

A History of Thought in Defense Acquisition

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1. **Unification, pp. 2:** *Alternative Views – Postwar Proposals – National Security Act of 1947 – Forrestal’s Challenge – A Curious Change*
2. **Program Budgeting, pp. 18:** *The Hoover Commission – 1949 Reforms – A Budgetary Examination – Comptroller’s Power – Substance of the Budget – Problem of Time – Problem of Classification – Effects on Service Organization – A New Culture*
3. **Systems Analysis, pp. 40:** *Atlas ICBM Program – The Decision Problem – Separating R&D from Procurement – Exercising Options – Insuring Weapons*
4. **Planning-Programming-Budgeting System, pp. 56:** *PPBS in Context – Defense Applications – To Optimize, Or Not to Optimize? – Management Systems – Direct Controls – Error Suppression – Into a New Era*
5. **Cost Estimating, pp. 82:** *Outsourced – Contracting – Incentives – Total Package Procurement – Task Partitioning – Whither Uncertainty? – Exchange and Welfare – An Exercise in Contracting – Boundaries of Administration – Towards Costing – Behind the Data*

In contrast to other fields of economic inquiry, experts in the acquisition of major defense systems appear to have reached an intellectual consensus. They largely agree with acquisition best practices dating from at least the 1970s, including requirements stability, realistic cost estimating, a “fly-before-you-buy” approach, and so forth. As a result, calls for reform cycle within a narrow range of tried-and-true best practices. Frank Kendall now speaks of “improvement” rather than reform. Norm Augustine concludes that “Management 101” is needed rather than new techniques. Harvey Sapolsky advises that this time, we “skip acquisition reform” rather than take on another blue-ribbon study. Many experts believe the problem exists not so much with acquisition theory as with the acquisition workforce. In a compendium of 31 expert views submitted to the Congress in 2014, over two-thirds pointed to weaknesses in acquisition workforce training and incentives leading to the poor execution of well-known best practices. This paper explores the origins of the consensus view that arose in the years between World War II and the early 1970s by surveying and interpreting some of the most important thinkers in defense acquisition. It will explain how the modern acquisition process descends from antiquated nineteenth century concepts of scientific management founded on a deterministic, closed-system, view of the natural sciences and a rejection of liberal principles for social organization. The paper will first discuss military unification and its organizational consequences. Then, a pair of chapters on program budgeting and systems analysis, two processes that laid the foundation for a fourth chapter on the Planning-Programming-Budgeting System. Finally, the challenges of defense contracting and the role of the cost estimator will be discussed.

1. *Unification*

“Who is to blame if the economic tail wags the political dog? It seems unfair to blame the evangelical economizer for spreading the gospel of efficiency. If economic efficiency turns out to be the one true religion, maybe it is because its prophets could so easily conquer.”

Aaron Wildavsky

“The Political Economy of Efficiency,” 1966

As the Allies made final preparations for the D-Day landings in Normandy during the Spring of 1944, a House Select Committee chaired by Representative Clifton A. Woodrum convened to address a seemingly distant proposal for post-war organization. General George C. Marshall set the pieces in motion on November 2, 1943, when he submitted a memorandum to the Joint Chiefs of Staff “relating to the single department,” or the administrative unification of the War and Navy Departments.¹ Marshall had already centralized the command structure of the War Department in March of the previous year.² He wanted a similar reform for the overall military structure, complaining that a “lack of real unity has handicapped the successful conduct of the war.” Coordinating boards staffed by Army and Navy advocates, like the Joint Chiefs of Staff for military operations or the Army-Navy Munitions Board for supply, had proven a “cumbersome and inefficient method for directing the efforts of the Armed Forces.”³ Recent combat experience overwhelmingly supported the idea for unity of command in theater; the idea appeared to logically extend into broader organizational matters of supply. Sympathetic to the cause of unification, Representative James W. Wadsworth, Jr. brought forward a resolution that initiated the Woodrum Committee.⁴

One of the first witnesses before the Woodrum Committee was the Secretary of War, Henry Lewis Stimson, the man who had held the same position during the First World War. He testified that only a unified military leadership could establish efficiency:

“In warfare it is a long standing and thoroughly attested principle that no voluntary cooperation of independent forces can achieve the effective results produced by a single authority in such planning, supervision, and control. Consequently, there have been in this war, in spite of the earnest efforts of the military leaders of the two services at cooperation,

¹ Chief of Staff, Memorandum (relating to a single department of war in the postwar period), presented for consideration of the Joint Chiefs of Staff, JCS 560, November 2, 1943.

² Hewes, Jr., James E. 1975, “From Root to McNamara: Army Organization and Administration.” Center of Military History, United States Army, Washington D.C., pp. 67-68.

³ Lynn, William J. “The Wars Within: The Joint Military Structure and Its Critics”, *Reorganizing America's Defense*, pp. 171.

⁴ Burrell, Robert S. “The Ghosts of Iwo Jima,” pp. 158-59. Representative James W. Wadsworth, Jr. was an Army veteran.

many duplications of time, material, and manpower, with the loss of effectiveness, resources, and power which such duplications inevitably produce. Such duplications will doubtless be brought before you by the officers from all the services who will follow me.”⁵

Stimson was followed by several men from the Army and Army Air Forces who provided, as Chairman Woodrum put it, “quite a number of illustrations of overlapping and duplications that were clearly caused by the two services and which could clearly be obviated by consolidation.” Assistant Secretary of War for Air and future Secretary of Defense, Robert A. Lovett, “mentioned as one of them... the two airfields at Anacostia and Bolling Field, that there was two of everything there.”⁶ Examples of duplication in manpower and materiel in fact abounded; the Army found such instances tantamount to waste and abuse. Lovett gave a run-down of the benefits from a unified defense organization that he believed should occur:

“Unification should eliminate the substantial duplication in personnel dealing with procurement and contracting, inspection services, and so forth... Saving should result from establishing uniform specifications where possible and avoiding the multiplicity of items which differ only slightly... Consolidation of certain research and experimental establishments with their properly specialized divisions should result not only in substantial savings in physical facilities but also, by the elimination of duplicating projects, should permit in peacetime the concentration of more funds on pure scientific research... Economy should result from consolidation and coordination of production and engineering supervision... It is merely a conclusion drawn from some experience.”⁷

The War Department succeeded in cataloging existing inefficiencies and went so far as to name some technical solutions such as uniform specifications. Specifications, however, certainly had to differ at some level. How large were the potential gains and what unintended negative consequences might result? Presuming that technical solutions led to large efficiencies, it wasn't clear that they could not be carried out in a decentralized framework. Indeed, the key assumption made by the Army and many others at the time was the overwhelming benefits of consolidation, not only quantitatively through economies of scale, but qualitatively through holistic decision making. Representative Melvin J. Maas challenged Lovett on the assumptions. “I wanted to get that from the Secretary,” Maas said, “how he thought we would improve our war effort and get any

⁵ Stimson, Henry L. 25 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 31.

⁶ Woodrum, Clifton, A. 28 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 122-23. In the original, Rep. Woodrum mistakenly attributed the observation to Under Secretary of War Judge Robert P. Patterson, who spoke to an extensive list of existing inefficiencies and technical solutions but did not explain why a single authority was better able to act upon them than a board structure.

⁷ Lovett, Robert A. 26 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 50-51.

economy by merely lumping all the procurement.” Lovett thought he had already thoroughly covered the question and left it there.

Brigadier General J. McAuley Palmer provided even less useful answers to committee members. As adviser to the Special Planning Division and confidant of General Marshall, Palmer made the opening statements for the War Department with a discourse on the history of U.S. military organization and the need for universal training. Presumably he would have studied the details and implications of unification. Yet after asserting the necessity of a single administrator, Palmer admitted that he had not studied the matter, and further, that it should not require study. “I have not given the matter very much study,” Palmer testified while under questioning, “and it has always seemed to me the object [unification] should be accomplished without going that far. I must confess I have not studied the matter fully.”⁸

Somewhat more concrete was Lieutenant General Joseph T. McNarney, deputy to Chief of Staff Marshall and chair of a reorganization committee in the War Plan Division. He brought a proposed organizational chart that nicely showed the clear chain of command from the President down to the Secretary for the Armed Forces, and from him to three Under Secretaries for Army, Navy, and Air. “I would add to the three armed services which are united in this single department,” McNarney explained, “a fourth element, directly under the Secretary for the Armed Forces, which would consist of the common supply services.”⁹ McNarney’s chart, excluding the Navy, closely resembled the actual organization of the War Department since 1942. To limit the number of units reporting directly to the Chief of Staff, General Marshall raised his office and created three new commands. All combat units were grouped into either the Army Ground Forces or Army Air Forces, and the various technical services were consolidated into the Army Service Forces. In order to coordinate the three commands with respect to resource allocation and operational planning, Marshall created the Operations Division (OPD). However, because each command had its own staff better suited to the tasks, the OPD became displaced. The OPD focused on monitoring theater planning and making those decisions which bubbled up to the top.¹⁰ McNarney’s plan had a similar mold. The focus of planning and direction would come from the staffs of the three Under Secretaries, tied together by the Secretary. The Common Supply directorate represented the Secretary’s ability to finally eliminate duplication. Despite the seemingly limited role for the

⁸ Brig. Gen. Palmer, J. McAuley. 24 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 16.

⁹ Lt. Gen. McNarney, Joseph T. 25 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 34-38.

¹⁰ Ries, John. C. *The Management of Defense: Organization and Control of the U.S. Armed Services* by, The Johns Hopkins Press, Baltimore, MD. 1964, pp. 26-29. See also Ray S. Cline, *The Washington Command Post: The Operations Division*.

Secretary, McNarney made clear that the plan would reverse the current bottom-up planning process:

Mr. Wadsworth. “Today, as I understand it, the planning as you have described it, starts from below and moves upward?”

General McNarney. “Yes, sir.”

Mr. Wadsworth. “You visualize the planning being made at the top and coming down?”

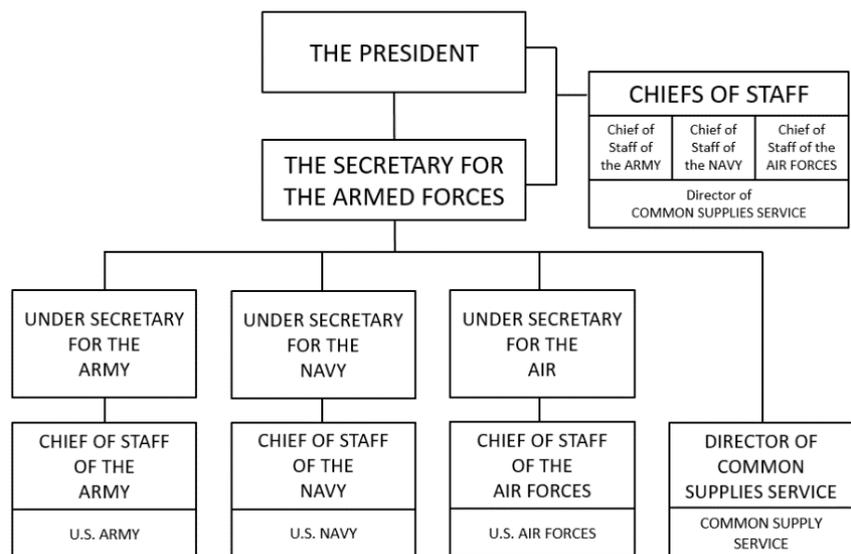
General McNarney. “That is correct. I believe the recommendations as to what our national military policy should be, as to the scientific allotment of our forces, as to a single war plan which provides for the most efficient use of our three armed services and as to the budgetary requirements to carry out our national military policy to include our strategic deployment and provision of forces necessary to implement our war plans, must necessarily come from the top.”

Mr. Wadsworth. “Today we have no statutory top?”

General McNarney. “That is correct, sir.”¹¹

Before the war, responsibility to the Congress for planning and operations did not come from the top of the military hierarchy in all cases. The Congress appropriated budgets directly to individual technical services and heard testimonies from their leadership. This source of autonomy allowed the technical services to flout coordinated direction from the general staff. McNarney urged for unified budget authority under the Secretary for the Armed Forces, who would allocate the budget downward based on the recommendations from the service chiefs.

Centralizing the budget would remove a major obstacle to unified planning by making the various technical services truly responsible to the Under Secretaries. Further, by making the Secretary the sole agent responsible to Congress, he would have the authority to eliminate duplication across the Under Secretariats. “One very great thing,” McNarney said of unification, “is that it would unify the Budget. Now, the Army and the Navy submit



Reproduced figure from that presented by Lt. Gen. Joseph T. McNarney to the Woodrum Committee on April 25, 1944. The McNarney plan reflected the actual organization of the War Department during the war.

¹¹ Lt. Gen. McNarney, Joseph T. 25 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 40.

separate budgets. They are not coordinated by any single agency. They are what each one of the services feels that they must have. The control of money, of course, is what not only makes military forces work but it makes the world go around. That is one great unification.” Without a change to the manner of appropriating peacetime budgets, a top administrator could not eliminate duplication regardless of formal lines of authority.

Alternative Views

On April 28, 1944, after three full days of testimonies from the War Department, the Navy finally had its first witness before the Woodrum Committee. Although the Secretary of the Navy, Frank Knox, might have been expected to lead the discussion, he died that very day of a heart attack. Despite the loss, the Navy found a strong advocate in the Under Secretary of the Navy, James V. Forrestal, “a man of modest physical presence, reticent, and burdened;” a man who “struck one as constantly absorbed in thought.”¹² The Navy’s “very real fear” about unification, Forrestal later wrote in his diaries, was of the Army’s intent to make the Navy “merely another arm” for itself, as the Army Air Forces had been.¹³ His fears may not have been exaggerated. For example, General Marshall reportedly told Admiral Earnest J. King that “I am going to see that Marines never win another war.”¹⁴ Further, the Air Force expected post-unification control of naval aircraft. Forrestal admitted that he “could not agree to anything which would involve the destruction of the integrity of the Navy.”¹⁵

As the one man more responsible than any other for “buying” the wartime Navy, Forrestal had an intimate understanding of public procurements and a keen intuition about how complex organizations work.¹⁶ He had no illusions about the difficulties of administering operations on the scale which the war required and advocated for a decentralized approach:

“I would like to emphasize, as far as my opinion is concerned, and I offer it in all humility, that there are no easy solutions to a problem with so many facets as this. However it may be organized, the military effort will inevitably involve multitudinous forms of planning, procurement, production, transportation, communication, training, supply, and actual fighting. The problem is how to coordinate all of these grand divisions and all of their subdivisions.

“There is one analogy which occurs to me out of my own experience in business. In the early years of this century following the formation of such great business enterprises as the United States Steel Corporation, the General Electric Co., and other large industrial concerns there was a vogue of consolidation. To some extent this was repeated in the

¹² Roherty, James. 1970. “Decisions of Robert S. McNamara: A Study of the Role of the Secretary of Defense.” University of Miami Press, Coral Gables, FL, pp. 27.

¹³ Forrestal, James. In Mills, Walter (ed.). *The Forrestal Diaries*, Viking Press, NY, 1951, pp. 152. Entry 17 April 1946.

¹⁴ O’Donnell, James P. (Maj., USMC) 1985. “The Struggle for Survival.” Citing Thomas B. Buell. *Master of Seapower* (Boston: Little, Brown and Co., 1980), p. 340. Marshall’s dislike for the Marines went back to his World War I experience. He believed the Marines took the Army’s glory.

¹⁵ Forrestal, James. In Mills, Walter (ed.). *The Forrestal Diaries*, Viking Press, NY, 1951, pp. 164. Entry 14 May 1946.

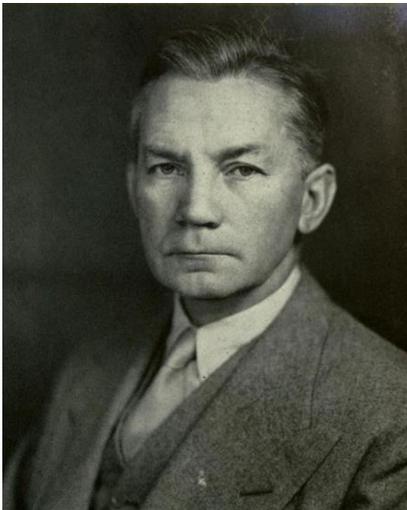
¹⁶ Mills, Walter (ed.). *The Forrestal Diaries*, Viking Press, NY, 1951, pp. xxii.

1920s. Some of those were successful, and General Motors is one I have in mind, and some were not. By and large, I believe that the economies gained through consolidation of administrative functions obviously seem bound to produce great savings, and therefore greater profits to the shareholders of the new combined enterprise; in actual practice it is frequently discovered that these probabilities that seemed so clear on paper were often difficult to transform into reality. You will recall that one architect of railroad consolidations, I believe it was Mr. James J. Hill, finally decided no one man could run more than 10,000 miles of railroad.

“I think any executive of a great corporation resulting from consolidation will tell you how difficult it is to preserve the vitality and initiative of these units of the combination which, as separate entities, have those qualities. Once swallowed in the amorphous mass of a vast and new organization, they are apt to be hamstrung by the very inertia of size.

“The point I am making simply is that size is no guaranty of efficiency. From my own experience in a small segment of the national war effort, I know how difficult it is to maintain contact with the individuals throughout the organization who really do the work. Organization charts are very fine things but they are of no value unless human beings, who have to make them work, have the necessary qualifications. Personally, whether in business or government, I would rather let the chart follow experience than the reverse.”¹⁷

Forrestal made a number of important insights that countered the assumptions in McNarney’s charts. First, he realized that local knowledge in complex organizations cannot be adequately centralized, necessitating “multitudinous” plans and processes. The difficulty was ensuring all the parts pursued a common end. Second, he pointed out the bias of overestimating the benefits of consolidation through economies of scale and underestimating the limits to the size of administration. Forrestal would know better than most, having been called “boy wonder” in his years on Wall Street after he orchestrated his firm’s takeover of Goodyear and Dodge.¹⁸ Third, and most importantly, Forrestal distinguished between seen and unseen costs. Consolidation may reduce the seen costs of duplication and overlap, but it may also reduce the unseen “vitality and initiative” of operational units. Continuing his antithetical arguments that recast duplication as a virtue, Forrestal again humbled himself before a select committee inclined toward unification:



James V. Forrestal,
Under Secretary of the Navy.

“There are certain things in the field of procurement where duplication has been, in my opinion, and again I say it very

¹⁷ Forrestal, James V. 28 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 122-23.

¹⁸ Heilbrunn, Jacob. “The Man Without Qualities” Review of *Driven Patriot: The Life and Times of James Forrestal* by Townsend Hoopes and Douglas Brinkley, in *The New Republic*, October 5, 1992, pp. 39. Recent studies have verified Forrestal’s experience that private sector mergers and acquisitions often fail to produce anticipated efficiencies. See the classic study, “The Post-Merger Performance of Acquiring Firms: A Re-examination of an Anomaly,” by Anup Agrawal, Jeffrey Jaffe, and Gershon Mandelker, *The Journal of Finance*, Vol. XLVII, No. 4, Sep. 1992.

humbly, extremely wise. I think in certain elements of ordnance, and certainly in aircraft, the fact that there was a friendly competition in the types of aircraft gave the Navy dive bombers, and I do not believe we would have had dive bombing as either a material or as an art without it. Whether it is good or bad is a matter for the professional men to say, but I think the fact remains that without that competition you would not have developed the air-cooled engine to the extent we have. I am confident the Army would not have completely ignored the development of an air-cooled engine, but the fact remains the Navy believed in, sponsored, and pushed the development of that engine, and today I think it is fair to say that it is carrying and fighting a very large part of the war.”¹⁹

Forrestal again hammered the point of the unseen costs to defense unification, that many weapon systems, and military arts enabled by them, would go undeveloped. And this time Forrestal struck at the heart of the matter. Instances of so-called duplication had really taken different approaches, often based on conflicting concepts of war or technology. The Navy “believed” in dive-bombers and air-cooled engines whereas the Army Air Forces did not. The resulting success is less relevant than the fact that different opinions were not only heard, but fully pursued. Unified direction meant just that, selecting the single best opinion or approach. However, under the fog of war and technological uncertainty, prudence suggests taking a diversity of approaches that only appear inefficient in the traditional business sense. A subsequent statement by J. Carton Ward, Jr., President of Fairchild Engine and Airplane Corporation, expanded on the idea of unseen costs. He found competition within government procuring agencies created desirable outcomes, particularly in naval aircraft, which put the U.S. on a strong footing:

“During my service abroad on these several missions I found that none of the countries, to whose records I had any access, had what I call a strong naval air arm that would compare with what has been developed in the United States. In discussing problems with some of the naval officers of these countries it was their point of view that, as they were set up in their respective governments’ procurements, they were generally dominated by the point of view of the biggest procurer of planes, which was the Army; so that the peculiar and specialized requirements of naval weapons was given a low place on the agenda.

“The result has been I think, as you gentlemen know, that the British Navy today is relying heavily upon American developed naval air weapons.”²⁰

The committee members appreciated the arguments for decentralization and competition. Representative Dewey Short summarized the view. “As an example, neither the Army’s football team nor the Navy’s football team would have been as good a team if they had not had the other team to oppose. It is that healthy competition that develops

¹⁹ Forrestal, James V. 28 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 126.

²⁰ Ward, Carton J. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 261.

it.”²¹ Likewise, decentralized procurement agencies created competition on the demand side that stimulated a diversity of innovation in ways a single monopsony buyer could not. The view turned an earlier football analogy sideways. The problem, particularly for conducting “triphibious” warfare, appeared to be one of attempting to coordinate specialized military players by consensus rather than direction. Representative Maas characterized it in the following way: “If Yale produced only ends and Harvard only quarterbacks and Minnesota produced only guards, what kind of a football team would we have? And yet that is the way we are trying to fight the war.”²² Did the United States have one military team, or two, or more?

Striking back from the pro-unification camp nearly three weeks later was Harold D. Smith, Director of the Bureau of the Budget. As a lifetime bureaucrat, Smith could put meat on the bones of the Army’s position for a single administrator. First, why would a centralized organization employ technical solutions more efficiently than the current bottom-up process? He built on the idea of a unified budget and outlined a system that would enable a single administrator to have all the relevant information required to actively direct the services according to integrated military plans. “Supporting programs,” Smith told the committee, “must be unified and related to the basic strategic plan—that is, a single master plan of supply requirements, a coordinated distribution system, a unified program of facility needs, and across-the-board determination of manpower requirements, and so forth.”²³ In the earlier practice, budgets only exerted control over classes of objects to be bought, such as personnel, contracts, and construction. It did not provide any unified control over plans and activities, just the means through which they would be accomplished. Smith’s recommendation had budgets submitted by program, allowing a single administrator to spot duplication and measure cost-effectiveness across military outputs. The idea of linking plans with programs with budgets was an extension of previous budgetary reforms from the turn of the twentieth century. In both business and municipal governments, the program budget was the instrument intended to give those with positions of titular power the necessary information to exert real control.²⁴

Second, what made the legacy board structure incapable of coordinating the disparate defense agencies in a centralized manner using the program budget? Budget Director Smith testified that “The boards have suffered from lack of authority and from the natural tendency of the board members to function primarily as the agents of their respective

²¹ Short, Dewey. 28 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 130.

²² Maas, Melvin J. 24 April 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 16.

²³ Smith, Harold D. 18 May 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 296.

²⁴ Mosher, Frederick C., “Program Budgeting in Foreign Affairs: Some Reflections” as part of Planning-Programming-Budgeting compendium, pp. 142.

services rather than as representatives of an over-all point of view... the boards seem bound to develop even more into polite trading mechanisms.”²⁵ Smith saw that board members, who tried to maximize their service’s interests, acted as both advocate and judge regarding the distribution of resources and projects. The boards, as a result, would transform into “horse trading” pits where the services divvied up resources.²⁶ Outcomes of inter-service compromises were largely viewed as inferior to the decisive outcome of one side alone. A single administrator would avoid the rivalrous pitfalls of the boards.

After hearing 28 witnesses between April and May 1944, the committee refused immediate military unification. Chairman Woodrum wrote, “The committee does not believe that the time is opportune to consider detailed legislation which would undertake to write the pattern of any proposed consolidation, if indeed such consolidation is ultimately decided to be a wise course of action.”²⁷ Though the topic was tabled, it succeeded in receiving the high-level attention the Army desired. Two major reports presented just months after the war’s end would frame the discussions to come.

Postwar Proposals

Major General Lawton Collins presented the official War Department position regarding unification on October 30, 1945, closely following the end of combat. He explained that the plan was a reworked version of what General Marshall and the Army had been working on since 1942. Indeed, it was the culmination of decades of organizational theory along two interrelated threads. The first thread came from public administration theory, introduced to America by a young Woodrow Wilson in 1886 based on German concepts of neutral experts, clear lines of authority, and hierarchy. The second thread came from the botched operations of the Spanish-American War, particularly the state of confusion in Tampa Bay during the staging of troops. In response, Secretary of War Elihu Root advocated the general staff concept used by the Germans in his 1902 Semiannual Report. The general staff was a reaction to the difficulties of administering increasingly large organizations in a straight-line hierarchy. The top administrator had to synthesize so much information to tie the disparate pieces together that he required a staff to help plan and coordinate. In fact, the general staff as implemented in February 1903, subsumed the technical services as “special staff organs.”²⁸ Yet until the 1942 Army

²⁵ Smith, Harold D. 18 May 1944. “Hearings Before the Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 298-99.

²⁶ Memo, Lt. Gen. LeRoy Lutes, Director of the Staff, for Directors and Division Chiefs, 31 August 1948, sub: Criticisms Made Before Eberstadt Committee, folder Hoover Commission (Eberstadt Committee), box 88, entry 221, RG 330. Found in Converse III, Elliot. *Rearming for the Cold War: 1945-1960*, pp. 56.

²⁷ Woodrum, Clifton, A. “First Report of the House Select Committee on Post-War Military Policy.” House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 3.

²⁸ General Staff Act of 1903, Section 4. Found in Simonie, Frank L. “Structure and Policy: The Evolution of the Military Staff.” Dissertation for New York University, Graduate School of Arts and Science, February, 1975.

reorganization, the general staff was largely on the losing end of a struggle to wield their legal authority over the autonomous technical services.

McNarney's organizational plan presented at the Woodrum Committee exhibited a neat hierarchy, but did not provide the Secretary for the Armed Services a staff of his own in order to "effect economies and improvements."²⁹ The fact that it closely resembled the actual Army organization during the war turned out to be a major defect, an internal study found. The Patch Board concluded that staff planning from the top, like the OPD, "should not again become devitalized as it had during the war... The old theory that a staff must limit itself to broad policy and planning activities has been *proved unsound* in this war."³⁰ As a result, the Collins plan moved the focus of the staff and operational direction from the service Under Secretaries to the Secretary himself. The Secretary's large staff would consist of "functional" Assistant Secretaries who, in addition to making general policy for the services, would supervise military operations, research, procurement, and hospitalization.³¹ The role of the service Under Secretaries, however, became unclear with many of their administrative functions being shared with the Assistant Secretaries. The organizational concept would later become known as the "active" or "functionalist" view of defense management.

Ferdinand Eberstadt, former Chairman of the Army-Navy Munitions Board, presented a report to then Secretary of the Navy Forrestal on September 30, 1945, a month before Collins. While the report that came to bear his name disapproved of unification, it at the same time approved the need to centralize decision making. The Eberstadt report found that competition often created duplication and other problems, stating that "there was a significant absence of centralized control."³² In this respect the Navy did an about-face from little over a year ago; the inefficient and duplicative aspects of competition were stressed over its effective and innovative aspects.³³ However, the report viewed the primary method for coordination coming not from a single point of authority, as with the "active" view, but from a political process where numerous service representatives voluntarily coordinated their plans and programs. The boards and committees would serve largely the same functional roles as the Assistant Secretaries, but deliberated democratically. The organization approximated that which developed in the

²⁹ Lt. Gen. McNarney, Joseph T. 25 April 1944. "Hearings Before the Select Committee on Post-War Military Policy." House of Representatives Seventy Eighth Congress, second session, pursuant to H. Res. 465: A Resolution to Establish a Select Committee of Post-War Military Policy. Part 1 of 1, pp. 36.

³⁰ Ries, John. C. *The Management of Defense: Organization and Control of the U.S. Armed Services*. The Johns Hopkins Press, Baltimore, MD. 1964, pp. 31.

³¹ Keiser, Gordon W. 1982. *The US Marine Corps and Defense Unification 1944-47: The Politics of Survival*. National Defense University Press, Fort Lesley J. McNair, Washington D.C., pp. 25. Note that the assistant secretaries are called "functional," which implies a non-human within systems, whereas humans are said to have "purpose." "Purposeful" assistant secretaries is more accurate from a systems point of view. See Donella Meadows, *Thinking in Systems*, pp. 15.

³² Keiser, Gordon W. 1982. *The US Marine Corps and Defense Unification 1944-47: The Politics of Survival*. National Defense University Press, Fort Lesley J. McNair, Washington D.C., pp 114.

³³ In 240 pages of text, the Eberstadt Report mentioned variations of the word "competition" 34 times, of which 25 were negative. Compare that to the liberal employment of variations of "coordination" at 357.

war, and kept the focus of staff work at the service level. The service staff officers would wear “two-hats” by also serving on joint boards. Compared to unification, the report found that voluntary coordination “is more in line with the principles of our Constitution, our customs, and our tradition.” The Eberstadt report also supported a unified program budget, directly quoting Budget Director Smith’s testimony from the Woodrum Committee.³⁴ The Eberstadt report found merit in a mechanism for unification precisely because it too saw the logic in eliminating waste and duplication. However, the budgetary reforms were not yet emphasized. In time, the evolving view of unification as a political process became known as the “passive” or “generalist” view of defense management.³⁵

On May 31, 1946, Naval and War Secretaries James V. Forrestal and Robert P. Patterson wrote a joint letter to President Harry S. Truman about their compromised views on unification. In it, Forrestal wrote that “The Navy favors unification but in a less drastic and extreme form.” He recognized “the need for a greater measure of integration than now exists,” but not a “single military department.”³⁶ The Navy could tolerate unification if it left intact the Navy’s integrity, along with its land and air forces.

National Security Act of 1947

Congress largely favored Eberstadt’s “passive” view and wrote much of it into law in the landmark National Security Act of 1947. The only major problem area that the Act strictly sided with the Collins plan over the Eberstadt report was on unification itself, though other provisions made it unification in name only.³⁷ The unified National Military Establishment would operate under the “general direction, authority, and control” of a single Secretary of Defense. It charged him to “eliminate unnecessary duplication or overlapping in the fields of procurement, supply, transportation, storage, health, and research.” Despite the apparently broad mandate given to the new Secretary of Defense, the act limited his administrative powers by reserving for the services all powers not expressly provided. The services “shall be administered as individual executive

³⁴ “Report to Hon. James Forrestal on Unification of the War and Navy Departments and Postwar Organization for National Security.” Printed 22 October 1944 by the United States Government Printing Office, pp. 35 and 80.

³⁵ Forrestal testified to Congress in 1947, “Well, there again, it is the battle between the specialist and what the social scientists call the generalist. I myself am for the generalist. I have the greatest respect for lawyers, accountants, military officers, and statesmen. But I think we are all very prone to look at things from the particular training that we have, and the particular job that we pursue, and I do not think that human events – I do not think anyone is wise enough to approach life from a particular point of view or a particular slant.

“Take the scientists, now. I think there is some danger of the scientists assuming that they have the universal wisdom of the universal statesmen. I think that in any field of knowledge in which a man becomes very competent, he is apt to try to impose that upon a much broader horizon... I have seen very few escape that tendency.”

²⁶ April, 1947. “Hearings Before the Committee on Expenditures in the Executive Departments,” House of Representatives, First Session, on H.R. 2319, the National Security Act, pp. 110.

³⁶ Forrestal, James V. Letter to President Harry Truman by James V. Forrestal and Robert P. Patterson, dated 31 May 1946. Source: U.S. Congress. *Congressional Record*, Volume 92, Part 6. Government Printing Office, Washington, 1946, pp. 7424-26.

³⁷ “The Department of Defense: Documents on Establishment and Organization 1944-1978.” Eds. Cole, Alice C.; Goldberg, Alfred; Tucker, Samuel A.; Winnacker, Rudolph A. Office of the Secretary of Defense Historical Office, Washington, D.C., 1978, pp. 54-59.

departments by their respective Secretaries and all powers and duties relating to such departments not specifically conferred upon the Secretary of Defense by this Act shall be retained by each of their respective Secretaries.” This means that the Service Secretaries were intended to sit on the President’s cabinet with their boss, the Secretary of Defense, giving the defense establishment a unique status.³⁸ As the Navy wished, the Secretary of Defense would take a coordinating role and have little power to administer operations. The Marines would not become “merely another arm” of the Army, nor would the Navy relinquish control of naval aircraft to the newly created third service, the Air Force.



President Harry S. Truman signs the National Security Act, 26 July 1947.

President Truman at first sought to appoint Patterson, the previous Secretary of War, as the first Secretary of Defense. Patterson refused due to his perception that the position lacked the power to effectively administer the services.³⁹ Truman then somewhat ironically asked Forrestal, who accepted the position and on September 19, 1947, was sworn in. A pivotal test for the new Secretary of Defense came early in 1948 with the development of the first unified budget for fiscal year (FY) 1950. Forrestal’s advisors were horrified that he had not intended “to exercise any personal judgement over the 1950 budget.”⁴⁰ McNarney, who then headed the Secretary’s budget advisory committee, wrote a memorandum to Forrestal imploring him to establish priorities for resource allocations.⁴¹ Forrestal’s initial reluctance to provide coordination over the budget increasingly fell at odds with Eberstadt, who came to believe that the Secretary must use the budget as “one of the most effective, if not the strongest, implement of civilian control.”⁴²

³⁸ As it turned out, the Service Secretaries did not sit on the President’s cabinet despite being the heads of their executive departments. The Service Secretaries would, however, sit on the National Security Council. This point confused even Congressmen at the time.

³⁹ Heilbrunn, Jacob. 1992. “The Man Without Qualities” Review of *Driven Patriot: The Life and Times of James Forrestal* by Townsend Hoopes and Douglas Brinkley, in *The New Republic*, October 5, 1992, pp. 40. However, Douglas Kinnard reports that Patterson as refusing the post because he wanted to leave the federal service for financial reasons (he provided no citation). Patterson ended up in private law practice, having also denied a judgeship. See pp. 18 in Kinnard’s book, *The Secretary of Defense*.

⁴⁰ Marx Leva memorandum for Forrestal, 22 June 1948, RG 330, CD 9-2-41. Found in Hogan, Michael J. 1998. *A Cross of Iron: Harry S. Truman and the Origins of the National Security State, 1945-1954*. Cambridge University Press, Cambridge, UK: 1998, pp. 167.

⁴¹ McNarney memorandum for Forrestal, 1 October 1948, Symington Papers, box 8, folder: Correspondence File, 1946-50, Memoranda, General. Found in Hogan, Michael J. 1998. *A Cross of Iron: Harry S. Truman and the Origins of the National Security State, 1945-1954*. Cambridge University Press, Cambridge, UK: 1998, pp. 168.

⁴² Ferdinand Eberstadt, found in Huntington, Samuel P. 1959. *The Solider and the State. The Theory and Politics of Civil-Military Relations*. Belknap press of Harvard University Press, Cambridge Massachusetts, pp. 437.

Forrestal's Challenge

The FY 1950 budget process demonstrated that coordination between the services using a unified budget required greater involvement by the Secretary than the “passive” view permitted. Each of the three services submitted requests on August 16, 1948, larger than the entire defense budget from the previous year. For example, the percentage increases over FY 1949 authorizations for the “Construction” appropriation were 720% for the Army, 826% for the Navy, and 837% for the Air Force. The Army requested an increase in the funding for the National Guard from \$197 million in FY 1949 to \$1,298 million in FY 1950, a 659% increase. Early attempts at program budgeting and assigning ordinal ranks to the resulting programs revealed duplication and excess. Ranked 15th in the Navy’s “indispensable” category for domestic items was the purchase of 53 acres of land for the Naval Academy. Ranked 49th was \$5 million for expanded facilities at the Naval Academy. Ranked 233rd in the “necessary” category was \$3.3 million for “rehabilitation and renovation” of the Naval Academy.⁴³ “Padding” budget requests through inflated or duplicative estimates highlighted the failure of the Munitions Board and the Research and Development Board to determine program costs and priorities. General McNarney pointed to 35 different guided missiles of all types being developed by the services, blaming the Research and Development Board for the “most fundamental of all deficiencies.”⁴⁴

The boards’ concerted attempts to create economies quickly failed to achieve their goals. The Research and Development Board sought to accumulate information on all R&D projects proposed by the services to develop an integrated program. 18,000 project cards were received but many did not indicate funding levels, and when they did, they were inflated. Different accounting standards and reporting requirements also made it impossible to compare what was actually spent on similar projects. Further, by the time the Board received the project cards, nearly one-third were completed, cancelled, or superseded.⁴⁵ The Board came to “rubber stamp” most projects because its members preferred not to argue against project advocates with fuller, more detailed information.⁴⁶ Similarly, the Munitions Board encountered limits to standardizing material specifications and aggregating purchases. One observer noted how well large purchases of standard equipment worked in reality: “Motorized cranes and shovels on rubber tires are assigned to the Army, and identical cranes and shovels mounted on caterpillar tracks

⁴³ *Report to the Commission on Organization of the Executive Branch of the Government by the Committee on the National Security Organization, Volume II*. 15 November, 1948. U.S. Government Printing Office, 1948, pp. 144-45, 142.

