat the Nazi program, but also fast-track an American bomb.

Manhattan Engineer District

The Army, specifically the Corps of Engineers, assumed control of American atomic bomb development. Vannervar Bush had recognized that the scientific community lacked the necessary expertise in process development, procurement, engineering capability, construction, intelligence, and operational security and that the Army would be best equipped to lead the effort. The Office of Scientific Research and Development retained control of university research and provided advice to the Corps of Engineers, but command of the project was transferred to an Army officer. To manage the project, the Corps of Engineers established the Manhattan Engineer District, selecting the name so as to disguise the nature of the program. Colonel Leslie R. Groves Jr. was chosen to command the district. Groves had previously served as the Army Deputy Chief of Construction, and his portfolio included managing the construction of the Pentagon. Groves was a plainspoken and decisive leader; he "had intelligence, he had good judgement of people, he had extraordinary perceptiveness and an intuitive instinct for the right answer."[7] More importantly, under Groves's leadership, people achieved extraordinary results.[8]

One of the first critical decisions that Groves (who, by that time, had been promoted to brigadier general) made was the selection of a process for producing fissionable materials. Office of Scientific Research and Development scientists identified five methods of producing fissionable materials: "three isotope separation processes (electromagnetic, gaseous diffusion, and centrifuge) for producing uranium-235 and two pile processes (uranium-graphite and uranium-heavy water) for manufacturing plutonium."[9] Given constrained time and resources, Groves decided to pursue two parallel efforts in order to develop fissionable material from both uranium-235 and plutonium. The centrifuge method of uranium enrichment was eliminated from consideration, and Groves designated that the laboratory at Oak Ridge, Tennessee, develop electromagnetic and gaseous diffusion plants.[10] He further selected the chemical manufacturer DuPont™, in concert with the Metallurgical Laboratory at the University of Chicago, to lead plutonium production at the Hanford Engineer Works in Washington. The Hannaford plutonium production plant was based on the Chicago Pile-1 uranium-graphic reactor; a heavy water process was not seriously considered.[11] With material production plants in place, Manhattan's next milestone was weapons system design.

Project Y

Brigadier General Groves next turned his attention to designing and testing the bomb, code-named "Project Y." He selected Los Alamos, New Mexico, as the location for the laboratory and then wrestled with the more important decision of naming a scientific director for this work, ultimately selecting University of California physicist Dr. J. Robert Oppenheimer to lead the team. Oppenheimer was an unconventional choice, given that ". . . he had had almost no administrative experience of any kind, and he was not a Nobel Prize winner."[12] Additionally, he posed a security concern due to ties to the Communist Party. Despite these risks, Groves considered that Oppenheimer was "a man of tremendous intellectual capacity, that he had a brilliant background in theoretical physics, and that he was well respected in the academic world."[13] Many of the scientists who Oppenheimer selected as members of the team were recent Jewish immigrants who came to the United States to escape the Nazis. With the location and director for Project Y in place, the premier scientists and engineers converged upon an isolated boy's school in Alamogordo, New Mexico, which served as the laboratory site.

