NATIONAL AIRSPACE SYSTEM CAPITAL INVESTMENTS HAVE NOT REDUCED FAA OPERATING COSTS

By
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Summary
The FAA modernization of the nation's air traffic control system, called the National Airspace System, or NAS, has not reduced the cost of providing air traffic control services, nor is it likely to, as currently planned. Since 1981, FAA operating costs have increased about as fast as the growth in aviation. Although its workforce took about 10 years to recover from the crippling controller strike, since 1992 it has only increased about 5 percent. The FAA predicts that in the next decade, its operating costs will continue to rise about as fast as forecast passenger-revenue miles, the principal source of Aviation Trust Fund revenues derived from ticket taxes. The aviation trust fund currently supports both FAA operations and NAS modernization appropriations.

We examined more than 20 years of NAS modernization and automation program investments to modernize operations and a variety of operations and controller work force data for Air Route Traffic Control Center (ARTCC) and Traffic Radar Approach Control (TRACON) facilities providing air traffic control services. At issue is why this large public agency performing an essential service could invest billions of dollars to modernize and increase its operations, but not reduce its costs per operation. We contend that FAA may have to reduce operating costs in a constrained budget environment, when confronted with potentially altered demand for aviation services. Either NAS modernization will have to change or aviation excise taxes will have to be increased. Otherwise, FAA's growing operations cost will crowd out future modernization investment.

Perspective

Aviation growth has provided a revenue stream that didn't require FAA to lower its cost of services for the economy to benefit. However, we think that the War on Terrorism, fuel and other costs are changing this revenue stream by altering the

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demand for air traffic control services. As a result of altered demand for services, FAA operating costs may continue to exceed aviation trust fund revenues, requiring higher excise taxes. Because of their assumptions about aviation growth, former NAS plans and the Capital Investment Plan (CIP) didn't require FAA change its operating procedures to achieve savings when it deployed new operating systems. There now may be insufficient Facilities and Equipment (F&E) funding to change the existing NAS without re-considering how the system is financed.

Cost avoidance benefits

We went all the way back to the early NAS plans, ARTCC and TRACON operations data and appropriations for the 1980s to find out what happened to FAA modernization investments, particularly those automating air traffic control. We found that the only NAS modernization benefits the FAA still claims are in the form of cost avoidances. Cost avoidances can be more conjectural than cost savings. Cost savings are actual reductions in operating costs that create additional resources, like a return on operations, reducing future operating funds. A cost-avoidance is created by "saving" money that will not have to be spent, that would otherwise. It usually is recurring, and reduces future operating requirements to less than they would have been.

We don't believe that FAA's modernization strategy has succeeded simply because rising operating costs that potentially curtail future investments will occur later than they otherwise would have, or because FAA could not have created user benefits in any more effective ways than spending billions of dollars on NAS infrastructure modernization.

The information technology revolution that radically transformed the Fortune 500 companies over the past 20 years and the way services currently are provided has not, fundamentally, changed the way that the FAA provides air traffic control services to consumers of the nation's airspace. NAS modernization is focused too much on modernizing the infrastructure providing services and not focused enough on changing the way that services are provided. As a result, FAA's benefit-cost data show that there are no cost savings from over $7 billion it is committed to spending for automation projects at ARTCC and TRACON facilities (See: SPIRE).

FAA claimed cost savings in earlier NAS plans (See: NASP), but they were derived by using inflated baseline numbers for Air Traffic personnel on board and assuming slower replacement rates and slower air traffic increases. Modernization benefits reflected in the NAS plans were poor precedents for achieving savings. They laid the groundwork for open-ended, infrastructure funding to provide users improved safety and efficiency and avoid future FAA operating costs. While early NAS plan modernization benefits were based largely on assumptions (See: Benefits), they justified annual NAS project appropriation requests that obscured the complexity, total cost, and opportunity costs of modernizing the nation's air traffic control system. Billions of dollars have been appropriated each year for modernization projects that essentially sustain the current methods of providing air traffic control services.

Neither the 7 NAS plans of the 1980s nor the 15 subsequent CIP planning documents have achieved cost savings from modernizing and automating FAA air traffic control services at ARTCC and TRACON facilities. Although our review of these documents showed almost $70 billion has been and will be invested in NAS modernization by 2012, few if any of the plans' identified benefits reduce FAA operating costs, as opposed to avoiding possible future costs.

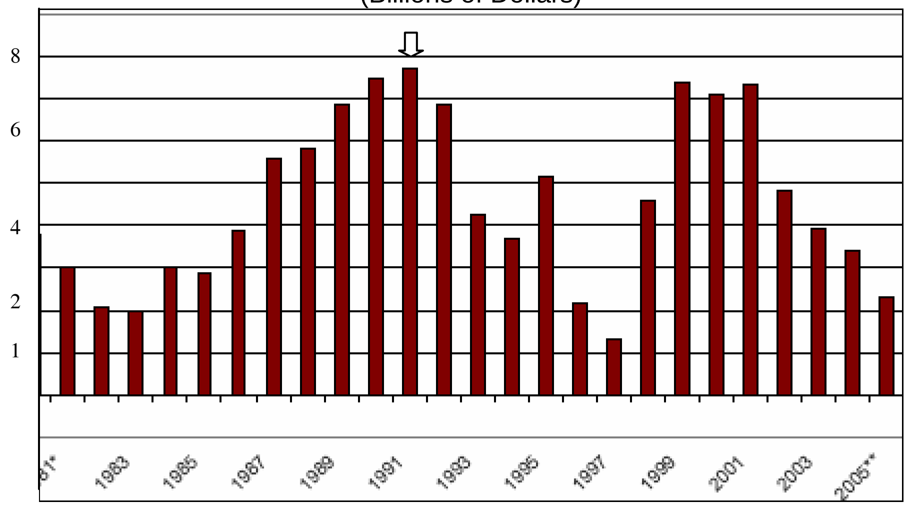
<u>Uncommitted trust fund balances</u>

There are a number of reasons why the NAS and CIP plans did not change air traffic service procedures in order to reduce operating costs by automating and modernizing ARTCC and TRACON facilities, to be sure. Delays, cost increases, and performance shortfalls all played a part. Essentially, however, FAA didn't have to change its operating procedures. Appropriations and agency management strategies permitted growing, operations budgets and modernization. The FAA's initial, post-PATCO impetus to modernize the NAS as reflected in the first NAS Plan in 1983 was different, but it changed. Later NAS plans added facilities and support modernization to critical projects, and the CIP became an infrastructure modernization plan.