⁴⁴ Memo, Gen. Joseph T. McNarney for the Secretary of Defense, 29 October 1948, sub: Research and Development Board, folder Research and Development Board, Organization and Functions, box 829 (Research and Development Board, 1947–1952), Subject Files, OSD/HO. Found in Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 31.

⁴⁵ *First Report of the Secretary of Defense*, 1948, Government Printing Office, Washington, pp. 15.

⁴⁶ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 34.

are assigned to the Navy. This makes sense to no one, least of all to industry.”⁴⁷ The “ridiculous assignment” occurred because actual implementation of economies of scale removed discretion from operational managers who had to make use of the equipment. The Munitions Board staff doubled between 1949 and 1950 due to the increasing number of procurement decisions it had to make on behalf of lower echelons.⁴⁸

While overseeing early developments in unification, Forrestal could not convincingly articulate the rationale for decentralized competition. He said that “My chief misgivings about unification derived from my fear that there would be a tendency toward over concentration and reliance on one man or one group direction. In other words too much central control – which I know you will agree, is one of the troubles with the world today. A lot of admittedly bright men believe that governments, history, science and business can be rationalized into a state of perfection.”⁴⁹ As historian James Roherty described Forrestal, he “consciously sought to rely on the merits of a measure of ‘disorder’ at lower levels; the structure would not stand or fall on its organizational symmetry.”⁵⁰ Yet Forrestal never clarified the link between “disorder” and military economy. Instead, he often invoked anecdotal experiences from Wall Street or the war as justification. For example, Forrestal pointed to the fact that the Germans used the concept of “a single and personal source of decision. It did not work successfully in the German war staff, in the German Government or, as the records of Albert Speer’s testimony show, in German war production... The Germans, to some degree, were the victims of overplanning for the last war. That planning was probably more precise and more nearly complete than in the history of any other nation. But the unplanned American economy, once the issue was joined, was able to far outstrip them.”⁵¹ Forrestal’s thinking on the troubles of rationalizing government and the benefits of disorder remained abstract, lacked constructivism, and focused on his opponents’ errors. As Richard Bellman of RAND Corporation would later write, “For those who are interested in becoming prophets with honor in their own time and in their own country, there is a fundamental principle which we may call the Principle of Optimism: *Never make negative predictions.*”⁵² Forrestal’s obstruction to the positive attitude of his opposition would stain his reputation and ruin his health.

⁴⁷ Memo, Lt. Gen. LeRoy Lutes, Director of the Staff, for Directors and Division Chiefs, 31 August 1948, sub: Criticisms Made Before Eberstadt Committee, folder Hoover Commission (Eberstadt Committee), box 88, entry 221, RG 330.

⁴⁸ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 54

⁴⁹ Forrestal, James. In Mills, Walter (ed.). *The Forrestal Diaries*, Viking Press, NY, 1951, pp. 152, 245.

⁵⁰ Roherty, James. 1970. *Decisions of Robert S. McNamara: A Study of the Role of the Secretary of Defense*. University of Miami Press, Coral Gables, FL, pp. 26.

⁵¹ Forrestal, James V. 26 April, 1947. “Hearings Before the Committee on Expenditures in the Executive Departments,” House of Representatives, First Session, on H.R. 2319, the National Security Act, pp. 96-97.

⁵² Letter from Richard Bellman, Rand Corporation, Santa Monica, California (received March 20, 1958) in response to “On “Heuristic Problem Solving,” by Simon and Newell. In “The Journal of the Operations Research Society of America,” Volume 6, 1958, pp. 448.

A Curious Change

Whether or not Forrestal had a genuine change of heart during his tumultuous stint as Secretary of Defense, he started working to increase the Secretary's ability to exercise control over the rivalrous services. In his first annual report, Forrestal recommended that the "statutory authority of the Secretary of Defense should be materially strengthened... by making it clear that the Secretary of Defense has the responsibility for exercising 'direction, authority, and control' over the departments and agencies."⁵³ To more ably make informed decisions on service programs, Forrestal established the Weapon Systems Evaluation Group in December 1948, a centralized office that leveraged new analytical techniques to appraise weapon programs at ever earlier stages.⁵⁴ Despite his willingness to increase the scope of centralized decision making, Forrestal could not resolve inter-service standoffs, reportedly leaving him weeping at his desk.⁵⁵ President Truman, who remained close to such developments, asked Forrestal to resign. It could have been in connection to a number of issues, including allegations of mental health issues or a meeting with Presidential rival Thomas Dewey.

With the end of his public service close in hand, an exhausted Forrestal testified to the Congress in support of an amendment to the National Security Act that significantly increased the power of the Secretary's office. Forrestal applauded the "economies" generated by "the consolidation of procurement," saying he lacked the power to take them further without an Under Secretary, a "sufficient number" of Assistant Secretaries, and a military staff of his own. Forrestal felt he had to explain such a complete reversal of opinion on his part for what may have been the last time. "I would like to address myself briefly to what I believe may be the chief objection raised to the proposed amendments; namely, that these amendments would vest in the Secretary of Defense too great a concentration of power... After having viewed the problem at close range for the past 18 months, I must admit to you quite frankly that my position on the question has changed. I am now convinced that there are adequate checks and balances inherent in our governmental structure to prevent misuse of the broad authority which I feel must be vested in the Secretary of Defense." When asked to describe those checks and balances, all Forrestal could muster was "I think the President and the Congress are the two great components in that system."⁵⁶ Forrestal almost immediately diverted questions to his legal assistant Max Leva. The second Secretary of Defense, Louis A. Johnson, was sworn

⁵³ Hitch, Charles J. 1965. *Decision-Making for Defense*. University of California Press, Berkeley and Los Angeles, CA, pp. 15.

⁵⁴ *First Report of the Secretary of Defense*, 1948, Government Printing Office, Washington, pp. 131.

⁵⁵ Heilbrunn, Jacob. 1992. "The Man Without Qualities" Review of *Driven Patriot: The Life and Times of James Forrestal* by Townsend Hoopes and Douglas Brinkley, in *The New Republic*, October 5, 1992, pp. 42.

⁵⁶ Forrestal, James V. 1949. Senate Committee on Armed services hearings on S. 1269 and S. 1843, 81st Cong., 1st sess., National Security Act Amendments of 1949, p. 9. Note that the language Forrestal uses sounds strangely similar to Eberstadt.

in four days later, on March 28, 1949. Forrestal quickly checked into psychiatric treatment and within two months, he died.

The life of James V. Forrestal had something of a cinematic aspect to it. From his stellar rise on Wall Street and in Washington to his downfall precipitated by tragic character flaws, the story is completed with rumors of Forrestal's assassination by secret conspiracy. The irony of centralization's leading opponent becoming its sponsor is repeated in defense by numerous policy makers. Another example of this pattern came from Forrestal's friend, Ferdinand Eberstadt. By trying to preserve the identity of the decentralized services while providing for civilian control, Eberstadt would seek to centralize the budget. If the experience of the FY 1950 budget helped change Forrestal's thinking on unification, it also affected Eberstadt's.



Forrestal died on the top floor of Bethesda Naval Hospital on 22 May 1949

2. *Program Budgeting*

“... in my mind, I equate planning and budgeting and consider the terms almost synonymous, the budget being simply a quantitative expression of operating plans.”

Robert McNamara
Congressional Testimony, 1961

Born to German parents in New York City in 1890, Ferdinand Eberstadt was called “Manny,” or, “little man,” by those who knew him best. However, during his years at Princeton, Eberstadt earned a new nickname, “The King,” due to his strong personality and numerous campus activities. It was at Princeton that Eberstadt forged a lasting relationship with James Forrestal, the man who brought him into the civil service immediately after the Pearl Harbor attacks. During World War II, Eberstadt earned respect throughout Washington for his sharp mind, tireless work ethic, and perhaps above all, for his connection to the Controlled Materials Plan.

The first wartime task Forrestal assigned to Eberstadt was a study on the Army-Navy Munitions Board organization, which propelled him into its chairmanship as well as conflict with the civilian War Production Board (WPB). He saw the Munitions Board’s primary duty as determining military requirements for production, which required an effective material allocation system. David Novick at the WPB had been working on such an allocation system based on plans from the War Industries Board of the First World War. The resulting Production Requirements Plan (PRP) got underway late in 1941, calling for each manufacturer to estimate their total requirements for scarce metals. The PRP’s “horizontal” method of control had WPB offices deal directly with every manufacturer regardless of its place in the production chain. Further, each estimate was broken down into various types and shapes of metals, leading to a “tremendous inflow of paper.” Because the estimates made no reference to the ultimate purpose it served, the WPB found that it had no basis on which to prioritize allocations. The “impossibility of selective cuts” broke the link between policy and allocation, and drove manufacturers to inflate their estimates in anticipation of across-the-board cuts. The director of the WPB’s Copper Division said that the PRP was a “silly plan... whereby a claimant for material would dream up what he would like to have and put in a claim for it.” The total requests for copper totaled nearly three times the world’s supply.

Eberstadt quickly saw that the WPB attempted to administer the entire allocation mechanism itself instead of providing top-level policy. As early as March 21, 1942,

Eberstadt made his displeasure with the PRP clear and by May 28 had gained approval from War Under Secretary Patterson and Naval Under Secretary Forrestal to study the matter. In collaboration with numerous staffers, including the PRP's David Novick, Eberstadt put forward the Controlled Materials Plan (CMP). The CMP was a "vertical" allocation mechanism where the WPB allocated large blocks of materials to major claimants, such as army, navy, aircraft scheduling, lend-lease, and various civilian departments, which in turn divided the materials among their subdivisions, themselves prioritizing across prime contractors, and so forth down the production chain. Estimates for materials flowed upward, classified by program, providing each level of the production chain the necessary information to prioritize its downward allocations. On November 2, 1942, Eberstadt formally presented the CMP to the Congress and its implementation quickly generated efficiencies over the PRP. Forrestal later commented that "these programs, destroyer escorts and landing craft, in my opinion, could not have been accomplished—neither could have a good many others—without Eberstadt's Controlled Materials Plan." Though Eberstadt could not claim sole authorship of the CMP, he more than any other was its "Godfather."⁵⁷



Ferdinand Eberstadt working for the War Production Board, October 1942.

The CMP clearly reflected the principles of public administration that Eberstadt learned at Princeton and underpinned much of his thinking.⁵⁸ From 1909 to 1913, Eberstadt attended Princeton during the height of Woodrow Wilson's influence on the school and the nation. One of Wilson's most important scholarly contributions was to separate policy, or the "broad plans" of an organization, from administration, or the "detailed execution of such plans."⁵⁹ Wilson sought to clearly separate politics from administration because he wanted to bring the "nearly perfected" techniques of German bureaucracy to the U.S. without threatening constitutional democracy. The goals and objectives of government would still be determined democratically, Wilson argued, but the detailed execution would be performed according to scientific principles of administration. The CMP is properly viewed in the context of the dichotomy between

⁵⁷ Christman, Calvin Lee. "Ferdinand Eberstadt and Economic Mobilization for War, 1941-1943." Ph.D dissertation thesis for The Ohio State University, 1971. The three foregoing paragraphs drew from Christman's work.

⁵⁸ Dorwart, Jerrfery M. *Eberstadt and Forrestal: A National Security Partnership, 1909-1949*. Texas A&M University Press, College Station: 1991.

⁵⁹ Wilson, Woodrow. "The Study of Administration," *Political Science Quarterly*, Vol. 2, June 1887, pp. 197-222. Public Administration scholars generally followed the administration-policy distinction at the time. For example, see J. A. Vieg (1946), E. G. Nigro (1951), Ordway Tead (1951), H. A. Simon (1955), L. D. White (1955), and J. M. Pfiffner (1960). Some scholars at the time preferred the fact-value distinction, such as Luther H. Gulick. See Fry, Brian R. 1989. *Mastering Public Administration; from Max Weber to Dwight Waldo*. Chatham, New Jersey: Chatham House Publishers, Inc. pp. 80.

policy and administration, though it was policy generated *within* the administrative hierarchy and not above it. The CMP allowed the War Production Board to determine broad policy by allocating resources across major government claimants, which also represented national goals. The concept rested on the fact that there existed a one-way direction from setting goals to executing goals; that planning programs could be performed outside the context in which programs are accomplished. It also rested on each claimant having mutually exclusive programs in order to avoid duplication or overlapping responsibilities. While the CMP created some inefficiencies—including a bias against small businesses at the bottom of the allocation mechanism—it greatly improved on the existing PRP by decentralizing the administrative detail without losing the information to set meaningful policy from the top.

It is difficult to underestimate the impact of the Controlled Materials Plan not only on Eberstadt's reputation, but on how Americans viewed central planning. If the Great Depression proved that markets failed, then the war effort and the CMP proved that central planning worked. In many ways, the CMP provided a template for budgetary reform. As David Novick later pointed out, the CMP was a particular instance of the program budget, tying together inputs and outputs through program elements.⁶⁰ The CMP, however, allocated scarce metals and tooling whereas peacetime program budgets allocated dollars. Though Eberstadt made reference to the program budget in his 1945 report, the question of unification loomed larger. When asked to lead a study in 1948 on defense organization, Eberstadt gave the program budget a central role.

The Hoover Commission

President Truman commissioned Herbert Hoover to lead a study on the administration of the executive branch, who in turn appointed Eberstadt to lead a “Task Force” devoted to defense on May 21, 1948. Eberstadt did not intend to jettison the board and committee structure in favor of functional Assistant Secretaries, as Hoover himself was inclined. Eberstadt found that the boards could not develop military plans without reference to programs and costs. Budget appropriations only provided resource control in terms of organization and object of payment; they did not provide the control of military programs and functions. Like the CMP, the budget needed to be classified in a way that helped it set policy from the top. While the Eberstadt report of 1945 had only brief mentions of the program budget, the report emanating from the Eberstadt Task Force on November 15, 1948, included a chapter devoted to budgeting longer than the pages given to all other aspects of the Secretary of Defense. It explained that the budget process was the Secretary's primary means for establishing efficiency:

“The National Security Act recognized the importance of the budget function and, in effect, made it the principal means by which the Secretary of Defense carries out his duties

⁶⁰ Novick, David. “Beginning of Military Cost Analysis 1950-1961. RAND Corp., March 1988, pp. 8-9.

to establish policies and programs, to exercise direction and control, and to take appropriate steps to eliminate duplication and overlapping among the departments... In the exercise of his power over the budget – by far the most important instrument of general management and control in the Secretary’s hands – the Secretary will require stronger agencies of administration and review.”⁶¹

Eberstadt believed that centralized plans could be accomplished through budgetary administration and review, without the need for administering operations themselves. With greater powers provided to the Secretary over the budget, Eberstadt hoped for the continuing viability of the democratic boards and a strong role for the Service Secretaries. To rectify a system that had “broken down,” the Task Force advanced the program budget as a means of channeling “the necessary information to key points at such time intervals that the necessary decisions can be made at each level in the complex chain.”⁶² Despite the fact that strengthening “central authority” topped the list of its recommendations, the Task Force did not seek to increase the Secretary’s enumerated powers substantially. Instead, the Secretary would establish policies, or programs, which when tied to resource control through the budget would act as a framework for service administration. The Secretary necessarily must stand above the services to establish programs, but does not need power to actively administer because performance to the budget would ensure the attainment of centralized objectives. The Secretary of Defense should not need much more than “the power ‘to exercise direction and control’ over the preparation of military budget, instead of his present right simply to ‘supervise and coordinate.’”⁶³

In its own report the Hoover Commission agreed with the urgency of a program budget, and in a bit of marketing renamed the concept the “performance budget.” The report recommended more than budget authority, which was all Eberstadt believed the Secretary needed. The Hoover report made its top recommendation that “full power over preparation of the budget and over expenditures as authorized by Congress be vested in the Secretary of Defense.”⁶⁴ Power over expenditures meant in effect the power to make decisions at the operating level, deciding how programs would get accomplished, powers that Eberstadt did not believe the Secretary required to attain his policy objectives. Hoover wanted to take all statutory authority previously dispersed across the various

⁶¹ “Report to the Commission on Organization of the Executive Branch of the Government by the Committee on the National Security Organization, Volume II.” 15 November, 1948. U.S. Government Printing Office, 1948, pp. 122 and 149.

⁶² “Report to the Commission on Organization of the Executive Branch of the Government by the Committee on the National Security Organization, Volume II.” 15 November, 1948. U.S. Government Printing Office, 1948, pp. 148-49.

⁶³ “The Commission on Organization of the Executive Branch of the Government.” The Committee on the National Security Organization. *Task Force Report on National Security Organization* (Appendix G), pp. 11-22. Washington: Government Printing Office, 1949. Found in “The Department of Defense: Documents on Establishment and Organization 1944-1978.” Eds. Cole, Alice C.; Goldberg, Alfred; Tucker, Samuel A.; Winnacker, Rudolph A. Office of the Secretary of Defense Historical Office, Washington, D.C., 1978, pp. 66-67.

⁶⁴ “The Commission on Organization of the Executive Branch of the Government.” *The National Security Organization Act. A Report to the Congress*, pp. 12-13, 16-21. Washington: Government Printing Office, 1949. Found in “The Department of Defense: Documents on Establishment and Organization 1944-1978.” Eds. Cole, Alice C.; Goldberg, Alfred; Tucker, Samuel A.; Winnacker, Rudolph A. Office of the Secretary of Defense Historical Office, Washington, D.C., 1978, pp. 75.

boards and three services and vest it in the Secretary of Defense, who would use the services to exercise his line authority and the board functions as his staff authority. With all statutory powers vested in the Secretary of Defense, he could adjudicate authority to the Service Secretaries and Assistant Secretaries as he saw fit. Further, the model maintained the vaunted unity of command concept, where all authority and responsibility flowed through the personal authority of the Secretary of Defense.

1949 Reforms

As with his battle against the Collins plan two years before, Eberstadt's evolved "passive" view largely won favor as the basis of an amendment to the National Security Act passed on August 10, 1949. While the "active" view's functional Assistant Secretaries, recommended by the Hoover Commission, were instituted across many executive departments including Treasury, Labor, Interior, Commerce, State, and Post Office, they did not sweep their way into to Defense. Yet in some ways, they did. The boards were all given an appointed chairman to resolve disputes, and the chairman reported directly to the Secretary of Defense. The Secretary of Defense also gained three Assistant Secretaries. Eberstadt opposed the Assistant Secretaries, asking whether they were senior to the three Service Secretaries, and, "If not, exactly what is their relationship?" He also stood against the confusion brought on by the chairmen of the boards, who would "bear no responsibility" for carrying out their own advice. The other board members had operational responsibilities within the services which maintained a democratic policy structure. Though Hoover gave "merit" to such claims, he highlighted the confusion between the Service Secretaries, the statutory boards, and the Secretary of Defense. He advocated what Eberstadt called a "Prussian type of military organization" that called for a single source of authority with a large general staff.⁶⁵ The battle over which lines of authority and responsibility contained the fewest contradictions extended into budgetary reforms.

Eberstadt personally saw to writing the budget reforms into legislation. He proposed a new Title IV with the optimistic name, "Promotion of Economy and Efficiency Through Establishment of Uniform Budgetary and Fiscal Procedures and Organizations." Without representation from either the Army or the Air Force in its preparation, and little debate before the Congress, Title IV was added to the National Security Act. It created an Office of the Comptroller who was also an Assistant Secretary of Defense (ASD), as well as comptroller offices in each of the services, to be in charge of budgeting, accounting, progress and statistical reporting, administrative organization, and managerial

⁶⁵ Eberstadt, Ferdinand. National Security Act Amendments of 1949. Hearing before the Committee on Armed Services United States Senate, Eighty-First Congress, First Session on S. 1269 and S. 18043. March 24 – May 6, 1949. United States Government Printing Press, Washington: 1949, pp. 53-54. Note that this interpretation by Eberstadt is wrong in some respects. The original Prussian general staff concept had two concurrent lines of authority through the commander and the chief of staff. In the American model, the chief of staff is an "alter ego" to the commander (not the Secretary of Defense) and thus does not conflict with the principle of unity of command. See Robert Golembiewski, *Organizing Men and Power*, 1967.

procedures. Eberstadt was pleased that Title IV avoided the “long and sometimes acrimonious” debates before Congress due to his view of “an extraordinary, and almost complete unanimity.”⁶⁶

Views on Title IV, however, were far from unanimous. Frederick J. Lawton, Director of the Bureau of the Budget, submitted a formal objection in a letter to Senator Tydings. Lawton worried that Title IV, which created a statutory Office of the Comptroller, would create confusion between his duties and those of the Secretary of Defense.⁶⁷ Did the service comptrollers report to ASD Comptroller or to the Secretary of Defense via the Service Secretaries? Lawton preferred the latter. The complaint took similar lines as the Hoover Commission’s when it recommended that the statutory authority be placed with the Secretary. While Lawton provided the only formal objection, another letter from the current Secretary of Defense Louis A. Johnson brought up an important point on the service-level comptrollers. Eberstadt’s proposed Title IV called for service comptrollers that reported to the civilian Service Secretaries, closer to how the Navy operated.⁶⁸ The top Army and Air Force comptrollers, however, were military officers and reported to their chief of staff. Johnson wrote that “you may... wish to give consideration to the advisability of either authorizing or requiring the departmental comptrollers to report to their respective Chiefs of Staff.”⁶⁹ It appears that the only important change between Eberstadt’s proposed Title IV and the version enacted was to allow for the service comptrollers to report to *both* the chief of staff and the Service Secretary, legally creating dual lines of command and upsetting the proverbs of administration.⁷⁰ Title IV stated that the service comptrollers shall be “directly responsible to, either the Secretary, the Under Secretary, or Assistant Secretary” and to have “concurrent responsibility to a Chief of Staff or Chief of Naval Operations.”⁷¹ Chairman Vinson of the House Armed Services Committee added the latter lines as a concession to the Army and Air Force, who employed military comptrollers and whose request to testify on the bill Vinson denied.

⁶⁶ Eberstadt, Ferdinand. “Implementation of Title IV, National Security Act of 1947, As Amended,” Hearings before the Preparedness Subcommittee No. 3 of the Committee on Armed Services United States Senate Eighty-Third Congress First Session (Nov. 2-4, 1953). United States Government Printing Office, Washington: 1954, pp. 12-13.

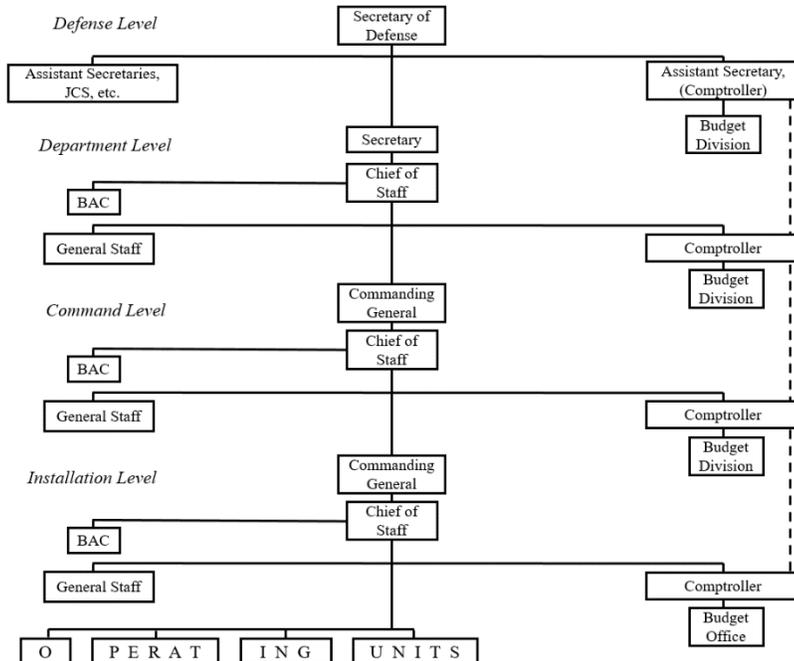
⁶⁷ Lawton, Frederick J. Letter to Tydings. National Security Act Amendments of 1949. Hearing before the Committee on Armed Services United States Senate, Eighty-First Congress, First Session on S. 1269 and S. 18943. March 24 – May 6, 1949. United States Government Printing Press, Washington: 1949, pp. 206-07. His assistant Mr. Stauffacher voiced Lawton’s concerns from the letter during the hearings.

⁶⁸ Civilian comptrollers in the Navy were largely a civilian liaison to his military deputy, a naval officer who administered much of the actual budget process. Eberstadt’s testimonies made clear he preferred a more thorough civilian organization, but found a military deputy acceptable.

⁶⁹ Johnson, Louis A. Letter to Tydings. National Security Act Amendments of 1949. Hearing before the Committee on Armed Services United States Senate, Eighty-First Congress, First Session on S. 1269 and S. 18943. March 24 – May 6, 1949. United States Government Printing Press, Washington: 1949, pp. 206.

⁷⁰ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 39-40. Other changes included: authorizing the Secretary to transfer among appropriations up to 5 percent; requiring the Secretary’s approval for any DoD office to request legislation from the Bureau of Budget, President, or Congress; and inferentially authorizing the President to incur deficiencies in emergency situations. The proverbs of administration alludes to Herbert A. Simon’s paper with the same title.

⁷¹ Sec. 402(b), National Security Act of 1949 as amended by Public Law 216, 81st Congress approved 10 August 1949.



Reproduced figure from Frederick C. Mosher in 1954, "Organization for Budgeting in Army and Air Force." Note the separation of the Comptroller's office from the Budget Advisory Committee (BAC) and General Staff which provided the substance of the budget. While the Comptroller reported through the Chief of Staff, he was also responsible to the Assistant Secretary of Defense (Comptroller) as represented by the dashed line of authority.

Apparently, some feared that the fight could have defeated Title IV as a bill.⁷² The passage of Title IV proved to only compound the existing confusion of authority and responsibility in defense organization, and began an on-and-off struggle between the military chiefs of staff and the civilian comptrollers.

A Budgetary Examination

In a book entitled *Program Budgeting: Theory and Practice*, Frederick C. Mosher reflected upon the Title IV budgetary reform. By the time of the book's publication in 1954, the forty-year old Mosher already had a prolific career as a scholar-practitioner. Mosher was born into public adminis-

tration "royalty", his father having been an American pioneer on the subject and a school dean. Mosher's practical experience came from working for the City of Los Angeles, the Tennessee Valley Authority and the Army Air Forces. His scholarly pedigree came with a Harvard diploma, a Syracuse professorship, and a role as lead editor for the *Public Administration Review*, during which time he published *Program Budgeting*.⁷³ Mosher emphasized the fundamental changes brought by the 1949 budgetary reforms:

"[The performance budget] represents a quite radical departure from previous practice and previous ways of thinking. It is simply that when we budget and authorize funds we are providing for things to be *done* rather than for things to be *bought*. Moneys are furnished for activities and functions rather than for purchases and payments. Almost our entire experience and heritage in governmental financial control is the other way around. In a sense, this amounts to substituting ends for means as the focal point of financial planning and control. For example, performance budgeting might require that funds for basic training be estimated on the basis of the total numbers to be trained and the over-all cost of training each man, in contrast to previous practices of assuming the training goal,

⁷² Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 39-40.

⁷³ Stephenson Jr., Max O. and Plant, Jeremy F. "The Legacy of Frederick C. Mosher." *Public Administration Review*, Vol. 51, No. 2 (Mar.-Apr., 1991), pp. 97-98. Fredrick was also son to the dean of the Maxwell School of Citizenship and Public Affairs, pp. 97. Mosher went on to professorships at UC Berkeley and the University of Virginia. He also advised numerous public offices, most notably the State Department.

then adding up the salary, supply, and contractual costs to reach the goal. Congress would thus exert control on the number trained, the quality of training, and the total cost per man, rather than on the number and salaries of positions filled. The difference is not merely one of technique and method; it is a basic departure in way of thinking. It is not surprising that the performance budget has not been accomplished overnight. Not only must new estimating methods and control techniques be developed; the very minds of the citizen, the Congressman, and perhaps most of all, the administrator must be trained to think in different terms. For all of our history—and long before it—we have conceived of financial management in the accounting terms of items to be paid for rather than of programs to be accomplished.”⁷⁴

Mosher highlighted how program budgeting changed the nature of decision making from the top, expanding financial control from classifications of resources bought to technical direction and review of operations. Mosher explained how program budgeting became associated with the comptrollership. In the medieval period, the comptroller primarily referred to the government function for keeping “a copy of a document to check against the transactions of a treasurer or other official.” American businesses picked up on the concept toward the end of the nineteenth century due to their increased “emphasis upon cost, dollars, careful planning, and allocation of resources.” For providing centralized management over increasingly large scale operations, the comptroller was a “made-to-order” answer not only because of his “objectivity” and “reliance upon facts and figures,” but because the comptroller was already the focal point of all resourcing information.⁷⁵ As David R. Anderson wrote in *Comptrollership in Modern Management* in 1949:

“From the standpoint of the sound business organization it would seem almost self-evident that the chief accounting officer is the logical person to assume responsibility for providing management with the information it needs to plan and control operations. It is his duty to construct and maintain the basic records of the business, in which the results of all operations are recorded and summarized; and, because he has no line-operating responsibility, he is in a position to report and interpret objectively the data available in those records.”⁷⁶

Comptroller duties in the business sector varied “all the way from simple responsibility for the accounts and records to those of a senior operating executive.” The expanded functions of management, policy, and planning were often associated with the term “controller” instead of “comptroller.”⁷⁷ The business controller concept implemented at General Motors, whose consolidations Forrestal called a success, used program budgets

⁷⁴ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 81-82.

⁷⁵ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 196, 198.

⁷⁶ David R. Anderson, “Controllershship’s Contribution to Executive Management,” in *Comptrollership in Modern Management*, ed. Thronton F. Bradsaw. Chicago: R.D. Irwin, 1949, pp. 48.

⁷⁷ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 195, 204. Note that Eberstadt used the word “Controller” in his 1948 report and less than a year later used the less provocative term “Comptroller” in the Title IV draft.

in the 1920s to plan resources by car model five years into the future.⁷⁸ The controller became a fast track to top management. Robert McNamara, a comptroller at Ford, quickly rose to become corporate president just before his appointment to Secretary of Defense in 1961.⁷⁹ Mosher explained how controllership made its way to the government and some potential problems:

“Controllers grew up to meet the demands of increasing complexity and bigness in private enterprise. In that realm, they have proven useful. The defense of the United States has often been called the biggest ‘business’ in the country. In fact, each of the military departments is bigger, by almost every measure, than any private enterprise. Therefore, so the logic runs, they should have controller.

“The flaw in this reasoning is that... the controller epitomizes, in an organizational sense, the supremacy of objective facts and figures in business management, and the recognition, as the ultimate criterion of success, of the profit and loss and balance statements. Where objectives and accomplishments can be *technically measured*, there is reason to juxtapose or even identify the technique with policy and program determination. But where they cannot be, such a relationship may well constitute a triumph of technique *over* purpose. In less cryptic terms, such an application of the controller concept may contribute to: the elevation of subsidiary purposes, which are measurable, over primary purposes, which are not measureable; the emphasis in program and performance upon activities where a ‘showing’ can be demonstrated and proven by ‘facts and figures’; the application of techniques to situations and problems for which they were not designed and are not suited; the incentive to show short-range economy in lieu of long-range effectiveness.”⁸⁰

Controllership sought the scientific management of complex operations using facts and figures to achieve optimized forecasts and plans. The concept assumed the controller could not only collect relevant facts, but he could interpret them and direct policy improvements based upon them.⁸¹ While traditional comptrollers had a foundation in accounting and record-keeping, the expanded business controller also served as policy-maker with quick access to the top administrator. In the role, the controller’s ability to administer is in direct proportion to the suitability of program performance to technical measurement. When programs can run on a profit and loss basis, or where “returns” on capital expenditures can be calculated, then the controller may have suitable information to administer operations. However, the difficulty of measuring the value of government programs means that the controller has unsatisfactory metrics, which, if they were strictly measured against, may lead to unintended consequences. Ultimately, an improper use of the controllership would degrade responsibility with respect to the organization’s true interests, which are imperfectly approximated by controller metrics.

⁷⁸ Novick, David, ed. 1969. *Program Budgeting, Second Edition*. RAND Corp., pp. xxvi-xxvii.

⁷⁹ Poole, Walter. . *History of Acquisition in the Department of Defense Volume II: Adapting to Flexible Response, 1960-1968*. Historical Office, Office of the Secretary of Defense, Washington: 2013, pp. 23-24.

⁸⁰ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 217-18.

⁸¹ Mosher, pp. 200.

Comptroller's Power

In many ways, the authority of the controller and the program budget are intimately tied – the controller’s authority over the program budget is the springboard for his authority over programs and plans. Mosher wrote that “The budget in government agencies, and particularly in the military, is the master “controller” (used in the generic sense) of virtually everything that is done.”⁸² The practical authority of the controller to shape policy then depended on his ability to shape the substance of the budget. At the time of Mosher’s writing, the full business controller concept had not yet made its way to defense. Mosher often noted, particularly for the Army, that the comptroller’s jurisdiction, “In theory, and for the most part in practice as well,” did not extend into “amending the programs or policies which provide the substance of the budget.”⁸³ Comptroller staff primarily concerned themselves with the procedural aspects of budgeting. That being the case, the comptroller’s authority over the program budget presented an “inconsistency.” Mosher noted that the “planning and forecasting” functions associated with the budget differed entirely from the “essentially backwards-looking functions involved in almost all the rest of the organization. Accounts, records, audits, management audits, reports, and program analysis all have to do with what *is* and what *was*.”⁸⁴ Mosher reasoned that if the budget was primarily a historical document that projected forward past rates of expenditures, then it belonged in the hands of the comptroller. If, however, the budget was primarily a future plan, then it belonged with the organizations responsible for executing the plan. Clearly, Eberstadt and Hoover intended the performance budget to reflect military plans.

Just days before the Title IV Congressional hearings, Don S. Burrows rationalized the program budget’s ties to accounting in the *Harvard Business Review*.⁸⁵ Unlike Mosher, Burrows believed that government programs could be measured. He advocated the budget “as a measurement of government programs, similar to the use of the profit and loss statement as an index of the success of private enterprise... Every program has an end-product which is in some fashion measurable.” Measured programs can then enter into “statistical units” for decision making, to assist in the rational upward or downward adjustments to program priorities. Burrows wrote that each program appropriation must be “justified,” explaining the “work units, the methods of computation, and the necessity for the sums requested.” In order to justify future plans using such methods, program budgeting first requires “an accrual method of accounting” to “establish costs on a program or activity.” For the controller to have adequate information for setting realistic program performance targets, he needed competence in accounting to generate baseline expectations to measure against. Program budgeting works only when there exists

⁸² Mosher, pp. 228-29.

⁸³ Mosher, pp. 125.

⁸⁴ Mosher, pp. 226.

⁸⁵ Burrows, Don S. “A Program Approach to Federal Budgeting.” *Harvard Business Review*, 1 May 1949, pp. 272-85.

programmatic accounting. With both budgeting and accounting under his purview, the relevant question for the controller is whether he merely reviews budgets and checks-up on accounting progress, or whether he actively formulates budgets and controls expenditure decisions.

Eberstadt intended ASD Comptroller to exercise the full business controller concept, and further it should represent civilian interests. Eberstadt lamented that “We hear many pious statements about civilian control... but not so much as to precisely how and where civilian control should be exercised.” Eberstadt intended the budget as the precise point of civilian control using “continuous year-round scrutiny” from the “early planning stages through appropriations and expenditures.” Mosher understood that “Civilian control cannot, in fact, be separated from the problem of unification. The rise in the power of the Comptroller of Defense *vis-à-vis* the Joint Chiefs of Staff may properly be considered from this standpoint, as may the position of the Comptroller in relation to the three military departments.”⁸⁶ Eberstadt made clear to the Congress on which side he stood. “If everybody all along the line was responsible only to the Comptroller of the Department of Defense or to the Secretary,” Eberstadt testified, the program budget “probably would have been easier to put into effect.”⁸⁷

A compromise was struck during President Eisenhower’s administration. The Secretary of Defense, assisted by the ASD Comptroller, provided a budget ceiling to each of the three services, which largely had free reign over further allocations.⁸⁸ Within the services, Eisenhower allowed for the chief of staff to handle military commands and the Service Secretary to handle the technical and administrative services. The comptrollers, now solely responsible to their Service Secretaries, took a growing role over R&D and procurement decisions.⁸⁹ At the recommendation of the Rockefeller Committee in 1953, the Congress abolished the statutory boards and provided the Secretary of Defense nine functional Assistant Secretaries. While the Rockefeller Committee clearly did not intend the Assistant Secretaries to have legal authority over the Service Secretaries—they were to advise and assist the Secretary of Defense only—in practice they had direct influence over service decisions.⁹⁰ As the end of his second term approached, Eisenhower campaigned to legalize the practice where Assistant Secretaries by-passed the Service

⁸⁶ Mosher, pp. 46.