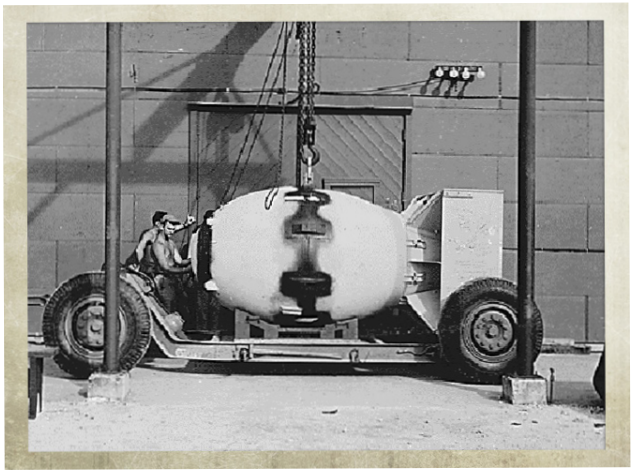
Dr. Oppenheimer began to tackle the initial challenge of designing a bomb that could accommodate both uranium-235 and plutonium as the fissionable material. This task was compounded by the fact that any knowledge of fission explosions was still completely theoretical. Project Y scientists struggled with determining the amount of fissionable material necessary for the weapons system, and Groves stated that this uncertainly "plagued us continually until shortly before the explosion of the Alamogordo test bomb."[14] The central problem involved creating a device in which two subcritical masses of fissionable material would come together in a precise manner at a high speed to form a supercritical mass, causing a super explosion.[15] To achieve this effect, the physicists experimented with a "gun type" design as well as an implosion method. In parallel with the bomb design, a metallurgical team worked on purifying the uranium and plutonium into a stable state and a mechanical design team worked on the physical structure of the bomb, including the arming and wiring devices. Despite initial concerns, Dr. Oppenheimer proved to be adept at complex project management and problem solving.

As work progressed, it became clear that the significant issue would be the design of the atomic "trigger." Scientists were able to perfect the much simpler "gun type" device, but making the implosion method work proved to be more problematic. By late 1944, work at the Los Alamos Laboratory shifted from research and development to production and testing. The team proceeded with building the uranium bomb with the "gun type" device while continuing to work on perfecting the implosion method for the plutonium bomb. The final components for the uranium "gun type" device, code-named "Little Boy," were shipped to Japan via the United States Ship (USS) Indianapolis in July 1945. Due to their confidence in the design, the design team shipped Little Boy without testing the weapon.

Dr. Oppenheimer appointed Dr. George B. Kistiaskowsky to lead a "Cowpuncher Committee" to fast-track the development of the implosion method. The design for a plutonium implosion bomb, code-named "The Gadget," was approved in March 1945, and "The Gadget" was prepared for 16 July 1945 testing at the Trinity Test Site. Brigadier General Thomas F. Farrell, deputy to Brigadier General Groves, described the situation as hectic and tense; at 0 hour, ". . . there came a tremendous burst of light followed shortly thereafter by the deep growling roar of the explosion."[16] Although the initial reaction consisted of both jubilation and relief, the Los Alamos team came to the sobering conclusion that it had given birth to "a great new force to be used for good or for evil."[17]

Little Boy and Fat Man

Having proved the concept of the plutonium implosion bomb at the Trinity Test Site, the Los Alamos scientists scrambled to assemble another weapon, code-named "Fat Man." A team of Army Air Corps engineers at Wendover Field, Utah, simultaneously worked to modify the B-29 Superfortress to deliver Little Boy and the larger Fat Man. Politically, Nazi Germany had surrendered and the Allies were meeting at Potsdam, Germany, to plan for the final defeat of Japan and the future of postwar Europe. Upon the death of U.S. President Franklin D. Roosevelt, President Harry S. Truman had ascended to the Presidency and the decision about whether to employ the weapon would be one of the first of his Presidency. During the Allied conference at Potsdam, Truman reluctantly briefed Premier Joseph V. Stalin on the atomic weapon. At the conclusion of the conference, the Allies issued Japan an ultimatum calling for its unconditional surrender, though the threat of the atomic bomb was not explicitly mentioned.[18] Truman then authorized the 509th Composite Group, 20th Air Force, to employ Little Boy on one of several military targets in Japan—one of the most consequential and controversial decisions ever made by a U.S. President.



Fat Man being unloaded on Tinian Island, Northern Mariana Islands (Photograph courtesy of the U.S. Army Corps of Engineers)

On 6 August 1945, 43 seconds after it left the B-29 Enola Gay aircraft, Little Boy exploded on Hiroshima, Japan. Much of the city was destroyed in an instant, and the blast resulted in more than 160,000 casualties. In spite of the devastation, Japanese military leaders refused to surrender. On 9 August 1945, Fat Man was deployed, exploding with a force of 22 kilotons and killing up to 140,000 more Japanese. On 10 August 1945, Japanese Emperor Hirohito offered unconditional surrender; and on 14 August 1945, he accepted the Allied terms, even as Brigadier General Groves was preparing a second Fat Man for shipment to the Pacific Theater.