The economic benefits of aviation growth generated revenue for the Airport and Airway Trust Fund accounts, created by the Airport and Airway Revenue Act of 1970 (See: CBO/Trust Fund), whether or not the FAA invested capital optimally. The original idea was that what was paid by travelers' taxes should be invested in modernizing the system, but by the late 1980s, the growth of uncommitted balances in trust fund accounts resulted in increased FAA appropriations for operations as well.

The Congress appropriated more funds to reduce uncommitted trust fund balances and assure the safe growth of aviation. From fiscal year 1991 through fiscal 2000, the Congress appropriated over 55 percent of the FAA's operations budgets from the aviation trust funds (See: CBO/Trust Fund), in addition to funding NAS modernization projects in FAA's facilities and equipment budget. These actions drew down balances between fiscal years 1991 and 1997 (shown by the arrow in figure 1).

Figure 1
Airport and Airway Trust Fund Uncommitted Balances
Fiscal Years 1982-2001
(Billions of Dollars)



Sources: FY1971-1988: *The Status of the Airport and Airway Trust Fund*, A Special Study, Congressional Budget Office, December 1988, pages 12-13; FY1989-1998: Trust Fund FY02 Mid-Session Review; FY1999-2007: FY05 President's Budget

We believe uncommitted trust fund balances undermined appropriations and management restraint and allowed FAA labor-management practices eliminating savings from modernization. While the Congress authorized and appropriated billions in NAS modernization projects, it supported increases in FAA operating budgets to reduce congestion, maintain safety and accommodate aviation growth.

Since the terrorist attacks and the resulting War on Terrorism, however, the trust funds' uncommitted balances have declined from over $7 billion in fiscal year 2001 (as shown in President's Budget in Figure 1) to about $2 billion in 2005. FAA operating costs and modernization investments exceeded trust fund revenues in each of the post-attack fiscal years, despite congressional efforts to allocate smaller proportions of trust fund appropriations for FAA operations.

Automation benefit claims

The FAA spent $4.8 billion automating facilities between fiscal years 1982 and 2001 and is currently committed to spending about $7.2 billion more for automation projects through fiscal year 2012. And, it has identified almost $2 billion more that it will need to spend after 2012 to complete the automation program. Disregarding the money spent and amounts identified as necessary after 2012, FAA data show it would achieve only a .5 benefit-cost ratio from the $7.2 billion it is committed to spending from the 12 automation projects with identified FAA benefits (See: SPIRE).

Virtually all of these automation benefits are cost avoidances---not savings (See: CDM). About $3.4 billion of them are attributed to reducing maintenance and “other” support costs (See: SPIRE). No cost avoidances from automation are attributed to providing air traffic services.

Claims that these automation expenditures will allow greatly increased aviation growth and thereby increase future aviation trust fund revenues, as well as reduce FAA costs below what they otherwise would have been are suspect. The causal connections between particular modernization projects and actual increases in aviation operations and decreases in future costs of service generally have not been established; and, forecasts of aviation growth are based largely on analyses of aviation trends that may not reflect post-terrorist attack patterns of aviation supply and demand (See: NGATS). In any case, we don’t think such claims justify potentially less efficient uses of public resources.

FAA operations cost increases

Since 1981, FAA operating costs have increased along with increased productivity, despite NAS modernization. Overall the number of Air Traffic controllers at ARTCC and TRACON facilities today is fairly similar to 1981 pre-strike levels. However, the estimated controller work force and contract controllers for fiscal year 2004 was 12.5 percent higher than in 1990 - there are still fewer FAA air traffic controllers now than when PATCO struck in August 1981 (14,674 at the end of 2004 versus 15,138 in 1981). FAA conducted 13.8 percent more operations for fiscal year 2004 than it did in 1990, making its operations per capita only slightly better than fiscal year 1990.

FAA’s operating costs, unlike its operations per capita, have increased fourfold since 1981, about as much as air traffic growth. Personnel compensation and benefits (PC&B) for ARTCC and TRACON controllers increased 137 and 130 percent, respectively, since 1990. Personnel related costs per ARTCC and TRACON flight operation increased 119 and 87 percent, respectively, since fiscal year 1990. Overall cost per flight operation increased significantly.

NAS infrastructure modernization has spurred operating cost increases, not reduced them. Agency labor contracts and agreements have not reduced controller personnel and have increased wages significantly. Expectations for FAA productivity improvements have been hard to quantify and elusive. The average salary for over 47,000 people in the FAA is about $90,000, while ARTCC and TRACON PC&B appropriations averaged over $183,000 and $162,000 per capita, respectively, for the estimated fiscal year 2004 FAA controller work force.

Methodology

We gathered flight operations data for the 6 largest and 6 smallest of 20 ARTCC facilities, the 11 largest and 11 smallest of 35 Operational Evolutionary Plan TRACON facilities, as well as for all ARTCC and TRACON-tower facilities, for every fiscal year since 1990 and selected years since 1981. We also gathered the annual number of total operations, size of controller work force, cost of facilities, and cumulative automation program expenditures for all ARTCC and TRACON facilities for selected years between 1981 and 2004 from FAA congressional budget hearings. In addition, we reviewed current FAA facility cost accounting and operations data for all ARTCC and TRACON-tower facilities, as well as our sample facilities, for fiscal year 2004.

