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How Systems Analysis, Cost-Effectiveness Analysis, or Benefit-Cost Analysis First Became Influential in Federal Government Program Decision-Making

Abstract: In 1948, the RAND Corporation, formed to connect military planning with research and development decisions, became an independent nonprofit organization. Before then, cost-effectiveness analysis, benefit-cost analysis, and systems analysis had no established home in the federal government. In the 1950s, under the leadership of Charles Hitch, Chief, RAND Economics, undertook a program of activities they called "systems analysis," including evaluation of the costs and effectiveness of weapon systems. In 1961, Robert McNamara appointed Hitch to be the Comptroller of the Department of Defense and invited Hitch to carry out his vision he described as "Programming and Systems Analysis." Programming became the Planning, Programming, Budgeting System (PPBS) and the Five-Year Defense Program that linked strategies to forces to budgets. Systems Analysis assisted the Secretary to make choices of weapon systems and strategies. In 1965, Hitch returned to California and ultimately became President of the university. McNamara wanted Systems Analysis to report directly to him, and on his recommendation, President Lyndon Johnson appointed me Assistant Secretary for Systems Analysis. In 1966, the President directed that all departments in the executive branch establish offices based on the Systems Analysis model. In 1967, Henry S. Rowen became President of the RAND Corporation. He broadened RAND's scope beyond the military to include Health Services, education, urban problems including homelessness, ethics in scientific research, and climate research. In 1970, Rowen led the establishment of the Pardee RAND Graduate School, offering a doctoral degree in Public Policy Analysis to extend widely the application of the RAND Systems Analysis approach to many fields.

Keywords: system analysis in federal government

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The story has its roots in the RAND Corporation in the 1950s. The RAND-U.S. Air Force contract was a broad charter, formed to identify and recommend preferred instrumentalities for warfare. Of course, to an economist "preferred" means "cost-effectiveness" and "value for money" because inevitably resources are limited. The project recognized that with rapidly advancing technology, present strategies and weapon systems can soon be rendered obsolete, so research and analysis were needed to evaluate alternative future U.S. weapons and strategies' performance against alternative threats posed by likely adversaries. The term "systems analysis" is explained below.

I use the term "cost-effectiveness" instead of "benefit-cost analysis" (BCA) because the objectives in the Department of Defense (DoD) were generally destruction of enemy forces and capabilities, not usually described as "benefits." Moreover, the term BCA usually suggests that the benefits and costs can be measured in common units, i.e., present value dollars so the analysis could produce a net value, positive or negative. RAND was also doing studies on water resources development, for which the term BCA would be appropriate.

Charles Hitch, an internationally famous economist, was recruited by RAND to found and head its Economics Division. One of the early efforts of the Economics Division was to develop the concept of "total system cost analysis," e.g., how much would it cost now and in future years, to add a wing of bombers or missiles to the Air Force Structure including not only the engineering and development and purchase of the aircraft or missiles now, but also the bases, training, fuel and spare parts, operations, and maintenance, in the future.

In the 1950s, Budgeting in the DoD was one year at a time, and by object classes of procurement, like "Procurement of Equipment and Missiles for the Army" (affectionately known as "PEMA") appropriations categories not related to force structure or strategy. So the Secretary of Defense had no way of knowing how much we were spending, e.g., on Continental Air Defense.

The next step at RAND was to analyze the effectiveness of weapon systems in various strategic contexts, including enemy countermeasures to our weapon systems. Originally, the term for this was "weapon systems analysis," abbreviated to "systems analysis," a discipline-neutral term. Of course, we economists thought of this as applied economics, but we needed and wanted the active participation of engineers, mathematicians, operations researchers, physicists, political scientists, and others, so we settled on a discipline-neutral term that could include them all.

This work was carried out in the 1950s. One of the main products was a then top-secret report called "The Selection and use of Strategic Air Bases." (RAND R-266) (Wohlstetter et al., 1954). The USAF asked where they should locate our strategic airbases. RAND researchers responded that to answer this question, they needed first to clarify the purposes of the Strategic Air Command (SAC). In the 1950s, under the

