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ESD.83 Research Seminar in Engineering Systems

October 16, 2001

Zachary, G. Pascal. *Endless Frontier: Vannevar Bush, Engineer of the American Century*. New York, NY: The Free Press, 1997.

G. Pascal Zachary is a senior writer for *The Wall Street Journal*. He is also a contributing editor of the newsmagazine *In These Times* and a columnist for *Technology Review*. His first technology-related book *Showstopper* (1994) focused on innovation at Microsoft. His second book, *Endless Frontier: Vannevar Bush, Engineer of the American Century*, follows the life and career of a highly controversial and deeply influential individual, who orchestrated the rise of a military-industrial-academic complex. The book illustrates a vivid portrait of Dr. Vannevar Bush (1890-1974) and completely captures his spirit and the times.

Zachary provides a framework for appreciating the impact of the power and influence of government-supported scientific and technological research in American society. The book is important for the view of how the science and technology establishment grew, not necessarily for the details of Dr. Bush's life. The author relies heavily on Dr. Bush's writings as well as on interviews with coworkers and family to paint the picture of the intellect who helped create the military-industrial-academia complex. Zachary calls Dr. Bush "the most politically powerful inventor since Benjamin Franklin." He registered his first patent for the profile tracer as a student at Tufts University around late 1910 or early 1911. Dr. Bush's other inventions and patents as well as his contributions at the Massachusetts Institute of Technology (MIT) and the Carnegie Institute are well documented. In the 1920s, as a young professor at MIT, Dr. Vannevar Bush worked on analog computing. He was also a co-founder of Raytheon, a company whose initial success was based on long-lasting radio tubes.

Today, Dr. Bush is best known for his role in Washington, D.C. during World War II (WWII). Zachary documents Dr. Bush's roles in the National Defense Research Committee (NDRC) and the Office of Scientific Research and Development (OSRD). Dr. Bush focused his efforts in joining science with the military to aid in winning WWII. As head of OSRD, Dr. Bush supervised all wartime military research and organized the nation's scientific and technological talent by funding private research with public funds. He also foresaw the value of American intellectuals as he tried to obtain deferments from their military service drafts. As President Roosevelt's advisor, Dr. Bush coordinated the Manhattan Project and

watched over the work of 6,000 civilian scientists designing the most awesome weapon of mass destruction yet produced - the atomic bomb.

Dr. Bush played a central role in creating America's military-industrial-academic complex. Academic research in the hard sciences, before WWII, occurred in a completely disconnected space from military research. Private organizations such as the Carnegie Institute or the Rockefeller Foundation provided funding. That all changed with Dr. Bush and WWII. Dr. Bush used the personal support of President Roosevelt to convince military leaders that it was in their best interest to contract out weapons research to academics at elite education institutions like MIT, Harvard and Berkeley. Dr. Bush, a civilian with his own formidable personality, had no problems yelling at generals and admirals and forced them to adopt new hardware, such as radar.

During WWII, Dr. Bush worked behind the scenes as an administrator distributing federal money. He transformed scientific research in the United States forever by bringing elite academic researchers, the military and the government into a closer relationship than ever before. In addition to developing the military-industrial-academic complex, Dr. Bush personally represented all of its interconnections. His company, Raytheon, became one of the nation's largest defense contractors. MIT, where he was a professor of electrical engineering and an administrator, became the largest academic recipient of federal science research funding. The Carnegie Institute, a think tank where he was the president, also benefited from government funding. As a technocrat, most of Bush's battles were fought with reports and in committee rooms. This material may not be exciting to many readers, making sections of Zachary's very detailed biography a little tedious.

Overall, the picture of Dr. Bush that surfaces from *Endless Frontier* is fascinating in his contradictory nature. He emerges as a clear thinker who despised central authority, but knew how to seize power and wasn't afraid to wield it to reach his professional height. He was a Yankee Republican who had faith in the free market, but he did more than any other individual to guarantee that the federal government got into the business of funding basic scientific research on a large scale. In addition to being proudly technocratic, Dr. Bush was an elitist who even questioned whether a post-WWII America could still function as a democracy. He had created advisory committees consisting of civilian engineers and scientists that often determined military research and development policy. The power to make policy and shape strategy and projects was taken out of the hands of the military. Dr. Bush was intensely distrustful of mass democracy and favored "rule by the well-to-do and highly educated." Yet, he revered the

individual, and was frequently bothered that the emergence of big business would overwhelm the little man, the inventor working at home in his garage.

Dr. Bush is also portrayed as a dedicated patriot who agonized over his participation in the wartime efforts. He became plagued by chronic nightmares as a result of having engineered the bombings of Germany and Japan and his growing belief that the Allies had won the war but lost the peace. He warned against the dangers of an arms race and led a failed attempt to stop the testing of the hydrogen bomb. Although he helped to give rise to the military-industrial-academic complex, Bush was a skeptical of the relationship between science and politics. Under the liberal administrations of Kennedy and Johnson, Bush was honored as an American institution but he chose to stay away from the White House. He tried to avoid the controversies that inevitably followed his iconoclastic nature. However, he never looked back: "Bush expressed no guilt over the nature of his achievement: he had married science and the state, invention and destruction."

Even though Bush's influence on public affairs quickly dropped after the death of Roosevelt, the model he founded remains in place today -- channeling hundreds of millions of dollars into the research laboratories that built the Information Age. Of particular interest to today's technocrat is Bush's visionary influence on the development of the Internet. Dr. Bush's Atlantic Monthly essay "As We May Think," in 1945, describes his memex machine (an information retrieval system) and rapid selector inventions that foreshadowed today's Internet. *Endless Frontier* is a must read for anyone attempting to comprehend how the computer industry rose from government seed money and military weapons research requirements. Dr. Bush's other publication in 1945, a report titled "Science - The Endless Frontier" hastened the establishment of a system of public support for university research. His pursuit at uniting universities, the military and the federal government heralded the establishment of institutions such as the Defense Advanced Research Projects Agency (DARPA) - a military research organization that depends directly on the work of civilian scientists - that built what became the Internet.