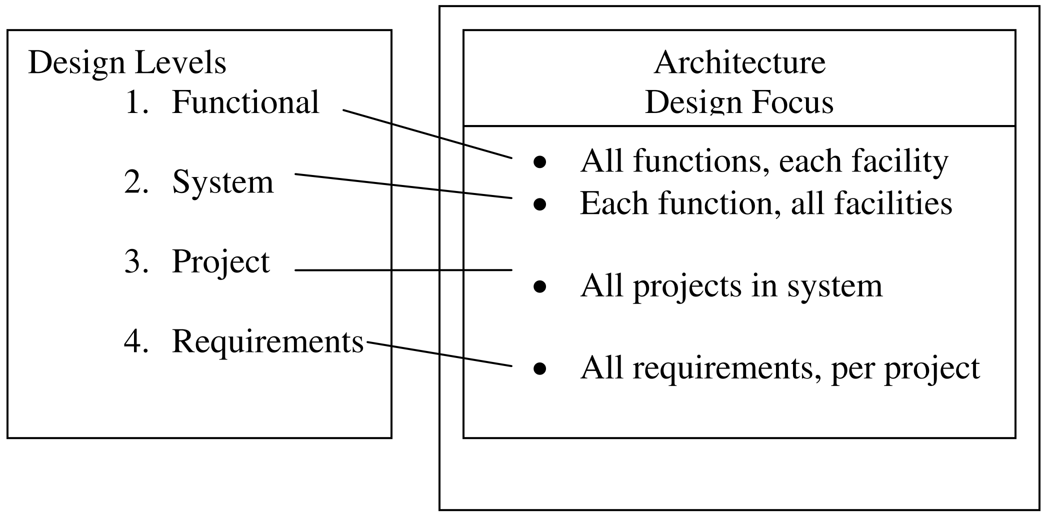
We reviewed funding for all 586 current and former NAS modernization projects contained in the 2004 CIP and all the projects in the earlier 7 NAS Plans (1983 – 1989). In addition, we reviewed a large number of FAA, GAO, and OIG reports concerning FAA acquisition management, as well as the CIP, NAS plans, and congressional appropriations hearings to understand the acquisition issues and concerns about project funding and FAA's management of NAS modernization. For example, we reviewed FAA, GAO, and OIG reports about modernization project cost, delay, and requirements growth in major acquisitions before and after the FAA changed its acquisition management system in 1996 to see if this change affected FAA benefits from automation. Similarly, we reviewed FAA and RTCA, Inc., documents related to the Free Flight Program in the late 90s affected automation program benefits for FAA.

NAS Architecture, Acquisitions, and Free Flight

The reasons that the FAA has not achieved benefits from modernizing are customarily attributed to its management of architecture, acquisitions, Free Flight Program (FFP) implementation, automation program difficulties, or NAS project delays. The early NAS plans' modernization sought to replace the aging Communications, Navigation and Surveillance (CNS) infrastructure and computers and displays at ARTCC and TRACON facilities, as well as create new automation software capabilities, in order to change the way the agency performed air traffic control (See: Helms). Notwithstanding the promise of the Plan, FAA never resolved the complex trade-offs between modernization project benefits and changing critical service procedures.

The NAS plans' simple project descriptions and merging timelines masked mind-numbing potential engineering development and project implementation complexities (See: SEIC). The FAA hired a Systems Engineering and Integration Contractor (SEIC) to design the NAS architecture and help it manage the implementation of NAS projects in 1985. The SEIC subsequently developed the four-level architecture designs, with their associated functions, systems, projects and requirements, allocated for FAA facilities, services, equipment and procedures. The architecture also permitted requirements-level, benefit tracking. The contract was for 5 years with 3-year and 2-year extensions; about the amount of time the FAA initially imagined it would need to implement the NAS modernization projects.

Figure 2
FOUR-LEVEL NAS ARCHITECTURE DESIGN



Behind the early NAS plans and its architecture and system engineering were partially documented assumptions about how the new systems would perform air traffic tasks and procedures to derive FAA benefits, like electronic flight strips. One of the real difficulties realizing benefits from modernization was the lack of consensus about these assumptions.

In the 1990s the FAA changed both its architecture and its acquisition management to deal with the consequences of the lack of consensus about benefit assumptions. Congressional stakeholders insisted the agency address delays and cost increases in major NAS modernization projects, so in 1996, FAA changed its acquisition management system to better manage modernization costs, timeliness, and requirements growth (See: GAO/OIG).

When aviation users, principally large airline, demanded improvements in air traffic services, FAA changed the NAS architecture in 1998 to reduce airline congestion-related delays and accommodate new technologies in FFP projects and enhancements to the Traffic Flow Management (TFM) program. Neither of these changes achieved FAA savings benefits from modernization, nor assured that FAA cost avoidance benefits will be realized.

Since the NAS plans, FAA has focused management attention on acquisition processes rather than on building a management consensus about changing operating procedures and services. An FAA evaluation of its acquisition management reform reported in 1999 that large programs were experiencing more schedule growth in the first 3 years of their contracts and between contract award date and the system's first operational readiness, and that both large and small programs had greater cost growth, after acquisition reform than before it (See: FAA99). Since then, the agency has tried to improve the provision of modernization systems to its operators, but its efforts to systematically address procedures for using these new systems to achieve benefits was limited to FFP projects.

FFP projects and TFM enhancements created new user capabilities and benefits, but they did not reduce FAA operating costs at ARTCC and TRACON facilities. They increased them. Although there have been fewer implementation requirement changes, schedule delays, and cost increases for FFP projects than for other major automation projects, the nature of their prototype test and demonstration processes, smaller size, and limited interface development with other NAS systems probably accounts for this. Although better implemented and more beneficial than earlier NAS modernization projects, FFP projects increased FAA operating staff and costs.

Early NAS Plan benefits

NAS Plan benefit estimates provided poor precedents for realizing FAA modernization savings. The 1983 NAS Plan promised aviation users efficiency and safety benefits, and the FAA economy and savings benefits totaling $21.5 billion. Of these, about $3.6 billion were cost savings benefits derived largely from staff reductions. The 1983 NAS Plan said implementing modernization would increase air traffic control and airway facility productivity by a factor of 2, reduce staff required to maintain and operate the modernized system by one-third, and maintain the cost of operations at the 1981 level through the year 2000 (See: NASP, Executive Summary). The 1983 Plan claimed that 14,200 air traffic personnel at 23 consolidated area control facilities would manage almost 100 million air traffic operations in the year 2000 (See: NASP, II-19, 67-69, III-17).

The 1983 NAS Plan claimed FAA could reduce Air Traffic personnel 36 percent overall through the year 2000, reducing the controller work force 14.5 percent at ARTCC facilities while flight operations increased 64 percent, and reducing the controller work force at air traffic control tower and TRACON facilities 63 percent by consolidating and contracting air traffic control while flight operations increased 119 percent (See: NASP). Together with Airway Facilities staff reductions of 29 percent and 49 percent at ARTCC and TRACON facilities, the Plan identified direct operating cost savings from personnel reductions through fiscal year 2000 of $3.6 billion (See: NASP, II-19, 67-69, III-17).