⁸⁷ “Implementation of Title IV, National Security Act of 1947, As Amended.” Hearings before the Preparedness Subcommittee No. 3 of the Committee on Armed Services United States Senate Eighty-Third Congress First Session (Nov. 2-4, 1953). United States Government Printing Office, Washington: 1954, pp. 17.

⁸⁸ Note Samuel P. Huntington’s summary in *The Soldier and the State*: “A hierarchial superior controls his subordinate by determining the goals which the subordinate is to pursue, controlling the resources available to the subordinate, or doing both. Vertical bargaining in the military establishment tends to divide these functions between superior and subordinate. The superior finds the limitation of resources easier than the definition of goals... The subordinate, if forced to choose, normally prefers fewer resources and greater freedom to allocate them as he sees fit than more resources less subject to his control. The result is a balance in which the subordinate acquiesces in the authority of the superior to limit resources while the superior leaves to the subordinate a relatively free hand in how he uses them.”

⁸⁹ Roherty, 1970, pp. 49.

⁹⁰ Ries, John. C. *The Management of Defense: Organization and Control of the U.S. Armed Services* by, The Johns Hopkins Press, Baltimore, MD. 1964, pp. 181-85.

Secretaries. In 1958, the Congress passed a Reorganization Act that created the position of Director, Defense Research and Engineering (DDR&E), a civilian staff organization with line operating authority. The weapons procurement functions were placed under DDR&E and the military functions put into unified and specific commands answering to the JCS, leaving the role of the Service Secretaries much diminished.

Substance of the Budget

Maintaining clear lines of authority and responsibility has long challenged complex organizations, but program budgeting injects additional forces that created confusion. Eberstadt took the lead on writing sections 401 and 402 of Title IV, which created the controversies over the organizational standing of the comptrollerships. He had help on the more technical aspects of comptroller functions in sections 403 onward. That help primarily came from Wilfred J. McNeil, who was Forrestal's fiscal director in the Navy and his budgetary and fiscal assistant as Secretary of Defense. He also became the first ASD Comptroller, with a tenure over a decade and lasting five Secretaries, not including Forrestal. McNeil testified to the Congress that he participated "as little as possible" in the wording on the comptroller organization.⁹¹ However, he took a leading role in the formulating and implementing the program budget itself.

McNeil's primary interest in the performance budget stemmed from his belief in the need for a more business-like Pentagon. To McNeil, that meant aligning financial responsibility with administrative responsibility. In other words, an administrator responsible for some military program should report to one higher authority and receive one source of funding from that exact same authority. The existing problem, as McNeil found it, was that budget appropriations had functioned in terms of object of payment, such as salaries, transportation, recruiting, facilities, etc. Not only did the budget appropriations conceal the goals and activities of the organizations, they placed arbitrary constraints on how managers spent funding. The Navy's hospital in Bethesda, Maryland became a notorious example. Hoover himself testified before the Congress that the Bethesda Hospital "receives allotments from 12 different appropriations and nowhere is its total cost shown."⁹² Those 12 appropriations are further divided into hundreds of sub-appropriations. As McNeil recalled in plain language:

"In years past the budget required a separate appropriation for water coolers; a separate appropriation for newspapers; separate appropriation for travel; separate appropriation for certain civilian hire; but nowhere could you tell what a function cost.

⁹¹ National Security Act Amendments of 1949. Hearing before the Committee on Armed Services United States Senate, Eighty-First Congress, First Session on S. 1269 and S. 18943. March 24 – May 6, 1949. United States Government Printing Press, Washington: 1949, pp. 235.

⁹² National Security Act Amendments of 1949. Hearing before the Committee on Armed Services United States Senate, Eighty-First Congress, First Session on S. 1269 and S. 18943. March 24 – May 6, 1949. United States Government Printing Press, Washington: 1949, pp. 129. Note that the language is correct. A set of allotments is an appropriation, but Bethesda Hospital isn't appropriated to because it is lower on the organizational hierarchy, it is allotted to. The number of allotments that Bethesda Hospital received was far higher than the 12 appropriations from which they came.

Nowhere could you tell what the operation of a hospital cost. In other words, 269 pots of money it took to operate the hospital at Bethesda. A little money here for fixing a fence and a separate appropriation for this and that. To run the Task Force One to test the A-bomb out at Eniwetok, it took 189 pots of money.”

McNeil recognized that in order for the director of Bethesda Hospital to manage effectively, his medical organization should be funded through one primary appropriation such that he gains financial authority to parallel his administrative authority. This implies that medical care will be a primary program of defense. The classification of budgets by program, and alignment of organizations with programs, was the first step to McNeil’s business goal. The larger vision was to identify programs that segregate the technical services from the operating forces. “That by doing so,” McNeil said, “you have a supplier-consumer relationship.”⁹³ Ultimately, he wanted to establish a competitive system where the suppliers (technical services) would bill the consumers (military commands) for goods and services which generated market-like prices. Working capital funds would be created for common stock used by multiple programs, helping achieve efficiencies provided through single inventories and bulk-buy discounts, as well as allowing for a “clean-cut charge” to the proper programs when the stock is consumed in operations. As McNeil pointed out, the Navy’s working capital fund started in 1893 and survived two world wars. “The experience has been excellent,” he said, and he wanted to expand the practice. All of the McNeil’s business reforms started with the classification of budgets by programs, activities, and functions that accomplish plans, goals, and objectives. McNeil summarized the performance budget for the Congress in 1950:

“After the determination of what constitutes a logical and identifiable program, there would be a logical and so far as practicable, uniform grouping of projects or budget programs by primary functions, with this grouping paralleling so far as possible the organization and management structure of the military departments. Next, there would be a segregation between capital and current operating categories. A further consideration in determining the programs to be adopted by one of the military departments was that those selected should lend themselves to comparison with similar programs of the other two military departments.

“Management is handicapped when fiscal responsibility is diffused. The financing of an identifiable program from a single source of funds clearly fixes management responsibility, simplifies reporting and permits departmental management and the Congress more easily to determine costs and to evaluate programs.”⁹⁴

⁹³ Oral History Interview with Wilfred J. McNeil by Jerry H. Hess, 19 September 1972, <https://www.trumanlibrary.org/oralhist/mcneilwj.htm>, 19th and 93rd minutes. McNeil, it appears, did not intend for all supply organizations to act as working capital funds which persisted through revenues from military operations, just the more commodity-based ones. Note that McNeil said that the Navy working capital fund started in 1893, but other sources have it starting as much as twenty years earlier.

⁹⁴ “To Improve Budgeting, Accounting, and Auditing Methods of the Federal Government.” Hearing before the Committee on Expenditures in the Executive Departments, United States Senate, Eighty-First Congress Second Session, on S.2054 (and Amendments). February 27-March 7, 1950. United States Government Printing Office, Washington: 1950, pp. 81-82.

To McNeil, the performance budget radically simplified the budgeting process and aligned it with administrative responsibility throughout the organizations. The Navy secretary wrote that the program budget “involved a complete change in the pattern of appropriating” but expected it to provide “substantial improvements in the management of the Department.”⁹⁵ When questioned on how much less personnel and time it took to create the performance budget, McNeil said that during the change-over year it will create a “double load” because “you have your information coming through the channels in the old categories” as well as the new. However, the future would see great reductions in the time spent in the budget process due to its alignment with organization and removal of object classes. It turned out that the double load of the change-over year did not go away because the budget never fully changed over. Mosher explained why the performance budget turned out to be “extremely difficult budgeting,” and claims of its simplicity a “delusion.” Mosher identified two “inherent problems” of the performance budget: the problem of time and the problem of classification.

Problem of Time

The problem of time in a performance budget stems from the fact that funds appropriated in one year are forecasted by organizations two years beforehand and are spent up to four years afterward. As Mosher explained, “Budgets by and large are requests for appropriations which in turn are authority to obligate funds.” Obligated, or guaranteed, funds may take additional time to be spent. “Some of the funds will be spent during the budget fiscal year. Others,” he continued, “will not be expended until one, two three, and in a few cases more years after the fiscal year.” While the practice provides some “short-range advantage” by assuring at least partial program funding for the on-coming years, it also creates problems. When budgets have a long outlay period and are in terms of programs, the operational plans and objectives become fixed for several years. When program elements are interrelated, the budget estimates for one program element constrain the estimates for the other up to four years into the future. Mosher reasoned that “Much of the budget is beyond recall,” particularly for programs that require long-lead times such as R&D and weapons procurement. The result is two-fold. First, program planning must incorporate “long range objectives and estimates of forces” in order to adequately account for the lock-in effect it will create on subsequent years. Mosher noted that the further in advance estimates are required, the “greater the uncertainty and probability of error.” Second, the up-front programming process forced another layer of planning on top of the traditional budget process. Programs had to be articulated two years in advance of funding receipt in order to accommodate the one year allotted to budget preparation and review. Mosher found that the lengthening of budget lead-time “makes program budgeting at the average installation virtually impossible for the simple

⁹⁵ The Navy Department, in the *Semiannual Report of the Secretary of Defense*, pp. 184.

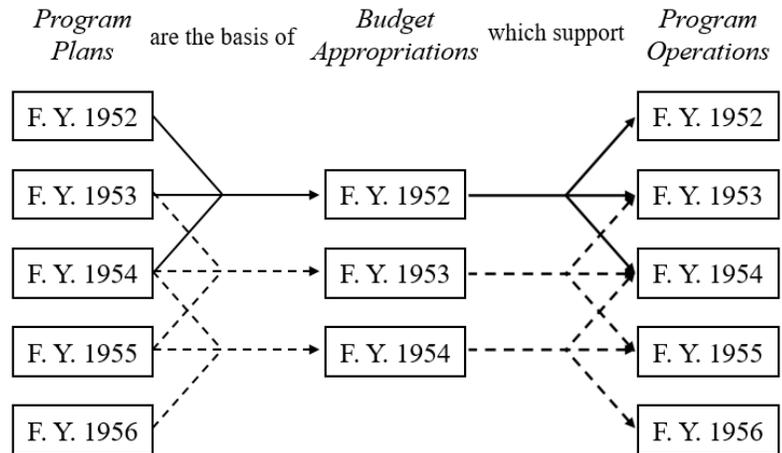
reason that it does not have program information that far in advance.”⁹⁶ The performance budget and the problem of time forces program plans, meaning the course of operations, to be set two years in advance of funding receipt and up to six or more years ahead of actual expenditure. The logic of the performance budget rested on the accuracy and integration of long range forecasts.

Problem of Classification

The problem of classification stems from the fact that existing organizational structures often conflict with program structures.

Mosher noted that different forms of classification differ greatly in their logical usefulness, and are principles of organizing budget appropriations. He made clear that the “avowed theme” of the performance budget is its effort to develop classifications based upon “identifiable functions, programs, and kinds of work, rather than upon organization units and objects of payment.” Mosher examined several important questions about the performance budget’s effects. First, does it lead to an alignment of fiscal and administrative authority? Second, is it proper for segregating capital from operational expenses? And third, do the budgetary classifications improve the quality of administration?

First, the performance budget only aligns fiscal and administrative authority when the lower-level organizations fulfill a single function in terms of the program structure. Mosher made the point quite clear in connection to Bethesda Hospital, the Hoover Commission’s “almost classic example of performance versus old-style” budgeting. He wrote that for the hospital to have one source of funds, the performance budget would logically necessitate medical care to be a primary program appropriation. The fiscal and administrative responsibility for Bethesda Hospital then flows through the Surgeon General in connection to the medical program and not through the military line command. In the case of Bethesda Hospital, a single function organization, the organizational structure and the program structure exactly paralleled each other. However, the outcome of exact alignment is the exception, not the rule. Mosher pointed to the example of Fort Benning, whose commander is in charge of a multi-function



Reproduced figure from Mosher showing the problem of time associated with budgeting. Current and future program plans are the basis of budget appropriations which support program operations for several years to come. Note that the program plan for F. Y. 1952 is to be developed during F. Y. 1950, allowing a one year lead-time for budget process.

⁹⁶ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 114-123 and 279-80.

organization. The commander should plausibly have all his functions funded through a single source. However, in support of its military operations Fort Benning also includes a medical facility. Does the head of the medical facility report through the Fort Benning's commander and his military program, or through the Surgeon General and his medical program? If the former, the Surgeon General loses control of the medical care program, the total cost of which is not under his appropriation. If the latter, the commander at Fort Benning, a multi-function organization, begins to lose all control over his subordinates because each of them reports through a different organizational chain that aligns with their logical program. Mosher demonstrated how the same issues in medical care extended to military personnel, training, installation support, and perhaps most of all, the technical services, whose operations supported nearly every identifiable military program.⁹⁷ The performance budget produced the same outcomes McNeil sought to eliminate, the diffusion of financial and administrative responsibility.

Second, the performance budget is at “cross-purposes” with separating capital and operational expenditures because programs include both, inevitably leading to “knotty questions of definition.” This is even true when programs are designed to segregate the two. For example, the budget appropriation “Major Procurement and Production Costs” included aircraft, ships, artillery, and guided missiles, but it also included “expendable” items such as ammunition. On the other hand, “the various appropriations for maintenance and operations cover a very large amount of procurement, including equipment items of long life expectancy and usefulness.” Reorganizing the budget appropriations only led to contradictions in different forms. The problem of segregating capital from operating expenses traced back to the multi-functioned nature of organizations. Returning to Bethesda Hospital, it was for budget purposes considered a single-function organization because it perfectly aligned with the medical care program. However, when the hospital includes both capital (such as medical R&D or equipment) and operating expenses (such as patient services), it turns back into a multi-functional organization. Segregating programs based on their capital or operating nature still forced multiple funding upon Bethesda Hospital. Even where capital segregations are logical, Mosher concluded that the practice “directs the reviewers’ attention again to an item-by-item and project-by-project analysis, only distantly related to program objectives.”⁹⁸

Third, unless the program structure and organizational structure are perfectly aligned, programming hampers effective administration. Mosher noted that the budgetary classifications “proceed from the broad and general to the increasingly specific; they go from the ‘top down.’” Subdivisions of the program budget structure must “feed into” the

⁹⁷ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration Service, American Book-Stratford Press, Inc., New York, pp. 94-100.

⁹⁸ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration Service, American Book-Stratford Press, Inc., New York, pp. 95-99.

top classifications in terms of both lines of authority and allotment of funds.⁹⁹ As has been shown, the multi-function nature of organizations leads to their supporting several logical programs. Each service handled the difficulties of aligning program and organization in different ways.

Effects on Service Organization

The Navy chose to compromise its program structure by “molding” it “around the existing organizational structure of its bureau system.” Mosher wrote that “Each bureau was given one or more appropriations over which it has virtually exclusive jurisdiction... The fundamental basis, therefore, is organizational rather than programmatic; the result is a classification that is functional in the same degree that the organizational bureaus are functional.” By interpreting programs along organizational lines, each operating unit had by definition a single budgetary function. However, the orientation continued the duplication of activities across organizations, including “procurement, maintenance and operations, industrial mobilization, research and development, and others.” The Navy’s Bureau of Ordnance, for example, attempted to develop guided missiles by constructing high-speed aerodynamic and ballistics studies carried out in captured and reconstructed German supersonic wind tunnels.¹⁰⁰ However, the Navy’s Bureau of Aeronautics believed itself naturally competent for such work and funded its own rocket and missile programs. Though molding programs around existing organizations led to a strengthening of fiscal and administrative authority, McNeil’s intent, it also led to a continuation of the duplication and overlap that unification expressly aimed to eliminate.

The Navy’s approach to program budgeting resembled the Controlled Materials Plan from the war. The CMP was an organizationally based budget and reflected programs, such as aircraft, tanks, and automobiles, insofar as the organizations did. For example, both army and navy programs employed aircraft program elements. For the effects of resource allocation on aircraft to be readily identified from the top, aircrafts had to be associated with a single claimant. The aircraft scheduling unit took that role in order to avoid duplication and multiple funding, essentially aligning the Navy’s Bureau of Aeronautics and Army’s Wright Air Development Center through joint coordination. The approach maintained existing organizational hierarchies, leading to vertical program budgeting where each successive level of the organization defined programs to increasing levels of specificity.

The Air Force took a completely different interpretation of the program budget. Not being endowed with an extensive technical service system, the Air Force defined its

⁹⁹ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration Service, American Book-Stratford Press, Inc., New York, pp. 84. Mosher is alluding to activity-based costing.

¹⁰⁰ Lassman, Thomas C. 2008. *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-200*. Center for Military History, U.S. Army, pp. 43-44.

program structure with less regard to existing organization. Don S. Burrows remarked on four principles that served as the basis for the Air Force program budget. First, each appropriation served as a “grouping of self-contained programs so that fund adjustments to a program can be made without crossing appropriations.” Second, to eliminate multiple funding, each “Air Force Station Commander will receive funds from one appropriation to support his station.” Third, budget estimates will be presented based on program requirements using “specific cost factors and program units.” Finally, the fourth principle segregated “capital procurement from operating costs.”¹⁰¹ As Mosher showed, achieving the first two principles requires unfunctional organizations; every budgeted project must be self-contained within an organization. As former Secretary of Air Robert Lovett testified to the Congress, “The whole idea of the performance budget is to set up a unit that is going to cost so much, put some fellow in charge of it, and give him the authority and hold him responsible.”¹⁰² The logical conclusion to making the program prior to the organization was the systems project office (SPO), where a single organizational unit handled all aspects of a project. However, Mosher also showed that programs are at cross-purposes with segregating capital from operating costs. Because appropriations segregated R&D from procurement from operations, an aircraft program did not benefit from single funding. As the program matured, it was handed-off from one appropriation to the next. The result in the Air Force was strong central direction from the staff because the program was made prior to the performing organization. It led to a horizontal, or “flat,” organization where the principal organizational units included one layer of staff and one layer of SPOs.¹⁰³

The Army, the last to develop a program structure, did so along Air Force lines despite having strong existing technical services. The effect was a misalignment of program and organization. Mosher wrote that “The technical and administrative services of the Army, in some respects the counterparts of the bureaus of the Navy, had formerly had their own clearly identified appropriations... Each technical service now receives funds from several different appropriations in which it had only a partial interest.” Because each technical service only had a partial interest in each program, it required budget estimates at the general staff level to properly coordinate activities. Unlike the Air Force staff which defined a program and created a SPO to fully acquire it, the Army staff had to receive input from below by organization and object, translate it into programs for higher-level reviews, and translate it back into organization and object upon receipt of appropriations for proper administration. The translations were largely done by statistics and “guesswork.” Mosher wrote that “unless organization structure and program classifications are identical down to and including the operating level, there must be conversions

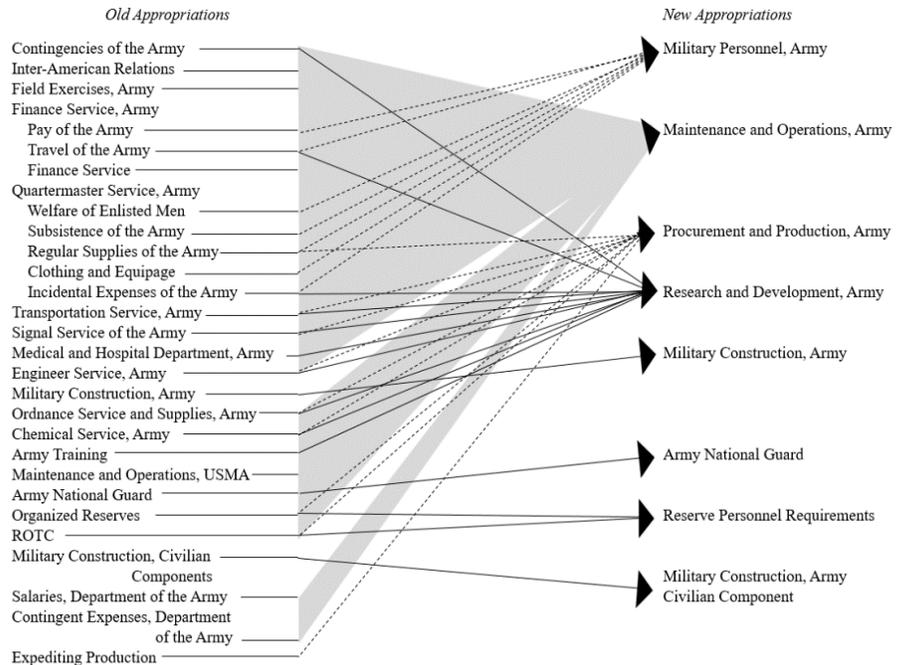
¹⁰¹ Burrows, Don S. “A Program Approach to Federal Budgeting.” *Harvard Business Review*, 1 May 1949, pp. 283.

¹⁰² “Implementation of Title IV, National Security Act of 1947, As Amended.” Hearings before the Preparedness Subcommittee No. 3 of the Committee on Armed Services United States Senate Eighty-Third Congress First Session (Nov. 2-4, 1953). United States Government Printing Office, Washington: 1954, pp. 34.

¹⁰³ Herbert Simon commented that “flat” organizations became all the rage in the 1950s.

in formulation from an organizational to a program classification.” He held hope in the development of a “standard Army-wide classification of Army functions from the bottom up rather than the top down.”¹⁰⁴ Though such classifications could reconcile programming and budgeting for the Army, it was never implemented.

The result of the new program structure and its “most important effect” on the Army had been to “lessen the independence and influence of the technical services, and, conversely, to strengthen greatly the position and the coordinating influence of the General Staff, *vis-à-vis* the budget... No longer do the technical services appear before Congressional committees as independent pleaders for funds.”¹⁰⁵ The same loss of authority that the Army technical services experienced was already a done deal for the Air Force. The SPO concept aligned programs and organizations, but required central staff planning to first define the program for the budget. Once the SPO was set up, it became primarily responsible for estimating changes in funding needs, under the authority of the staff. The ability of an organization to secure funds in the program budget relied on its ability to build and defend a cost estimate based on the military requirements involved. Mosher wrote that “the ‘requirements’ approach has implicit dangers, not alone that it may encourage inflated estimates but also in the ‘pass-the-buck’ psychology it encourages among budgeteers.” “If carried to its dangerous extreme,” he later explained, “this attitude might result in completely irresponsible behavior within the service. It is an attitude which might be expressed: ‘This is what I need, even though I know it is impossible for you (Secretary of Defense, Bureau of the Budget, President, or Congress) to give it to me. However, it will not be possible to do my job without all of it. If you make any cuts, you assume full responsibility for any dire consequences which may result.’” Mosher found that “the very expectation of budget



Reproduced figure from Mosher depicting Army budget structure before and after the performance budget. Note that the old appropriations clearly delineated organization and object. Based upon Department of the Army, “Pertinent Data on Revised Budget Structure Based on Fiscal Year 1952 Budget Estimates as Transmitted to Congress.”

¹⁰⁴ Mosher, 1954, pp. 112-13.

¹⁰⁵ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 87-88.

review may encourage budget padding.” When administrators expect higher levels to cut estimates, it is only “common sense and self-protection” that leads them to budget “padding” and “empire-building.” Further, it gives the higher levels “an opportunity to make and proclaim cuts without real damage.”¹⁰⁶ With the staff officers in control of the budget but dependent upon the line officers for information regarding program estimates, the line officers will attempt to build in as much flexibility as possible to compensate for uncertainty. The same principal-agent problem went for higher levels of review, leading to calls for pushing the primary estimating responsibility to ever higher—and therefore more independent—levels of administration.

Problems of time and classification plagued the performance budget, leading to a greater diffusion of authority and responsibility than the traditional budget. The problem of time meant that program decisions in one year constrained actions in future years. The problem of classification meant that program structures and organizational structures often conflicted in their administrative implications. Mosher quoted scholarly findings that “Even a leading technician in business budgeting states that profitable business can and do operate without completely developed or sufficient long-range budgets.”¹⁰⁷ Mosher concluded that “The budget plan and the program plan of a large agency may quite properly and necessarily *not* be the same thing. Their scope and coverage are almost certain to differ in some respects; their relation to time periods differs; the organization units and individuals primarily concerned for each may be different; the channels through which they proceed may well be parallel but not identical.”¹⁰⁸ His recommendations for an administrative budget along organizational lines went as follows: 1) each command or technical service should constitute an organic class in the budget; 2) each subcommand, a class at the second level; 3) each installation, a class at the third level; 4) each activity at the installation, a class at the fourth level.¹⁰⁹

A New Culture

Despite the power program budgeting provided the staff in general and the civilian comptroller in particular, there lacked the will to enforce it. Implementation of the first statutory performance budget in the Spring of 1950 never really got started due to the onset of the Korean War. A series of “crash budgets” took precedent over careful

¹⁰⁶ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 45-46, 174-75, and 14-15.

¹⁰⁷ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 227. From Walter Rautenstrauch, and Raymond Villers, *Budgetary Control* (New York: Funk and Wagnalls Co. in association with Modern Industry Magazine, 1950, pp. 4.)

¹⁰⁸ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 50.

¹⁰⁹ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 243.

programming which required two years of lead-time.¹¹⁰ For several years after Title IV was enacted, the program budget remained very much a “paper” plan. For the Army, where organizations and programs misaligned, some “scoffed” it and passed budgets “whether or not the ‘program’ has caught up to it.” Even the Air Force—which organized itself around the program budget through the SPO—was “still regarded by many, including some of its own staff, as being an opportunistic and largely ‘unplanned’ organization.” For Mosher, the departure of the Air Force from its own programs suggested that the programming portion of budget largely remained “plans and hopes.”¹¹¹

In the end, Mosher had mixed feelings on program budgeting. In 1954, Mosher was skeptical but still believed that “budgeting and program planning must be intimately and frequently, if not continuously related, even if they are not married.”¹¹² In 1956, Mosher argued that program budgeting, and the scope public administration itself, had crossed a threshold from which it could not return.¹¹³ By 1967, he would write of the program budget that “I have been a supporter for about thirty years.” Mosher did not take a stand against program budgeting in principle, just that it had been “oversold” and “misrepresented by its own advocates.”¹¹⁴ In fact, he looked upon programming as a central element for accountability to the public, though he feared whether program experts will be “on top or on tap.”¹¹⁵

Mosher found that the program budget attained unique success in the DoD for two reasons. First, he believed that defense lent itself towards unifunctional organizations in terms of program structure. In 1969, Mosher wrote with respect to program budgeting in the State Department, “Inevitably the definition and classification of programs and subprograms will differ from the structure of the organizational hierarchy... there is no way one can design complex organizations without overlaps, competing perspectives, and interdependence.” Defense, however, provided a “pretty misleading” example for other governmental departments because it only applied the true program budget to “areas of weapons development and major equipment.” Such programming required the unifunctional SPO concept, which only became institutionalized in the Army and Navy after their bureau systems were formally abolished in 1962 and 1966, respectively. The SPO organization in weapon acquisition, Mosher argued, meant that “decisions could be,

¹¹⁰ Hewes, Jr., James E. 1975, “From Root to McNamara: Army Organization and Administration.” Center of Military History, United States Army, Washington D.C., pp. 279-80.

¹¹¹ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 76.

¹¹² Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 50.

¹¹³ Stephenson Jr., Max O. and Plant, Jeremy F. “The Legacy of Frederick C. Mosher.” *Public Administration Review*, Vol. 51, No. 2 (Mar.-Apr., 1991), pp. 97-98. Fredrick was also son to the dean of the Maxwell School of Citizenship and Public Affairs, pp. 101.

¹¹⁴ Mosher, Frederick C., “Limitations and Problems of PPBS in the States,” *Public Administration Review*, Vol. 24, No. 2 (March-April, 1969), pp. 160.

¹¹⁵ Mosher, Frederick C. Letter to Editor-in-Chief, *Public Administration Review*, Vol. XXVII, No. 1, March 1967. “PPBS: Two Questions.” See his 1968 *Democracy and the Public Service*.

and were, almost totally centralized in the Pentagon.”¹¹⁶ However, budgets for military operations continued to have a fundamental basis in organization and object.

The second precondition to a successful program budget is competence in more advanced forms of estimating. Mosher noted program budgeting required “essentially statistical, rather than accounting, skills and techniques.” While the traditional budget process adds up salaries and expenses, the program budget required “cost factors” and “analysis of previous cost experience.” The DoD had a long history of such analyses, some of which Mosher believed attained “a high degree of accuracy.”¹¹⁷ He wrote that “Cost effectiveness studies had after all been going on in the military sphere ever since World War II and particularly in The RAND Corporation for most of the decade of the ‘50s. There was no such familiarity and experience in most of the civil activities of government.”¹¹⁸ As Mosher explained to the Congress, “the nature and acceptance of program budgeting depends heavily upon the ‘culture’ of the organization.”¹¹⁹ Mosher’s understanding of the power of the budget process led him to foresee in 1954 that a push for programming would create the rise of a “new class” of specialism associated with statistics and cost effectiveness subordinate to the comptroller:

“If the business concept [of controllership] is pushed hard by its supporters within and outside the departments, it could conceivably lead to an outright struggle for power and control between the military specialism and the accounting specialism. In such a struggle, there can be little doubt who in the long run would win. More likely is the gradual emergence of a compromise involving the absorption of a new type of specialism, more or less divorced from military command and planning channels, responsible for dollars, numbers, records, and budgets.”¹²⁰

¹¹⁶ Mosher, Frederick C., "Limitations and Problems of PPBS in the States," *Public Administration Review*, Vol. 24, No. 2 (March-April, 1969), pp. 160-61.

¹¹⁷ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 239.

¹¹⁸ Mosher, Frederick C., "Limitations and Problems of PPBS in the States," *Public Administration Review*, Vol. 24, No. 2 (March-April, 1969), pp. 160.

¹¹⁹ Mosher, Frederick C. "Program Budgeting in Foreign Affairs: Some Reflections." Prepared by the Subcommittee on National Security and International Operations (Pursuant to S. Res. 212, 90th Cong.) of the Committee on Government Operations. United States Senate. U.S. Government Printing Office. Washington, 1968, pp. 141.

¹²⁰ Mosher, Frederick C. 1954. *Program Budgeting: Theory and Practice with Particular Reference to the U.S. Department of the Army*. Public Administration service, American Book-Stratford Press, Inc., New York, pp. 228-29.

3. *Systems Analysis*

“Little boys and matches neither logically nor inevitably lead to fires, but the probability is distressingly high, if it’s your boy and house.”

Armen A. Alchian
“A Proper Role of Systems Analysis,” 1954

Centralization and its tool, program budgeting, theoretically allows for efficient resource allocation by enabling integrated operations based on unified long range plans. Yet the whole concept relies on numerous estimates about future states of the world as a basis for plans and evaluations. For example, capability requirements depend on future military environments, enemy capabilities, technological readiness, and so forth. Further, there may be several technical specifications which can fulfill any given requirement, each of which has its own uncertainties as to cost, schedule, and performance attributes. Program budgeting, therefore, first requires defining the bounds of each estimate and then systematically evaluating all relevant costs and measures of effectiveness to inform the optimal course of action.

The set of techniques used to inform programmatic decision-making is broader than that of statistics and probability alone, including optimizations, marginal costing, game theory, and cost effectiveness comparisons. The whole set of quantitative techniques became known as systems analysis. The systems analysis approach was nurtured by Air Force General Henry H. (“Hap”) Arnold, who sought to improve innovation by creating a “university without students” funded by and devoted to military research.¹²¹ Project RAND was first put on contract through Douglas Aircraft, and broke away as an independent corporation in 1948.¹²² It attracted some of the most famous academics from a diverse set of fields fostering a quantitative revolution in the social sciences.

Championed by RAND, the systems analysis approach was most fully adopted by the Air Force and the aerospace industry. The Wright Air Development Center began suggesting that contractors make their proposal as the result of a systems analysis study.¹²³ Industry proponents, such as Lockheed, suggested the practice become a

¹²¹ Hounshell, David. A. “The Medium is the Message, or How Context Matters: The RAND Corporation Builds an Economics of Innovation, 1946-1962.” In *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*. Edited by Agatha C. Hughes and Thomas P. Hughes. The MIT Press, Cambridge, Mass., 2000, pp. 257-58.

¹²² Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 214.

¹²³ Alchian, Armen A and Kessel, Reuben A. “A Proper Role of Systems Analysis,” RAND Corp., 1954.

requirement for all design and procurement decisions.¹²⁴ RAND analyst E. S. Quade wrote that “there seems to be a feeling in some parts of the Air Force that the systems approach may provide the complete answer to all questions of development, procurement, and operation as well as those of design.”¹²⁵ One ambitious Air Force officer under General Arnold that carried the mantle of systems analysis was Colonel Bernard Schriever. As a planning officer in bomber development, Schriever insisted on systems analyses that recommended the single best configuration.¹²⁶ Planning around an optimal design allowed for “concurrent” progress on R&D and production tooling such that the greatest technological advancement could be achieved for the least cost and shortest schedule. Schriever would bring the systems analysis concept to its summit through its use on a competitor program to the mission role for the strategic bomber, the inter-continental ballistic missile (ICBM).

Atlas ICBM Program

During the budget drawdown for FY 1947-1948, the Air Force gutted its missile R&D budget in favor of bombers. Twenty-eight full-scale missile projects in 1946 fell to only three in 1950.¹²⁷ By that time, however, RAND Corp. and other industry studies began to show increasing feasibility for long range missiles to carry nuclear payloads. Starting in 1951, the Air Force provided limited funds to a relatively low-priority ballistic missile project, designated first “Project MX-1593” and later “Project Atlas.”¹²⁸ Schriever supported the ICBM concept believing that space technologies would dominate over the long haul, leading him into conflict over resource priorities with General Curtis LaMay who continued to favor strategic bombers. Project Atlas didn’t get fully underway until a change of leadership occurred with the inauguration of President Eisenhower. Trevor Gardner, special assistant for R&D to the new Secretary of the Air Force, also supported ICBM technologies. He initiated a committee of distinguished scientists and engineers to make recommendations. Under the leadership of Dr. John von Neumann, the “Teapot Committee” report issued in February, 1954 found that an ICBM could be operational by 1960, but only if it were



*Convair SM-65F Atlas #102, Site 11
New Mexico, 14 Oct 1962.*

¹²⁴ Bailey, Robert A. “Application of Operations-Research Techniques to Airborne Weapon System Planning,” *Journal of Operations Research Society of America*, August, 1953.

¹²⁵ Alchian, Armen A and Kessel, Reuben A. “A Proper Role of Systems Analysis,” RAND Corp., 1954.

¹²⁶ Hounshell, David. A. “The Medium is the Message, or How Context Matters: The RAND Corporation Builds an Economics of Innovation, 1946-1962.” In *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*. Edited by Agatha C. Hughes and Thomas P. Hughes. The MIT Press, Cambridge, Mass., 2000, pp. 264.

¹²⁷ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 210.

¹²⁸ Federation of American Scientists. Early ICBMs. <https://fas.org/nuke/guide/usa/icbm/early.htm>.

placed under a new agency “relieved of excessive detailed regulation.” A month later the Air Force put Atlas on a crash basis. Three months later Atlas became assigned the Air Force’s top priority. By August, 1954, Trevor Gardner would convince Schriever, now a brigadier general, to manage the ICBM program by granting him sweeping authority.¹²⁹ Largely freed from time-consuming approvals involving nearly 40 military offices, Schriever could transcend the coordinating role of other program managers and actually manage the program to success.¹³⁰

Systems analysis promoted the use of a single prime contractor. While Convair had been the incumbent on Atlas, Schriever chose Ramo-Woolridge to take its spot in systems engineering and technical direction. Schriever relied on Ramo-Woolridge, an upstart company created by former Caltech physicists at Hughes Aircraft, to make sure that all parts of the program moved together and minimized the risk of specification change during integration and production. The systems analysis approach generally pursued a single best system configuration resulting from a cost effectiveness study across alternatives. Schriever took the same approach with Ramo-Woolridge, selecting one design for the airframe (Convair), the propulsion (North American), the nose cone (General Electric), inertial guidance (Sperry Rand), and so forth. However, before Schriever could get underway the Scientific Advisory Board recommended a second parallel source of ICBM development using more conventional technology as a hedge against Atlas’ possible failure.¹³¹

The genesis of the Titan ICBM, the Air Force’s parallel effort to Atlas, actually lay with RAND president, Frank Collbohm. As historian David A. Hounshell showed, Collbohm was the only member of the Scientific Advisory Board to formally object to Schriever’s systems analysis plan. In fact, RAND was initially asked to take the lead systems integrator role for Atlas before Ramo-Wooldridge, and Collbohm turned it down. Although the reason is unclear, Hounshell provided some clues as to his thinking:

“From Collbohm’s statements to von Neumann, we know that he believed there was a misfit between the air force’s new religion of systems engineering and what Collbohm thought was the best way to get an ICBM built and fully operational. Also, Collbohm believed that RAND’s undertaking such a task would not be consistent with his institution’s fundamental mission for the air force. Unquestionably Collbohm’s views matched quite closely the ideas that Armen Alchian had been developing since the late 1940s about the importance of diversity in technological development; the critical differences between research, development, and procurement; and the inherent problems

¹²⁹ Neufeld, Jack. *Bernard A. Schriever: Challenging the Unknown*. Office of Air Force History, Washington D.C., 2005, pp. 7-10.