The development of the atomic bomb was an American-initiative triumph that stretched the known limits of science. An unlikely pair of leaders transformed the theoretical into the workable through the management of multiple complex projects across scientific disciplines. The Corps of Engineers developed a sophisticated supply chain to acquire and refine highly experimental materials. Unlike the acquisition procedures of today, Brigadier General Groves and Dr. Oppenheimer developed a novel weapon system with little input from the warfighter or from industry. The unconventional approach of the Manhattan Project team illustrates how problem solving, risk management, and integrated process teams serve as the hallmarks of complex project management.

Endnotes:

[1]"The Manhattan Project: An Interactive History—A Miniature Solar System," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Events/1890s-1939/solar_system.htm>, accessed on 5 December 2022.

[2]"The Manhattan Project: An Interactive History—Einstein's Letter to Roosevelt," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Resources/einstein_letter_photograph.htm#1>, accessed on 5 December 2022.

[3]Ibid.

[4]Vincent C. Jones, *Manhattan: The Army and the Atomic Bomb*, U.S. Army Center for Military History, Washington D.C., 1985, p. 28.

[5]"The Manhattan Project: An Interactive History—The MAUD Report," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Events/1939-1942/maud.htm>, accessed on 4 January 2022.

[6]Richard Rhodes, *The Making of the Atomic Bomb*, Simon and Shuster, New York, 1989, p. 325.

[7]John Landsdale Jr, Cynthia R. Kelly (ed.), "Not Right, Do It Again," *The Manhattan Project: The Birth of the Atomic Bomb in the Words of its Creators, Eyewitnesses and Historians*, Black Dog and Leventhal Publishers, New York, 2007, pp. 13–14.

[8]Ibid.

[9]Vincent C. Jones, Manhattan: The Army and the Atomic Bomb, U.S. Army Center for Military History, Washington, D.C., 1985, p. 36.

[10]"The Manhattan Project: An Interactive History—Uranium Isotope Separation," U.S. Department of Energy Office– History and Heritage Resourcs, <https://www.osti.gov/opennet/manhattan-project-history/Processes/UraniumSeparation/uranium-isotope.html>, accessed on 4 January 2023.

[11]"The Manhattan Project: An Interactive History—CP-1 Goes Critical," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Events/1942-1944_pu/cp-1_critical.htm>, accessed on 4 January 2023.

[12]"The Manhattan Project: An Interactive History—Early Bomb Design," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Events/1942-1945/early_bomb_design.htm>, accessed on 6 December 2022.

[13]Ibid.

[14]Leslie Groves, Cynthia R. Kelly (ed.), "Proceeding in the Dark," *The Manhattan Project: The Birth of the Atomic Bomb in the Words of its Creators, Eyewitnesses, and Historians*, Black Dog and Leventhal Publishers, New York, 2007, p. 90.

[15]"The Manhattan Project: An Interactive History—Early Bomb Design," U.S. Department of Energy Office–History and Heritage Resources, <https://www.osti.gov/opennet/manhattan-project-history/Events/1942-1945/early_bomb_design.htm>, accessed on 6 December 2022.

[16]Thomas Farrell, Cynthia R. Kelly (ed.), "Watching Trinity," *The Manhattan Project: The Birth of the Atomic Bomb in the Words of its Creators, Eyewitnesses and Historians*, Black Dog and Leventhal Publishers, New York, 2007, pp. 18–24.

[17]Ibid.

[18]Kenneth B. Pyle, "Hiroshima and the Historians: History as Relative Truth," Asia-Pacific Review, Vol. 22, Issue 2, 2015, pp. 14–27.

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