The 1983 NAS Plan projected fiscal year 2000 operations of 100 million, about 14 million below the actual number, but its savings benefits were largely illusory. The creators of the NAS Plan assumed the FAA only would staff up to about 14,200 controllers by fiscal year 2000, almost 50 percent more than the planners assumed in 1983,[•] thereby holding down future FAA operations. This is why the

[•] Only about 4,700 of 15,138 controllers remained after the PATCO strike in 1981. FAA had around 6,575 controllers on board by the end of the fiscal year. The NAS Plan writers assumed about 8,800 controllers would on-board by the end of for fiscal year 1983, about 1,000 less than the agency subsequently claimed for the end of fiscal year 1983.

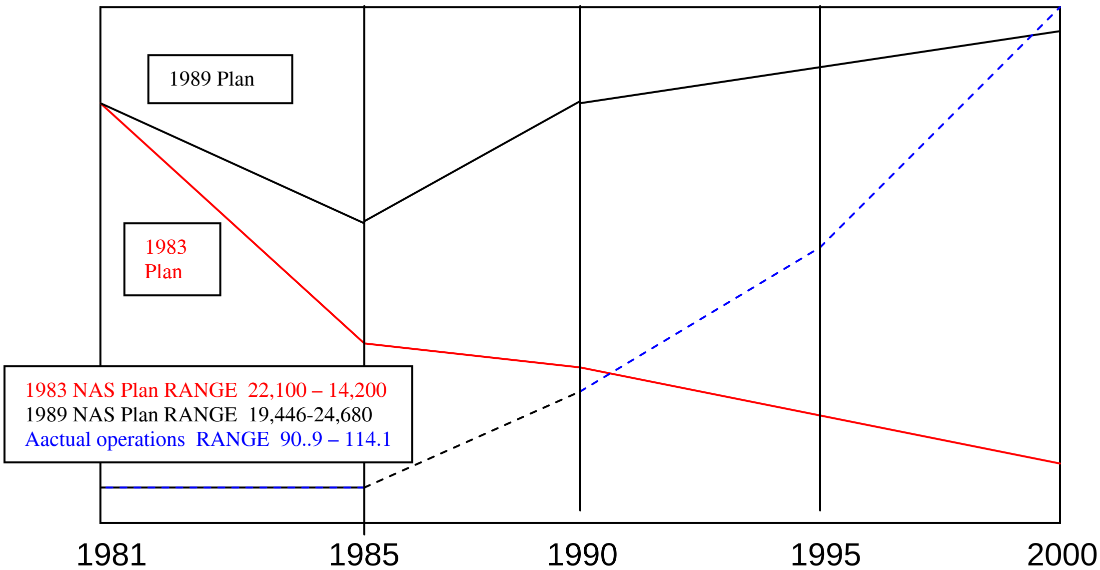
Plan underestimated operations for fiscal year 2000. The Plan's readers could imagine that the technologies described produced labor savings, because the Plan said FAA would reduce the controller work force by almost 8,000 (from 22,100 to 14,200) by the year 2000. More informed readers might have realized that the fiscal year 2000 controller work force was about 1,000 less than the 1981 pre-strike work force. Neither the plan's statements nor astute observations were the basis for the NAS Plan's controller personnel cost savings, however.

All of the NAS plans' controller staff savings were based on the FAA hiring about 7,600 more controllers than the agency had on board at the end of fiscal year 1981, and about 5300 more than the planners thought would be on-board by the end of fiscal year 1990. A continuing annual savings benefit was created by the difference between the controller work force used as the basis for the 1981 baseline (22,100), and the number of controllers estimated to be on board at the end of each fiscal year through 2000. Forecast operations between fiscal year 1981 and 2000 were said to double, but the fiscal year 2000 operations prediction was actually about 11 percent more than the 1981 base year (90.1 million). Operations were not assumed to increase until the 1990s, after NAS systems were implemented and the controller work force was increased.

Adding over 5,000 new controllers, new CNS systems, and automating communications, airspace configuration, flight tracking and flight plan filing must have seemed like adequate assurance in 1983 that ARTCC and TRACON operations could accommodate anticipated growth by 2000. However, although aviation operations did not recover much faster than the plan assumed, FAA hired more controllers sooner than the plan anticipated, partly because the automation program was delayed and its functional assumptions strongly contested. By fiscal year 1990, ARTCC and TRACON operations increased only 5.5 percent more than 1981, but the controller work force increased 170 percent over the end of fiscal year 1981 level (6,575 to 17,266). Over the same period, the cost of completing the automation program increased from about $2.7 billion in 1983 to almost $12 billion in 1990, and its implementation stretched into the next century.

Since the NAS plans' staff year savings from personnel reductions mainly were due to the PATCO strike recovery rather than modernizing, personnel-related savings attributed to modernization had to be reduced in subsequent NAS plans to reflect the increases in ARTCC and TRACON-tower controller work forces on board, or anticipated. The 1989 NAS Plan assumed 24,680 would be on board in 2000. Though significantly higher than the actual 2000 figure (18,490), it removed any controller personnel saving benefits from NAS modernization.

Figure 3
Declining NAS Plan Personnel Savings
And Controller Work Force
Fiscal Year 1981 to 2000



The NAS plan projects offered reasons to assume modernization and automation technologies would permit airspace re-configuration, user preferred routing, automated ground-to-air communications, and less aircraft separation. They did not specify the benefits of doing these things for any of the described project capabilities. While the benefits described in the plans may have been based on reasonable implementation assumptions, none were supported by analyses until at least three years after the first plan. The NAS plans' labor savings were misleading, but all cost savings disappeared with the CIP.

Technology and the evolution of the NAS
Air traffic control procedures evolved as a result of the Federal Government's expanded aviation role, from promoting and regulating aviation commerce and safety to providing services to improve operations and safety. Subsequent changes in aircraft performance and mission provoked changes in air traffic control system requirements. The air traffic control mission began by supporting regional air carriers flying federally subsidized mail routes with radio communications, navigational beacons and airport lighting in the 1920s (See: Komons, Nick).

Newer, primary and secondary radar surveillance and flight tracking systems were added to established airways and radio controller procedures in the 1950s and 60s. However, the air routes and approaches frequently still were defined by the location of older navigational aides. As aviation expanded, the amount of air traffic, the number of aircraft routes, and the requested route changes, all factors used to determine the size of air traffic control sectors, increased. While air traffic sectors were made smaller, the controller roles and procedures for monitoring and communicating with aircraft in these sectors changed more slowly.