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Eisenhower Administration, the official strategy for the defense of our European Allies from Soviet Aggression was known as "trip wire and massive retaliation." The main role of SAC was to be used as a threat of massive destruction to deter Soviet aggression, including nonnuclear armed force, against our NATO allies. The role of the theatre forces in Europe was to serve as a "trip wire." If the Soviets attacked, they would first find themselves in a war against nuclear-armed American forces. But the Soviets first detonated an atomic bomb in 1949, and then a hydrogen bomb in 1953. So awareness that the Soviets had thermonuclear weapons and the capability to deliver them to targets in the USA made threatening to start a nuclear war a much less attractive strategy for the USA and NATO. RAND researchers identified that a priority for the SAC must be to be able to survive a Soviet attack intended to destroy it, and to strike back and inflict such damage on the Soviet Union as to deter attack. RAND research demonstrated the vulnerability of SAC to Soviet surprise attack. RAND developed such proposals as underground shelters to protect our bombers and evaluated "airborne alert" or keeping one-third of our bombers in the air at all times. For practically all of the 1950s, SAC was a force of manned bombers intended to be able to deliver nuclear weapons at intercontinental ranges from a number of bases that was small in relation to the projected number of Soviet ICBMs. The recognition of the importance of the vulnerability of our SAC bombers, and the proposed solutions was not welcome news to General Curtis Lemay, soon to be Chief of Staff of USAF and one of the founders of RAND. General Lemay was the "Father of the Strategic Air Command" and the outstanding air combat leader of World War II. He was a heroic figure and the most formidable opponent when it came to the B-70 bomber (see below).

In the run up to the 1960 presidential election, candidate John F. Kennedy (JFK) campaigned against the "trip wire and massive retaliation" strategy and said that in the event of even limited Soviet aggression (e.g., using force to expel us from Berlin), it would leave the President with a choice between "suicide and surrender." We needed and, when he became President, JFK demanded better alternatives.

In November 1960, JFK was elected President, determined to remedy both the vulnerability problem and the inadequacy of NATO conventional (nonnuclear) forces. He picked Robert S. McNamara to be his Secretary of Defense. McNamara picked Charles Hitch of RAND to be his Comptroller ("Assistant Secretary for Financial Management") and he ordered the accelerated deployment of Minuteman ICBMs, each based in a concrete and steel underground blast-resistant silo, and also Polaris missile-carrying nuclear powered submarines, an effective response to the problem of vulnerability of SAC bombers. McNamara also directed Hitch to form and lead a task force to review the problems of our Strategic Offensive and Defensive forces and to recommend any needed changes.

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President Kennedy directed that the so-called "Strategic Offensive Forces" be renamed "Strategic Retaliatory Forces," to clarify their purpose was to survive a Soviet nuclear attack and strike back in retaliation.

I had first joined RAND in 1955, and was currently on leave from RAND to serve in the Office of the Secretary of Defense and to learn about the Department's program decision process. Hitch asked me to join him in the Comptroller's office, to work to carry out his vision that he called "Programming and Systems Analysis." "Programming" came to be known as "PPBS" and it centered on the Five-Year Defense Plan, which linked forces, strategies, and budgets, and which became the central budget management tool of the Secretary of Defense. I headed the Systems Analysis Office whose purpose was to apply systematic quantitative analysis to assist the Secretary in program and budget decisions.

These tools were just what was needed by the Secretary of Defense determined to carry out a fundamental change in the Defense Program, from vulnerable to invulnerable Strategic Retaliatory Forces, and from weak unready nonnuclear war forces to combat-ready, well-equipped and supplied land and tactical air forces and able to oppose effectively Soviet Aggression in Europe and elsewhere without our first-use of nuclear weapons.

This also represented a fundamental change in defense management and decision-making process. Before Kennedy-McNamara, force-structure decisions were made by the Joint Chiefs of Staff subject to a budget constraint set by the Secretary of Defense and the White House and not explicitly related to force requirements or strategy. Civilians were not expected to know much about defense issues or to decide choices of weapons and strategies. McNamara, under the direction of the President, demanded and used independent civilian analyses of weapons and forces to help him decide which and how many to deploy.

I remember my first meeting with McNamara. In January 1961, Charlie Hitch came down with pneumonia and was out of work for a few weeks. At his invitation, I stepped in and started working with McNamara to discuss the findings of our task force. The first issue I presented to him concerned the semiautomatic ground environment (SAGE) system, which replaced air controllers at the radar sites where they could track incoming enemy bombers and vector our interceptors, with about 20 computerized control centers, a number that was likely to be small in relation to the projected number of Soviet ICBMs. The SAGE was a system of large computers and associated networking equipment that coordinated data from many (about 170 as I recall) radars and processed them to produce a single unified image of the air space over a wide area. SAGE in 20 centers was above ground and not blast resistant. As I recall, the estimated cost was some $20 billion in 1960 dollars, which would be $177 billion in 2019 dollars. The main trouble was that intelligence projected that in the 1960s, the Soviets would deploy hundreds of ICBMs, easily enough to knock out

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SAGE. I recommended that the Secretary cancel SAGE to save billions of dollars to help pay for the accelerated deployment of Strategic Retaliatory Forces, and improved (nonnuclear) conventional forces in Europe. After years of hearing RAND recommendations turned down or ignored, I found it remarkable, impressive, and exciting to see the Secretary of Defense actually give the order to cancel SAGE.