¹³⁰ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 494-95.

¹³¹ Neufeld, Jack. *Bernard A. Schriever: Challenging the Unknown*. Office of Air Force History, Washington D.C., 2005, pp. 12-14.

in employing systems analysis to optimize the performance of an advanced weapons system that had yet to be developed.”¹³²

RAND had a small number of economists, led by Armen A. Alchian, who criticized systems analysis as the wrong way to promote innovation. Collbohm appeared to reflect those sentiments, despite the fact that RAND rose to prominence precisely because it campaigned for the systems analysis approach as a cure to project inefficiencies. One of the primary advocates for systems analysis within RAND, engineer E. S. Quade, later recalled “It wasn’t until Armen Alchian, Jack Hirshleifer, and other economists tore my first system study apart that I became aware that economic theory had anything much to contribute to weapon choice.”¹³³ One paper in particular exposed the critical errors of systems analyses.

The Decision Problem

On January 27, 1954, Armen Alchian released a paper entitled “A Proper Role of Systems Analysis.” Though Reuben A. Kessel co-authored, it clearly built on numerous papers Alchian previously released making his thought leadership unmistakable. It starts by reviewing Quade’s work and finding four rationales in support of systems analysis. “(1) contractors seldom feel well compensated for development effort alone, hence systems analyses are required in order to avoid unprocured development; (2) resources are wasted when perfectly sound aircraft are developed and then not procured; (3) superiority of particular planes proposed by competitors could reliably be evaluated by the Air Forces; (4) there is too long an interval from research to production.” The existing practice had been for Air Force contractors to assume development risk by investing their own funds to ensure the best testing units and a lucrative production contract. A systems that didn’t make it to production risked financially ruining the contractor. Systems analyses helped choose the specification with the maximum effectiveness for the least cost, eliminating wasteful “loss leader” investments in R&D.

An already well known issue with systems analysis was the problem of the criterion, or the character of the values upon which alternatives are judged. Does the analyst want to maximize accuracy, or reliability, or damage, or something else? The numerous attributes inherent to complex systems often conflict such that an increase in, for example, accuracy usually comes at the expense of reliability and/or damage. Systems complexity makes selecting the correct criterion difficult, and the quantitative implications may depend completely on the selected criterion. For example, the first systems analysis performed by RAND in 1949 found turbo-prop bombers more cost effective than pure jet bombers. Displeased with the results, General LeMay changed the

¹³² Hounshell, David. A. “The Medium is the Message, or How Context Matters: The RAND Corporation Builds an Economics of Innovation, 1946-1962.” In *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*. Edited by Agatha C. Hughes and Thomas P. Hughes. The MIT Press, Cambridge, Mass., 2000, pp. 264-65.

¹³³ “A History of Cost Effectiveness” April 1971, E. S. Quade, The Rand Corp, Santa Monica, CA, pp. 11.

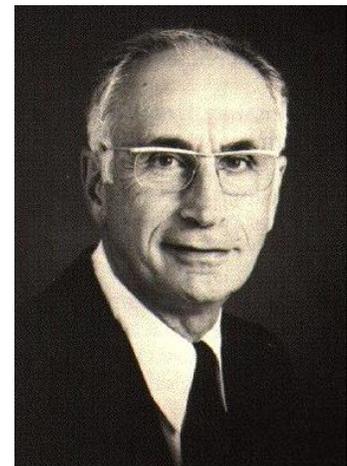
assumptions of the systems analysis and found that the turbo-prop costs had doubled at the same time that the pure jet bomber costs fell by half.¹³⁴ Systems analysis seemed to confirm the preexisting biases.

Alchian, however, did not pile onto the “criteria problem” and instead focused on clarifying the “decision problem.” He found the most basic problem in decision analysis to be whether a situation calls for a single best choice or whether a diversity of action should be taken. Continuing the example, should the Air Force choose between turbo-prop bombers and pure jet bombers, or pursue both designs? Alchian asked the pivotal questions:

“For some problems, great gains will come from unique binding choices resulting from systems analyses; for others the gain will come from diversity of actions... In what situations is the latter principle of diversity preferable? And in what situation is the former appropriate? Do systems analyses help us to answer these questions? Does it help us select the diverse or unique actions?”¹³⁵

To answer his own questions, Alchian examined the issue of when the implications of a maximization exercise equated with a decision or choice of action. He found that “If the assumptions were regarded as perfectly accurate forecasts and if the predictability of technological capabilities were known with perfect accuracy, then the maximization criterion, assuming one has the correct criterion, would reveal the optimal choice of action.” In other words, if all estimates of future states of the world were perfectly known, including 1) the design and production feasibility of new weapons—questions of R&D; and 2) the enemies’ capabilities, intentions, and environments—questions of procurement, then maximization along the correct criterion will lead to the optimal decision. Importantly, this decision will also look optimal when viewed after-the-fact, meaning no newly generated information would lead observers to have found mistakes or more efficient system configurations.

On the other hand, when forecasts contain uncertainty, “there is not available any generally accepted rule for rational behavior.” The limitation occurs because outcomes correspond to a “probability distribution of costs under each type of choice.”¹³⁶ To illustrate, suppose the Air Force evaluated two design proposals with the same performance. Design A costs \$100M to fully develop and Design B costs \$50M. If the forecasts of cost and performance were known to be perfectly accurate, the decision is clear. Design



Armen A. Alchian, after his time at RAND Corp.

¹³⁴ Novick, David. “Beginning of Military Cost Analysis 1950-1961.” RAND Corp., March 1988, pp. 2.

¹³⁵ Alchian, Armen A. and Kessel, Reuben A. “A Proper Role of Systems Analysis.” RAND Corp., 27 January 1954, pp. 6.

¹³⁶ Alchian, Armen A. and Kessel, Reuben A. “A Proper Role of Systems Analysis.” RAND Corp., 27 January 1954, pp. 6.

B wins. Supposing that Design B now also costs \$100M, the Air Force will be indifferent between the two. However, if Design B employs a new team or technology, it will create uncertainty resulting in a distribution of potential outcomes. For simplicity, suppose Design B is equally likely to cost \$50M as it is to cost \$150M. Though the expected value is \$100M, the same as Design A, the decision now depends on the decision maker's preference for risk. The more risk-loving the decision maker, the more he is willing to gamble that Design B will prove successful and accept that if it isn't, he will pay dearly. The more risk-averse the decision maker, the more he would be willing to pay for the assurance provided by Design A. In reality, both designs will likely have extensively overlapping probability distributions for each of cost, schedule, and performance estimates. Systems analysis, which relies on expected values from possible future states of the world, cannot provide the single best choice under conditions of sufficient uncertainty.

Separating R&D from Procurement

When uncertainty reigned, Alchian believed that decisions pertaining to R&D should be separated from those pertaining to procurement. The former requires determining the feasibility of new weapons. The latter requires determining the correct weapon to fight or deter the enemy. Alchian referenced a 1952 paper of his called "The Chef, Gourmet, and Gourmand." There, he wrote that "These two decisions are very different in their timing, in the information required, in their criterion of proper decision, and in their intended effects." He continued:

"...since we suffer from predictive myopia in both eyes [the R&D and procurement decisions], we either can guess and then design what we hope will be the optimal, or, a good weapon—or, we can truthfully admit we don't know and obtain insurance by designing several alternative weapons, one for each possible contingency. The Research and Development effort is intended to create designs of new weapons which will form our confirmed and broad set of weapons available for procurement. It must be recognized that R and D is directed toward providing a set of available choices rather than toward providing the one weapon that *ex post* best collates with the realized state of the world ten years hence. To assume that our foresight is adequate for this purpose is the error of not knowing how blind we really are. R and D not only advances us technically—it is also our only assurance of flexibility and wide range of choice in the future."¹³⁷

Alchian believed that good R&D policy created a menu of available weapons that reduce the uncertainty of procurement decisions. With a menu of weapons, the procurement decision need only focus on its own uncertainties of operational environment instead of compounding uncertainties on top of those of R&D. In this way, procurement decisions gain from the availability of options emerging from realized outcomes of R&D decisions,

¹³⁷ Alchian, Armen A. "The Chef, Gourmet, and Gourmand." 24 March 1952. The RAND Corp., Santa Monica, CA, pp. 7.

minimizing the scope and magnitude of errors. He developed a useful analogy that formed the title of his paper:

“Research and Development decisions are those of the Chef, who concocts new dishes and plans a menu of available alternative dishes, from which the Gourmet at a later time has the privilege of choosing in light of his tastes, companions, and income. A good Chef provides a broad menu—thereby assuring the Gourmet the opportunity to make the best selection. The difference between the Chef and the Gourmet must be kept strictly distinct. To confound the two is as disastrous in the military as in the restaurant business.”¹³⁸

Alchian’s critical insight was the principle of insurance. He advanced an idea of insuring procurement and operations outcomes by fully developing a diversity of systems that could be selected from. Similar to how individuals pay a premium to insure themselves against natural uncertainties related to health, financial, and other risks, Alchian argued the military should pay a premium in R&D to hedge against weapon system uncertainties in procurement and operations. The insurance policy of diversity is especially important when the costs to procure and operate a system are large relative to R&D, which, at a 20-to-1 cost ratio, was certainly the case. In other words, diversification has a higher “most likely” cost than a single best choice in R&D, but it also leads to better developments with less cost uncertainty overall, and ultimately lowers procurement and operations costs. The savings and increased utility of resulting weapons more than pays back the increased outlays in R&D.

Yet Alchian did not see the Air Force pursue the diversity strategy in R&D, leading him to fear that “we shall all soon cease to be economizing gourmets with a la carte menus and become expensive, undernourished table d’hôte gourmands.” A table d’hôte is a fixed menu and a gourmand likes to overeat. Alchian applied the analogy to the Air Force because many of its officers believed that pursuing the single best choice for a mission requirement allowed them funds left over to pursue even more requirements. Yet by having no alternatives to the single contractor once selected, the Air Force pre-commits itself to potentially sub-par developments and higher prices in procurement and operations. Escalating backend prices increasingly squeeze out R&D funding, straining diversity and creating a harmful cycle. As a result of the Air Force’s desire to overeat it ends up undernourished. Alchian recognized that such gourmands would proactively suppress diversity for the sake of efficiency, or, what is the same in their eyes, reducing waste:

“We, therefore, must recommend the development of a menu of several alternative weapons—guaranteeing that ignorant or malevolent critics will be able to show that a large majority of them were “useless” and “wasted” millions of dollars—but assuring ourselves flexibility in order to have safety and economy with optimal weapons in actual use.”¹³⁹

¹³⁸ Alchian, Armen A. “The Chef, Gourmet, and Gourmand.” 24 March 1952. The RAND Corp., Santa Monica, CA, pp. 8.

¹³⁹ Alchian, Armen A. “The Chef, Gourmet, and Gourmand.” 24 March 1952. The RAND Corp., Santa Monica, CA, pp. 8.

Exercising Options

While diversification achieves insurance, it does not involve funding more projects based on systems analyses, as one might spread investments across financial asset classes. Diversification in management results from taking intermediate actions, each of which benefits from optionality previously gained. Alchian did not recommend pursuing the development of the top two, three, or more designs resulting from systems analyses, only to wait and see which fully integrated system went from paper to hardware most effectively. Rather, he favored placing options at regular steps which allowed for reflection upon the information gained. As Alchian explained:

“There will not result a specific series of particular steps which must be taken each year. The only firm decision now is the one applying to steps taken in the first year. Actions of succeeding years, while conditioned by the chosen moves in this year, are to be selected from the choices available in later years... In a nutshell, we seek a strategy for selecting actions as the need arises; we do not seek a particular series of actions to be committed to now.”¹⁴⁰

The diversification Alchian posited, particularly in R&D, is roughly equivalent to the principle of optionality. An option is a right without an obligation to take future action depending on how circumstances unfold. Options provide the ability to defer decisions into the future, usually at a cost. Optionality in management recognizes that when organizations make investments they can: 1) change direction or funding levels before project completion; and 2) use project outcomes in a variety of ways. By placing options throughout an investment project, through multiple paths, intermediate decision points, or both, managers can take advantage of information as it becomes available without pre-committing to one approach. The Manhattan Project provided an early example of the benefits of “real” options. Four major paths for developing fissionable material were taken in 1943, but it took a composite of a fifth path and two existing paths to achieve success. As Lenfle and Loch showed:

“For the production of fissionable materials, a breakthrough came when it was discovered that a new process, thermal diffusion, could provide slightly enriched uranium, which would then feed the gaseous diffusion and electromagnetic processes for further enrichment. The parallel processes were unexpectedly combined into a composite process that finally achieved the desired performance.”¹⁴¹

Had the program manager, General Leslie Groves, decided to pursue only the single best path, the atomic bomb may not have completed on time. However, it also turned out that a “diversity” of four paths would not have created the solution on their own had they taken the systems analysis approach. Without the option to start new paths *and* modify the

¹⁴⁰ Alchian, Armen A. “The Chef, Gourmet, and Gourmand.” 24 March 1952. The RAND Corp., Santa Monica, CA, pp. 11-12.

¹⁴¹ Lenfle, Sylvain and Loch, Christoph. “Lost Roots: How Project Management Came to Emphasize Control Over Flexibility and Novelty.” *California Management Review*, vol. 53, no. 1, pp. 32-55, Fall 2010, pp. 5.

course of existing paths, the atomic bomb may have not had such a timely completion. The use of options was in fact pervasive in early Air Force developments. A 1963 RAND study found that of the Air Force's six most recent fighters, four ended up with different engines than originally planned, three with different electronic systems, and five with different airframes.¹⁴² The examples highlight important implications of Alchian's work: 1) the information necessary to select the best weapon systems is not available outside the process in which they are brought to test; 2) project controls should allow for the flexibility to take advantage of information as it arises by placing options at regular steps to reevaluate direction and funding; and 3) project outcomes create positive spillovers by solving problems on other, potentially unrelated, projects. Taken together, the implications call for a trial-and-error approach to program management as opposed to systems approach of systematically planning all steps before-the-fact.

Like the general staff concept that relies on a one-way flow from policy to administration, or from planning to doing, the systems analysis approach relies on a one-way flow from science to engineering. If science is an exploration of the unknown and engineering is the application of scientific knowledge already gained, then telescoping development and production makes sense if a scientific foundation exists. What remains relies on planning the engineering steps to bring the scientific knowledge to life. Wernher von Braun, Chief of Army missiles in 1958, said "I believe an established missile program, like the Jupiter, has much more similarity with an industrial planning job than with a scientific project [...] I would say it was 90% engineering and 10% scientific."¹⁴³ While systems analysts often believed that basic science requires duplication and overlap, engineering development and production tooling should not. However, even if development efforts can be characterized as engineering-based, it does not relieve them of fundamental uncertainties. In fact, the engineering discovery process often creates solutions that precede a fundamental scientific understanding. The Army, for example, conducted the Jupiter's "industrial planning" very differently from that recommended by systems analysis, to its own benefit as well as the benefit of the Air Force.

Harvard researchers Martin Peck and Frederic Scherer found that the Air Force Atlas ICBM program led by General Schriever had critical technical problems solved by the Army's Jupiter program. They show that the engineering method used by the Army was characterized by trial-and-error processes that systematically searched for information without understanding all physical aspects before-the-fact:

"There remained, as General Schriever noted, one critical problem—re-entry of the warhead into the atmosphere—about which little physical knowledge existed. When ballistic missile warheads re-enter the atmosphere at speeds up to 20,000 mph, shock

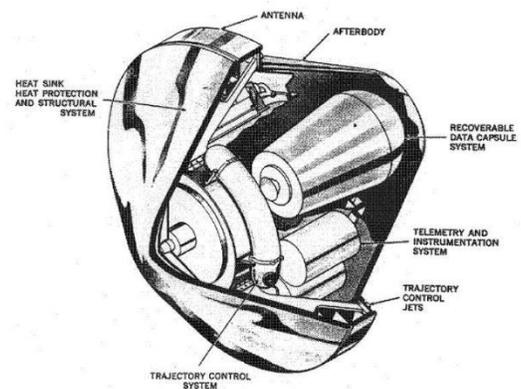
¹⁴² Poole, Walter. History of Acquisition in the Department of Defense Volume II: *Adapting to Flexible Response, 1960-1968*. Historical Office, Office of the Secretary of Defense, Washington: 2013, pp. 101.

¹⁴³ Peck, Martin and Scherer, Frederic. *The Weapons Acquisition Process: An Economic Analysis*. 1962, Harvard University Press, pp. 40.

waves with temperatures of 15,000F or more are generated. But just how these shock waves were formed, how they behaved in contact with various physical shapes, and how the tremendous temperatures would react with materials in a shock wave environment were all unknown. In this respect Atlas was a “scientific” project. Even then, however, it turned out that the re-entry problem was resolved by [engineering] activities before a complete [scientific] understanding existed. The Jupiter IRBM nose cone problem was solved largely in an empirical manner. It was known from theoretical calculations that the nose cone had to resist certain general heats and shock waves. Guided by test data on rocket throat temperatures, one material after another and one shape after another were tried in the exhaust blast of a rocket engine until the most successful combination was found.

"This nose cone illustration reflects a broader set of technical problems typifying advanced weapons developments. Fundamental scientific knowledge about the environments within which new aircraft, guided missiles, and space vehicles must operate has frequently been lacking during many developments of the 1950-1960 era. For example, science has yet to provide sufficient understanding of how objects behave in various supersonic and hypersonic environments to predict fully the problems which will be encountered in flight. All too often, these problems do not become apparent until a prototype vehicle is test-flown unsuccessfully. Then isolating the problem requires lengthy trial-and-error testing in which scientific theory may be of little assistance."¹⁴⁴

Had not the Army pursued its own parallel path on ballistic missiles that rejected the systems analysis approach, the Air Force Atlas ICBM may not have proved successful. If a system requires all components to function and marry, then the Atlas would never have reached operational status until every single component, including the nose cone, functioned. Had the Air Force chosen to break off nose cone engineering until they could generate the scientific knowledge, it isn't clear that the objective could have ever been accomplished. In technological progress, there exists a reflexive relationship between scientific and engineering discovery that complement each other, rather than a one-way flow of information from the scientist to the engineer.¹⁴⁵



Prototype design of the General Electric's Mk-2 nose cone for the Atlas program. The blunt body concept shown above was scrapped for the Mk-6 which used a similar design to that of the Jupiter IRBM.

It will help to take these concepts further to more fully illuminate the justification for the trial-and-error approach to diversification. Consider the attributes of a project estimate: cost, schedule, and performance. How do they vary with respect to uncertainty? As uncertainty increases, all three probability distributions are bounded at zero, but grow a “fat tail” toward infinity. Uncertainty then harms projects with respect to cost and

¹⁴⁴ Peck, Martin and Scherer, Frederic. *The Weapons Acquisition Process: An Economic Analysis*. 1962, Harvard University Press, pp. 40.

¹⁴⁵ A reflexivity that also applies to the staff and line officers, the policy-maker and the administrator, the planner and the doer.

schedule because, though the best possible outcome is a cheap system, the worst is bankruptcy before receipt. Humans may never find the solution to some technical problems, no matter how many dollars or hours are devoted. Conversely, uncertainty benefits projects with respect to performance because the worst that can happen is the loss of a fixed investment, while the best outcomes can revolutionize in military technology. The primary objective of portfolio management in an uncertain environment, therefore, is to find ways to limit risk exposure to project cost and schedule, and, unintuitively, to maximize risk exposure to system performance. This is in practice achieved by fixing cost and schedule targets and providing maximum discretion to the managers of a wide diversity of projects. There are few projects that a central planner can afford *not to take part in*. When technical achievement proves easy, it can be followed up on, and when it proves difficult, projects can be cut and alternatives sought. On the other hand, if systems performance is fixed, only minor performance gains can be sought unless there is a willingness to accept high cost and schedule risk.

Insuring Weapons

Alchian identified an optimistic bias in industry emerging as a result of the lock-in problem generated through the systems approach that selected the development, procurement, and operational support all at once and all based on estimates of cost and performance. Traditionally, contractors would finance development overruns—or the entire project—themselves to ensure the system would make it to large and profitable procurement contracts where they recouped the developmental losses. Development was therefore in a state of “hyper-competition” and procurement in a state of “hypo-competition,” since there was no incentive for efficient procurement, only development.¹⁴⁶ Still, government procurement decisions could have a diverse menu of tested systems to select from financed by the contractors. Systems analysis, however, intended to relieve the contractors of loss leaders by selecting the single best option ahead of time. This is effect meant deciding upon the best design, moving the state of hyper-competition from hardware developments to paper designs. As a result, contractors were incentivized to abuse forecasts because the most optimistic one in the design phase would win both development and procurement funds. J. L. Atwood, President of North American Aviation, summarized the Air Force’s industrial environment:

“There is a disproportionate premium attached to winning a design competition. It is the ticket of admission to the production show, but after all a design is just a list of promises based on calculations, which in turn are predicted on assumptions that can vary with the optimism of the producer.

¹⁴⁶ The services sometimes competed out the production of hardware designed by one firm to other firms, particularly during war. This led to the risk of what seems like a paradox: good innovations creating losses.

“Rarely if ever have there been any real penalties when the glowing forecasts of the design proposal were adjusted downward to the physical facts of the airplane. And it is then too late to change.”¹⁴⁷

Alchian’s recommendations to avoid the lock-in problem were to start more R&D projects, make them pay, and break the relationship between developer and producer. “The way to weaken the importance of winning design competitions is simply to bring enough competitive designs through the development stage.” Alchian essentially advocated replacing before-the-fact controls based on paper designs with after-the-fact controls based on hardware. Instead of letting the contractors take losses as they had before systems analysis, Alchian advocated getting contractors “to go into development work for what they can get as profits in development rather than a vehicle for obtaining production profits.” By making development pay, procurement contracts should be awarded for efficiency in procurement, and need not be tied to the same contractor that developed it. Technical skills in development and production differed in form and function, and need not always be under the same roof. The increased development costs in support of diversity were returned by: 1) generating savings in procurement and operations—the far larger slice of the pie; 2) increasing the quality of systems available to procure; and 3) insuring against changing states of the world with functional alternatives ready for production. He wrote:

“The insurance principle of diversified investments in development is superior to the principle of developing and procuring one flexible weapon. This assertion is refutable. But so strong is our conviction in this, that we strongly recommend this theorem as a basic part of the systems analysis. In all frankness, we are obstinately insistent that this is true for research and development decisions; we are of an open mind on the issue of whether or not it is true for procurement and other categories of decisions.”¹⁴⁸

Interestingly, Alchian leaves open the idea for the application of diversity to procurement, presumably where operational costs are particularly high or environments uncertain. This would push the primary benefits of optionality to operations and, potentially, increase relative procurement costs.¹⁴⁹ Alchian revisited the four rationales for systems analysis and flatly called all their implications “False.” He wrote:

¹⁴⁷ Atwood, L. J. “Airframes.” *Air Force*, October 1953, pp. 58. Found in Alchian, Armen A. and Kessel, Reuben A. “A Proper Role of Systems Analysis.” RAND Corp., 27 January 1954, pp. 12.

¹⁴⁸ Alchian, Armen A. and Kessel, Reuben A. “A Proper Role of Systems Analysis.” RAND Corp., 27 January 1954, pp. 9-10.

¹⁴⁹ One critique may be that a diversity of procurements would lead to far higher operating costs. However, the strength of commercial businesses is clearly in extended lines of logistics for the variety of goods demanded by consumers. Further, if more developments are pursued which primarily seek to integrate existing technologies for ruggedness and simplicity, commonality can emerge rather than being enforced in large scale multi-mission programs. The most important and obvious reason for lower operating costs is that diversity will lead to much increased reliability. Systems which favor flexibility over simplicity are naturally more complicated, and are exponentially more likely to run into reliability problems (see O-Ring theory).

“1. Inadequate compensation for development work is the reason developers feel inadequately compensated. It’s not because of some other technological or natural fact of life. Therefore the cure is not in using systems analyses, however desirable that may be for other reasons; the cure is to break the link between development and procurement and make development pay.

“2. Resources are not wasted when perfectly sound aircraft are developed and then not procured. In fact, such an outcome is a necessary result of an adequate development program. Failure of such an outcome is absolute proof of inadequate development.

“3. Superiority of particular planes cannot be ascertained by systems analyses; the ignorance giving rise to this inability is not the kind that systems analyses will remove.

“4. The time from research and development to production is not too long. This view confuses the time required to perform a task with the completion date. We want early completion dates, and this can be achieved despite lengthening the interval between development and procurement, if we can arrive at given states of technical knowledge even earlier...

“We may summarize our conclusions:

“1. Systems analyses are machines for generating implications of postulated initial information; they do not generate decisions.

“2. Under uncertainty, the criterion of decisions is not simple maximizations; the essence of the decision process is to affect the scope of random factors so as to give a “good” probability distribution of outcomes. The insurance principle is to decisions what maximizations are to analytic implications.

“3. Insurance requires diversity of investment—not variety of possible environments or flexibility of particular weapons.

“4. Optimal diversity in concrete situations cannot be ascertained. But institutional arrangements, wherein biases are created against diversity and toward identification of analysis with decision, are prima facie evidence of a system that yields suboptimal diversity.

“5. Stratification of the military problem into categories according to those in which diversity is economical and not optimal will facilitate an appreciation of purpose and usefulness of systems analyses.”¹⁵⁰

As the 1950s progressed, Alchian stopped spending as much time at RAND to pursue university economics and built his reputation as a leading professor in the field at the University of California, Los Angeles. He continued to support other RAND economists who worked on problems of military R&D. A 1958 paper by RAND economist William Meckling et al. provided policy recommendations based on the fact that R&D is “a *search*, a process of discovery... R&D is not intended to buy airplanes or missiles; it buys

¹⁵⁰ Alchian, Armen A. and Kessel, Reuben A. “A Proper Role of Systems Analysis.” RAND Corp., 27 January 1954, pp. 16-17.

*knowledge.*¹⁵¹ Put another way, R&D does not involve defining projects around future technological states because “to be able to predict an answer is tantamount to solution.”¹⁵² The very act of performing systems analyses before-the-fact implies having already solved all potential problems; the remainder is just to administer the solutions without discretion.

The authors gave five policy recommendations to improve R&D: 1) the planning process needs to be simplified by defining work scope in the broadest terms; 2) there should be more authority in project offices to take advantage of knowledge discovery if and when it happens; 3) alternative approaches to difficult problems should be fully developed and brought to test; 4) financial commitments to a single design should be kept modest in the early stages of development; and 5) quick tests of all new equipment should be insisted upon as early as possible.¹⁵³ The systems analysis approach, however, flies in the face of all five recommendations. The analogous points for systems analysis may go as follows: 1) the planning process needs to be well-defined to select the single best design; 2) project offices should require central direction to ensure optimality across the department; 3) only pursue the single best design for a particular mission, and fulfill multiple missions when possible; 4) financial commitments should be set aside up-front for the total expected costs of development and procurement; and 5) only tests of the final integrated system matter, not those for individual components, and production tooling should begin before operational test is complete.

The diversification and systems analysis approaches, both with their own set of proponents in RAND, implied starkly different organizations and management techniques. RAND’s schizophrenic attitudes were reflected by the DoD more broadly. For example, the Voorhees report of April, 1950, found that small and diversified Army R&D programs provided “greatly increased strength with unexpected economy.”¹⁵⁴ A year later, a different report found that the Army staff passively accepted programs from the technical services rather than aggressively formulating, coordinating, and evaluating an Army-wide program.¹⁵⁵ However, the systems approach eventually won out because of the allure of scientific management. Despite problematic efforts like the F-102, the systems analysis approach claimed the Atlas program as proof of its efficacy. Using the Atlas model of systems analysis, the Air Force instituted the “375-Series” of regulations in 1961, institutionalizing the systems project office and its reporting and approval process

¹⁵¹ Klein, B. H., Meckling, W. H., Mesthene, E. G. “Military Research and Development Policies.” RAND Corp., 4 December 1958, pp. 1-2.

¹⁵² Peck, Martin and Scherer, Frederic. *The Weapons Acquisition Process: An Economic Analysis*. 1962, Harvard University Press, pp. 300.

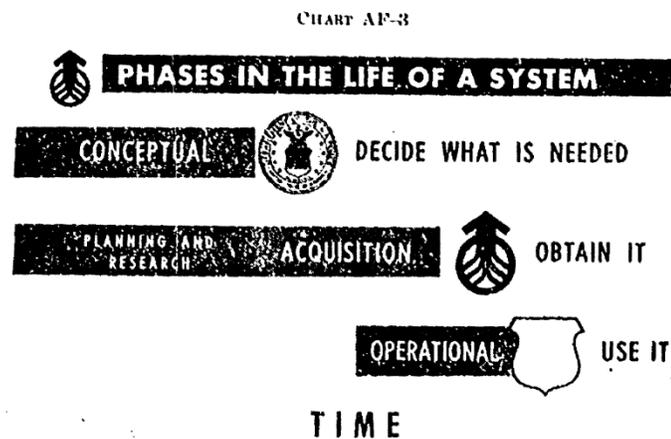
¹⁵³ Klein, B. H., Meckling, W. H., Mesthene, E. G. “Military Research and Development Policies.” RAND Corp., 4 December 1958, pp. 13-19.

¹⁵⁴ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 155.

¹⁵⁵ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 158. “Report on Organization and Administration of the Army Research and Development Program.”

controlled by Headquarters staff.¹⁵⁶ As described to the Congress, the steps to a procurement program were first, the staff officers “decide what is needed.” Second, the systems project office is created to “obtain it;” and third, the combatant commands “use it.” In deciding what is needed, the staff performs extensive before-the-fact planning, such as to “Identify responsibilities, tasks, and time phasing of major actions of each participant.”¹⁵⁷ To start any kind of work on a project, the budget had to be there. For the budget to be there, there had to exist a detailed “program definition” that spelled out exactly how the full system would be obtained, from research to development to procurement, preferably all phases concurrently. In this way, the policy-making of Headquarters staff truly determined the administration of the program. Planning translated to doing with little discretion required by the one doing. However, the 375-Series recognized uncertainty and that administration might require re-direction at a later date. Whenever discretion was required, it should run up the chain to Headquarters, which would “Assure that all participants are provided with adequate, consistent, and timely decisions, guidance, and resource allocations.”¹⁵⁸ While the form of centralization did not assure extensive barriers to diversity and optionality, it solidified an “institutional bias” that Alchian worried about.

The 375-Series largely reflected the RAND approach to systems analysis that dominated over diversification. To some degree the skeptics, such as RAND president Frank Collbohm, were never skeptics of systems analysis in the way Alchian was. Collbohm, for example, wrote a withering critique of the “criteria problem” in systems analysis and protested in support of a parallel development to Atlas. However, he fundamentally held faith that better designed analyses and more scientific management can generate efficiencies if “economic facts” can be “related expertly.”¹⁵⁹ By 1962, the systems analysis debate had a clear victor, the tenants of which were written



375-Series chart shown to the Congressional Committee on Government Operations by Colonel Jewell Maxwell in August, 1962. Air Force Headquarters staff will “decide what is needed,” the Air Force Systems Command sets up a project office to “obtain it,” and the combatant commands “use it.”

¹⁵⁶ Johnson, Stephen B. “From Concurrency to Phased Planning: An Episode in the History of Systems Management.” In *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*. Edited by Agatha C. Hughes and Thomas P. Hughes. The MIT Press, Cambridge, Mass., 2000, pp. 97.

¹⁵⁷ Colonel Maxwell, Jewell C., Chief of Staff, Headquarters, Air Force Systems Command. “Systems Development and Management (Part 3),” pp. 840

¹⁵⁸ Colonel Maxwell, Jewell C., “Systems Development and Management (Part 3),” pp. 854

¹⁵⁹ Collbohm, Frank R. “Scientific Aids to Decisionmaking – A Perspective.” 31 January 1957, pp. 7-9.

down in a book proclaimed the “Bible” of the Pentagon. Collbohm verified that “RAND’s general philosophy concerning costing and cost effectiveness studies... is reflected in the Project RAND report, subsequently published as a book, entitled ‘The Economics of Defense in the Nuclear Age,’ by Charles Hitch, now Assistant Secretary of Defense, and Roland McKean.”¹⁶⁰ The book, which propelled Charles J. Hitch from head of the RAND’s economics department to ASD Comptroller, relegated Armen Alchian to a footnote that dismissed his concepts as “natural selection.”¹⁶¹ The systems analysis approach emerged from the 1950s largely unreformed, and when packaged with a revival of the program budget concept, would form a lasting institutional framework for defense management called the Planning-Programming-Budgeting System.

¹⁶⁰ Collbohm, Frank R. “Systems Development and Management (Part 3),” pp. 925.

¹⁶¹ Charles J. Hitch and Roland N. McKean. 1960. *The Economics of Defense in the Nuclear Age*. RAND Corp., published by Antheneum, pp. 106. Note that Alchian engaged Hitch in mainstream economic theory as well. Hitch had gained notoriety before the war by asking whether firm managers actually followed the profit maximizing rule of setting price equal to marginal cost. He found that most managers set price equal to average cost instead. Many interpreted the results to be that markets generate inefficiencies, and that public management would set price equal to marginal cost, thereby increasing the quantity supplied while lowering the price. In 1950, Alchian published perhaps his most famous paper, “Uncertainty, Evolution and Economic Theory.” It took a completely different approach to the problem by addressing uncertainty. Alchian wrote, “First, to clear the ground, a brief statement is given of a generally ignored aspect of ‘profit maximization’; that is, where foresight is uncertain, ‘profit maximization’ is *meaningless* as a guide to specifiable action. The constructive development then begins with an introduction of the element of environmental adoption by the economic system of the *a posteriori* most appropriate action according to the criterion of ‘realized positive profits.’” For Alchian, the “pertinent requirement” is positive realized profits of the amount that allows one firm to survive in a process of economic natural selection, and not maximized profits. Alchian explains, “As in a race, the award goes to the relatively fastest, even if all the competitors loaf. Even in a world of stupid men there would still be profits. Also, the greater the uncertainties of the world, the greater is the possibility that profits would go to the venturesome and lucky rather than the logical, careful, fact-gathering individuals.” Alchian applied these ideas to defense acquisition over the next several years.

4. *Planning-Programming-Budgeting System*

“The man of system... is often so enamoured with the supposed beauty of his own ideal plan of government, that he cannot suffer the smallest deviation from any part of it... He does not consider that the pieces upon the chess-board have no other principle of motion besides that which the hand impresses upon them.”

Adam Smith

The Theory of Moral Sentiments, 1759

The defense management revolution ushered in by the rise of the Planning-Programming-Budget System (PPBS) found its roots squarely with RAND, but reflected a broader trend in public administration dating back in the U.S. to the late nineteenth century. If the logic of military unification derived from German concepts of administration and the general staff, then the PPBS derived from the German historical school of economics.¹⁶² Essential to the German tradition is analytical holism and a rejection of the “fictitious individualistic assumption” of classical liberals. Because markets produced social and economic failures, particularly monopoly, a new class of expert were required to identify remedies using the administrative state. The economist as an American profession was built on men schooled in Germany, who then solidified their expertise by creating university departments, prestigious associations, and new government bureaus on statistics and regulation. To justify its role for guiding government, the economic expert relied on the legitimacy of the scientific method. One top expert, Henry Farnam, compared the evolution of the economic sciences to the medical sciences. He found that surgery was once primitive and dangerous, but advances in science had made it most beneficial to society. Similarly, the economic expert had by 1910 enough scientific knowledge to make its reforms “more effective and less dangerous.”¹⁶³ The analogy was repeated over 50 years later by Alain C. Enthoven, Assistant Secretary of Defense for Systems Analysis, who said “My general impression is that the art of systems analysis is in about the same stage now as medicine during the

¹⁶² F. A. Hayek traced the ideas inherent in the German school, particularly logical positivism, back to the French Revolutionaries and the Ecole Polytechnique – but he attributed its spread to the U.K. and U.S. through Germany. This form of rationalism also finds precedent thinkers such as Francis Bacon, who opposed Copernican Astronomy, and Lord Kelvin, who denied evolution because he calculated the Earth too young for its emergence. Ultimately analytical holism goes back to Plato, who believed in a “Guardian” class to guide policy and abhorred asymmetries so much that he thought humans should use both hands with equal dexterity.