It was apparent before the PATCO strike that this ground-based and procedures driven "system" would have to change to accommodate increases in aviation operations created by commercial jets. But the PATCO firings of air traffic controllers left this system of defined controller roles and procedures so severely understaffed that user-preferred and more fuel efficient routing, automated air ground communications, and re-configurable airspace sectors, along with more contract and consolidated air traffic control facilities, became secondary modernization objectives. The first was to restore air traffic control services.

The FAA and Department of Transportation reviewed other, high-level systems for modernizing and automating the NAS, but the PATCO strike forced the FAA leadership to think about how to maintain services first, and then change the roles and procedures for providing services. The emotional impetus of FAA post-strike leadership was to revitalize the agency's mission of public services. The Administrator's objectives implementing the NAS Plan---overwhelming understaffed facilities with new capabilities, remained a source of controversy and misgivings among agency employees (See: Helms, J. Lynn).

Advances in communications and computers made much of the ARTCC and TRACON equipment obsolete by 1981 and developing satellite navigation and transponder communication capabilities would permit very different CNS by 1995. But the original idea behind acquiring and simultaneously implementing over 100 modernization projects in a span of 10 years also changed. Instead of flooding understaffed air traffic control facilities with new technical capabilities that allowed them to transform the way they provided services, NAS modernization became an opportunity to replace and upgrade all of the FAA facility and service infrastructure.

Automation program difficulties and delays

Automation programs in the NAS plans and in subsequent CIP issuances have proven particularly difficult to implement. The NAS plans sought to physically consolidate ARTCC and TRACON facilities in 23 Area Control Facilities (ACF) and to replace their existing hardware and software systems, and those of large towers, with advanced terminal and en route display and processing systems like the Advanced Automation System (AAS). Enhanced functional capabilities for the new, distributed processing and display systems - called Sector Suites – were originally to occur in parallel software development projects, called the Advanced En Route Automation System (AERA).

Functional automation raised difficult operational and technical issues that created cost increases and schedule delays. Over time, AERA software enhancements were split from AAS computing and display projects and deferred to the next millennium. But between 1983 and 1994, the FAA was forced to repeatedly revise its AAS program schedule, cost, and implementation strategy until it finally canceled the AAS program and removed its prime contractor.

The current approach to ARTCC and TRACON automation reflected in Version 5 of the NAS architecture that evolved between 1995 and 1999 separates hardware and software project development and implementation and schedules each, successively, as either a replacement or an enhancement project. Hardware replacement projects generally precede software replacement projects, which are deferred until after the new computing and display system hardware acquisitions for TRACON and ARTCC facilities are completed and operating with existing software. Software enhancement projects occur after the operating software has been replaced with re-coded software.

The 3-step strategy reflects the reality of the old AAS program, in that the hardware is replaced first, deferring more difficult software replacement re-coding and postponing functional software enhancements until after the operating software is replaced. The process reduces technical risks and resulting schedule and cost increases. It also postpones costs and benefits.

By 2003, FAA had replaced virtually all the automation related, computing hardware and operating displays for terminal-TRACON and ARTCC facilities. The Standard Terminal Automation Replacement System (STARS) program and En Route Automation and Modernization (ERAM) program now faced the same critical problems that bedeviled earlier AAS contractors. They must now replace operating software with new, more robust operating codes while minimizing service interruptions. Later, they must implement existing, service-related functionalities in the re-coded software. Ultimately, these programs also must re-code the enhancements that are currently being developed and tested for TFM, FFP and weather systems. The FAA is unlikely to receive any cost avoidance benefits from automation before 2010 and has not identified any cost savings from this 3-step automation of ARTCC and TRACON facilities.

Expansion of the NAS modernization

In 1988 a US General Accounting Office official testified that including related infrastructure and maintenance modernization projects necessary to complete facility modernization and consolidation would increase the cost of the NAS Plan to $27 billion (See: GAO/cost). Automation and CNS projects at that time were organized in the NAS plans by facility-related chapters. NAS Plan chapters initially emphasized the importance and interrelatedness of projects and their impact on FAA operations. Over time, however, the emphasis of the NAS plans began to shift to include other, FAA high priority F&E projects, as well as new requirements and other capital investment priorities.

As focus of NAS modernization became more diffuse, its purpose was obscured. Instead of new technology systems allowing operating facilities to adopt new procedures, new technology systems became part of facility-enhancement and other initiatives. By 1989, the NAS Plan contained 24 Other Capital Needs projects and 11 Transition projects, over one fourth of the Plan's 128 projects.

Table 1
Growth of NAS Infrastructure Modernization
1983 - 1990

Plan Year	NAS Projects	New Initiatives	Total Projects
NAS 1983	80	0	80
NAS 1984	88	0	88
NAS 1985	88	4	92
NAS 1986	91	8	99
NAS 1987	92	16	108
NAS 1989	93	29	122
NAS 1989	93	35	128
CIP 1990	53	150	203

The NAS plans were replaced and most of their projects transferred to the CIP when it was published in 1990.The CIP represented a more expansive and inclusive concept of NAS modernization and reflected both the emergence of political support for expanding FAA services and modernization, as well as differing purposes of successive Administrators influencing the modernization of facilities and infrastructure. Instead of controllers and technicians being flooded in new capabilities and adopting new procedures to use them, the new systems were modified to combine with others and meet controller and technicians requirements for facility and maintenance procedures.

Successive versions of the NAS modernization architecture have followed CIP revisions since 1990. Version 2 of the architecture included TFM enhancement and aviation weather development projects. Version 3 (1996) eliminated the AAS projects for en route and terminal areas. And Version 4 of the architecture (1999) included the FFP projects. The original 80 NAS Plan modernization projects have been more than quadrupled by CIP projects. FAA now identifies 568 current and former CIP modernization projects. But only 29 current projects have identified FAA cost-avoidance benefits (See: SPIRE).

Although the 1983 NAS Plan estimated modernization benefits of $21.5 billion, the 1993 CIP identified $285 billion in modernization benefits (See: CIP, 1993, pp.1-0-13-14). FAA's cost avoidance benefits seem only to have increased enough to cover its anticipated cost of modernization. For example, the 1990 CIP claimed FAA cost avoidance benefits of $27 billion, about what GAO estimated as the cost of modernization in 1987 (See: CIP, 1990). Currently, FAA claims accrued and future CIP cost avoidance benefits of around $60 billion, about what we estimate the agency spent on completed projects ($12.6 billion) and is currently committed to funding through 2012 ($47.5 billion).