A much more controversial issue soon followed. General Curtis LeMay, Chief of Staff of the Air Force, was absolutely determined to develop and deploy the proposed new B-70 bomber, capable of flying thousands of miles at three times the speed of sound, while flying at 70,000 feet over the Soviet Union, the speed and altitude thought to be beyond the reach of Soviet interceptors, at an estimated cost of over $5 billion per plane in today's dollars. The B-70 had a lot wrong with it: vulnerable on the ground to Soviet ICBM attack, vulnerable in the air to Soviet surface-to-air missiles like the ones that shot down our U-2 spy plane, poorly adaptable to low altitude penetration of Soviet defenses by flying below enemy radars, and it cost far too much for what it did, especially compared to Minuteman and Polaris. The Senate voted 99 to 1 to force the President to spend the appropriated development money, but the President stood his ground and in 1962 the project was cancelled. Helping McNamara fight the B-70 was more than a full time job for several of us in the Office of the Secretary of Defense.

Cost-effectiveness analysis did not play much of a role in these decisions. The deficiencies of SAGE and the B-70 were apparent in any strategic scenario, particularly unsuitable for the Kennedy-McNamara strategic goals. SAGE and the B-70 were rendered obsolete by new technologies.

Charlie Hitch was not a stickler for bureaucratic protocol. Early on, I was working directly for McNamara and keeping Charlie informed. McNamara asked me "how many Minuteman ICBMs should we deploy?" I think our existing plan included about 1000. The Joint Chiefs of Staff were recommending 2400. Calling on my economics training and recalling the generalized law of diminishing marginal returns, I prepared a diagram with Targets Destroyed on the vertical axis and number of missiles on the horizontal axis. Even under a fairly wide range of possible assumptions, the curve was nearly flat between 1000 and 2400 missiles. In other words, the extra targets destroyed would be a small number at a very high cost. McNamara could look at the data and apply his own judgment.

I came to call this the "single all-purpose cost-effectiveness curve" and it proved to be a very useful tool in a variety of situations. When I switched from Defense to health care policy, I found a great deal of "flat of the curve" medicine.

I do not remember very clearly all the issues the Systems Analysis Office worked on in the early 1960s. Around 1970, Wayne Smith Ph.D., the editor and coordinator of our main draft memorandums for the President, and I wrote *How Much is Enough?* to record this work (Enthoven and Smith, 1971). What I do remember about the early

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1960s is that the excitement and prestige of Kennedy and McNamara made the Systems Analysis Office a very attractive place for very talented and capable people to work. I am reluctant to name some for fear of leaving out others. But we had most of the living Naval Academy Rhodes Scholar graduates, ROTC Lieutenants with PhDs from top-level programs in sciences and quantitative disciplines, engineers from the aerospace industry, serving military officers, and Harvard and Stanford Business School graduates. One of the most remarkable of these was Les Aspin, PhD, in Economics from MIT. Upon completion of his tour of Duty in Systems Analysis, he ran for Congress from Wisconsin and was elected to the seat recently held by Paul Ryan. He managed to talk his way onto the House Armed Services Committee ("the upper Midwest was underrepresented, and he knew something about Armed Services"), and later led a revolt in the Committee against the Chairman and became Chairman himself. He was later appointed Secretary of Defense by President Clinton. Sadly, he died early in 1995.

Another issue and decision in those years: the F-105 was the main tactical fighter for the Air Force. It was really designed for the one-way delivery of a nuclear weapon, a kind of "junior SAC". It was not built for sustained nonnuclear combat. We recognized that the F-105 did not fit with the Kennedy-McNamara strategy of strong nonnuclear land and tactical air forces. We noticed that the Navy's F-4 Phantom was much closer to being designed for sustained nonnuclear combat with two engines, a navigator and a pilot, rugged for Carrier operations and a high payload. We recommended and McNamara cancelled production of the F-105 and offered to replace it in the Air Force with F-4s. It turned out later, in the Vietnam War, that that decision was a good one.