¹⁶³ Leonard, Thomas C. *Illiberal reformers*, Princeton University Press, 2016, pp. 22, 33

latter half of the 19th century; that is, it has reached the point at which it can do more good than harm.”¹⁶⁴

Enthoven, a former RAND economist, was one of the staunchest advocates for the PPBS and its components parts, programming and systems analysis. He found them based on the scientific method which “itself does not depend upon the personalities or vested interests.”¹⁶⁵ They injected quantitative measurements and modeling that allowed for the “greatest clarity of thought” to be achieved, “even when uncertainties are present.”¹⁶⁶ He said that “Many people seem to feel that quantitative analysis is not possible if there are any uncertainties. But this view is incorrect. In fact there is substantial literature on the logic of decision-making under uncertainty going back at least as far as Pascal, Bernoulli, and Bayes in the 17th and 18th centuries.”¹⁶⁷ The triumph of “the scientific method” in management and economics replaced the need for so-called “direct experience” and “reading of history books.”¹⁶⁸ Enthoven held the highest hopes that the marginal analysis he learned in sophomore class would translate into actual defense decisions.¹⁶⁹ He wrote that “The economic theory of price and allocation, a branch of moral philosophy in Adam Smith’s day, had been reduced to mathematical terms and made into a useable instrument for quantitative analysis of problems of choice.”¹⁷⁰

Though he headed the Office of Systems Analysis from 1961 until 1969, Enthoven joined defense leadership at the tender age of 31. He went to RAND in 1956 straight out of his doctorate program at M.I.T. and came under the direction of Charles Hitch in the economics division. There, Enthoven joined a team that worked to develop a defense resource allocation system based upon the methods of program budgeting and systems analysis. However, it followed in the tradition of the economic expertise that had taken hold during the Progressive Era. As had been shown, the Title IV performance budget had precedent in the Controlled Materials Plan (CMP), which was an outgrowth of the Production Requirements Plan (PRP), itself having referenced the allocation system of the War Industries Board of the First World War. One prominent RAND analyst who took a major role in the PRP, the CMP, and the PPBS was David Novick, later called the “father of cost analysis.” He also fancied himself the father of program budgeting in the federal government because of his personal development of the CMP. With almost complete lack

¹⁶⁴ “Planning Programming Budgeting” Inquiry of the Subcommittee on National Security and International Operations (Jackson Committee), U.S. Senate, U.S. Government Printing Office, Washington: 1970, pp. 127

¹⁶⁵ “Planning Programming Budgeting” Inquiry of the Subcommittee on National Security and International Operations (Jackson Committee), U.S. Senate, U.S. Government Printing Office, Washington: 1970, pp. 3.

¹⁶⁶ Poole, Walter. History of Acquisition in the Department of Defense Volume II: *Adapting to Flexible Response, 1960-1968*. Historical Office, Office of the Secretary of Defense, Washington: 2013, pp. 24.

¹⁶⁷ “Planning Programming Budgeting” Inquiry of the Subcommittee on National Security and International Operations (Jackson Committee), U.S. Senate, U.S. Government Printing Office, Washington: 1970, pp. 4.

¹⁶⁸ Roherty, 1970, pp. 69.

¹⁶⁹ Enthoven, Alain. “Defense and Disarmament: Economic Analysis in the Department of Defense.” In the *American Economic Review* 53 (May 1963): pp. 287-301.

¹⁷⁰ Enthoven, Alain. “Introduction.” *A Modern Design for Defense Decision: A McNamara-Hitch-Enthoven Anthology*. Edited by Samuel A. Tucker. Industrial College of the Armed Forces. Washington D.C. 1966, pp. 5.

of regard for the existing debates, Novick wrote that the “CMP was a budgeting system, planning system, and a programming system to manage the nation’s resources for war. I thought that, if we could adapt this same concept to the structure of the Air Force’s planning, budgeting, and accounting, life could be very simple.”¹⁷¹ Carrying out his idea, Novick prepared a paper with a “real jazzy title,” which in effect argued for the exact same principles that had been already legislated in Title IV three years before.¹⁷² Novick expressed puzzlement that his ideas were not immediately applied by the Air Force and it had to wait until 1961 for Secretary of Defense Robert McNamara to see its value. When considering the reforms Novick, Hitch, Enthoven, and others at RAND promoted, eventually called the Planning-Programming-Budgeting System (PPBS), Frederick Mosher wondered “what is really new and distinctive about it?”¹⁷³

PPBS in Context

The program budget represents an idea that naturally arises from the requirements of central economic planning. It displaced exchange with allocation as the focal point of economic discourse. In fact, the War Industries Board (WIB) in the First World War represented the culmination of a generation’s work in economic planning. The WIB’s Central Bureau of Planning and Statistics was headed by Harvard graduate school dean Edwin F. Gay, who became a leading administrative expert after studying in Germany. Gay fixed prices in more than 60 strategic industries and directed railroads by determining output priorities and resource allocations. He said that the scientific administration used in the WIB was “the most important advance in industry since the introduction of the factory system and power machinery.” WIB member and historian Grosvenor Clarkson echoed the sentiment, finding that the “whole productive and distributive machinery of America could be directed successfully from Washington.” John Dewey found that the WIB represented a “revolution” in economics and finally demonstrated the efficiency of expert central planners.¹⁷⁴

The program budget was part of a broader discourse on resource allocation. All central planning requires relating resources to objectives through an analytical framework. The PPBS relates dollar budgets to military force structures using systems analysis. The socialist central planner relates physical capital to the social welfare using industrial analysis. The economic expert and socialist alike believed that central planning could far outstrip the productive capability of uncoordinated markets. John Dewey said that the

¹⁷¹ Novick, David. “Beginning of Military Cost Analysis 1950-1961. RAND Corp., March 1988, pp. 3.

¹⁷² Even the names of Novick’s paper and Title IV were almost the same. The former’s title was “Efficiency and Economy in Government through New Budgeting and Accounting Procedures,” the latter’s title was “Promotion of Economy and Efficiency Through Establishment of Uniform Budgetary and Fiscal Procedures and Organizations.” Novick does admit some precedence in the WIB in Novick, David. *Program Budgeting*. Second Edition, Edited by David Novick. pp. xxi.

¹⁷³ Mosher, Frederick C. “Two Questions.” Letter to editor-in-chief of *Public Administration Review*, Vol. XXVII, No. 1, March 1967.

¹⁷⁴ Leonard, Thomas C. *Illiberal reformers*, Princeton University Press, 2016, pp. 47-48.

WIB did more to advance central planning than a generation of socialist theorizing.¹⁷⁵ It was not hyperbole when in 1964 historian John C. Ries called military staff planning “almost socialist in its metaphysics.”¹⁷⁶

Centralized planning for an entire economy stemmed from a belief in the power of science and human rationality. It stemmed from a Newtonian view that if a scientist knew the disposition of all particles at a given instant, then the future is completely predictable based on a set of equations. With confidence that administrative experts could emulate the triumphs of the natural sciences through central direction, prominent scholars such as Austrian Otto Neurath believed that the war economy should be extended. Neurath wrote that, "As a result of the war, in-kind calculus was applied more often and more systematically than before... war was fought with ammunition and with the supply of food, not with money."¹⁷⁷ Neurath advocated a moneyless system planned from the center that allocates resources based on labor standards. Ludwig von Mises, also an Austrian, rebutted that such economic calculation is impossible without reference to prices. Changing factors affecting resource shortages or surpluses are reflected in the price. Allocation decisions do not require the individual to have detailed knowledge of all relevant information dispersed across the economy. The impossibility of centralizing all knowledge of ever changing production factors to solve a system of equations in an effort to maximize output means that there is no rational basis for allocation decisions without reference prices.

Many socialist planners appreciated Mises' arguments exposing problems in central planning. Oskar Lange wrote that “a statue of Professor Mises ought to occupy an honourable place in the great hall of the Ministry of Socialisation or of the Central Planning Board.”¹⁷⁸ Lange recognized the challenge, but believed central planning could work by employing neoclassical economics to equilibrate supply and demand. He described the problem of the central planner: “The economic problem is a problem of choice between different alternatives. To solve the problem three data are needed: (1) a preference scale which guides the activity of choice, (2) knowledge of the ‘terms on which alternatives are offered,’ and, finally, (3) knowledge of the amount of resources available. Those three data given, the problem of choice is soluble.”¹⁷⁹ The market economy took the first as given to consumers, the third as given to suppliers, and the second as given by prices that arise from market exchanges. Central planning, whether in the socialist form,

¹⁷⁵ Leonard, Thomas C. *Illiberal reformers*, Princeton University Press, 2016, pp. 47-48.

¹⁷⁶ Ries, John. C. *The Management of Defense: Organization and Control of the U.S. Armed Services* by, The Johns Hopkins Press, Baltimore, MD. 1964, pp. 39.

¹⁷⁷ Neurath, 1919. Found in Cockshott, Cottrell, and Dieterich, *Transition to the 21st Century: Socialism in the European Union*, pp. 33. Calculation-in-kind was called “Naturalwirtschaft” in German. See *Otto Neurath's Economics in Context*. Edited by Memeth, Schmitz, and Uebel, Springer, 2007.

¹⁷⁸ Lange, Oskar. “On the Economic Theory of Socialism: Part One.” *The Review of Economic Studies*, Vol. 4, No. 1 (Oct., 1936), pp. 53.

¹⁷⁹ Lange, Oskar. “On the Economic Theory of Socialism: Part One.” *The Review of Economic Studies*, Vol. 4, No. 1 (Oct., 1936), pp. 54-55.

traditional budgeting, or PPBS, assumes that the first and third are also given, and that the “terms on which alternatives are offered” is generated through analysis. In socialism, the alternatives are determined through industrial analysis; in traditional budgeting, political analysis; and in the PPBS, systems analysis. The final solution proposed by Lange and elaborated on by Abba Lerner is that prices were required, but they need not emerge from decentralized market exchanges. Instead, industrial units would produce from a given supply of inputs and set price equal to marginal cost of production based on labor standards. Shortages and surpluses would then expose the need to adjust allocations to industrial units, and markets would be brought into equilibrium, not through immaculate calculations, but from a series of trial-and-error approaches that sequentially minimize the misallocation of resources. Information problems brought the most realistic form of socialist planning back to the principles of trial-and-error inherent in a market economy.

Belief in the efficacy of central planning pervaded not just economists who leaned toward government intervention like J. M. Keynes, John Bates Clark, and Irving Fisher, but also the market oriented thinkers like Frank Knight and Joseph Schumpeter. Schumpeter is often revered as a champion of market economics, associated with the creative destruction view of technological innovation. Yet Schumpeter was smitten with the Lange-Lerner model of central planning and believed that innovation itself could be planned. In his 1942 classic, *Capitalism, Socialism, and Democracy*, Schumpeter wrote that:

“...innovation itself is being reduced to a routine. Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways. The romance of earlier commercial adventure is rapidly wearing away, because so many more things can be strictly calculated that had of old to be visualized in a flash of genius.”¹⁸⁰

Schumpeter’s views supported central planning because innovation worked in “predictable ways.” Creative destruction could then be planned for and was not the outcome of decentralized actions associated with tinkering and exchange. The view maintained that information necessary to plan existed in an aggregable form, making it consistent with systems analysis because technology could be predicted and its parameters “reduced to a routine.” A withering critique of central planning came in 1945 from Friedrich A. Hayek, an Austrian economist of Mises’ mold.¹⁸¹ He posed a simple question, “What is the problem we wish to solve when we try to construct a rational

¹⁸⁰ Schumpeter, Joseph. *Capitalism, Socialism, and Democracy*. 1942, pp. 132. This extreme view of Schumpeter, largely held by Hayek, could be claimed unfair. Schumpeter quoted A. F. Burns, *Production Trends in the United States Since 1870*, p. 262, “Strict logic is a stern master, and if one respected it, one would never construct or use any production index,” Schumpeter added that “... for not only the material and the technique of constructing such an index, but the very concept of a total output of different commodities produced in ever-changing proportions, is a highly doubtful manner.” See page 63. He also appreciates the “antagonisms” of capitalist society, but may not have seen antagonisms as resulting from local uses of knowledge of time and place that differ qualitatively from one another.

¹⁸¹ Hayek, Friedrich A. “The Use of Knowledge in Society.” *American Economic Review*. XXXV, No. 4. September 1945, pp. 519-30.

economic order?” Hayek started his answer in a similar way Alchian did when analyzing weapons choice:

“If we possess all the relevant information, if we can start out from a given system of preferences, and if we command complete knowledge of available means, the problem which remains is purely one of logic. That is, the answer to the question of what is the best use of the available means is implicit in our assumptions.”

If information is perfectly known to the central planner, he can determine the optimal allocation of resources across an entire economy as much as he can across weapon systems.¹⁸² Hayek said that his contemporaries believed “scientific knowledge” to be the only relevant knowledge in existence, allowing “a body of suitably chosen experts” to be in the “best position to command all the best knowledge available.” However, Hayek found a different form of knowledge to be at the center of economic progress. “Today it is almost heresy to suggest that scientific knowledge is not the sum of all knowledge. But a little reflection,” he continued, “will show that there is beyond question a body of very important but unorganized knowledge which cannot possibly be called scientific in the sense of knowledge of general rules: the knowledge of the particular circumstances of time and place.” He explained:

“...the sort of knowledge with which I have been concerned is knowledge of the kind which by its nature cannot enter into statistics and therefore cannot be conveyed to any central authority in statistical form. The statistics which such a central authority would have to use would have to be arrived at precisely by abstracting from minor differences between the things, by lumping together, as resources of one kind, items which differ as regards location, quality, and other particulars, in a way which may be very significant for the specific decision. It follows from this that central planning based on statistical information by its nature cannot take direct account of these circumstances of time and place and that the central planner will have to find some way or other in which the decisions depending on them can be left to the ‘man on the spot.’”

Hayek identified the problem that the local knowledge of time and place was only available to dispersed actors. A rational economic order, then, required a solution that is “produced by the interactions of people each of whom possesses only partial knowledge.” To assume all such knowledge is available to a central planner is “to disregard everything that is important and significant in the real world.” Hayek’s idea that knowledge of economic activity was inherently non-aggregable harmonized with Alchian’s ideas on weapon systems analysis. They both pertained to the discovery of knowledge dispersed across time and place. For Hayek, entrepreneurs acted upon localized information and those who speculated well generated social welfare and were rewarded with profits. For

¹⁸² Note that the views of Hayek and Alchian maintained theoretical predictability in a deterministic system if all relevant information is known. However, Soviet mathematician Yakov Sinai proved in 1963 using “dynamical billiards” that some deterministic systems are nevertheless unpredictable. Soviet economic planners did not apply what Soviet mathematicians were saying about simple systems, namely, that predictions will not be accurate. Decades before Sinai, the great mathematician Henri Poincare pointed out that while gravitational interaction between two objects was completely described by Newton, add one more object and long-term predictions can no longer be made in most cases.

Alchian, defense decision makers must take advantage of knowledge discovery in a similar way. Knowledge of the correct technology does not exist in the planning stage. It only revealed itself in the process of its discovery across time and multiple technical approaches. Innovation in weapons and the economy at large are then processes which generate information which would not otherwise have existed for quantitative analysis.

At the time very few shared the economic outlook of Hayek and Alchian, who themselves differed in several respects. The particulars of time and place were largely overlooked in favor of macroeconomics, which utilized economic aggregates such as total consumption, investment, and employment to predict future policy decisions. In his path-breaking 1947 textbook *Foundations of Economic Analysis*, Paul Samuelson developed a mathematical framework that explained macroeconomic theory and swept through the economics profession. Before that time, economics still relied on the spoken language and diagrams. By providing a rigorous mathematical treatment of the social welfare function, the fiscal multiplier, the production function, and other economic concepts, the textbook first and foremost presented policy makers with a formula to influence an economy. Throughout Samuelson's life, however, he could not appreciate Hayek's ideas about the dispersed knowledge of time and place. His textbook took the initial conditions as given and solved for the dynamic equilibrium without any treatment of process in which equilibrium came about. One consequence of Samuelson's macro-economic approach was that he looked at aggregate investments and not the particular qualities of individual investments. Samuelson concluded that Soviet income would grow "two to three times" faster than the U.S. due to its higher investment rate. In at least ten editions of his textbook up until the fall of the Soviet Union, Samuelson continually updated a graph showing Soviet income at half the level of the U.S. in the present, but growing and surpassing the U.S. in the future. That future in which Soviet income exceeded the U.S. never came, but it did not force the economic mainstream to reconsider its confidence in predictions based on statistical aggregates.¹⁸³

The historical context of the economics profession in the middle part of the twentieth century is central to understanding the rise of the PPBS. It focused on mathematical models, identification of market failures, and administrative remedies. Axel Leijonhuvud recalled the economic atmosphere inherited by the 1960s. "What I learned in graduate school," he said, "was arid stuff, trivial optimization exercises combined with equilibrium conditions that had no foundation in any examination of how actual markets work. This was not the fault of my teachers—this was the state of the art in the profession in general." James Buchanan echoed the sentiment, finding congruence between Armen Alchian and Friedrich Hayek in their "genuinely innovative" introduction of "evolutionary thinking"

¹⁸³ Levy, David M. and Peart, Sandra J. "Soviet Growth & American Textbooks." 3 December 2009. <https://ssrn.com/abstract=1517983>.

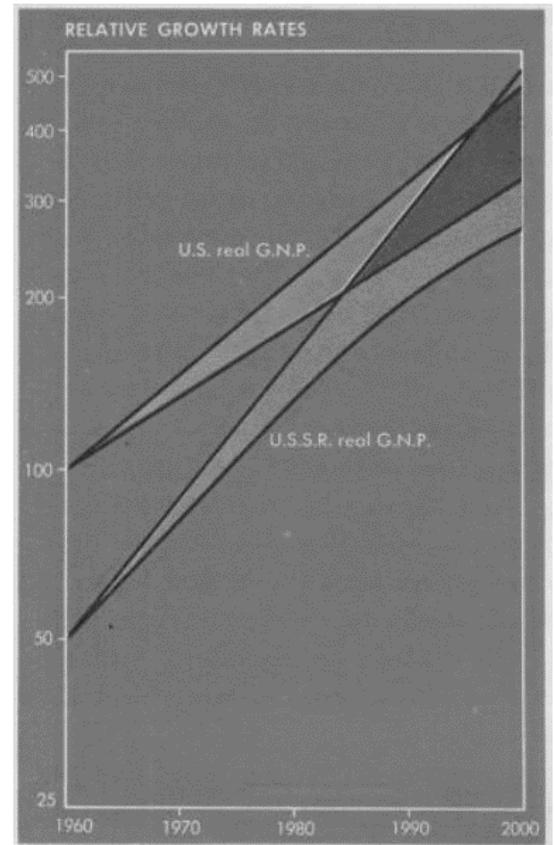
to economics.¹⁸⁴ Both the optimization and evolution models of economics existed in RAND in the 1950s, the former leading to the systems analysis approach and the latter to the diversification approach. Both could be found in a seminal 1960 book on the PPBS by Charles J. Hitch and Roland McKean.

Defense Applications

In *The Economics of Defense in the Nuclear Age*, Hitch and McKean laid out the principles for PPBS. Presented in the economic jargon of the day, the authors explained that in order to “facilitate an economic calculus within the services,” the “most important reform” is to “reveal the costs of meaningful end-product missions or programs (like ‘active air defense’), rather than the costs of classes of objects (like ‘personnel—military’).”¹⁸⁵ Programming provides the important link that allows for traceability between resource inputs (budgets) and military outputs (plans). The system allowed for a holistic “economic analysis” of the defense organization by joining cost and capability analyses under program elements. The program elements, like other market goods and services, were then able to be subject to optimization using Samuelson’s framework:

“In principle the answer is easy: We want to choose that efficient point which maximizes the “utility” or “military worth” of the combined forces. In practice... the explicit measurement of military worth frequently presents formidable difficulties. If we abstract from these difficulties for the moment in order to clarify definitions, we can draw curves (called indifference curves) that reflect our preference for some combinations of target destruction or kill potential over others.”¹⁸⁶

The tangency point of the indifference curve and the production possibilities frontier, or the budget constraint, represents the optimal allocation. Despite “formidable difficulties” presented by defense problems, the authors devoted large swaths of the book, in addition to an extended mathematical appendix, to the optimization exercises in the context of



Graph from Paul Samuelson’s *Foundations of Economic Analysis* showing the real gross national product (GNP) for the U.S.S.R. (bottom) growing faster and eventually surpassing that for the U.S. (top). Despite contrary evidence, Samuelson did not update his prediction.

¹⁸⁴ “In Celebration of Armen Alchian’s 80th Birthday: Living and Breathing Economics.” *Economic Inquiry*, Vol XXXIV, July 1996, pp. 412-426.

¹⁸⁵ Charles J. Hitch and Roland N. McKean. 1960. *The Economics of Defense in the Nuclear Age*. RAND Corp., published by Antheneum, pp. 233.

¹⁸⁶ Charles J. Hitch and Roland N. McKean. 1960. *The Economics of Defense in the Nuclear Age*. RAND Corp., published by Antheneum, pp. 111.

defense and the PPBS. At the same time, however, the book contained ideas that clearly aligned with Alchian; they wrote:

“Research and development are uncertain by definition. Research is a search, and one rarely knows in advance whether the search will be successful at all, let alone how long it will take or which route will lead to the treasure. The military Services have all too frequently tried to command the research and development community to invent new weapons to specification, just as they would command a platoon of infantry to march by the right flank... One of the most important and obvious corollaries of the uncertain character of research and development is the desirability of some duplication.”¹⁸⁷

The inconsistency between optimization, often associated with central direction, and duplication was picked up in a 1962 Congressional Hearing on Systems Development and Management. By that time, Hitch was ASD Comptroller and right-hand man of Secretary of Defense Robert McNamara. He had been working to strengthen centralized control in the Office of the Secretary of Defense, including in the recently established Director, Defense Research and Engineering (DDR&E). *The Economics of Defense in the Nuclear Age*, however, criticized just this centralization of R&D. Herbert Roback, a committee staffer, asked the incisive questions:

Mr. Roback. “... One of the points you made in that book was that it was a serious mistake to try to centralize control over R. & D., because you might dry up initiative or you might do many other things... In other words, you thought it was a mistake to set up that kind of an office [DDR&E] on the grounds that the people who were setting it up just did not know the nature of the problem. Now, how does it look to you today?”

Mr. Hitch. “I do not remember having said anything like that in that book.”

Mr. Roback. “You do not? ... Under the caption ‘Reorganizing Research and Development,’ the authors discussed these critics who had been complaining about the uncoordinated nature of R. & D., the diffusion, the duplication, and who had recommended strong central direction and coordination. ‘In response to these criticisms,’ say the authors at page 256, ‘a new echelon of research and development planners and managers is being added to the Pentagon at the Department of Defense (DOD) level to direct all lower echelons...’”

Mr. Hitch. “Let me assume that that sentence was written by Mr. McKean. [Laughter.]”¹⁸⁸

Representative Chet Holifield piled on, reading out the whole paragraph. The authors wrote of those who would centralize R&D: “They treat as certain what is highly uncertain. They try to strengthen control at the top when what is needed is initiative and spontaneity at the bottom. They try to suppress competition and diversification because particular duplications are obviously wasteful from the vantage point of hindsight, apparently unaware that duplication is a rational necessity when we are confronted with uncertainty

¹⁸⁷ Charles J. Hitch and Roland N. McKean. 1960. *The Economics of Defense in the Nuclear Age*. RAND Corp., published by Atheneum, pp. 248-49. Lenfle and Loch also noticed that the book is contradictory, see “Lost Roots: How Project Management Came to Emphasize Control Over Flexibility and Novelty.”

¹⁸⁸ “Systems Development and Management (Part 2).” Hearings before a Subcommittee of the Committee on Government operations House of Representatives Eighty-Seventh Congress, Second Session, July 23-27, 1962. U.S. Government Printing Office, Washington: 1962, pp. 541.

and that competition is our best protection against bureaucratic inertia.” The book Hitch co-authored strongly criticized management techniques that Hitch now testified in support of. Hitch, after again deflecting the comments onto McKean, felt he had to address the point. “No, I have not changed by views, Mr. Chairman, about the fundamental nature of research and development,” Hitch said bluntly, “it is important to distinguish between... research and development that is directed toward the development of new ideas and the testing of those ideas, on the one hand, and the fabrication of prototypes of operational systems, on the other.” He continued, “I think that the kinds of remarks that you have just quoted are directly applicable to the first kind of research and development.”

Hitch and his team at RAND had been working on distinguishing the stages of R&D.¹⁸⁹ Hitch believed that basic research, the pursuit of science, played by different rules than full-scale development, the pursuit of engineering. The latter was better suited in Hitch’s mind to optimizations, detailed long range plans, and tight central control throughout execution. The apparent contradiction between Hitch’s book and his policy plans may therefore be seen as a difference of opinions between authors as to which stages of R&D required diversification. McKean believed diversification should be pursued for a wider range of R&D activities than Hitch, who believed diversified investments only make sense in the earliest stages. McKean’s position sat closer to Alchian, who applied diversification throughout all stages of R&D, as well as test and evaluation. McKean later wrote that program budgets should not define R&D program elements, and instead treat the whole as one undivided appropriation.¹⁹⁰ Only in procurement would program elements be defined and their performance measured. Hitch, on the other hand, wanted program elements defined in the budget once scientific knowledge is put toward operational hardware. The intent of operational capability called for program definition and central control through the program budget.

To Optimize, Or Not to Optimize?

While Hitch’s response may have resolved the apparent contradiction – there only existed a difference in opinions as to matters of degree – there still lingers another issue. Hitch and McKean remained committed to systems analysis and optimizations despite the presence of uncertainties and other fundamental issues. The authors reconciled the problem by arguing that a central planner does not need perfect information in order to employ optimizing techniques. Sub-optimizations on smaller defense problems can improve decisions actually made, moving the planner toward an optimum. The authors wrote that “while we cannot usually find optimal, or second-best, or even jth-best,

¹⁸⁹ For example, see Novick, David. “What Do We Mean By ‘Research and Development?’” The RAND Corp., P-1779, 25 August 1959. Novick broke down Research into basic, experimental, advanced, and applied. Development included basic, product, and application. R&D was expanded to RDT&E, with Test and Evaluation with their own sub-phases.

¹⁹⁰ McKean, Roland and Anshen, Melvin. “Limitations, Risks, and Problems.” In Novick, David. *Program Budgeting*. Second Edition, Edited by David Novick, pp. 285-307

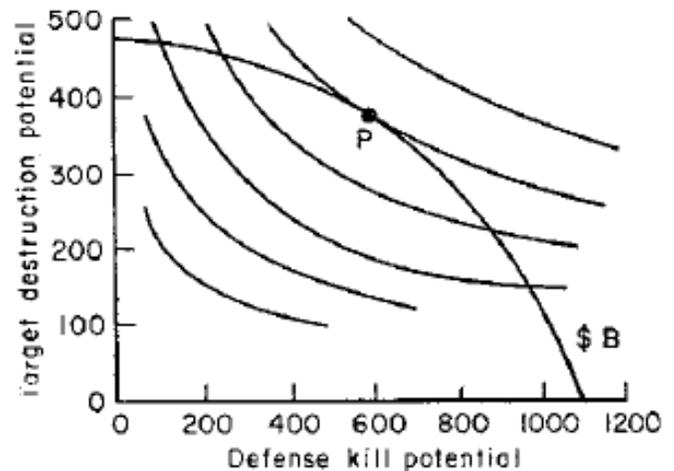
solutions, it frequently enables us to identify improvements over existing proposed policies.”¹⁹¹ Simply put, sub-optimization might not generate perfect solutions, but they should be used so long as benefits outweigh costs. Harvard researchers Martin Peck and Frederic Scherer addressed the topic. They start by quoting Hitch, who viewed optimizations with some pessimism:

“So what does the poor operations researcher do? Here he is, faced by his fundamental difficulty. The future is uncertain. Nature is unpredictable, and enemies and allies even more so. He has no good general purpose technique, neither maximizing expected somethings, nor *maximizing*, nor gaming it, to reveal the preferred strategy. How can he find the optimal course of action to recommend to the decision maker? The simple answer is that he probably cannot...”

Yet Hitch clearly intended for weapons choice to have a quantitative foundation. Peck and Scherer, who subscribed to the power of optimizing in spite of their appreciation for uncertainty, explained why Hitch may also have endorsed the practice—and even design management systems to support optimizations — despite the numerous obstacles that he had identified:

“Hitch recommends that instead of attempting to find optimal solutions and to implement them on a single-minded basis, development planners and decision makers seek merely to find solutions *better* than those already existing. Hitch’s emphasis on the search for the better instead of the best solution follows more general concepts advanced by Professor Herbert Simon. Simon uses the term ‘satisficing’ to describe decision making as a process of reaching ‘satisfactory’ positions rather than optimal positions, where the standard of satisfactory is given by complex psychological and sociological considerations. He argues that the satisficing notion not only describes more realistically how organizations actually make decisions, but also that it is a better normative decision-making rule, given uncertainty and limits of the problem-solving capabilities of organizations.

“As Chapter 9 makes clear, we are committed to an optimizing model. Yet the conceptual differences between optimizing and satisficing are not necessarily great, since optimizing considerations may play a role in determining what positions are ‘satisfactory.’ As March and Simon point out: ‘The standard setting process may itself meet standards of rationality; for example, an ‘optimizing’ rule would be to set the standard at the level where



Graph from Hitch and McKean’s *The Economics of Defense in the Nuclear Age*, labeled “Indifference curves and optimal point.” The convex curves are indifference curves and the concave curve is the budget constraint. Any allocation that does not create a point of tangency is associated with a lower indifference curve representing less utility gained.

¹⁹¹ Charles J. Hitch and Roland N. McKean. 1960. *The Economics of Defense in the Nuclear Age*. RAND Corp., published by Atheneum, pp. 114.

the marginal improvement in alternatives obtainable increasing it would be just balanced by the marginal cost of searching for alternatives meeting the higher standard. Of course, in practice the ‘marginal improvement’ and the ‘marginal cost’ are seldom measureable in comparable units, or with much accuracy. Nevertheless, a similar result would be automatically attained if the standards were raised whenever alternatives proved easy to discover, and lowered whenever they were difficult to discover. Under these circumstances, the alternative chosen would not be far from the optima, if the cost of search were taken into consideration...’

“Thus, in a dynamic context the concepts of satisficing, optimizing, and successive improvement tend to be congruent. There remain differences in emphasis, but these are not decisive for our present analysis, especially since program decision makers must take the costs of searching for additional technical alternatives into account. Furthermore, for indicating the significant relationships among variables in program decisions, the optimizing approach provides a more meaningful and powerful analysis. It is for this reason, we believe, that Hitch—no doctrinaire optimizer—retains the optimizing approach in his analysis of efficiency in military decisions.”¹⁹²

The passage briefly touches on an important belief of the optimizer, a critical thinker who fully understands and embraces uncertainty. Decisions must be made whether or not they face uncertainty, or even unknown uncertainty distributions. For each decision, the only relevant question is whether or not it is efficient to attempt a quantified optimization across identified alternatives to inform judgement. Herbert Simon put it well himself: “My argument is that men satisfice because they have not the wits to maximize. I think this is a verifiable empirical proposition. It can be turned around, if anyone prefers: If you have the wits to maximize, it is silly to satisfice.”¹⁹³ As the logic goes, if systems analysis is expensive relative to the potential gains, then successive improvement is preferred. But the cost of systems analysis is a pittance compared to the cost of large development projects. Because path dependency in large projects leads to extreme variation in outcomes, it should pay well to consider the final system and how it will be achieved. Systems analysis clarifies issues and guides decisions toward the optimum, even if the result is non-optimal in the rigid sense. Hitch testified that “I think that the expense of the systems dictates the necessity of that approach.”¹⁹⁴

The critical error in the optimizer’s logic is that the marginal choice between performing an optimization across alternatives and acting on diversification is not independent of the decision making regime. Hitch wrote that program budgeting was a

¹⁹² Peck, Martin, and Scherer, Frederic. 1962. *The Weapons Acquisition Process: An Economic Analysis*. Harvard University Press, pp. 304. The authors don’t explain the successive improvement model and its origins thoroughly. Note that successive improvement, which is in some ways analogous to Alchian’s evolution model, is explained by Professor Charles E. Lindblom in “The Science of “Muddling Through.” *Public Administration Review*, Vol. 19, No. 2 (Spring, 1959), pp. 79-88.

¹⁹³ Simon, Herbert A. “The Decision-Making Schema’: A Reply.” Reprinted from *Public Administration Review*, Vol. XVIII, No. 1, Winter, 1958 quarterly journal of the American Society for Public Administration 6042 Kimbark Avenue, Chicago 37, Illinois.

¹⁹⁴ “Systems Development and Management (Part 2).” Hearings before a Subcommittee of the Committee on Government operations House of Representatives Eighty-Seventh Congress, Second Session, July 23-27, 1962. U.S. Government Printing Office, Washington: 1962, pp. 541.

prerequisite to getting “good estimates of the cost of systems for use in RAND's systems analyses.”¹⁹⁵ The whole purpose of the program budget was to measure programs and the performance of their administration. Budget justifications require precise definition of the system and a consistent means for evaluation throughout using detailed accounting data. Hitch wrote that “Economic efficiency demands that alternative programs... be costed *prior* to the selection of the preferred program.” For programs to be institutionally viable, they first required the exact type of information generated for systems analyses. To perform a systems analysis, there needed to be a history of program budget information, the very purpose of which was to spot and remove duplication.

Funding a diversity of approaches with regularly placed options to change direction defeats any generalizable measure of program success. In support of program measurement, RAND had been promoting the use of control systems in which programs were fully planned from the start and measured to that plan. The establishment of such control systems institutionally biased the DoD towards systems analysis; and systems analyses were themselves biased towards large projects. Program budgets and systems analyses are not conducive to adaptive planning by local actors who will naturally overlap one another. Enthoven explained that the “system” in systems analysis “should be considered in as broad a context as necessary.”¹⁹⁶ Hitch agreed that systems analyses should apply to the entire operational system, incorporating costs of R&D all the way through operations. It should also be performed at even higher levels of complexity than Minuteman squadrons or Polaris submarines; systems analyses applied even to “the determination of forces required to perform the strategic retaliatory mission.”¹⁹⁷ Alchian clearly stated that systems analyses should be confined to procurement decisions alone, and have no role in determining weapon performance characteristics or the research decisions required to achieve them, let alone tactical, strategic, or international policy decisions.¹⁹⁸ To Alchian, systems analyses were confined to determining which already fully developed system should be procured, as only such well-defined problems were amenable to measurement and optimization.

Management Systems

To illuminate the connection between institutions and program decision making, it is necessary to describe the defense management systems as employed by Charles Hitch in the PPBS. The management systems largely depended upon deciding in advance the particulars of what must be done, and measuring progress to that centrally approved plan.

¹⁹⁵ Young, Stephanie C. “Power and the Purse: Defense Budgeting and American Politics, 1947-1972.”, Doctor of Philosophy in History in the Graduate Division of the University of California, Berkeley, Fall 2009, pp. 55.

¹⁹⁶ Young, Stephanie C. “Power and the Purse: Defense Budgeting and American Politics, 1947-1972.”, Doctor of Philosophy in History in the Graduate Division of the University of California, Berkeley, Fall 2009, pp. 50-51.

¹⁹⁷ “Systems Development and Management (Part 2).” Hearings before a Subcommittee of the Committee on Government Operations House of Representatives Eighty-Seventh Congress, Second Session, July 23-27, 1962. U.S. Government Printing Office, Washington: 1962, pp. 516.

¹⁹⁸ Alchian, Armen A and Kessel, Reuben A. “A Proper Role of Systems Analysis,” RAND Corp., 1954, pp. 15.

Less than a year after publication of *The Economics of Defense in the Nuclear Age*, Hitch became the Comptroller for Secretary of Defense Robert S. McNamara who wanted its principles immediately employed. Yet the foundations of the PPBS were broadly consistent with the intent of the 1949 performance budget.¹⁹⁹ The programming process created new budget classifications that allowed for quantified analyses to aid in the allocation of resources within and between programs. The intended result was a unified budget that outlined the cost and objectives of programs, including the implications of funding changes. Hitch, however, believed that the early performance budgets provided “little unification in fact.” The Secretary of Defense had used budget ceilings rather proactively selecting between service programs because he “lacked the management techniques to do it.”²⁰⁰ Hitch complained that “military planning and budgeting have traditionally been treated as independent activities... the first falling within the province of the Joint Chiefs of Staff... and the second within the province of the Comptroller.” As a result, each year the Secretary of Defense “found himself in a position where he had to make major decisions on forces and programs without adequate information, and all within a matter of the few weeks allocated to his budget review.”²⁰¹ Hitch tried to bind programming and budgeting analyses in the Comptroller’s office, which had purview over the Office of Systems Analysis (OSA).

The program budget process started from military requirements set by the JCS in what was called the Joint Strategic Objectives Plan. The service staffs then interpreted those requirements into well-defined program packages in the Draft Presidential Memoranda (DPMs), submitted for review by OSA and the Secretary of Defense. The systems analysis laying out a quantified program plan became “unquestionably the largest factor” in Secretary McNamara’s decisions.²⁰² After elaborate stages of review and revision, ASD Comptroller then assembled, organized, and reviewed all program elements, becoming the one point that brings together all defense program information. The result—reminiscent of socialist industrial plans—is a Five Year Defense Program (FYDP), a register of approved program elements with budget estimates for the next five years.²⁰³ The services could request changes to the FYDP by submitting a Program Change Proposal (PCP) to OSA. The Bureau of the Budget reported that the paperwork involved in the process, particularly for the PCPs, was “bogging down” the system. As a result, OSA attempted to head off PCPs by providing guidance for changes likely to be approved in the Tentative Force Guidance (TFG).²⁰⁴ By the Spring of 1964, the Systems Analysis office of

¹⁹⁹ And even consistent with the intent of General Brehon B. Somervell’s WWII Army Service Forces Control Division.