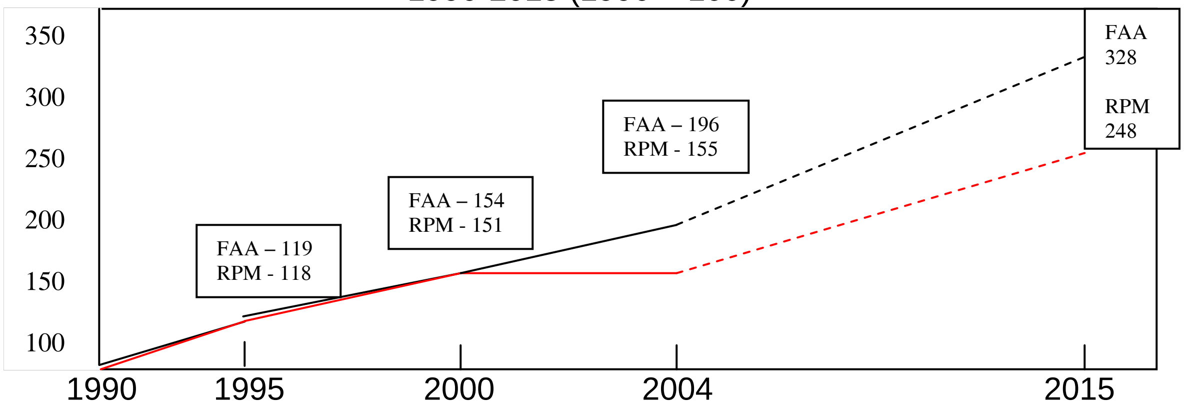
Free flight projects
The FAA created the FFP because of public and congressional criticism for increased flight delays and weather disrupted flights resulting from the growth of air traffic in the latter half of the 1990s, and the availability of satellite-based CNS capabilities supported by the Department of Defense. The agency was convinced that it could create significant, new, user benefits from these capabilities in 1998 by years of RTCA, Inc. studies (See: ffp, Introduction). Building on TFM efforts to exploit new flow management tools, the User Request Evaluation Tool (URET) formerly developed by an FAA contractor as part of AERA, and users' demand for satellite-based area navigation and autonomous dependent surveillance capabilities, the FAA created FFP projects to fill the gap in the automation program.

The FFP projects acquisitions minimized cost and schedule risk by demonstrating the benefits of technology applications and the necessary operator procedures before project development, acquisition and implementation plans were created to justify investment decisions, and by minimizing project interfaces with the NAS architecture (See: ffp, Background). Critical procedural components of the FFP projects had to be demonstrated, negotiated, and then codified in project protocols with users and service providers before their relatively modest hardware and software requirements for communications and decision aides were acquired.

The FFP processes of prototype development and testing created the infrastructure and operator requirements for implementation success and the program created substantial user benefits. Despite spending over $1 billion, however, none of the FFP projects resulted in any FAA cost savings, or even cost avoidances (See: SPIRE).

Productivity, capital investment, and operating cost data
The relationship between FAA capital investment, operating costs, and productivity is the result of past public policy and FAA management practices. Quite simply, FAA operations budgets increased about as much as air traffic growth. The agency anticipates that this pattern will continue. FAA predicts that its operating costs and passenger revenue miles, the aviation trust funds' major source of funding, will increase about 167 (See: FAA/CATS) and 170 percent (See: FAA/03frcst, and 04frcst), respectively, between 2003 and 2015. This means the average annual difference between the two would be less than a fraction of a percentage point per year. Indexed FAA operations appropriations and domestic revenue passenger miles to fiscal year 1990 show the close link between excise tax revenue and operations appropriations, the effects the War on Terror has had on revenue passenger miles, and emphasize how much more rapidly FAA operating costs are predicted to increase.

Figure 4
Index of Rates of Growth: FAA Operations Appropriations and Domestic Revenue Passenger Miles
1990-2015 (1990 = 100)



Productivity measured by operations per capita is an enigmatic indicator. Between end of fiscal year 1981 and 1985, for example, the agency increased its strike depleted controller work force from 6,575 to 13,998, but FAA performed only a half million more operations in fiscal year 1985 than it did in 1981. Although ARTCC and TRACON-tower facilities' operations per controller fell from 6,660 in 1981 to 6,472 in 1985, reflecting adjusted staffing increases, they remained historically high. Even the lower 1985 productivity number has not been equaled since.

Table 2
Controller Work Force, Operations and Per Capita Productivity

Year	**CWF**	**Operations (Mil.)**	**Ops/CWF**
1981	13,528*	90.1	6,660
1985	13,998	90.6	6,472
1990	17,226	95.4	5,538
1995	17,778	101.9	5,687
2000	18,490	114.1	6,171
2004	19,387E	108.6	5,576E

* FAA had a controller work force of 16,234 until July 31. It ended the fiscal year with a controller work force of 6,575 as a result of the PATCO firings. The number in the table represents a monthly weighted average of the controller work force in fiscal year 1981, rather than the end of year figure.

We used FAA cost accounting data to examine variations in the numbers of flight operations, controller work force, and operations per capita, among our large and small facilities samples, compared to all ARTCC facilities for fiscal year 2004. We found that the accounting system's CPC classification understated the payroll controller classifications by about 20 percent. Over 1,100 more people are classified as controllers at ARTCC facilities by payroll than the accounting system includes in its CPC classification of individuals managing or controlling air traffic. Since the differences were not distributed evenly, facility productivity and rankings varied, depending on whether we used CPC or CWF work force classifications.

FAA data show a large number of controller workforce classifications, especially at large volume facilities that are not controlling aircraft. Although the indexed range between the least and most productive ARTCC facilities (169) was identical with either employee classification, using the Controller Work Force classification pulled down the productivity of the larger facilities and made the six smallest ARTCC facilities more productive than the average ARTCC.