In the mid-1960s, we did in-depth analyses of the Army's proposed deployment of an anti-ballistic missile (ABM) system to protect the USA, called "Nike Zeus," with a $60 billion price tag, as I recall (in 1965 dollars). McNamara personally and actively participated in the analysis, asking questions and suggesting alternative scenarios. The Soviets were deploying their own ABM system, and in response, our offensive forces were being fitted with "penetration aids," that is devices to confuse and overwhelm the defense, and also multiple warheads. We could find no persuasive reason to believe the Soviets would not do the same, rendering ABM systems ineffective. McNamara concluded the logical outcome would be for the USA and the Soviets to agree not to deploy ABM systems, and he sought to start the process that led to the Strategic Arms Limitation Treaty (SALT).

In 1965, Charlie Hitch decided to return to California and he accepted an appointment as Chief Financial Officer of the University of California. (Not long after, in a dispute with Governor Reagan, the existing President of the University, Clark Kerr resigned, and Charlie became President of the University.) McNamara called me into his office and explained that he believed the head of the Systems

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Analysis Office was so important to his idea of Defense management that it should be an Assistant Secretary to attract and retain the kind of talent the importance of the position merited. So in the summer of 1965, President Johnson appointed me Assistant Secretary of Defense for Systems Analysis.

Where was the office of the Assistant Secretary of Defense for Systems Analysis (OASDSA) in the Vietnam War? As the war grew more important, I offered to McNamara to help, even though I doubted our quantitative tools would be of much relevance to what was basically a political problem. McNamara said the main way I could help was to continue doing a good job on the issues we were focused on (Strategic Retaliatory and Defensive forces and NATO) so he would be free to focus on Vietnam. We did create a Southeast Asia Programs Office to manage manpower deployments, but this was recording decisions made by the Secretary of Defense. (It turns out that managing the numbers of soldiers "in Vietnam" was very complex. For example how to count soldiers whose units were deployed in Vietnam but who are in hospitals in Thailand. Rules had to be developed and enforced.)

In the 1968 Presidential campaign, candidate Nixon promised "to root out the Whiz Kid approach from the Pentagon." ("Whiz kids" was originally a term applied to a group of 10 Army Air Force veterans who sold their services as a team to the Ford Motor Company where they introduced modern quantitative management methods. McNamara, one of them, subsequently became President of Ford Motor Company. Arjay Miller was another who subsequently became Dean of the Graduate School of Business at Stanford, and recruited me to a Professorship there. The term "whiz kids" then was inflicted on the Systems Analysis Office.) I wondered whether the Systems Analysis Office would survive Nixon's election. In fact, in 1969-1970, Wayne Smith and I wrote *How Much is Enough* to record memory of what we accomplished, and to provide a guide to future Secretaries of Defense who shared McNamara's perspective. I am happy to be able to report that the Systems Analysis Office still exists though under different titles and organizational levels (see below). A vocal critic of OASDSA in the House Armed Services Committee demanded that Nixon fulfill his promise to root out the whiz kid approach, presumably by abolishing the office. But Nixon had appointed David Packard, Cofounder of the Hewlett Packard Company, and a famous industrial leader, to serve as Deputy Secretary of Defense. Packard wrote a sternly worded letter to the effect that he had accepted responsibility to manage the Department and he could not possibly do so "without the information these people provided." The office continued under an Assistant Secretary until March 1973, part of the time as an Acting Assistant Secretary by Ivan Selin, (a brilliant man with doctorates in Electrical Engineering and Mathematics) who had been one of my Deputy Assistant Secretaries. In May, the head was downgraded to "Director of Defense Program Analysis and Evaluation." But then in 1974 it was returned to Assistant Secretary, and then in 1976, back to Director. Then, in 1977, it

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was returned to Assistant Secretary reporting to Secretary Harold Brown, and Russell Murray II as Assistant Secretary. Russ Murray was my Principal Deputy in the 1960s, then down again to Director and back up again to Assistant Secretary. In 2009, the name was changed to "Director of Cost Assessment and Program Evaluation" (CAPE) doubtless reflecting Secretary Gates' rising concern with the exorbitant costs of new weapon Systems, and where it remains today.

According to Wikipedia (2018), "(DCAPE) provides independent analytic advice to the Secretary of Defense on all aspects of the DoD program including alternative weapon systems and force structures, the development and evaluation of defense program alternatives, and the cost-effectiveness of defense systems. The Director of CAPE reports directly to the Secretary of Defense and the Deputy Secretary of Defense. As a political appointee, the Director of CAPE is an Executive Service Level IV official who is nominated by the President of the USA and confirmed by the U.S. Senate (same as Assistant Secretary) … CAPE's staff of approximately 155 people includes a combination of government civilians and military officers and is augmented by contractor support. The CAPE staff is recognized as among the most capable in the Pentagon." I am confident its future is secure. McNamara's original judgment about the need for such an office has been vindicated by over 50 years of experience.