²⁰⁰ Hitch, Charles J. 1965. “Decision-Making for Defense.” University of California Press, Berkeley and Los Angeles, CA, pp. 17.

²⁰¹ Hitch, Charles J. “Plans, Programs, and Budgets in the Department of Defense,” in *Operations Research*, Jan-Feb 1963, Vol II, pp. 5.

²⁰² Roherty, 1970, pp. 79-80.

²⁰³ Called at the time the Five Year Force Structure and Financial Plan. Today it is called the “Future Years’ Defense Program.”

²⁰⁴ Young, Stephanie C. “Power and the Purse: Defense Budgeting and American Politics, 1947-1972.” Doctor of Philosophy in History in the Graduate Division of the University of California, Berkeley, Fall 2009, pp. 125, 160-161.

about fifty analysts became in the words of one former member, “the basic force planners in the whole system.”²⁰⁵

Admiral Hyman Rickover commented that “It is important to recognize the degree of detailed technical control over military matters the systems analysts exercise through the DPMs.” He noted that the DPMs and PCPs did not provide the services a “serious voice at the table.”²⁰⁶ Captain Stanley Barnes worried that “*programming*, as it is now conceived by civilian authority, will dominate *the total defense planning process*,” eventually replacing military planning with “a body of ad hoc civilian sponsored, directed, or conducted studies and analyses.”²⁰⁷ In fact, that was precisely Hitch’s goal. He wrote that “the job of economizing, which some would delegate to budgeteers and comptrollers, cannot be distinguished from the whole task of making military decisions.”²⁰⁸ Hitch made ASD Comptroller the principle administrator the program budget and not share its activities with the JCS. As the Office of Systems Analysis, and the Comptrollership more generally, grew in competence it took effective control of much of the force planning, making it less dependent on input from military staff officers. Mosher had been prescient in 1954 when he predicted that there would be a struggle between “military specialism” and “accounting specialism,” with the most likely outcome being the rise and domination of “a new type of specialism,” which took the form of systems analysis.²⁰⁹

The form and function of the specialism involved in the PPBS is best explained by describing the planning and reporting systems levied on programs. The framework for such plans and reports came from similar systems independently developed by DuPont—the Critical Path Method—and by consultants in concert with the Navy—Program Evaluation and Review Technique, or PERT. The latter was formulated in 1958 and applied to the Navy Polaris program in 1959.²¹⁰ Admiral “Red” Raborn, program manager at the Polaris SPO, testified to the Congress that PERT forces discussions and estimates of cost, time, and performance “in far greater detail than you normally do. You come up, then, with a very much better answer.”²¹¹

²⁰⁵ Murdock, Clarke, pp. 81-84. Note that OSA was supposed to assign “primary responsibility to either the Systems Analysis Office, Director of Defense Research and Engineering (DDRE), Manpower, or Installations and Logistics.” However, “All Program Change Proposals involving changes in force structure went to OSA.”

²⁰⁶ Hyman G. Rickover, Senate Armed Services Committee, 90th Cong., 2nd sess., March 13, 15, 19, 27, 1968, Enthoven Papers, LB J Library, Box 8, Folder “DPM Process, ‘Article on the DPM Process (Rickover testimony re. DPM and OS A). Found in Young, Stephanie C. “Power and the Purse: Defense Budgeting and American Politics, 1947-1972.”, Doctor of Philosophy in History in the Graduate Division of the University of California, Berkeley, Fall 2009, pp. 177.

²⁰⁷ Roherty, 1970, pp. 81.

²⁰⁸ Hitch, Charles J. 1965. “Decision-Making for Defense.” University of California Press, Berkeley and Los Angeles, CA, pp. 71.

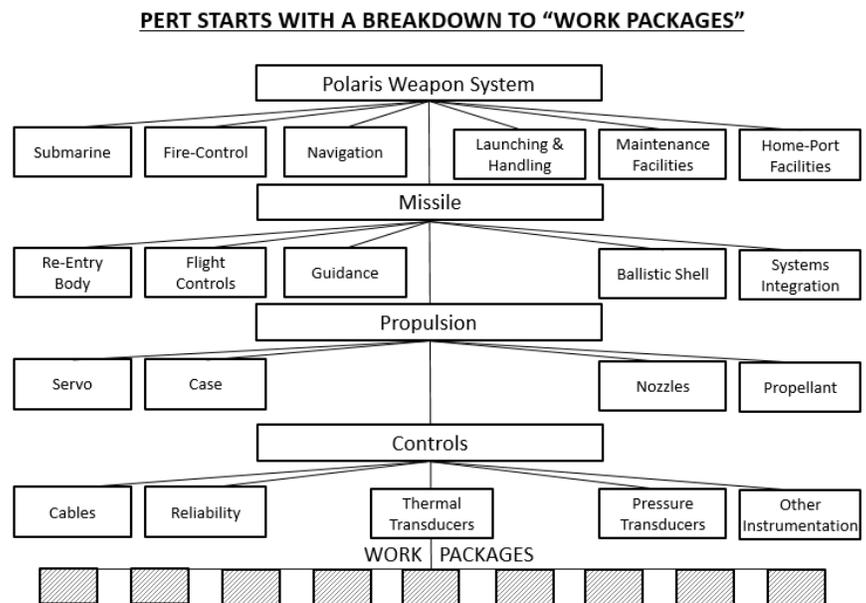
²⁰⁹ Mosher, 1954, pp. 228.

²¹⁰ Stretton, Alan. “A Short History of Modern Project Management.” *PM World Today*, October 2007 (Vol. IX, Issue X). The consultants included Lockheed and Booz, Allen, and Hamilton.

²¹¹ Systems Development and Management (Part 2).” Hearings before a Subcommittee of the Committee on Government Operations House of Representatives Eighty-Seventh Congress, Second Session, July 23-27, 1962. U.S. Government Printing Office, Washington: 1962, pp. 585.

Direct Controls

Thomas D. Morris, Assistant Secretary for Installations and Logistics, described the PERT system to the Congress. PERT was specifically designed to pre-plan the “fantastic complexity of modern weapon systems,” such as Polaris which alone employed over 10,000 people. “What is PERT?” Morris asked rhetorically, “First, break down each project into those tasks which are significant for control... The second objective of PERT is to estimate the expected time and cost required to complete each task. Third, to continually review actual performance versus estimates, in order to readjust schedules and financial plans well in advance of time slippages and cost overruns.”²¹² He went into an in-depth discussion. PERT breaks down the system into a hierarchy of parent-child relationships between subsystems, components, and assemblies called a Work Breakdown Structure (WBS). For example, the Polaris system includes the missile, the submarine, facilities, and other subsystem elements. The missile itself has children elements for guidance, body, propulsion, etc. The missile propulsion is made up of the case, nozzles, controls, etc. The missile propulsion controls include cables, reliability, thermal transducers, etc. And there ended the product oriented WBS for Polaris; however, the lowest level WBS elements are themselves made up of smaller work units. Thermal transducers, for example, are made up of several work packages which are further divided into a set of logically identified activities. A set of thermal transducer activities might include System Layout, Source Selection Studies, Final Drawings, Fabrication, Assembly, and Operational Test. Each activity requires estimates as to duration, sequencing, and inter-relationships. With a network of activities connecting every step necessary to complete the project, the longest single path of activities in the schedule represents the “critical path.” Any slippage to activities on the critical path will cause the entire program to slip. PERT



Reproduced figure from “Systems Development and Management (Part 2).” The Work Breakdown Structure begins with the total system, and is divided into parent-child relationships with subsystems and components, and eventually scheduled work packages and activities. The product oriented structure aligns with, and may “feed,” the program budget structure.

²¹² “Systems Development and Management (Part 2).” Hearings before a Subcommittee of the Committee on Government operations House of Representatives Eighty-Seventh Congress, Second Session, July 23-27, 1962. U.S. Government Printing Office, Washington: 1962, pp. 555-56.

appreciates the fact that a project progresses only as fast as its weakest link and seeks a targeted application of management. Activities not on the critical path have “slack” to slip without affecting the rest of the scheduled network of activities. Admiral Raborn commented that the effect of slips and changes on the critical path was calculated “through the magic of computers.”

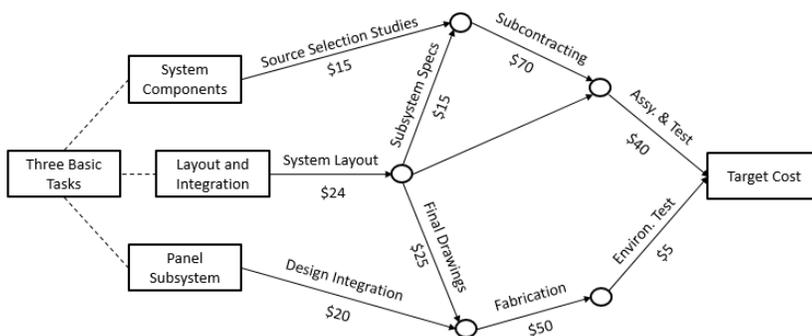
Activities were also given cost estimates such that the project plan had a time-phased baseline upon which to measure cost performance. For example, suppose an activity was planned to take a month and cost \$1,000. If that activity were actually accomplished in a month at a cost of \$1,000, then that portion of the project is on-time and on-cost. However, suppose the activity slipped. In that case, by the time the activity was baselined for completion, the project could not claim accomplishment of \$1,000 worth of work and is behind schedule by that value. Suppose that the activity is actually completed two weeks late and at a much higher cost, it took \$1,500 of actual expenditures to complete the activity that was planned to cost \$1,000. Therefore, the activity experienced \$1,000 worth of schedule variance for two weeks and contributes to \$500 worth of cost variance. In this manner, when activities are completed the project *earns value* which is compared to the baseline in terms of cost and schedule.²¹³ Problem areas may be exposed quickly and can receive managerial attention. The PERT system also provides a basis upon which internal predictions can be generated. An independent cost estimate at completion is possible by projecting forward current cost performance. If, aggregating over all activities, the project has expended \$1,000,000 and has only accomplished \$500,000 worth of baseline work, then if current performance persists the entire project may cost twice as much as expected. If the project had only planned to accomplish \$500,000 worth of work by that time, then the project is maintaining schedule by burning at a higher expenditure rate. The information generated in the management process has implications on the budget process by providing decision makers an early indication of project performance such that tradeoffs can be made in a timely manner.

In 1962, the joint “DoD/NASA PERT Guide” was released and over 200 major defense projects started to employ PERT systems. David Novick at RAND called the change a “major step toward effective control of new programs.” While the systems had only reached acquisition projects, Novick held hopes that the same kind of progress reporting could be employed for military operations using workload indicators.²¹⁴ In 1966, Work Breakdown Structures for major acquisition commodity groups were standardized by

²¹³ Technical notes: there are various methods of accounting for earned value. The above assumes the 0/100 method where all budgeted value is earned when the activity is complete. Other methods include percent complete and 50/50, the latter earning 50% of the value when the task starts and 50% when it finishes. Progress on the work packages, where accounting is usually performed, is informed by various methods using the scheduled activities in which resource loading is a best practice. When future activities are not fully planned, they are held in what is called a planning package.

²¹⁴ Novick, David. “Program Budgeting: Long-Range Planning in the Department of Defense.” Memorandum. RM-3359-ASDC., November 1962, pp. 11.

THERMAL TRANSDUCERS – COST ESTIMATES (000)



Each work package associated with the lowest level WBS elements is scheduled in a network. They are then provided a cost estimate to which actual expenditures are tracked. Reproduced figure.

DDR&E to aid in cost estimating.²¹⁵ In 1967, ASD Comptroller issued a regulation that solidified existing PERT guidance with 35 industry standards to which contractor systems must apply.²¹⁶ Progress on implementation of PERT-like systems proved slow. The optimistic view found the failure unrelated to the methods of PERT, such as poor government implementation and inadequate computer software to support it.²¹⁷

Because PERT planning and control had many complex requirements that strained even the best accounting systems, the contractors kept a dual set of books rather than fully switching over.²¹⁸ The dual set of books proved inevitable because of the same organizational issues inherent with program budgeting. Even if defense organizations could be made unfunctional with respect to the program structure, individual contractors could not be forced to align organization with program – especially for large and complex firms that performed a wide variety of contracts. The contractor organization, in other words, is prior to the government program. Contractors had to keep one set of books for the government programming and another based on object and organization for their internal administration. While the first set of books aligned with the product oriented Work Breakdown Structure mandated by the government, the second set of books aligned in what became called a contractor-defined Organizational Breakdown Structure. Prime contractors, then, ran into similar problems that service bureaus did before their replacement with project offices ushered in by the PPBS.

A more pessimistic view found that PERT not only strained organizations and accounting, but actually impeded the success of R&D projects. “Huge sums of money,” L. E. Loveall wrote in 1966, “have been spent on PERT programs before discovering that the PERT approach was not feasible within the context in which it was planned.” He found that in the Polaris program, “Many of the activities were compressed into time periods that were not adequate for completion. Other activities were allocated too much time and

²¹⁵ Durbrow, B.R., “C/SCSC Implementation Guide Reflects Evolution of the Program,” *Defense Management Journal*, April 1974.

²¹⁶ Lee, Tae H., “Procuring contracting officer’s guide to Cost/Schedule Control Systems Criteria (C/SCSC).” Monterey, California. Naval Postgraduate School, 1996, pp. 14. C/SCSC eventually became the name of PERT systems, overtaken in the 1990s by Earned Value Management Systems (EVMS). This paper will continue to refer to the controls as “PERT.”

²¹⁷ Lee, Tae H., “Procuring contracting officer’s guide to Cost/Schedule Control Systems Criteria (C/SCSC).” Monterey, California. Naval Postgraduate School, 1996, pp. 13.

²¹⁸ Hough, Paul G. “Birth of a Profession: Four Decades of Military Cost Analysis.” August, 1989, pp. 9.

effort.”²¹⁹ Small errors in estimates could lead to major re-planning of scheduled activities. Indeed, the early success of the Polaris program was not due to PERT. By the time PERT had been employed in 1959, Polaris had been a SPO for 4 years, which itself had consolidated on existing projects. Further, Polaris did not deliver the full operational capability in the performance estimates. The first missile had half the range and destruction, and it wasn't until 1964 that its requirements were met. Polaris benefitted from diversity in the early stages and rapid testing; it did not set detailed plans until many technical issues had been resolved.²²⁰ Some of those working on Polaris from 1955-1960 argued they would have been “hamstrung by the policies instituted during 1961-1965.”²²¹ Oskar Morgenstern had “great doubts” about the success of Polaris had systems analysis been applied from the start.²²²

In 1967, Harvard researcher Harvey M. Sapolsky was invited by the Polaris Special Projects Office to write a history of the program in a book published five years later entitled *The Polaris System Development*. In it, he devoted a chapter to “PERT and the Myth of Managerial Effectiveness.” Sapolsky found that PERT was not used for major parts of the effort until years after the first Polaris launch. Not a single group within the project claimed to have benefitted from the original PERT:

“In interviews with contractor executives reviewing their experience with the original PERT system, not one of them said that he had used the data... Instead many thought that it was the Special Projects Office technical officers and engineers that actually had used the PERT system data. The technical officers and engineers, in turn, denied ever using PERT data to manage their segments of the FBM [Polaris] Program; they thought it was the program evaluators in the Plans and Programs Division, if anyone, who made use of the PERT system. Persons who held positions in Plans and Programs, however, admitted that they themselves never used the system; rather, they thought it was either the technical branch heads or the Special Projects plant representatives who worked with the PERT reports. The plant representatives were similar in their response: ‘No, it must have been someone else.’”

Though not a single group of project participants could be found that benefitted from PERT, the project as a whole did. Sapolsky was told that “It had lots of pizzazz and that's valuable in selling a program.” Another participant said that “The real thing to be done was to build a fence to keep the rest of the Navy off of us. We discovered that PERT charts and the rest of the gibberish could do this. It showed them we were top managers.” Sapolsky discovered that Polaris used PERT to market itself to leadership in defense,

²¹⁹ Loveall, Lynn E. “PERT: Military Contributions to Management Science.” 1966, pp. 5-6 and 27.

²²⁰ Lenfle, Sylvain and Loch, Christoph. “Lost Roots: How Project Management Came to Emphasize Control Over Flexibility and Novelty.” *California Management Review*, vol. 53, no. 1, pp. 32-55, Fall 2010, pp. 8.

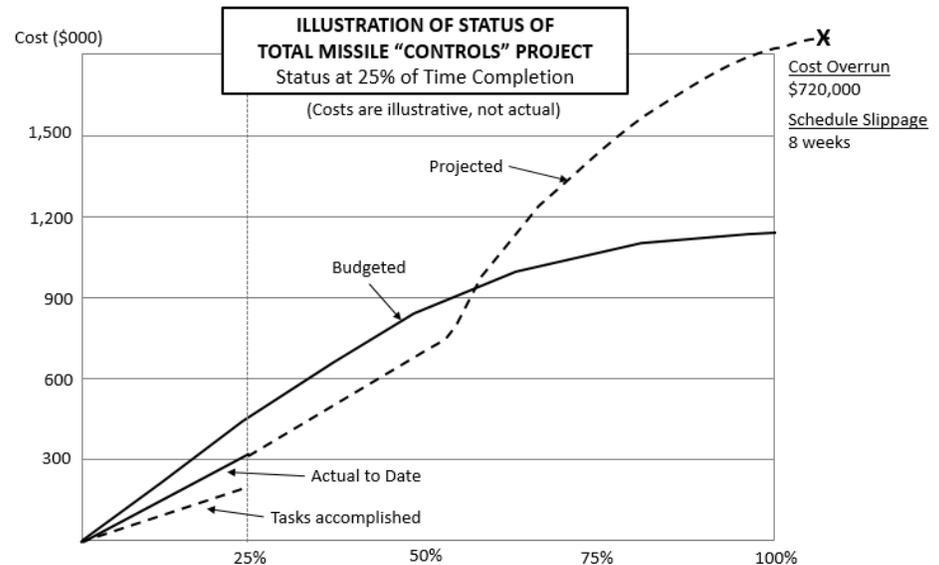
²²¹ Poole, Walter. History of Acquisition in the Department of Defense Volume II: *Adapting to Flexible Response, 1960-1968*. Historical Office, Office of the Secretary of Defense, Washington: 2013, pp. 67.

²²² Murdock, Clark A. *Defense Policy Formation: A Comparative Analysis of the McNamara Era*. Albany, State University of New York Press, 1974, pp. 150.

Congress, and the public such that it could more easily secure large budgets without the detailed oversight that often comes with it. With that privileged position of authority over its own budget, the SPO pursued two or three alternatives simultaneously for major components and subsystems. Sapolsky reported on an encounter that typified the SPO's unorthodox methods: "When a Navy field office accountant sought to apply the usual bureaucratic delays to FBM contractor requests, he was told that he would be immediately transferred to another, less desirable assignment if he attempted to do so again. 'Think big or get out' was the message."²²³

Error Suppression

The critical question is whether program budgeting, and its control systems such as PERT, create an institutional bias against diversity and optionality in R&D. In some ways the question is the same as asking whether or not a networked schedule of costed activities encourages or discourages trial-and-error or tinkering approaches. Designing a networked schedule is "difficult and time consuming [and] only as sound as the activity time and resource estimates."²²⁴ Further, it "requires a mathematical formulation of the problem which includes objectives and constraints" that are used to compute a most likely project end date. Networked schedules provide advantages only when "the problem allows for a crisp and precise mathematical formulation [and] the amount of randomness in the environment is minimal."²²⁵ The advantages of networked schedules arguably apply best to procurement efforts, which tend to require numerous repetitive tasks that interact deterministically. Unlike procurement projects which tend to be close-ended systems, R&D projects are open-ended systems in which interactions between activities cannot be predicted. If interactions between activities cannot be defined, or are reflexive rather than



With a fully costed network of activities, the actual amount and timing of expenditures can be compared to the budgeted plan, providing the basis for quantitative measures of progress. Reproduced figure.

²²³ Sapolsky, Harvey M. *The Polaris System Development: Bureaucratic and Programmatic Success in Government*. Harvard University Press, MA: 1972, pp. 123-24 and 45.

²²⁴ Defense Acquisition University (DAU), "DAU Scheduling Guide," pp. 41.

²²⁵ Pinedo, Michael and Yen, Benjamin. "On the Design and Development of Scheduling Systems", 2014.

causal, then a networked schedule falsely represents as “crisp and precise” that which is highly uncertain.

Uncertain environments require a learning process to overcome problems. Philosopher Karl Popper found that all problem solving, whether in nature or in the lab, required “the method of *trial and error*.” He continued, “To be more precise, it is the method of *trying out* solutions to our problem and then discarding the false ones as erroneous. This method assumes that we work with a large number of *experimental* solutions. One solution after another is put to the test and eliminated.” By making the entire weapon system a single potential solution, the systems approach constrains problem solving by restricting the number of solutions tried and thus errors exposed. Popper wrote that “if there were not *very many* [solutions], they would not be worth considering as attempted solutions.” Without numerous solutions tried, there can be no experiment in which errors are identified and new problems exposed. Popper realized that “We are always learning a whole host of things through falsification. We learn not only *that* a theory is wrong; we learn *why* it is wrong. Above all else, we gain a *new and more sharply focused problem*.”²²⁶ Because PERT fixates on completing interdependent tasks, each task is non-separable from the whole system. An error in one task is no longer localized and the only new solutions available are those which are close substitutes in system integration. When scale increases in such tightly networked systems, errors become increasingly harmful and the solution space for problem solving very much narrowed. New problems and new solutions no longer have the freedom to arise; instead, more resources and management pressure is placed on the same solutions. Popper concluded that “Error correction is the most important method in technology and learning in general. In biological evolution, it appears to be the only means of progress. One rightly speaks of the trial-and-error method, but this understates the importance of mistakes or errors – of the erroneous trial.”²²⁷ PERT makes each task not a solution, but only one step toward a solution. When the solution is a total system, both the cost of an error is high and attribution of the sources of error difficult if not impossible. Methods such as PERT, particularly when accompanying the systems approach, create an institutional bias against error correction and towards error suppression.

The trial-and-error origins of industrial revolution technologies, such as textiles and the steam engine, are well established. “Engineers are notoriously more successful,” RAND analysts found in 1958, “when they can tinker with pieces of machinery than when they are asked to make all their decisions at the drawing table before there are any test data on which to base them.”²²⁸ The same process is true for medicine, a science that

²²⁶ Popper, Karl. 1972. “The Logic and Evolution of Scientific Theory,” in *All Life is Problem Solving*, Routledge, NY: 1999, pp. 3-13.

²²⁷ Popper, Karl. 1991. “All Life is Problem Solving,” in *All Life is Problem Solving*, Routledge, NY: 1999, pp. 100.

²²⁸ Klein, B. H., Meckling, W. H., Mesthene, E. G. “Military Research and Development Policies.” RAND Corp., 4 December 1958, pp. 11.

Enthoven believed analogous to systems analysis. Unlike systems analysis, however, the medical sciences progressed by taking advantage of unexpected results from many, sometimes random, solutions. One such example came in 1942, when a German bomber hit an American ship carrying mustard gas. The beneficial effect on the soldiers with some forms of cancer led to the discovery of chemotherapy.²²⁹ There was no inevitability of the discovery using a system of scheduled plans.

The PERT system has little managerial or predictive value when activities require trial-and-error. PERT systems handle uncertainty by assuming a distribution of potential outcomes for each activity's cost and duration estimates. The total effect on the project's cost and schedule is calculated using a Monte Carlo simulation that randomly selects an outcome for each activity according to often arbitrary cost and duration distributions.²³⁰ Numerous runs of randomized selections allows the Monte Carlo to generate a distribution of cost and schedule outcomes for the project as a whole, including the worst, most likely, and best case scenarios. Despite the enormous effort required for such integrated cost-schedule risk analyses, and the weeks or months of computer programming it required, the Monte Carlo method only works if there is zero uncertainty as to the content or interrelationship of activities, only as to how much time or effort each one will take.

Under true uncertainty, when planners cannot know the content or interrelationships of future activities until more information is generated, PERT proves a wasted effort at best and a rigid encumbrance at worst. Suppose that a planner accepts that innovation cannot be predicted and would like to schedule a trial-and-error approach. While each trial can have a notional schedule for its activities, there exists no acceptable way for defining the activities involved in the second solution due to uncertainty as to what will be learned in the first solution—assuming a second solution is needed at all. Integration plans cannot be scheduled until characteristics of the components are discovered. A similar fate befalls the costing of options. There can be no detailed plan outlining when and by how much a success should be followed up by; or when it is time to cut losses and seek alternatives. PERT does not allow for rapid updates to expectations of the project's direction. In fact, PERT fixes project specifications and, as the Monte Carlo exercise illustrates, forces an acceptance of cost and schedule risk in order to overcome prediction errors. PERT is the practical application of long range planning, and unlike the diversity approach, is fragile with respect to uncertainty in weapons project outcomes. As Meckling et al. wrote in 1958:

“Any attempt to schedule an entire R&D program at one time is likely to lead to inefficiency, either because plans for the later stages may have to be scrapped and remade on the basis of information yielded by early tests, or because, in pursuing premature plans,

²²⁹ Meyers, Morton. *Happy Accidents: Serendipity in Modern Medical Breakthroughs*.

²³⁰ Normally such risk analyses use a triangular distribution that only requires a min, max, and most likely estimate.

a development program may fail to profit from new information gained along the way. Either case will cause delays, or raise costs, or both.”²³¹

The utility of diversification and options diminishes in procurement and operations. The PERT system works fine in procurement, where the system is more well-defined and a production order can largely be planned. Uncertainties still exist, particularly in tooling which is best considered R&D, but they are not often fundamental. Production activities are often stable in content and sequence, making Monte Carlo simulations a more reasonable approximation of uncertainty. And yet it is precisely because stable systems have fewer uncertainties in production that PERT was not levied on procurement contracts that tend to be of the fixed-price variety. Perhaps both sides, Hitch and Alchian alike, accepted the theoretical proposition to separate basic research from quantity production because the former requires more duplication and the latter more central direction. The critical questions came in development and its boundaries. Hitch felt development benefitted from detailed planning much like procurement did. Alchian—as well as Roland McKean and various others—believed that development, like research, was primarily a search that benefitted from diversity.

An increased confidence in predictions directly led to major troubles in one of McNamara’s first acquisition initiatives, the TFX aircraft. Not only was the TFX intended to fulfill the roles of interceptor, fighter-bomber, *and* strategic bomber for both the Navy *and* Air Force, the TFX also included pioneering technologies in airframes, engines, and radar.²³² The result of the TFX program, eventually the F-111 Aardvark, is legend in defense acquisition history and reasons for its failure a source of disagreement. However, the facts are that the program cost quadrupled even though the Navy dropped out after only 8 aircraft and the Air Force reduced its procurement to one-third that was planned. This does not even take into account the substantial decrease in aircraft performance from estimates. Program troubles arose despite a year-long program definition phase.

The TFX’s technical failures must be viewed as institutional failures in acquisition management. Cost effectiveness was the greatest factor in driving decisions. McNamara, and even top military advisors like General Schriever, believed that he could fulfill the roles of multiple aircraft with only one development program, one set of tests, and one supply network.²³³ The TFX would also generate enormous economies of scale in procurement and vastly simplify maintenance and logistics. Unfortunately, none of those

²³¹ Klein, B. H., Meckling, W. H., Mesthene, E. G. “Military Research and Development Policies.” RAND Corp., 4 December 1958, pp. 3.

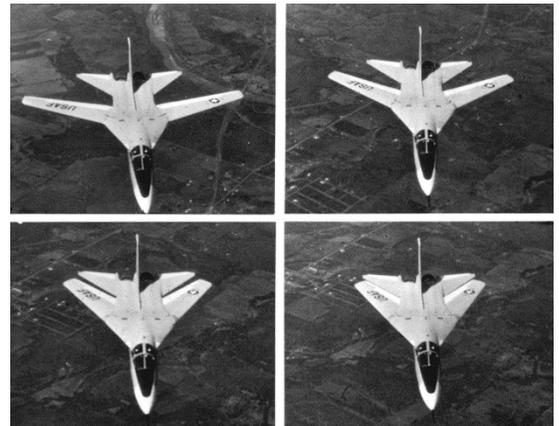
²³² Reece, Brian L. (Maj.) “Development of the TFX F-111 in the Department of Defense’s Search for Multi-Mission, Joint-Service Aerial Platforms.

²³³ General Bernard Schriever, of Atlas fame, agreed with the TFX acquisition strategy. “One system that we have under consideration now is the tactical fighter-bomber. I might say that I completely agree with the steps that are being taken with respect to it.” See “Systems Development and Management (Part 3).” Hearings before a Subcommittee of the Committee on Government operations House of Representatives Eighty-Seventh Congress, Second Session. U.S. Government Printing Office, Washington: 1962, pp. 819.

realities, which appeared so certain as the result of systems analyses, came to pass.²³⁴ Congressional investigations repeatedly questioned cost realism and activity scheduling in 1963 and 1964, and yet the program continued. A 1970 investigation failed to attribute responsibility for the fiasco, stating that that not enough information existed at the time to make a “final determination” about the reasonableness of system estimates that ultimately led to an “operationally inferior and more costly aircraft design.”²³⁵ The example, repeated numerous times in the defense decision making, shows that when there exists systemic biases that underestimate the cost of scale, there will exist a systemic bias to select larger scale projects. One Senator opined that Secretary McNamara should have “listened to the recommendations made by the men who knew what they were talking about” and admitted that “he was wrong and the aeronautical engineers were right.”²³⁶

Into a New Era

Cracks quickly formed in the integrated program budget under the Office of the Comptroller. To start, many Program Change Proposals were not decided upon until after the budget had passed, reflecting execution to the unplanned. The exit of Charles Hitch from the Comptrollership in 1965 marked the definite breakdown of an integrated program budget function. His replacement, Robert N. Anthony, believed that programming and budgeting required different information, and sought to “undermine the programming system.” Anthony wrote that “Strategic planning is essentially *irregular*. Problems, opportunities, and ‘bright ideas’ do not arise according to some set timetable.”²³⁷ Hitch, keenly aware of Anthony’s disposition, insisted that the Office of Systems Analysis (OSA) move out of the Comptroller’s office. Still sympathetic to Enthoven and systems analysis, McNamara elevated OSA to an Assistant Secretariat, leading some insiders to observe a power struggle resulting between Enthoven



The F-111A, formerly Tactical-Fighter Experimental (TFX), showing its movable swept wings in flight.

²³⁴ While Enthoven and the Office of Systems Analysis did not produce the study that resulted in the TFX, it did follow the prescriptions laid down by RAND. I. F. Stone reports that a systems analyst submitted a critical memo on the TFX early in the debates, and that Enthoven rejected the memo “on the grounds that it would call down bureaucratic wrath on the fledgling systems analysis office.” See Murdock, Clark A. *Defense Policy Formation: A Comparative Analysis of the McNamara Era*. Albany, State University of New York Press, 1974, pp. 165.

²³⁵ “TFX Contract Investigation: (Second Series). Hearings before the Permanent Subcommittee on Investigations of the Committee on Government Operations, United States Senate, Ninety-First Congress, Second Session, S.Res 308, March 24, 1970. U.S. Government Printing Office, Washington: 1970, pp. 3-6. Also see “TFX Contract Investigations” Parts 1-9, 1963-64.

²³⁶ “TFX Contract Investigation: (Second Series). Hearings before the Permanent Subcommittee on Investigations of the Committee on Government Operations, United States Senate, Ninety-First Congress, Second Session, S.Res 308, March 24, 1970. U.S. Government Printing Office, Washington: 1970, pp. 8.

²³⁷ Anthony, Robert N. *Planning and Control Systems: A Framework for Analysis*. Harvard University Press, Boston: 1965, pp. 38-39.

and Anthony. Anthony commissioned the McKinsey Company to study the programming portion of the budget, finding extensive rigidities that hampered effective administration. One official recalled that during Hitch's time as Comptroller, "OSA was automatically fed into the budget; but once separate offices were created, OSA often was not even consulted in decisions taken during the budget phase."²³⁸

In the same year that Anthony took the Comptrollership, President Lyndon B. Johnson implemented the PPBS principles across the remaining executive departments. The Bureau of the Budget instructed that each department develop a program budget along with systems analysis capabilities.²³⁹ Without prior experience in the analytical tools necessary for the program budget, implementation proved controversial. Two years later, in 1967, the Congress started to hear testimonies on the effectiveness of the PPBS. The final report emanating from the Jackson Subcommittee clearly showed skepticism for systems analysis and civilian control of programming. The report opened with thirty famous passages from a wide range of thinkers. From Aesop's Fable and Aristotle to David Hume and Machiavelli, it even included pieces of the Bible. The passages have a clear message. Technical specialism associated with program budgeting is not a panacea for coordinating complex human interactions. Instead, the political process was accredited for its ability to generate decisions in uncertain environments where participants have diverse and legitimate interests. Chairman Henry M. ("Scoop") Jackson provided a concise explanation. "Modern-day specialists can make important contributions in decision-making; but there is no substitute in government for the wise generalist with skill and shrewdness."²⁴⁰ Though the report presented many sides of the argument, from Admiral Rickover on one extreme to Assistant Secretary Enthoven on the other, Jackson's centrist viewpoint appears to have prevailed among witnesses. Professor Klaus Knorr wrote that systems analysis studies "must count for no more, and no less, than their due."²⁴¹ Despite some stirring arguments, particularly from Professor Aaron Wildavsky who noted the "extreme centralizing bias" of program budgeting, the PPBS remained largely intact.²⁴² McNamara's successor as Secretary of Defense, Melvin Laird, vowed to

²³⁸ Murdock, Clark A. *Defense Policy Formation: A Comparative Analysis of the McNamara Era*. Albany, State University of New York Press, 1974, pp. 99-100. Note in the original, "SA" was used instead of "OSA."

²³⁹ Murdock, Clark A. *Defense Policy Formation: A Comparative Analysis of the McNamara Era*. Albany, State University of New York Press, 1974, pp. 53.

²⁴⁰ Jackson, Henry M. "Forward." 7 November 1968. "Planning, Programming, Budgeting: Inquiry of the Subcommittee on National Security and International Operations." U.S. Government Printing Office, Washington: 1970, pp. 29.

²⁴¹ Knorr, Klaus. "On the Cost-Effectiveness Approach to Military Research and Development." Found in "Planning, Programming, Budgeting: Inquiry of the Subcommittee on National Security and International Operations." U.S. Government Printing Office, Washington: 1970. Note that the Jackson Committee hearings can be thought of as a prelude to the backlash to error-prone macroeconomic models that occurred in the 1970-1980s called the "credibility revolution." In effect, statistical modeling often involved a specification search such that historical data "fit" the model well, but because the model was in some sense arbitrary it had little use in "prediction." The credibility revolution added treatments, or so-called natural experiments, into macroeconomic regressions to better tease out relationships and causality.

²⁴² Wildavsky, Aaron. "The Political Economy of Efficiency: Cost-Benefit Analysis, Systems Analysis, and Program Budgeting." *Public Administration Review*, Vol XXVI, No. 4, Dec. 1966. Found in "Planning, Programming, Budgeting: Inquiry of the Subcommittee on National Security and International Operations." U.S. Government Printing Office, Washington: 1970.

“purge” the DoD of Enthoven’s control through systems analysis. Regardless of the rhetoric, Laird did not abolish the systems approach. He devolved many of OSA’s functions to the services, and in 1972 changed its name to Program Analysis and Evaluation (PA&E). The role of PA&E was largely to assist in the review of service programs at major “milestone” decision points.

By giving the military services primary control over programming, Laird sought to generate “participatory management.” Yet the form of decision making in the PPBS changed little. It still required extensive before-the-fact controls on program requirements and cost. Laird replaced the Draft Presidential Memorandum (DPM) with the Program Objective Memorandum (POM), which retained the essentials from McNamara’s program package framework that fed the same Five Year Defense Program, but with greater service administration. The services, which had grown their own systems analysis capabilities to combat OSA, now employed them to define and control programs. John Dawson wrote in *Armed Forces Comptroller* in 1972 that “Today is not a replay of the 1950s” because systems analysis was “firmly established” in the DoD.²⁴³ Craig Powell shared the sentiments, finding that “the majority of volleys that have been fired at the principles of Systems Analysis have been blanks.” Historian Charles R. Schrader found it “evident that both at the DoD level and within the Service Departments, systems analysis is considered sound application of economic theory and scientific method... and is generally accepted as a good thing.” He concluded that the McNamara era reforms “prevailed in the battle” because its concepts “proved superior to traditional ways of doing things. Their triumph thus represented a triumph of rational scientific methods over experience and intuition.”²⁴⁴

Scientific management of weapons acquisition, with its extensive before-the-fact control mechanisms of detailed planning regulations, proved unassailable. Historian Walter Poole asked “Should centralization be labeled an acquisition failure?” He answered that “Unanticipated unknowns’ continually thwarted efforts to trade off cost against performance in setting requirements.”²⁴⁵ If unanticipated unknowns are expected in acquisition, and certainly the pursuit of R&D is the pursuit of the unknown, then acquisition processes that are fragile with respect to uncertainty should be replaced with those that are robust to, or benefit from, uncertainty. Instead, systematic errors were viewed as challenges to develop better estimates, and because Laird’s reforms separated program definition from the systems analysis framework, quantitative estimates focused on costing systems already planned from above through political mechanisms.