Table 3
Average Variations in Operations, Operations Per Capita, And Controller Work Force Among All, Large and Small ARTCC Facilities
Fiscal Year 2004

ARTCC	Ops/CPC	Ops/CWF	OPS	CPC	CWF
Large 6	8,361	**6,669**	16.339	1,977	2,450
Small 6	7,451	**6,641**	9.131	1,243	1,375
All	7956	**6563**	41.882	5,308	6,421

Increases in personnel compensation and benefits (PC&B) appropriations, controller work force, and operations for ARTCC and TRACON-tower facilities were compared over time for changes between 1990 and 2004. Large PC&B increases significantly increased facility cost per operation and were reflected in very large cost per capita (CWF) increases, while operations at ARTCC and TRACON facilities increased 23 and 8 percent, respectively, between fiscal years 1990 and 2004. These data suggest the trend of increasing wages and benefits that adversely affects cost per operation and contributes significantly to increased ARTCC and TRACON operating costs. PC&B increases overshadowed significant productivity increases reflected in 1990 to 1995 for ARTCC facilities and 1990 to 2000 for TRACON-towers. PC&B cost per ARTCC and TRACON-tower operation increased significantly more than operations per capita in every 5-year period.

Table 4
ARTCC Operations, PC&B, Controller work Force Cost Per Operation, Cost Per Capita, and Operations Per Capita
Fiscal Years 1990 – 2004

Fiscal Year	Ops. Mil.	PC&B$	CWF	PC&B$/Op	PC&B$/CWF	Op/CWF
1990	36.9	654.7	8105	17.74	84,499	4553
1995	39.5	859.2	7748	21.75	110,893	5098
2000	45.4	1,165	8262	25.66	141,007	5241
2004	45.5	1,508	8229	33.14	183,254	5229
%CHG	23	130	1.5	87	117	14.8

Table 5

TRACON Operations, Operations, PC&B, Controller work Force Cost Per Operation, Cost Per Capita, and Operations Per Capita

Fiscal Years 1990 – 2004

Fiscal Year	OPS Mil.	PC&B Mil. $	CWF	PC&B$/Op	PC&B/CWF	Ops/CWF
1990	58.5	690.3	9616	11.80	71,787	6084
1995	62.4	896.7	9552	14.37	98,876	6533
2000	68.7	1,238	9415	18.02	131,492	7297
2004	63.1	1,634	10,058	25.90	162,458	6274
%CHG	8	137	4.5	119	126	3

We reviewed two decades of controller work force productivity for ARTCC and TRACON facilities. At ARTCC facilities, major automation appropriation increases seemed to be followed by operations and operations appropriations increases that resulted in productivity per capita increases and cost per operation increases. At no time in the 1981 to 2004 period we reviewed did we find productivity increases followed by decreases in cost per operation and declining operations appropriations for ARTCC and TRACON-tower facilities. Automation appropriations seemed to precede increased operations, but did not result in reduced labor, cost per operation, or operations appropriations.

FAA data presented to the RTCA Aviation Forum last June by the FAA Air Traffic Organization Vice President (See: Brown, Steven) show variability in cost per operation for large terminal and ARTCC facilities. The depreciated facility infrastructure cost and the controller variable PC&B costs per operation are driven by traffic volume. Since the fewer operations a facility had to distribute its fixed and variable costs over during the month covered by the FAA data influenced its costs per operation, smaller facilities generally had higher costs per operation than larger facilities. The total of fixed and variable costs per operation for 16 ARTCC facilities[*] ranged from a low of about $39 to a high of $65, while those for 50 Terminal facilities[**] ranged from $44 to $136, a more significant difference.

Although ARTCC facilities have very large fixed costs associated with computing and display systems, radar networks, and extensive communications, the 50 largest terminals varied more with respect to staffing. Consequently, both the fixed and variable costs varied more by Terminal than by ARTCC, but fixed costs varied more than variable costs at ARTCC facilities. The ranges of fixed costs for ARTCC and Terminal facilities, however, were similar; ARTCC fixed costs were between $12 and $24 per operation and Terminal facilities' fixed costs were between $10 and $25 per operation.

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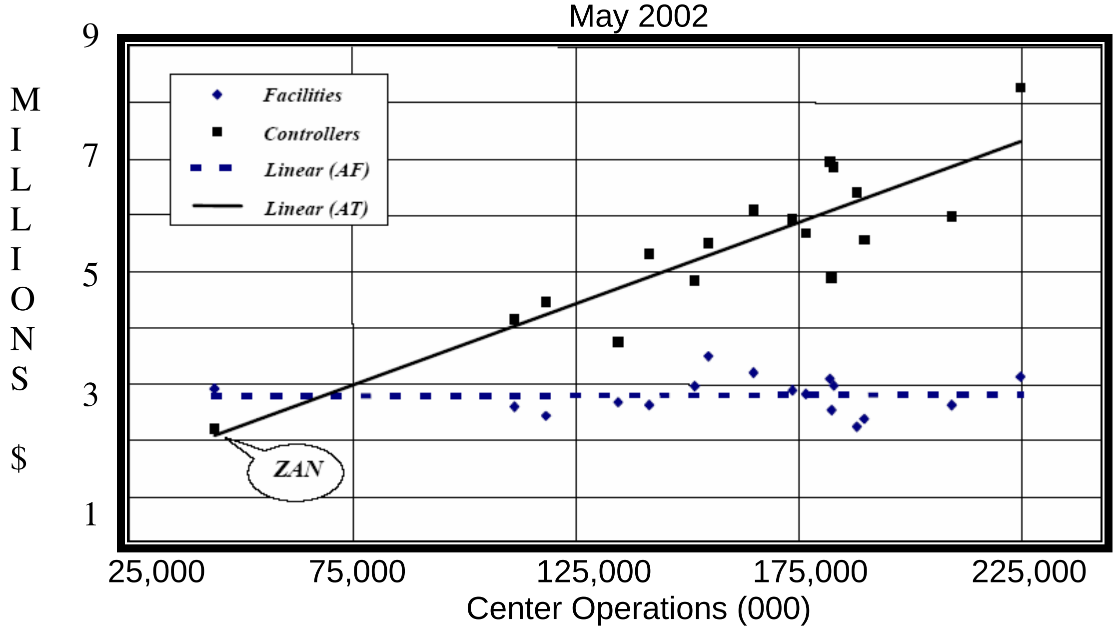
[*] We adjusted the 17 ARTCC facilities in FAA data by removing Anchorage (ZAN).