Perhaps of greatest interest to members of the Society for Benefit-Cost Analysis is that in 1966, President Lyndon B. Johnson called for a government-wide introduction of offices based on the Defense Department's Systems Analysis model. For example, from that time to now, DHHS has an Office of the Assistant Secretary for Planning and Evaluation (ASPE). The first person to hold this job was William Gorham, my Stanford classmate and veteran of RAND Economics and the Office of the Secretary of Defense. This has created many opportunities for Society members to perform valuable public service. But the story did not end there.

In the words of a history of the Congressional Budget Office (2016):

> "Conflict between the legislative and executive branches reached a high point during the summer of 1974, when Members of Congress objected to President Nixon's threats to withhold Congressional Appropriations for programs that were inconsistent with his policies (a process known as impoundment). The dispute led to the enactment of the Congressional Budget and Impoundment Control Act of 1974 in July of that year."
>
> "That Act reasserted the Congress's constitutional control over the budget by establishing new procedures for controlling impoundments and by instituting a formal process in which the Congress could develop, coordinate and enforce its own budgetary priorities independently of the President. In addition, the law

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> created new legislative institutions to implement the new Congressional budget process: the House and Senate Budget Committees and the CBO to provide Budget Committees and the Congress with objective impartial information about budgetary and economic issues. The agency began operating on February 24, 1975, when Alice Rivlin was appointed its first director."

Alice Rivlin and I became friends as she sought my advice on Systems Analysis veterans and other qualified persons who might staff the new agency.

This story began with RAND, so let us circle back and see what RAND was doing about all this.

Harry (Henry S.) Rowen was a leading pioneer in Systems Analysis at RAND in the 1950s. (He spent two years of that decade as a graduate student in Economics at Oxford where we met and, in effect, he recruited me to RAND.) He spent most of the 1960s in the Office of the Secretary of Defense playing a leading role in the development of U.S. NATO policy and strategy. He became President of RAND in 1967. He left two important monuments.

The first was based on his recognition that Systems Analysis could be applied fruitfully to many areas of public policy beyond National Defense. (As noted above, President Lyndon Johnson was recognizing the same insight about the same time.) He led the expansion of the scope of RAND research to domestic policy issues such as health, education, and energy. This research was needed to support the work of the newly created "Systems Analysis Offices" throughout the Executive Branch. (I use quotation marks because they each had their own names appropriate to the agency they served.) In fact, in my view, RAND Health became the leader in its field.

The second was the Pardee RAND Graduate School. (Fred Pardee was a former RAND researcher and philanthropist who made the initial endowment.) The school would play a critical role in expanding RAND's systems analysis into the new broader field of policy analysis covering the broad scope of public policy issues, a graduate school that could train a new type of thinker, bringing together exceptional analytic skills and tools with a deep understanding of the messy reality of the real world and real world problems. What was unique about this is that it is a full-scale graduate degree program leading to a Doctor of Public Policy within the research institution itself so that, instead of obtaining graduate advanced degree training, and then going out to learn policy analysis on the job (as most of us have done) this is formal training and working on policy problems in parallel. In the words of Charles Wolf, the first Dean, this parallel approach "possess[es] the powerful advantage of enhancing motivation to learn, and sharpening the perception of purpose and relevance in learning."

So RAND is at work developing the research base to support the newly created offices, and also developing and training the personnel to staff them.

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References

Congressional Budget Office. 2016. An Introduction to the Congressional Budget Office. Available at https://www.cbo.gov/sites/default/files/cbofiles/attachments/2016-IntroToCBO.pdf. (accessed June 13, 2019)

Enthoven, Alain and K. Wayne Smith. 1971. *How Much is Enough? Shaping the Defense Program 1961-1969*. Santa Monica, CA: RAND Corporation.

Wikipedia. 2018. Director of Cost Assessment and Program Evaluation. Available at https://en.wikipedia.org/wiki/Director_of_Cost_Assessment_and_Program_Evaluation.

Wohlstetter, Albert, Henry S. Rowen, Fred Hoffman, and Robert Lutz. 1954. *The Selection and Use of Strategic Air Bases*. Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/reports/R0266.html.

https://doi.org/10.1017/bca.2019.23 Published online by Cambridge University Press