²⁴³ Young, Stephanie C. “Power and the Purse: Defense Budgeting and American Politics, 1947-1972.” Doctor of Philosophy in History in the Graduate Division of the University of California, Berkeley, Fall 2009, pp. 282-88 and 309.

²⁴⁴ Schrader, Charles R. *History of Operations Research in the United States Army, Volume II: 1961-1973*. Office of the Deputy Under Secretary of the Army for Operations Research, United States Army, Washington: 2008, pp. 60-65.

²⁴⁵ Poole, Walter. “Acquisition in the Department of Defense, 1959-1968.” In *Providing the Means of War: Perspectives on Defense Acquisition, 1945-2000*. Ed. Shannon A. Brown, pp. 93.

5. *Cost Estimating*

“It is a profoundly erroneous truism, repeated by all copy-books and by eminent people when they are making speeches, that we should cultivate the habit of thinking what we are doing. The precise opposite is the case. Civilization advances by extending the number of important operations which we can perform without thinking about them.”

Alfred Whitehead

An Introduction to Mathematics, 1911

Before program budgeting existed, bureaucratic control was placed on organization and object, meaning the budget estimating process generally performed a straight-line extrapolation from past rates of expenditures with incremental adjustments. Accountants still kept records, but did not seek to apportion each dollar expended to a pre-specified military output. Cost information existed only in bits and pieces scattered both across and within contributing organizations. Administrative superiors evaluated the military output with less regard to preconceived metrics and had discretion to reward or punish behavior as seen fit. The traditional set of rules associated with military procurement, as with operations, focused on conduct as judged after-the-fact. Perhaps the most significant effect of the comptroller’s rise in defense is the replacement of local control with control at a distance, the latter typified by regulations dictating programmatic cost, schedule, and performance. With the half-hearted rejection of systems analysis as the basis for weapons choice, a system’s performance requirements returned to selection through a quantitatively informed political process. Yet the PPBS still required program definition up front, and so it became the cost estimator’s job to put a dollar figure to the politically planned acquisition.

Outsourced

Prior to World War II, the services had robust in-house production capabilities. Army production centered around six arsenals in the Ordnance Department, the first established in Springfield, Massachusetts in 1794. The Navy had its technical bureaus and owned a large network of shipyards. Except for wartime surges when private industry supported production, the services’ in-house capabilities were the centerpiece of U.S. weapons expenditures. For example, between 1866 and 1883, two-thirds of Navy ships were constructed in government yards.²⁴⁶ Though a Congressional push toward the private sector procurement occurred for the Navy in 1883 and Army in 1916, not until

²⁴⁶ Brunton, Bruce. “The Origins and Early Development of the American Military-Industrial Complex.” The University of Utah, 1989.

after WWII was lasting emphasis placed on outsourcing. Vannevar Bush, Director of the Office of Scientific Research and Development, promoted research through “contracts or grants to organizations outside the Federal Government. It should not operate any laboratories of its own.”²⁴⁷ The Navy, which had a strong research focused organization since 1923, quickly saw its share of dollars diminish. After WWII, the Navy outsourced 65% of research, though the figure for development was somewhat less at 40%.²⁴⁸ In 1946, the Army’s Ordnance Department allocated two-thirds of its R&D to private sources.²⁴⁹ The Air Force, without a large legacy bureau system, had by 1953 already outsourced 90% of its R&D budget. The Air Force didn’t seek substantial in-house capabilities in R&D or production. The slow demise of Army and Navy in-house capabilities, which largely focused on component development, accelerated in the 1960s. The Army bureaus lost their statutory role in 1962 and later scaled back operations, including shutting down Springfield, Watertown, and Frankford arsenals. The Navy bureaus lost control of R&D in 1958, and by 1966 the Navy abolished the bureau system, though their remnants continued to be an important source of innovation in missiles, rockets, and lasers.²⁵⁰

The transfer of weapon systems expenditures to organizations external to the Defense Department brought issues of contracting to the fore. When the actual operations of doing experiments or bending metal occur in-house, the executive may act very much like a military commander in the field. He can express his desires, or lay out his “demand function,” and command action be taken. Depending on how he judges the resulting action when compared with his updated expectations, the executive or commander can reward or punish his subordinates. This method of administrative control is often called *after-the-fact control*. However, when defense executives seek production from the open market, whether it be firms, universities, or non-profits, they must use market exchange mechanisms characterized by contracts. A contract essentially seeks voluntary agreement between two or more parties where the exact responsibilities of each party and methods for evaluation are detailed before action is taken. A similar method of administrative control is wielded by the controller using program budgets. Both contracts and program budgets use the method of *before-the-fact control*. Professor Thompson compared the two methods with respect to internal administration:

“[Before-the-fact] controls necessarily take the form of authoritative mandates, rules, or regulations that specify what the subject must do, may do, or must not do. The subjects of before-the-fact controls are held responsible for complying with these commands and the controller attempts to monitor and enforce compliance with them.

²⁴⁷ Bush, Vannevar. “Science – The Endless Frontier.” 1945. <http://www.nsf.gov/about/history/vbush1945.htm>.

²⁴⁸ Mayer, *Political Economy of Defense Contracting*. 1991, pp. 44.

²⁴⁹ Lassman, Thomas C. 2008. *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-200*. Center for Military History, U.S. Army, pp. 17.

²⁵⁰ Lassman, Thomas C. 2008. *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-200*. Center for Military History, U.S. Army, pp. 17, 81, 8, 50-52.

“After-the-fact controls are executed after the subject, either an organization or an individual, decides on and carries out a course of action and, therefore, after some of the consequences of the subject's decisions are known.”²⁵¹

The congruence between the methods of contracting and program budgeting made the two natural bedfellows, the enabler being the unifunctional project office structure. The program budget demands that organizations find perfect alignment with program structure, which Mosher had showed impossible for any significant organization. These forces, coupled with an expressed desire for private production, led the Air Force to favor the systems project office and a single prime contractor. For the pre-existing Army and Navy organizations to be viable, there needed to exist an auditable accrual accounting system by program. Without such an accounting system, the policy maker could not effectively monitor execution to plan; nor could the policy maker forecast future plans. Though Congress mandated such an accrual accounting system in 1955, it was never accomplished.²⁵² Thus, the move toward unifunctional project offices can be seen as a means of outsourcing accounting compliance as well as production knowledge to industry. Control through the program budget would otherwise require multifunctional in-house organizations to perform such accounting themselves.

Contracting

Increased reliance on industry required different forms of contracting than those historically permitted by the Congress. Contracting before WWII was almost entirely of the fixed-price sealed-bid procurement auction form. In such an auction, the government advertised its requirements publically and interested parties responded with proposals. Advertisement and unbiased appraisal was viewed as a democratic means of source-selection. It also had the benefit of holding the supplier to reasonable speculations in the cost, schedule, and technical trade-space. The supplier would bear the full risk of not meeting the contract obligations.

The uncertainty of R&D contracts made them legally ambiguous because terms could not always be met in the manner pre-specified. Instead of taking firms to court for contractual default, the bureaus punished firms which did not expend resources in an appropriate way when judged after-the-fact by not awarding them future work. The repeated interactions between a diverse set of government and industry participants led to significant reputational effects. Contract specification as written before-the-fact therefore mattered less than the purchaser's satisfaction when viewed after-the-fact.

²⁵¹ Thompson, Fred. “Public Economics and Public Administration.” <http://www.willamette.edu/~fthompso/ECON&PA.html>.

²⁵² Lander, Ezra. “Performance Budgeting and Accounting Policy in the Department of the Army.” The American University, Ph.D., 1961, pp. 242. Accrual accounting was first emphasized to the Congress in the Second Hoover Commission of 1955, but its need was understood much earlier. Amazingly, and despite repeated mandates, an auditable accrual accounting system remains years away in the Department of Defense.

The weapon system concept put emphasis on pre-specified plans such that all components could integrate with the greatest technical advancement in the shortest possible time. The systems approach then required detailed specifications of future components for ensuring integration. The increased scale and complexity of the task strained the fixed-price contracting regime mandated by legislation. In 1947, the Congress created eleven broadly worded exemptions to the use of advertised fixed-price contracts in the Armed Services Procurement Regulation. For exempted contracts, it also required detailed documentation and justification for each expenditure, leading to “tedious and time consuming steps.”²⁵³ But the process allowed the services to skip advertisement and directly negotiate with a single supplier.²⁵⁴ Further, the legislation authorized the use of cost-reimbursable, or “cost-plus,” contracts. Cost-plus contracts shielded contractors from risk by having the government reimburse the contractor for all auditable cost expenditures related to the project. On the downside, cost-plus contracts discouraged cost control in favor of achieving the required performance in the shortest schedule – as well as expensing the buildup of future company capabilities to the current contract.

The expense control problems resulting from cost-plus contracts seemed to remove the competitive incentives from the defense industry. Perhaps the most pernicious problem of cost-plus contracts to the PPBS’s planning functions was that it encouraged overly optimistic pricing on major projects. Contractors could “buy in” on a major weapon system with low bids and get fully reimbursed for overruns. Systematic use of “foot in the door” strategies distorted the decision trade space and crowded out future investment to cover current overruns. Cost-plus fixed fee (CPFF) contracts were especially pervasive in missiles, accounting for over three-quarters of all missile contracts in 1960.²⁵⁵ CPFF contracts had steadily risen as a percentage of the DoD total until it peaked at 38% in 1961, the year McNamara took office. At the time, nearly 40% of the DoD budget went to cover cost overruns. McNamara quickly sought to turn the tide and five years later, he pushed the total proportion of CPFF contracts down near nine percent.²⁵⁶ A memo from McNamara to President Johnson in 1964 claimed that “At a minimum, our analyses indicate that 10 cents is saved for each dollar shifted from a CPFF to other forms of contracts.”²⁵⁷ The contracts let for weapons acquisitions did not, however, return to the old model of advertisement and firm fixed-price contracts. Sole-source awards continued instead and the government took a larger role in sharing risk on a fixed-price basis.

²⁵³ Converse III, Elliot. 2012. *Acquisition History Volume I: Rearming for the Cold War, 1945-1960*, pp. 428.

²⁵⁴ The 1926 Air Corps Act was an earlier exemption to advertised sealed-bid auctions.

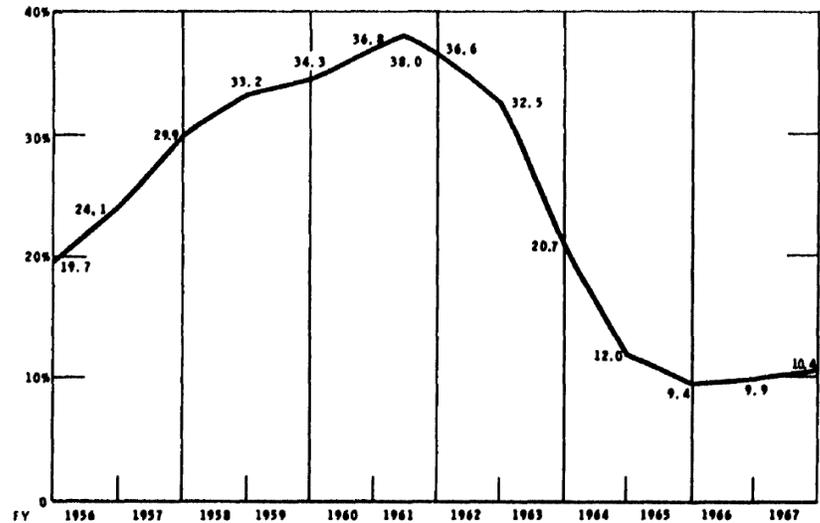
²⁵⁵ Moore, Frederick T. “Military Procurement and Contracting: An Economic Analysis.” The RAND Corp., RM-2948-PR, June 1962, pp. 15.

²⁵⁶ Statement of Secretary of Defense Robert S. McNamara Before the House Armed Services Committee on the Fiscal Year 1969-73 Defense Program and 1969 Defense Budget. Prepared Jan 22 1968. See chart on pp. 228. These numbers pertain to cost-plus fixed fee only, and does not account for incentive fee or other cost-plus structures.

²⁵⁷ “Department of Defense Cost Reduction Program – Second Annual Progress Report.” Memorandum from the Secretary of Defense to the President, 7 July 1964, pp. 8.

Incentives

Adding incentives to contract structures seemed to offer a cure for expense control problems. Using an incentive contract, both parties agree to a “share ratio” whereby the supplier retains a proportion of underruns as profits and pays for a proportion of overruns as losses. A common share ratio was 80/20 where the government retained 80% of risk and reward and 20% was retained by the contractor. The government could tailor the share ratio on either side of the target depending on circumstance. At one extreme, a CPFF contract has a continuous government share ratio of 100/0, while a firm fixed-price contract flipped the ratio to 0/100 and the contractor retained all of the risk as well as reward. Because of the stakes involved, the incentive approach put a premium on negotiating a target cost and required auditable accounting for all expenditures.



Cost-plus fixed fee (CPFF) contracts as a percent of total Department of Defense contract awards, presented to the Congress for the 1969 budget request. The proportion of CPFF contracts doubled between 1955 and 1961, and fell by nearly three-quarters between 1961 and 1965.

In June 1962, Frederick T. Moore published a seminal paper examining the use of cost-plus contracts relative to incentive-based contracts on aircraft and missile programs. In “Military Procurement and Contracting: An Economic Analysis,” Moore examined 290 incentive contracts of all types and 2,501 CPFF contracts. He found that while less than 5% of CPFF contracts resulted in cost underruns, 74% of incentive contracts did.²⁵⁸ However, Moore could not conclude that incentive contracts automatically led to better outcomes. He fully recognized that CPFF contracts systematically received low buy in estimates, while incentive contracts received high estimates “such that the contractor can easily beat the target with no better than average performance.”²⁵⁹ Though Moore could not determine what each contract objectively should have cost, and thus which contract type provided relative efficiencies, he admitted that “Clearly we don’t want to go to cost-type contracts.” Without much substantiation, Moore wrote that for CPFF contracts, “the results would be much worse” than had incentive contracts been used, despite the obvious effect on higher target costs leading to “windfall” profits.²⁶⁰ Moore’s primary

²⁵⁸ Moore, Frederick T. “Military Procurement and Contracting: An Economic Analysis.” The RAND Corp., RM-2948-PR, June 1962, pp. 42 and 48.

²⁵⁹ Moore, Frederick T. “Military Procurement and Contracting: An Economic Analysis.” The RAND Corp., RM-2948-PR, June 1962, pp. 50.

²⁶⁰ Moore, Frederick T. “Military Procurement and Contracting: An Economic Analysis.” The RAND Corp., RM-2948-PR, June 1962, pp. 75-76.

recommendation to control high target costs was the idea of a “hard target,” whereby after traditional negotiations, the government provided the contractor the option to accept a lower target cost with an increased share of profits if the lower target is achieved.

Despite the problems of fixed-price incentive contracts, namely contractors playing it safe by negotiating high target costs, they became fashion in 1960s weapons procurement. In a second installation of *The Weapons Acquisition Process*, Frederic Scherer, this time writing alone, provided a searching review of incentive contracting. Scherer wrote that “Virtually all the detailed cost estimation for weapons program budget decisions of the 1950s was undertaken by contractors.” Because contractor accounting systems often did not allow for estimating unit costs of items already produced, let alone future items, the ambiguity over a reasonable cost often strained contract negotiations. Scherer reported on one government negotiator’s frustration, “We have piles of cost documents, but none of them tell us what we need to know in making projections.” Scherer characterized the contractor who would say “the cost of collecting data detailed enough to be useful in cost projections exceeds the value of the additional precision attainable.” PERT regulations, Scherer noted elsewhere, mandated programmatic accounting that also supported estimating techniques. The resulting data not only benefitted the contractor, but the government as well. He reasoned that if target costs were to be made more objectively, “the military services and the Office of the Secretary of Defense must acquire independent competence in estimating program costs.” Scherer wrote that over “many large negotiations... our case study research turned up only one trifling example (involving costs of roughly \$1 million) in which a really penetrating job of cost analysis was done by the buying agency.” He applauded government investment in building cost analysis, writing “That such efforts will lead to improvements seems a virtual certainty.”²⁶¹

Total Package Procurement

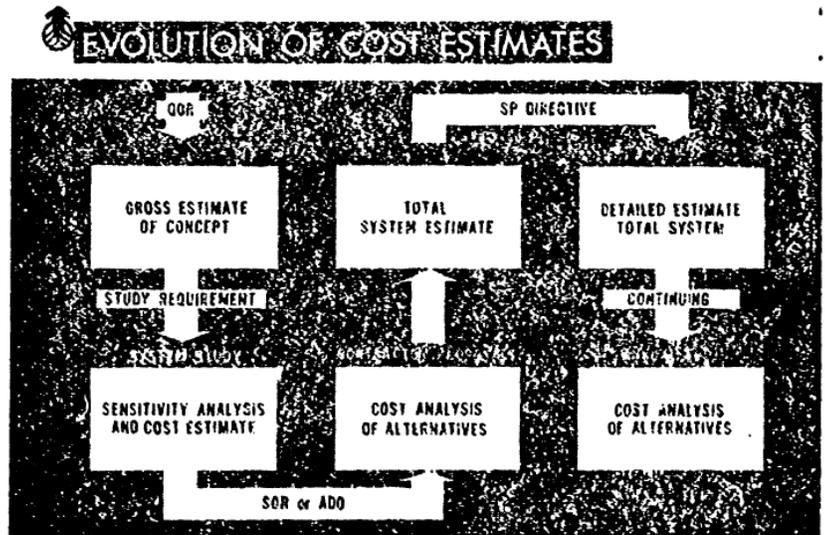
A year after Scherer’s writing, a new form of contracting began to emerge. The Total Package Procurement (TPP) concept attempted to acquire the entire program in just two major fixed-price contracts, one for development and one for production, putting greater emphasis on the government’s ability to validate target costs. It was the brainchild of Assistant Secretary of the Air Force for Installations and Logistics, Robert Charles. The intent of the enlarged contracts was to alleviate the problem of unrealistically low buy-ins where the contractors expected to make up the revenue on change orders or procurement. The TPP induced realism by exposing the contractor to three risks: “1. Commitment to the price and performance of production articles before their development; 2. Total system performance responsibility; 3. Extreme length of commitment.”²⁶² The TPP’s pilot program, the C-5 cargo aircraft, experienced the exact problems that the TPP tried to

²⁶¹ Scherer, Frederic M. *The Weapons Acquisition Process: Economic Incentives.* Harvard University Press, Boston: 1964, pp. 64-67 and 206-09.

²⁶² Charles, Robert H. “Memorandum for Secretary Brown, Subject: C-5.” Found in “Hearings on Military Posture and Legislation to Authorize Appropriations During the Fiscal Year 1970,” Part 2, H.A.S.C. No. 91-14, pp. 2961.

avoid with Lockheed's winning bid coming in at half the cost of the next lowest competitor, Boeing.²⁶³ Despite the C-5 being, from an engineering standpoint, a "straight-line extrapolation" based on "proven" technologies, substantial cost growth ensued. Assistant Secretary Charles said that the C-5 would "get away from the fuzzy notion that the Government and industry should be 'partners'" because it leads to "several adverse results."²⁶⁴ The TPP supposedly provided contractors freedom from government oversight to develop and produce the best system within a negotiated price. It attempted to more clearly place responsibility for performance with the contractor. However, because the government levied excessively detailed requirements, the contractor's freedom to explore new solutions was limited and its responsibility remained entangled with the government. Charles later agonized that "We wanted a transport which has only a few basic requirements, such as cargo area, cruise speed, range, payload, takeoff and landing distances and conditions, and navigational capabilities. But it took us over 1,500 pages to say this. In reply, the five competitors sent in... 240,000 pages."²⁶⁵

Just two years after the Air Force had called the program "a miracle of procurement," one of its own officials, Earnest A. Fitzgerald, disclosed a \$2 billion cost overrun on the C-5. For his efforts, Fitzgerald was fired. He later told the Congress that "I think Lockheed was confident that they were going to be bailed out. I think they never believed from the very start that they were going to be held to their contract, because other people were not then being held to their contracts."²⁶⁶ While an analyst at the Office of Systems Analysis said that the C-5 was "one of the major successes of systems analysis in the Defense



Air Force Headquarters methodology taught to Systems Project Offices in a 5 week cost estimating course at Air Force Institute of Technology. Scherer applauded building up government capabilities in cost estimation to counter the contractor's asymmetric information.

²⁶³ Thompson, Fred. "Public Economics and Public Administration." <http://www.willamette.edu/~fthomps/ECON&PA.html>.

²⁶⁴ Charles, Robert H.. "Hearings on Military Posture and Legislation to Authorize Appropriations During the Fiscal Year 1970," Part 2, H.A.S.C. No. 91-14, pp. 3075.

²⁶⁵ Poole, Walter. *History of Acquisition in the Department of Defense Volume II: Adapting to Flexible Response, 1960-1968*. Historical Office, Office of the Secretary of Defense, Washington: 2013, pp. 71-73.

²⁶⁶ "Major Systems Acquisition Reform." Hearings before the Subcommittee on Federal Spending Practices, Efficiency, and Open Government of the Committee on Government Operations, U.S. Senate, Ninety-Fourth Congress, First Session, Part 2. Government Printing Office, Washington: 1975, pp. 119, 129, and 137. Fitzgerald, who claimed to be skeptical of TPP from the beginning, supported the TPP as a concept in certain programmatic circumstances. His claim of \$2 billion overrun at the time was closer to \$1.3 billion in the opinion of the General Accounting Office (GAO).

Department,”²⁶⁷ Senator William Proxmire reached a different conclusion. Proxmire criticized the C-5 program for severe cost overruns and performance defects, saying that it was acquired in a “scandalous way.” Despite his tough stance, Proxmire did not place blame with the TPP scheme. He said, “Would it have made any difference if the C-5A contract was written or awarded differently? I don’t think so.”²⁶⁸ A report on military spending prepared for the Congress in 1969 disagreed. “Total-package and other large contracts,” it reported, “should be broken down into smaller, more manageable segments.”²⁶⁹ The General Accounting Office and the Fitzhugh Commission Report followed up with their own cautions about the TPP, the latter recommending an outright prohibition.²⁷⁰

Task Partitioning

Addressing the issue of contract scale before the consequences of the TPP came in was RAND economist and future Noble laureate Oliver E. Williamson. Williamson noticed a conspicuous omission when considering Scherer’s analysis: breaking down contracts to smaller segments. Scherer wrote that the government had “two main ways” of attaining successful weapon systems without the “guides and restraints provided by the market’s ‘invisible hand.’” The first way is using direct control characterized by “participation in the contractor’s internal operations.” The second way is using incentives characterized by “rewarding desirable performance and penalizing unsatisfactory performance.” In 1965, Williamson complained that Scherer “does not even consider task definition as a means of influencing contract behavior.”²⁷¹ Two years later, Williamson concluded that:

“...neither the manipulation of profit incentives nor the monitoring of contract progress can be expected, in any dependable sense, to yield significant improvements in contract performance as long as the specification of the task remains unchanged. From a contractual point of view at least, the ‘systems approach’ to weapons procurement which has prevailed since 1953 appears to be distinctly suboptimal.”

Using a mathematical model, Williamson showed that adjusting the share ratio changes optimal contractor behavior with respect to negotiating target cost. Under sufficient uncertainty as to an objective target cost, contract incentives induce higher bids to

²⁶⁷ Murdock, Clark A. *Defense Policy Formation: A Comparative Analysis of the McNamara Era*. Albany, State University of New York Press, 1974, pp. 87. Note that in “Acquiring Defense Systems: A Quest for the Best,” David D. Acker argues that the Maverick Air-to-Surface missile was the only success for the TPP, while the C-5A, SRAM, AH-56A, and DD-963 destroyer were largely failures. The TFX largely followed a TPP-like strategy.

²⁶⁸ Sen. Proxmire, William. “Major Systems Acquisition Reform.” Hearings before the Subcommittee on Federal Spending Practices, Efficiency, and Open Government of the Committee on Government Operations, U.S. Senate, Ninety-Fourth Congress, First Session, Part 2. Government Printing Office, Washington: 1975, pp. 4-5.

²⁶⁹ “Report on Military Spending” 2 July 1969, in “Hearings on Military Posture and Legislation to Authorize Appropriations During the Fiscal Year 1970,” Part 2, H.A.S.C. No. 91-14, pp. 4083. Also see Fitzgerald, Ernest A. “Gilbert Fitzhugh’s Golden Fleece.” *The Washington Monthly*, November, 1970. Note that the 1969 President’s Economic Report singled out the TPP as an improvement to defense contracting, after problems with the technique were clear.

²⁷⁰ See “Report to the President and the Secretary of Defense on the Department of Defense by the Blue Ribbon Defense Panel.” 1 July 1970 and “Report on Military Spending” 2 July 1969, in “Hearings on Military Posture and Legislation to Authorize Appropriations During the Fiscal Year 1970,” Part 2, H.A.S.C. No. 91-14, pp. 3056.

²⁷¹ Williamson, Oliver E. “Defense Contracts: An Analysis of Adaptive Response.” The RAND Corp., June 1965, pp. 1.

account for added risk. Uncertainty also means that the government is not positioned to refute the substance of the proposal. “The principal difficulty,” Williamson wrote, “in evaluating the effect of incentive contracts on cost performance rests on the negotiation of target costs.” Many observers of defense contracts understood the importance of establishing an objective target cost from defensible analysis of historical data. But the weapon system approach focused cost analysis on the total system and the single prime contractor. Williamson suggested that major systems should be partitioned and contracted separately, thereby narrowing the scope of each contract task and narrowing the range of an objective target cost. He argued that rather than determining incentives, a “more fundamental way by which to improve defense contracting is to decompose the task into technically separable components.”²⁷² Task partitioning provides a practical method for arriving at a contract cost target of genuine significance. Williamson summarized the “manifold” advantages task partitioning promised:

“1. It reduces the amount of uncertainty and hence increases objectivity in contract negotiations, reduces the felt need for defensibility in administering contracts, and permits more reliable evaluations which in turn allow cost-performance reputation effects to be assigned with confidence. Each of these effects should help to prevent excessive contract costs.

“2. It creates a contract environment in which the full potential of parallel R-and-D approaches... can be exploited.

“3. It complements R-and-D strategies which emphasize the need for maintaining options by providing support for work on adaptable components and flexible capabilities...

“4. It permits greater competition by increasing the number of eligible contractors.

“5. It lends itself to sales and employment stabilization.”²⁷³

Williamson argued that both the military services and the contractors avoided task partitioning, and consequently accepted uncertainty, “because of the beneficial consequences that each associates with it.” The benefits to both parties derive from defensibility. For the service purchasers, “Defensibility can be secured if, in the nature of the task, a wide range of outcomes are ex ante possible. And nonuniqueness will result if the task is defined in such a way as to preserve substantial uncertainty.” For the contract supplier, defensibility exists when “it is difficult to assess efficiency-reputation effects with any degree of confidence.” Large contracts satisfied both parties’ interests by making

²⁷² Williamson, Oliver E. “The Economics of Defense Contracting: Incentives and Performance.” In *Issues in Defense Economics*, ed. Roland N. McKean, 1967, pp. 229 and 218.

²⁷³ Williamson, Oliver E. “The Economics of Defense Contracting: Incentives and Performance.” In *Issues in Defense Economics*, ed. Roland N. McKean, 1967, pp. 252. Frederick Moore suggested something similar in 1962: “... we may note that CPFF contracts might be used more effectively than they have been in R&D work. Rather than concentrating on the final result to be achieved, the contract might be let for a period of, say, a year with the explicit understanding that at the end of that time the contractor’s performance would be evaluated, and that, if he gave evidence of substantial progress and hope of ultimate success, the contract would be extended. Otherwise it would be canceled. This puts pressure on the contractor to perform substantively in a short period of time. Of course this same procedure might be used with an incentive type contract as well.” See page 62.

defensible almost any conceivable outcome, and, with the sunk cost fallacy at work, aided in the petition for an enlarged budget.

Williamson identified four drawbacks to task partitioning: “(1) possible interfacial problems, (2) contract proliferation expenses, (3) sacrifice of scale economies, and (4) possible time delays.” He addressed each in turn. First, he found issues of interfacing, or integrating components into a final system, “exaggerated.” In the normal course of system developments when the entire work is contracted at once, the prime contractor will partition tasks across components but without the option to partition tasks across time. Second, “although contracts will increase in number they will decrease in complexity—both at the negotiation and administration stages—so that administrative cost increases for this reason may be kept within quite acceptable limits.” Third, Williamson called the economies of scale issue “mainly a bogus one” with five quick jabs. In 1962, Peck and Scherer arrived at the same conclusion that economies of scale “are not so significant as to be the decisive factor in the organization of the weapons industry.”²⁷⁴ Fourth, Williamson gave credence to the “time-is-of-the-essence” critique and the occasional need for a crash basis through the systems approach, but he did not find moon-shots appropriate on a continuing peacetime basis.²⁷⁵

Williamson looked back to the work of RAND colleagues William Meckling et al. and quoted their perspective. The problem is not “one of choosing among specific end-product alternatives, but rather a problem of choosing a course of action initially consistent with a wide range of such alternatives; and of narrowing the choice as development proceeds.” This is exactly what Alchian meant when he said that “the essence of the decision process is to affect the scope of random factors so as to give a ‘good’ probability distribution of outcomes.” The practical application, as Williamson noted, is overlapping research efforts with regularly placed options.

²⁷⁴ Peck, Martin, and Scherer, Fredric. 1962. *The Weapons Acquisition Process: An Economic Analysis*. Harvard University Press, pp. 188.

²⁷⁵ Williamson, Oliver E. “The Economics of Defense Contracting: Incentives and Performance.” In *Issues in Defense Economics*, ed. Roland N. McKean, 1967, pp. 246-52. Williamson’s five jabs at the scale economies issue are: 1) contracts will remain sizeable in absolute value; 2) if scale economies exist then larger firms would submit lower bids; 3) Edwin Mansfield (1964) finds R&D productivity higher in small firms; 4) smaller and more numerous contracts stabilize sales and thus diseconomies resulting from demand variation; and 5) expense control problems in defense contracts are not primarily concerned with scale.

To each of the four critiques, an additional response may be given. First, government performs well stimulating component development and contractors perform well in putting together existing products in novel ways with ruggedness and simplicity. Second, administrative costs are less because subjective reputational evaluations are increased. Third, Peck and Scherer cite a backwards-bending output curve, where adding more resources to a project actually creates negative productivity (too many cooks in the kitchen effect). Additionally, research finds small firms better able to handle “soft” information associated with incomplete contracts, see A. N. Berger et al., 2005. And fourth, Alchian found no need for crash-programs if technological states are arrived at earlier using the diversity approach.

Whither Uncertainty?

Williamson's analysis sought to reduce and control uncertainty as opposed to harness it as a fundamental aspect of innovation. Williamson did not discuss "broadening the scope" of tasks and delegating authority, as Meckling et al. had. Williamson's stated that "My proposal for *limiting discretionary opportunities* involves restructuring the problem by partitioning the task [emphasis added]." He saw task partitioning as a way to better define contract requirements, limit contractor discretion, and arrive at an objective target cost. He rejected any "drastic changes in the institutional arrangement." Williamson continued to view specifications as fixed and focused on the cost of achievement. Perhaps unwittingly, Williamson's plan to partition tasks would move more technical planning out of the contractor's hands and back into a military acquisition system characterized by decreasing production capabilities and increasingly centralized decisions.

As previously discussed, uncertainty benefits projects in performance aspects due to the unbounded possibilities of innovation. Karl Popper wrote that "the scientific method is not *cumulative*... it is fundamentally *revolutionary*."²⁷⁶ Achieving a "good probability distribution of outcomes" depends on expanding task discretion for those at the lowest level possible because it cannot be predicted in advance which outcomes, and who's expectations, will prove most successful. Nassim Taleb argued that payoffs from research follows a "power-law type of statistical distribution, with big, nearly unlimited upside but, because of optionality, limited downside. Consequently, payoff from research should necessarily be linear to number of trials, not total funds involved in the trials." Taleb and Benoit Mandelbrot recommend the "1/N" research policy which can simply be expressed as "if you face n options, invest in all of them in equal amounts."²⁷⁷ For the defense system of innovation, the 1/N rule pertains to people and organizations, not ideas. It is a matter of having the right set of structural rules guiding exchange; the set of voluntary choices resulting from local states of knowledge is, in some sense, both random and efficient.²⁷⁸

The most important innovations occur from ideas that a diverse set of competent observers do not agree on. Otherwise any idea whose benefit and technical achievement are both obvious will already have been pursued. Pursuit of politically agreeable specifications is then an invitation to surprise challenges; pursuit of non-consensual

²⁷⁶ Popper, Karl. 1972. "The Logic and Evolution of Scientific Theory," in *All Life is Problem Solving*, Routledge, NY: 1999, pp. 11.

²⁷⁷ Taleb, Nassim N. *Antifragile: Things That Gain From Disorder*. Random House, NY: 2012, pp. 230. That is Benoit Mandelbrot of the Mandelbrot Set and fractal geometry fame. Mandelbrot has made major contributions to many academic fields, particularly mathematics, finance, and biology. Perhaps of most relevance to defense acquisition is the idea that infinite complexity can arise from simple rules or processes.

²⁷⁸ During Armen Alchian's 80th birthday celebration, John Lott said that Alchian "defined the term efficiency as 'Whatever is, is efficient.' If it wasn't efficient it would have been something different. Of course, if you try to change anything that is there, that is efficient too." Benoit Mandelbrot's views on efficiency are also as humorous as they are insightful: "Efficient is a cheerful word put to many uses. A good pump is efficient if it moves the most water for the least energy. A portfolio is efficient if it produces the most profit with the least risk."

concepts by independent and responsible decision makers invite surprise payoffs.²⁷⁹ On a similar note, Peck and Scherer described the institutions of successful innovation:

“When technological uncertainty is substantial, it may be desirable to base weapons program decisions on something resembling interpersonal confidence rather than, or as well as, on objective analysis. The history of technology is replete with examples of innovations which were supported, not because the logic behind the idea was overwhelming, but because someone with funds believed in someone with an idea.”²⁸⁰

Peck and Scherer recognized that the decision maker need not objectively define, or even understand, project plans so long as he can evaluate and hold responsible the project performer. Innovation often results from non-consensual ideas precisely because non-consensual ideas represent greater uncertainty. When institutions do not tolerate failure, political programs will accept extreme cost risk and must limit performance gains to avoid surprises. If quantitative evidence is limited, meaning 1) the gains are potentially large relative to cost, and 2) political support is unlikely, then a successful portfolio of projects requires a diverse set of individuals. Each individual must also have broad and alienable budgetary authority, as well as opportunity to build “interpersonal confidence” with other, potentially private, individuals advocating for non-consensual ideas. Such interpersonal confidence can only arise in the context of repeated exchanges where reputation effects can be established. Peck and Scherer found that interpersonal confidence allowed important innovations to overcome political barriers of adequate justification because the service and contractor together risked reputation and resources to achieve it. In many cases, the innovations came from the riskiest firms, new entrants to the defense industry, who eagerly sought to build a reputation.²⁸¹

Exchange and Welfare

In a 1969 compendium of economic papers assembled for the Jackson Committee hearings on the PPBS, two papers in particular provided insights into exchange. First,

²⁷⁹ Clearly, politics is important in determining that a public good, such as defense, be addressed and can weigh judgment on broad allocations of budgets. However, because of the highly uncertain nature of defense, as well as the localized and often secret nature of its information, neither public preferences nor statistical aggregates can be used as a reasonable guide for specific action.

“Non-consensual” ideas as the basis of success makes reference to Marc Andreessen, tech entrepreneur and venture capital manager. Pursuit of non-consensual projects is often done using sky-blue research, where the individual or organization is funded and not any specific idea. It is interesting to observe that the education and skill of the acquisition workforce has often been blamed for reform failures. However, program budgets—and the resulting program office structure—is precisely what puts people and organizations in the back seat. The program is preconceived; the people and organizations that make it work are a forced fit.

²⁸⁰ Peck, Martin, and Scherer, Fredric. 1962. *The Weapons Acquisition Process: An Economic Analysis*. Harvard University Press, pp. 246.

²⁸¹ Peck, Martin, and Scherer, Fredric. 1962. *The Weapons Acquisition Process: An Economic Analysis*. Harvard University Press, pp. 529 and 199-204. The authors write that “... an innovator in a large organization was like a fat man in quicksand.” They found a history of “old money, new brains.” The same behavior is observed in modern industry where large firms or venture capital buy-out small entrepreneurs with good ideas instead of generating those ideas with large internal R&D centers as Bell Labs had done in the past. More often it depends on the market. While many firms seek to buy competitive ideas, particularly in technology and pharmaceuticals, 3M has a unique internal innovation system across thousands of products.

future Noble laureate and long-time RAND analyst Kenneth Arrow, discussed social choice theory in the context of different market environments. Known for his logical mind and mastery of mathematical modeling, Arrow nevertheless arrived at non-quantifiable answer:

“I want, however, to conclude by calling attention to a less visible form of social action: norms of social behavior, including ethical and moral codes. I suggest as one possible interpretation that they are reactions of society to compensate for market failures. It is useful for individuals to have some trust in each other's word. In the absence of trust, it would become very costly to arrange for alternative sanctions and guarantees, and many opportunities for mutually beneficial cooperation would have to be foregone.”²⁸²

However, under significant information asymmetry, Arrow warned that an abuse of trust could lead to monopoly. Economist Harold Demsetz wrote the second paper of interest, finding voluntary exchange to be the key test for determining welfare improvement. He wrote that “The test of voluntary consent... is the filter that separates and selects efficient resource allocations from inefficient ones.” When the cost of exchange looms large and non-market allocations are required, the government first incurs costs to “secure the consent of many,” and second encounters a “greater likelihood of error.” Demsetz found that only where the “test of voluntary agreement is lacking is it desirable to undertake special investigations of the cost-benefit variety to help insure against errors.”²⁸³ Yet cost-benefit analyses treat all individuals uniformly and abstract away from the peculiarities which matter to individual choices.

It is illuminating to examine why interpersonal confidence resulting from exchange plays such a large role in weapons acquisition. The criterion for success in any exchange is whether or not both parties felt better off as a result. Did the purchaser feel gratitude toward the supplier for making a good use of his resources, and if so, was the supplier rewarded? Equally important to any system of exchange, however, is assigning punishment for harm.

Contracts embody a system of negative evaluation. First, either the supplier met the requirement as written before-the-fact or it did not. The criterion benefits the purchaser as it allows for precise and accurate measurement of outcomes that forces the suppliers to bid a reasonable proposals. Second, the suppliers are not legally responsible for delivering any attribute that was not pre-specified as a requirement. Ultimately, the purchaser cares about the output and not individual requirements. As weapon systems

²⁸² Arrow, Kenneth J. “The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Nonmarket Allocation.” Found in “The Analysis and Evaluation of Public Expenditures: The PPB System. A Compendium of Papers Submitted to the Subcommittee on Economy in the Government of the Joint Economic Committee.” Congress of the United States. Volume 1. Washington: U.S. Government Printing Office. 1969, pp. 62.

²⁸³ Demsetz, Harold. “Contracting Cost and Public Policy.” Found in “The Analysis and Evaluation of Public Expenditures: The PPB System. A Compendium of Papers Submitted to the Subcommittee on Economy in the Government of the Joint Economic Committee.” Congress of the United States. Volume 1. Washington: U.S. Government Printing Office. 1969, pp. 167-74.

become increasingly complicated, the number of attributes which must be pre-specified and then measured increases as well. If unmeasurable or unforeseen attributes are complements of the specified attributes, then no problem exists. If they are substitutes, then the suppliers can provide a system that in no way meets those expectations while fulfilling all contractual requirements.

Consider the supplier who found one or more of the requirements were ill-conceived given new knowledge discovered in the production process. The situation often occurs because contract assumptions do not turn out to be realistic, or even desirable, from the purchaser's point of view. If the supplier delivers on all contract requirements, he clearly has not violated the agreement. A symmetrically informed observer may, however, step back and ask whether the supplier acted properly with respect to the exchange, and whether or not he deserves reward or punishment.

In the case of the contractually compliant supplier who delivers upon what were later discovered as ill-conceived requirements, an observer would first want to understand the motives of the supplier. If the supplier's motives were to fulfill the contractual obligations, and the purchaser's sympathies harmonized with those motives, then despite the mischief that results the supplier may not deserve the observer's resentment. But would the observer have found the supplier blameworthy for knowingly fulfilling requirements that produced a dysfunctional system? The observer wants to know not only motives, but outcomes and the sentiments which they excite. Because the contract comes at the expense of the taxpayers, and its deficiency could cause harm to the common security, the supplier did not act properly with regards to the employment of its resources. Yet had it done differently, the supplier would have taken a loss for either the greater expense or breach of contract requirements. Was the supplier blameworthy for his prudence? Was he blamable for employing his own resources for his self-interest, and the interest of his shareholders, ahead of the purchaser's interest, and indeed the national interest? The matter demonstrates that the terms of the contract were loose and vague, and were made more so by treating their judgment as precise and accurate.

One can also evaluate the justice not of the supplier's employment of resources, but the justice of the circumstances encompassing the contract as an object. Did the contract serve as a good vehicle for the purchaser to obtain his desired end, and, if he felt gratitude, did it properly reward the supplier? Now framed more broadly, one can clearly say that the supplier acted in a blameworthy manner. During contract negotiations, the supplier interpreted the purchaser's goals for the project. By awarding the contract, the purchaser approved of the proposal as a representation of his goals and both sides harmonized sympathies around the justness of the contractual requirements. With full knowledge of their deviation, the supplier delivered on the requirements rather than the shared goals, and was due his profits. Yet the purchaser did not attain the realization of his goals, and did not benefit despite the supplier's profits suggesting otherwise. From the observer's

perspective, the supplier was blameworthy for not acting upon the harmonized sympathies around the shared goals, as opposed to the contract requirements which they imperfectly represented.

Using a contract to procure innovation, then, takes a loose and vague matter that requires after-the-fact judgment using updated information, and forces it into a system of negative evaluations according to requirements written before-the-fact. The different forms of evaluation do not agree in all circumstances because after-the-fact controls are flexible with respect to time and the accumulation of knowledge, while the before-the-fact controls are rigid and invariant to time or context.

An Exercise in Contracting

One can evaluate justice resulting from before-the-fact controls and from after-the-fact controls, both at contract signing and when the contract comes due, in order to see whether the evaluation methods agree. Before-the-fact controls will evaluate the exchange by whether or not both sides met the exact wording of the contract. After-the-fact controls will evaluate the exchange by observing whether or not both sides behaved in the spirit of the contract that was struck under uncertainty as judged by an observer with all the information available to both parties.²⁸⁴

At the time of contract negotiations, the purchaser has some set of goals for the project which are reflected in the advertisement. Suppliers bid proposals, and the purchaser evaluates which proposal most closely harmonizes with his goals and his budget. As described before, the competitive procurement auction incentivizes suppliers to bid their best informed estimate, so long as the suppliers expect to be held to fulfilling the requirements. Suppliers have exposed their honest estimates and the purchaser acknowledges that the contract requirements are a fair interpretation of the shared goals. Both before- and after-the-fact controls are in complete agreement at this stage as both sides voluntarily entered into a contract with symmetric expectations.

At the time of contract delivery, the firm has accumulated a great deal of knowledge about the effort required to fulfill the requirements, as well as the suitability of the requirements' arrangement to the shared goals. Again, before-the-fact control is rigid and invariant to time so both parties understand at the outset how the requirements will be evaluated. If all contract assumptions come to pass, then before- and after-the-fact controls still agree. However, the two can diverge depending on discovered knowledge

²⁸⁴ The concept of the symmetrically informed observer is shorthand for Adam Smith's impartial spectator, which is imperfectly represented by the "man in the breast." Similarly, before-the-fact controls are shorthand for the rules associated with Smith's *commutative* justice, which are precise and accurate and Smith only extend them to matters of life, property, and promises. However, as argued here, promises under sufficient uncertainty are matters that are loose, vague, and indeterminate. These should make reference to Smith's *general rules* associated with *distributive* and *estimative* justice, here termed after-the-fact controls, because they rely on judgments of propriety using hindsight that depends on context. See Adam Smith's *The Theory of Moral Sentiments*.

that contract assumptions were unrealistic. The observer, who has symmetric information from both parties, can update his evaluation of propriety as it becomes available. There are two common forms of knowledge which can lead an informed observer to conclude that adherence to contractual requirements would be unjust.

First, knowledge of whether or not the arrangement of requirements actually concatenates to the goals, or whether there are superior arrangements for a similar effort. Like the previous example, the supplier may fulfill the requirements while neglecting how discovered knowledge could have vastly improved the welfare of the purchaser at little or no expense to himself. The observer would find the supplier's actions blameworthy, though he has met all before-the-fact controls. The supplier may also deviate from the contract requirements and deliver what could, with hindsight, properly represent the shared goals. Here, the supplier violates the contract and expects to incur losses. He could have informed the purchaser and amended the contract, but there may be friction to knowledge transfer, such as trust. The presence of strict contract requirements is in fact evidence that the purchaser does not trust the supplier in the first place. The observer, who has symmetric knowledge with both parties, would approve of the supplier's decision to deliver a superior product and would have estimated his conduct as praiseworthy, and instead of reward the supplier takes losses for breach of contract requirements. When the suitability of requirements to the welfare of the purchaser changes over time, different evaluations may result from the use of before- and after-the-fact controls.

Second, evaluations may vary when the assumed cost of contract requirements turned out to not be realistic through no fault of any party. Suppose that the contract requirements did concatenate to the exact capabilities the purchaser desired. If fulfilling one requirement was more expensive than anticipated and the delivery was deficient in that measureable attribute, then the supplier has breached controls as set before-the-fact. If the observer judged that the requirement was not justly considered achievable given the economic or technical circumstances, then the supplier acted with propriety as viewed after-the-fact. Had the purchaser full knowledge of the circumstances as in the same manner as the supplier, he may have been satisfied with lower performance, or a change of direction, and amended the contract. Suppose, on the other hand, that the supplier devoted extra resources at his own expense to deliver the additional requirement. He would have no longer have violated the contract, but he would have incurred a loss. The observer would judge the supplier's choice as praiseworthy, and the purchaser should feel gratitude for the effort. Though the supplier is the proper object of reward, in this case profit, he actually incurs losses.

While in the first case, the supplier discovers knowledge about whether the purchaser made a good forecast of the requirements, in the second case the supplier discovers knowledge about whether he made a good forecast of the expense. Whenever contract requirements are uncertain and the purchaser lacks up-to-date information, or the

correct interpretation of that information, to ensure that the requirements conform to the desired ends, outcomes as interpreted through before-the-fact controls will vary with respect to interpretations formed after-the-fact. The important mechanism that drives the variation between the evaluations is the discovery of knowledge that conflicts with contract assumptions.

Boundaries of Administration

When asymmetric knowledge problems can be alleviated, the worst deformities to before-the-fact controls are corrected. If the purchaser knew as well as the supplier whether a contract requirement proved more technically difficult, or that it would create negative unintended consequences, the purchaser prefers to renegotiate the contract so that the assumptions which connect the requirements to his ends incorporate updated knowledge. At the limit, if transaction costs to knowledge transference are zero, the contract requirements can reflect a specific application of the after-the-fact evaluations at every point in time and maintain their agreement. However, if knowledge transfer is imperfect or difficult, the contract becomes a poor mechanism as it forces evaluation using controls based on potentially incorrect expectations.

Defense officials have sought to directly achieve knowledge symmetry by requiring regular cost, schedule, and technical reporting. PERT, for example, reports cost and schedule by technical component, providing near real-time information on contract progress. As new information arrives and changes the purchaser's perspective of propriety, the purchaser may choose to exercise his decision rights to amend the contract requirements so that the eventual outcomes with respect to contractual requirements conforms to his subjective judgment after having reviewed the updated information. Cost-plus contracts, in this light, allow for continual updates to cost targets without the need for expensive contract renegotiations.

With a stream of contract information available, defense analysts attempt to approximate the idealized outcome where both parties to the contract have identical knowledge. In such cases, the contract can with little trouble be modified such that the terms of the contract will approximate what the informed observer would estimate to be proper given access to the most comprehensive and timely information. The ideal, however, can never be implemented because no report can fully capture the specific information of time and place that the supplier holds. Even if it could, it cannot be guaranteed that the information would be interpreted in the same way as the supplier.

When the government attempts to duplicate the supplier's knowledge and continually redirect the contract, it is tantamount to actually directing the firm's capital itself. As F.A. Hayek wrote about similar proposals, "All this involves planning on the part of the central authority on much the same scale as if it were actually running the enterprise... This division in the disposition over the resources would then simply have the effect that

neither the entrepreneur nor the central authority would really be in a position to plan.”²⁸⁵ When attempting to obtain and exercise knowledge, defense officials first incur substantial investment costs to duplicate the knowledge outsourced to private firms, then they incur transaction costs to renegotiate and modify the contracts, and finally they risk having misinterpreted the information, or having received fraudulent information.

In order for the purchaser to insure that he receives justice with the fulfillment of contract requirements, he will have to incur large transaction costs of knowledge generation and contract modification. Ronald Coase drew similar conclusions in his landmark 1937 essay “The Nature of the Firm.” Coase wrote that when direction of resources in a contract must be decided later by the purchaser, relative efficiencies can be gained by internalizing those resources to avoid transaction costs. He found that “owing to the difficulty of forecasting, the longer the period of the contract is for the supply of the commodity or service, the less possible, and indeed, the less desirable it is for the person purchasing to specify what the other contracting party is expected to do... A firm is likely therefore to emerge in those cases where a very short term contract would be unsatisfactory.”²⁸⁶

Like Alchian and Williamson, Meckling was a RAND analyst who later made significant contributions to economic theories of the firm. Meckling used Coase’s concepts to explore the relative efficiencies of internal administration and markets, and determined that both processes successfully co-located decision rights and knowledge:

“When knowledge is valuable in decision-making, there are benefits to collocating decision authority with the knowledge that is valuable to those decisions. There are two ways to collocate knowledge and decision rights. One is by moving the knowledge to those with the decision rights; the other is by moving the decision rights to those with the knowledge. The process for moving knowledge to those with decision rights has received much attention from researchers and designers of management information systems. But the process for moving decision rights to those with the relevant knowledge has received relatively little attention in either economics or management.”²⁸⁷

The government’s attempt to use information reporting systems, such as PERT, has produced an ineffective mix where the defense officials outsource production knowledge but continue to demand the information necessary to exercise decision rights. The matter is made more difficult because defense production requires “specific” knowledge that, “almost by definition, is difficult or impossible to aggregate and summarize.” In effect, Meckling argued that government procuring agencies should seek to either provide more decision rights to its contractors, or, to acquire in-house capabilities necessary to exercise those decision rights.

²⁸⁵ Hayek, F. A. *Individualism & Economic Order*. Chicago: The University of Chicago Press, 1948, pp. 237.

²⁸⁶ Coase, Ronald. 1937. “The Nature of the Firm.” *Economica* 4(16): pp. 391.

²⁸⁷ Jensen, M., Meckling W. 1992. “Specific and General Knowledge and Organizational Structure.” *Contract Economics* 8(2): pp. 251-74, pp. 253-54.

When the purchaser internalizes production capabilities, he evaluates the distributive justice of resource allocations using general, as opposed to precise and accurate, rules. Within the firm's boundaries, the entrepreneur can, up to a point, direct resources at will and requires no contract to intermediate. He is no longer obliged to act according with pre-specified rules. The matter is reduced to the loose and vague judgments about whether or not the resources were justly distributed as evaluated after-the-fact. He may employ laborers and has the advantage of rewarding praiseworthy behavior if they distribute his resources, and their own, in a way appeasing to him. If he fully approves of his employees and believes that distributional justice was done, he feels gratitude and the proper objects of gratitude deserve reward. If he cannot approve of his employees actions and feels resources, such as time and attention, were misallocated, he feels resentment and the proper objects of resentment deserve punishment.

Theories of the firm suggest that for uncertain ventures using highly specific knowledge or capital assets, the government should internalize resources to avoid transaction costs associated with loose and vague contracts. For relatively mature production processes, the government can use contracts where requirements are somewhat stable. While Demsetz and Williamson gave this view merit—and indeed it was the predominating acquisition approach from before WWII—the economists believed a better option is to lower transaction costs to contracting. Stated simply, this can be done by partitioning tasks, *increasing* discretion within a fixed budget, and allowing reputation through repeated exchanges to hold more sway than legal reprisals. However, government in-house capabilities remain vital to building technical knowledge that allows for reputational effects, because no impartial and symmetrically informed observer exists to reference. Both private and public managers know how difficult monitoring can be.

Towards Costing

As Williamson realized in 1967, defense management focused on either direct control of contract expenditures, or getting the incentives right. Direct control is achieved through information reporting systems such as PERT, but because the government gains in decision rights, evaluation becomes murky. Incentives attempt to establish responsibility by determining target cost, and other requirements, in advance, but continue to require similar information reporting systems. In both cases, the role of the informed observer is imperfectly approximated by the cost estimator, who is relied upon to determine an objective position of what the contract “should cost.”

PERT, it turned out, did not provide an adequate basis for cost estimating functions. PERT applied to large cost-plus contracts, and only sometimes to fixed-price incentive contracts. Because various contract types contribute to systems, PERT often missed the full scope. As programs enter production, PERT information progressively vanishes. PERT also failed to regularly adhere to cost collection by the standard product oriented

Work Breakdown Structure. Lower level elements were often tailored to individual program needs making their normalization difficult. More fundamentally, PERT was a management and planning function that did not provide three classes of accounting information necessary for cost estimators. First, a segregation of the total cost attributable to recurring expenditures associated with quantity production and non-recurring costs associated with development or change orders. Second, reporting on labor hours and end-item quantities, which

serve as the basis for cost estimating relationships. Third, functional break-outs of activities such that cost and hours are segregated by direct inputs including engineering, manufacturing, subcontracts, and raw materials, and by indirect allocations of common or overhead costs to the contract. One legacy of concurrency was the need for functional categories related to tooling, the cost of which would otherwise be hidden. The additional breakouts, as well as control of a standard WBS, were partially implemented in 1966 and were later revised on October 24, 1973 with the Contractor Cost Data Report (CCDR).²⁸⁸

The CCDR was essentially an itemized receipt, but provided at cost of production with a separate line-item for profit. With the information, many hoped to objectively derive target costs for future purchases. Receiving cost information from all contractors in a standard WBS may even improve the government's position during negotiations because it could compare across contractors. Applying statistical techniques to the incoming data, government analysts could control for system characteristics and predict future costs based not on opinion or judgment, but on quantitative evidence. With enough data, such modeling could isolate relative productivities of individual contractors in the past. A target cost derived from statistical models in effect does the same thing. Barring necessary controls, the predicted target cost will reflect average historical productivity and impart

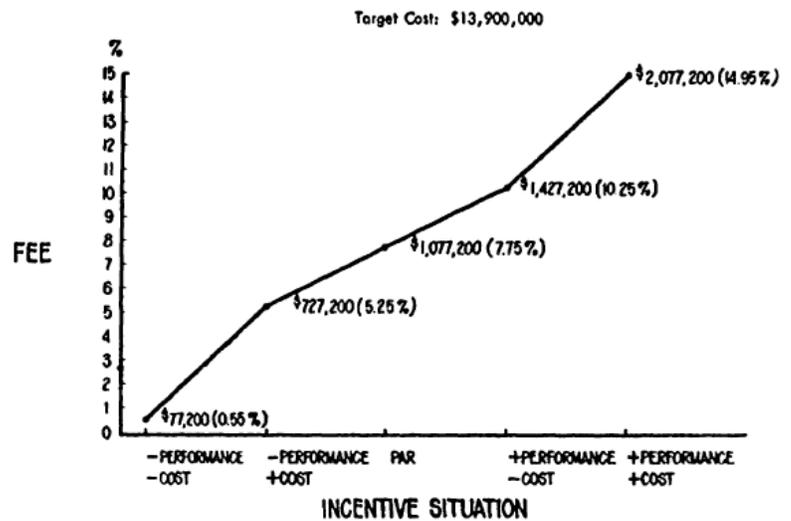


Illustration of an actual incentive arrangement applied to a spacecraft program, presented to the Congress by Assistant Secretary of Defense for Installations and Logistics Thomas D. Morris on 26 July 1962. Note that within the range of contract incentives, contractor profit or fee is determined by pre-specified performance and cost targets.

²⁸⁸ The CCDR was established in 1973 and replaced two earlier reports, the Cost Information Report and the Procurement Information Report. See "Inaccuracy of Department of Defense Weapons Acquisition Cost Estimates." Subcommittee on Legislation and National Security, Committee on Government Operations, House; Committee on Government Operations, House. Jun 25-26, 1979, pp. 109. Also see S. J. Balut and J. J. Cloos, "Assessment of the Contractor Cost Data Reporting (CCDR) System." Sept. 1994, IDA Paper P-2964. Note that the earliest CCDR-like report found by the author was submitted by McDonnell Douglas in 1958 for the FY 1956 Lot 1 buy of the F-4A aircraft.

incentives with real significance. Because the data are authoritative, contractors can only argue over assumptions.

The CCDR came to be applied on all major acquisition contracts as a result of one particularly convincing case study. On December 2, 1971, Deputy Secretary of Defense David Packard received a briefing that compared the cost estimates for the Navy's new F-14 swept-wing fighter aircraft. It showed the cost per pound of airframe (the assumed cost-driver) as estimated by two sources. The prime contractor, Grumman, provided the first, presumably building up to the total price based on engineering plans. Government cost estimators provided the second using a "parametric" technique based on statistical analysis of historical data. The chart showed Grumman's 1969 contract proposal cost ranging between one-quarter and one-third of the cost estimated by the government depending on the aircraft quantity produced. Less than two years later, Grumman's estimates had grown so much as to reach the government estimate almost exactly. Keenly aware that the F-14 program would have looked very different had decisions been based on what turned out to be the realistic cost estimate, Packard issued a memorandum five days later demanding an independent parametric estimate be performed for each major weapon system at key decision points. The next month, Secretary of Defense Laird established the OSD Cost Analysis Improvement Group (CAIG) to perform such independent cost estimates as part of the program milestone review process. In order to quickly perform its duties, Laird authorized the CAIG to collect the cost data it required.²⁸⁹

As might have been expected, the number of ways complex systems differ exceeded the number of systems cost data were collected on. In statistical terms, there are not enough degrees of freedom to make proper inferences. Analysts would only have a handful of data points from which to work, and more often used scaling factors on a single analogy. Not only does an analyst require enough data to obtain a probability distribution to make predictions, he also requires enough data to generate a probability distribution as to whether his data are sufficient to make predictions. Of the data available, models drawing from a large random sampling should return stable parameter estimates to each other and the model drawing from the whole dataset. Without sufficient data that are independently and identically distributed, statistical models face a self-referencing problem where predictive power is unknown. The larger and more flexible the systems being acquired, the fewer and less relevant are statistical data.

Assuming an adequate quantity of data, there may exist a bias problem. When an observation like the TFX becomes an early data point in an acquisition system that had already severely cut back on project starts—four times more aircrafts were prototyped in

²⁸⁹ Srull, Donald (ed.). *The Cost Analysis Improvement Group: A History*. Logistics Management Institute, VA: 1998. Note that Laird placed the CAIG underneath the successor to Enthoves Office of Systems Analysis, OSD Program Analysis and Evaluation (PA&E).

the 1950s than the next forty years combined²⁹⁰—the dataset becomes extremely biased. Indeed, systems experiencing the worst performance often have the best collected, organized, and analyzed data because of additional scrutiny from OSD and the Congress. Future target costs will then have high costs from past failures baked into them. Anything other than large underruns to target costs so derived actually signal escalating prices and continued deterioration of performance. When past performance influences current standards (for example, last time I ran a mile thirty seconds slower than the eight-minute miles I used to run, so I'll set my new target at eight minutes and thirty seconds), the system enters a reinforcing feedback loop and drifts to ever lower performance. The process is further reinforced when decision makers tend to believe bad news more than good news, and a more realistic cost estimate is in their minds a higher one.²⁹¹

Parallel efforts, which allow for experiments in the data, are in some ways necessary to useful statistics. Yet even with consciously generated experiments, statistical techniques often rely on unrealistic assumptions. For example, suppose there existed cost and effectiveness data for subsonic aircraft. One independent variable affecting aircraft cost is its speed. Models often assume a linear or log-linear relationship between cost and aircraft speed, holding other important variables constant. However, when predicting the cost of the first aircraft that can operate in transonic speeds, the model would neglect the difficulties presented by shock waves. After a certain point small speed increases produce outsized stresses to the airframe. The solution arose in England in an empirical manner after diverse testing. It turned out that the elevators in the aircraft's tail had to be removed and the entire horizontal stabilizer would be movable instead. The example demonstrates that even so-called straight line extrapolations encounter unexpected nonlinearities, which in nature are the rule and not the exception. Innovation is by definition an endeavor to attain parameter values outside the range captured by the historical data. Problems take on new characteristics and solutions tend to require new ways of doing things instead of getting more efficiency out of the old ways.

Behind the Data

The suitability of statistical methods does not matter when data are incomparable to begin with. As Hayek understood, economic data contain too many dissimilarities of time and place such that they could never enter statistics in aggregable form with sufficient accuracy for decision makers. Those aspects abstracted away from in order to enter into statistics are precisely the problems that economic actors face. Data on weapons acquisition proved no less troublesome to aggregate. A fully functional system often resulted from numerous contracts with individuated clauses. Because cost accounting is

²⁹⁰ Jeffrey A. Drezner, Giles K. Smith, Lucille E. Hogan, Curt Rogers, and Rachel Schmidt, *Maintaining Future Military Aircraft Design Capability* (Santa Monica, CA: RAND, 1992), pp. 28.

²⁹¹ Perhaps a more pernicious problem is the selection bias that results from making decisions about the specification of parameters and not accounting for the loss of degrees of freedom. In other words, cherry picking tests on the same data can be a problem.

a contractual requirement, government analysts must normalize and aggregate the data on the back end. A primary impediment to aggregation is the different accounting standards used by contractors. For example, CCDRs ask for the total cost of accomplishing the contract by Work Breakdown Structure elements. Contractors then cannot merely sum up their total receipts over a fiscal year and subtract total expenses to calculate an operating profit. The contractor must attribute every cost incurred in production with each individual contract, and further, all contractor transactions must be associated with specific products in the WBS. In some cases, such as a line worker fabricating materials for the fuselage, the cost accounting is relatively simple. He is a recurring manufacturing labor cost associated with the fuselage WBS element. The matter is often one of more detailed charging by the workers. However, awkward questions arise, such as whether an engineer providing manufacturing support charges to the function of engineering (the skill he provides and how the contractor is reimbursed), or, as the CCDR intended, the function of manufacturing (the production process he supports).

In increasingly complex organizations, there are large common costs which must be allocated back to individual contracts. There is no generally acceptable way of performing such allocations. For example, how much of facilities rent and utilities costs are associated with one project relative to another? How much to fabrication of the fuselage relative to design engineering of the avionics? Similarly, administrative and management functions often span multiple projects. Even when program managers apply themselves to just one project, and just the airframe of one project, how can they segregate costs between the fuselage, the wing, the empennage, and so forth? The allocation problem brings up the question of whether a particular cost, such as for the fuselage, has a meaningful value outside of the total production setting that encompasses it.

The DoD employed two primary methods for capturing costs that cannot be directly attributed to specific work. First, the WBS can change such that it no longer fully represents end-items. For example, instead of expecting allocations of program management costs, the WBS morphed away from pure product orientation to include common process elements such as program management, systems engineering, and test and evaluation. The mixed product and process based WBS forced allocations of common costs to the government analyst. However, morphing the WBS only fixed problems of common costs within a contract, and not between multiple contracts. The more common method is to have the contractor allocate costs to the contract based on negotiated rates. The method acknowledges that only some costs are directly attributable to the contract WBS, and when those charges are created, pre-approved rates and factors are applied to fully burden the direct cost with allocated indirect costs. The difficulty becomes the fact that one contractor's direct cost is another's indirect. Indirect rates can come down if the contractor charges more work as a direct cost.

Though the CCDR segregated direct from indirect costs, the idiosyncrasies of each contractor's system of accounting made it difficult to compare across them, particularly for lower level WBS elements. Even for a single contractor, costs are often not comparable across time. Organizational and accounting updates lead to resource transactions changing classifications both within and between direct and indirect categories. Even when accounting classifications are stable, past rates are not predictive of future rates. Direct labor rates depend on demographics, skill types, and various labor market conditions. Indirect rates depend a fair amount on the volume and content of the entire business base of the contractor. For example, if the contractor lost a major contract award, it will spread its indirect costs over less existing work, leading to higher unit costs.

While three of the CCDR's reports were oriented around contract costs, the fourth report—the plant-wide report—focused on the contractor's total business position. The plant-wide report collected costs for entire factories segregated by direct and indirect costs. Direct costs were segregated by defense programs, other government work, and commercial work, further segregated by the major functional categories engineering, manufacturing, materials, and so forth. Indirect costs were segregated by the same functional categories, but had cost line items such as employee benefits, building/land facilities, administration, and so forth. The report asked for these cost breakouts, which also included employee headcounts, for the prior year, the current year, and three years into the future. The 1973 memorandum implementing the CCDR stated a preference for cost estimators to independently assess the contractor's overhead cost status “in the context of the overall incurrence posture rather than just expressed as a non-specific rate of some base.”²⁹² Though the plant-wide report could be used to estimate future overhead rates, more often than not it was the on-site plant representatives who performed overhead analysis and provided the answer in the form of a “non-specific rate of some base.” The contract community's own processes provided the basis for negotiating forward pricing rates with contractors for use in estimating direct and indirect costs for proposals. Because rate agreements had built into them forecasts of the business base, cost estimators could focus on estimating from direct costs or hours and apply approved rates and factors to build up to a fully burdened cost. One CAIG cost estimator remembered that “In the '70s, we spent most of our research money on understanding direct costs and we ignored overhead costing issues.”²⁹³ A later study found that DoD cost analysts clearly preferred using contract approved overhead rates, and that “Nearly all offices reported not using the 1921-3 [plant-wide report] at all.”²⁹⁴

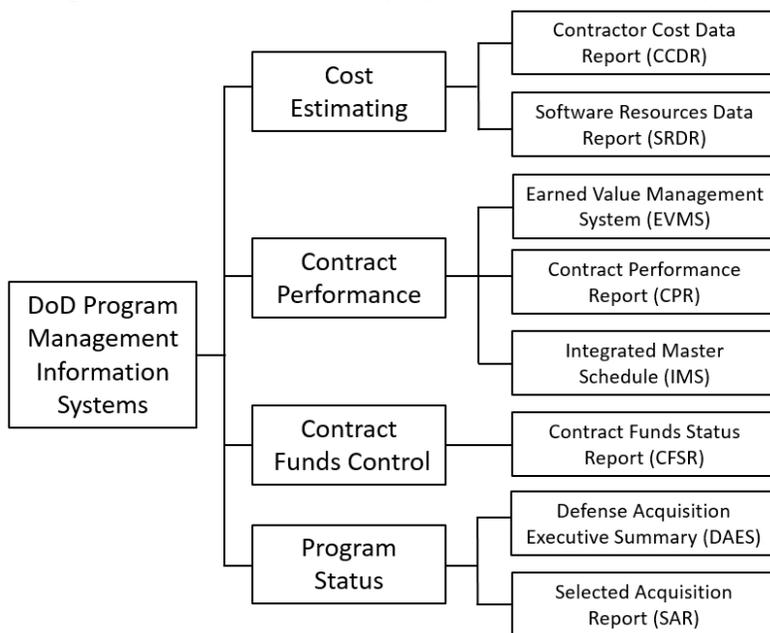
²⁹² Memorandum on Contractor Cost Data Reporting (CCDR), dated 24 Oct. 1973. Found in “Acquisition Management Contractor Cost Data Reporting (CCDR) System” 5 Nov. 1973.

²⁹³ Manetti, Howard J. Found in Balut, S. J. “IDA 2004 Cost Research Symposium: Investments in, Use of, and Management of Cost Research.” Sep. 2004, Institute for Defense Analysis, IDA D-3018, pp. 36. <http://dtic.mil/get-tr-doc/pdf?AD=ADA428260>.

²⁹⁴ S. J. Balut and J. J. Cloos, “Assessment of the Contractor Cost Data Reporting (CCDR) System.” Sept. 1994, IDA Paper P-2964, pp. IV-7 (PDF pp. 49).

The separation of direct and indirect costing allowed analysts to ignore a problematic feedback loop. The cost estimate of a future contract depends on other contract awards at the plants employed, and the contract awards themselves depended on the initial cost estimate. In other words, the cost estimator cannot estimate the total contract cost without knowing the contractor's future indirect rates, and the contractor cannot know its future indirect rates without knowing what its business base will be, itself determined by a set of on-going negotiations. It is not surprising, then, that more contract awards funnel to fewer contractors on the expectation that a large and stable business base will bring indirect rates down. Slowly and imperceptibly, the defense official's interests are subordinated to the contractors' interests, the former finding himself captured by the data and the narrative supplied by the latter.

The information reporting structures in the Department of Defense have largely persisted since the early 1970s. While in theory cost estimators used standard cost reports



from PERT, the CCDR, and so forth, more often than not cost estimates derived from ad hoc data collections by the responsible program office or by contractor site visits. Ultimately, the defense allocation process followed input-output prescriptions of central planning. Program budgeting, the systems approach, and other detailed before-the-fact controls associated with the Planning-Programming-Budgeting System continue to dominate defense acquisition in the twenty-first century.

Many of the standard DoD program management information systems in 2017 (above) were already in place by the 1970s. **Cost estimating:** The CCDR, including the 1921-3 plant-wide report, was introduced on 24 Oct. 1973. Besides small changes to functional categories, these reports are the same in 2017 as they were in 1970s (though major updates to both are currently in the works by OSD Cost Assessment and Program Evaluation). In the early 2000s, the Software Resources Data Report (SRDR) was added and included code counts and other measures for estimating software development costs. **Contract performance:** In 1967 PERT system criteria were standardized in the Cost/Schedule Control System Criteria (C/SCSC), later renamed Earned Value Management System (EVMS). The two major reports from EVMS include the Contract Performance Report (analogous to PERT/COST) and the Integrated Master Schedule (analogous to PERT/TIME). **Contract funds control:** The Contract Funds Status Report (CFSR) was first implemented in 1973, is submitted today with EVMS data, and connects budgets with contractual requirements. The three above mentioned categories of reports currently reside in the Cost Assessment Data Enterprise (CADE) system. **Program status:** First implemented by ASD(Comptroller) Robert Anthony in 1967, it includes the Selected Acquisition Report (SAR) sent to the Congress. The Defense Acquisition Executive Summary (DAES) is essentially a quarterly update to the annual SAR, though it is not reported to the Congress and contains some differences. Unlike the CCDR and EVMS, much of the SAR/DAES reflects budget appropriations to defense programs and by-in-large do not reflect actual program expenditures. The SAR and DAES reside with other budget information in the Defense Acquisition Management Information System (DAMIR).

Conclusion

In February 2015, Leonard Wong and Stephen Gerras at the Army War College published their findings on the proliferation of requirements placed on Army combat officers. The problem had grown so great that by 2002 there were more days of mandatory training than total days available in a year. One Army officer told the authors that “We can probably do two or three things in a day, but if you give us 20, we’re gonna half-ass 15 and hope you ignore the other five.” Given the “impossibility” of total compliance, Army officers began individually determining the relative importance of requirements. The resulting data collected for analysis from above were inaccurate, as different officers falsified different sets of reports.²⁹⁵ Army leadership quickly understood that the problem lay not with its officers, but with the ethical quandary placed on them in a zero defect environment. Wong later said of the Army’s willingness to self-correct: “... we don't need Congress to tell us to do this. We need to do it ourselves. And that’s what professions do. So, this is just part of the Army being a profession.”²⁹⁶

The proliferation of before-the-fact controls in Army operations has been more than matched in the defense acquisition system. For example, a program manager must execute a tightly defined program within a particular cost and schedule target, cannot make major decisions without support from over fifty separate offices, must abide by a deluge of regulations, and has no formal control over contracting officers or plant representatives. An overflow of rules and regulations quickly erodes the professional ethics that provide a basis for interpersonal trust. If resource allocations and innovation can be strictly calculated from the data, then before-the-fact controls make sense because the optimal course of action is already known. But when no individual can have but a small piece of the total knowledge, progress requires after-the-fact controls that emphasize norms and duty as they emerge from the complex operations in which they are performed. Diversity, optionality, redundancy, self-organization, self-affinity, resilience, decentralization, decision rights, responsibility, individualism, and exchange are all words describing different aspects of the same social system that nurtures complexity and adaptation. The program budget is not consistent with such a system because it embodies nineteenth century concepts of scientific management. If leadership finds value in delegating broad acquisition authority and accepting failure as a precondition to success, then rethinking the budget process is the first and most important place to start. The defense acquisition profession cannot wait for meaningful reform to come from outsiders in the Congress who neither have the capacity nor the interest. As Leonard Wong of the Army War College remarked, self-correction is “what professions do.”

²⁹⁵ Wong, Leonard and Gerrad, Stephen J. “Lying to Ourselves: Dishonesty in the Army Profession.” Strategic Studies Institute and U.S. Army War College Press, February 2015.

²⁹⁶ Wong, Leonard. Interview with Russ Roberts on *EconTalk*, April 2015.