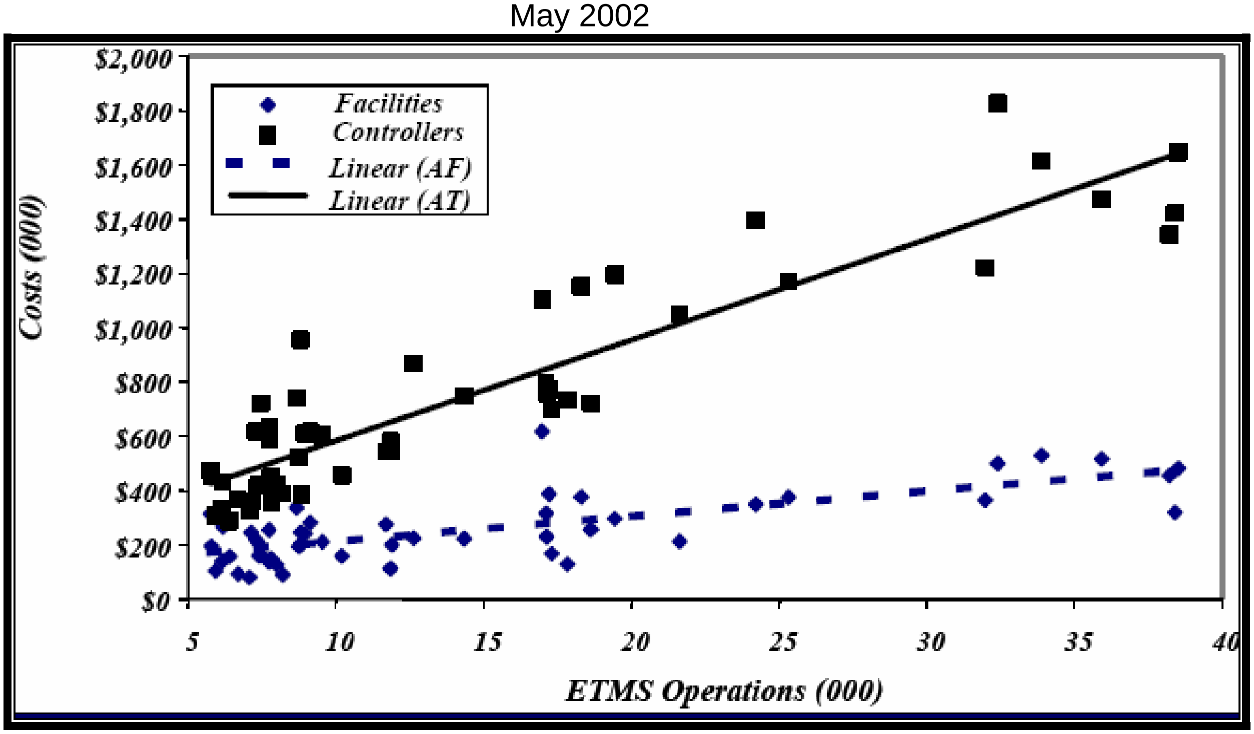
[**] Brown used the 50 largest terminals rather than our 35 OEP TRACON facilities.

Figure 5
ARTCC Facility and Controller Cost Per Operation
May 2002



SOURCE: Steven Brown, Vice President of Operations Planning, *Building Today to Ensure Our Future*, RTCA Forum, Air Traffic Organization, FAA, June 30, 2004.

Figure 6
Terminal Facility and Controller Cost Per Operation
May 2002



SOURCE: Steven Brown, Vice President of Operations Planning, *Building Today to Ensure Our Future*, RTCA Forum, Air Traffic Organization, FAA, June 30, 2004.

Automation and modernization investments may have actually widened the variable cost range between high and low volume facilities. They provided all these facilities with capacity expanding capabilities, but didn't alter the underlying facility staffing and operating procedures. High volume facilities were able to immediately exploit the new capabilities, while low volume facilities accumulated a potential reserve operating capacity that they couldn't exploit with current staffing, procedures, and traffic volume. The range in facility costs per operation reflects traffic volume, staffing allocations, and procedures, rather than simply automation and modernization investments. Together with the ARTCC and TRACON PC&B data, these FAA data suggest FAA cost avoidance assumptions of NAS infrastructure modernization are unrealistic. Some facilities are much more productive than others, because they have more effective procedures and staffing levels, given their traffic volume.

Our operations data for ARTCC and TRACON facilities since 1981 show regional economic variations. Regional economic patterns also affect the distribution of controller workload. Regional differences in demand for aviation services due to local economic performance exaggerate differences in per capita controller operations in some years. Likewise, changes in aviation demand due to the War on Terror are not uniformly distributed. They could actually benefit smaller, under utilized ARTCC and TRACON facilities more by increasing their traffic volume, while constraining those of the major metropolitan areas. Potential aviation operations could expand more quickly in areas with under utilized capabilities created by infrastructure modernization, if information about available capacity were shared with aviation users.

The decline of the legacy airlines' hub-spoke systems and the growth of price-competitive, direct flights in major markets, on the other hand, may be having a perverse effect on the most productive TRACON and ARTCC facilities. Increasing demand for aircraft operations at hub-spoke airports at the same time that hub-spoke operators are declining indicate competitors' demands for market access may exceed the FAA's collaborative decision making capabilities, limiting its ability to smooth congested traffic flows.

Conclusion

Although the FAA has quadrupled its air traffic operations since 1981, it has not been able to contain its cost of services, despite having completed more than $12.5 billion on modernization projects between 1982 and 1997, and continuing to support over $47 billion in ongoing NAS modernization through 2012. NAS modernization investments have become more diffuse and unfocused since the early NAS plans' sought to modernize systems critical to the provision of air traffic control services. NAS modernization is not a sign of significant change in the way that the FAA provides services.

Modernization plans and architecture have been unreliable guides to transforming air traffic control services. They changed from trying to influence critical air traffic control processes with new systems, to capturing all of the changes necessary to modernize FAA's existing facilities and service infrastructure. FAA failed to achieve cost savings from NAS modernization. Cost savings promised by early NAS plans were not related to modernization, but a slowed aviation recovery from the PATCO strike.

The CIP was developed for an era of generous appropriations and unfocused and changing leadership priorities. It correctly identified the expanding importance of aviation in the economy, indicated by its order of magnitude greater user benefits. But the CIP abandoned cost savings and made assumptions about FAA future cost avoidances that lacked discipline and purpose. It failed to track modernization benefits to project implementation and never attempted to identify cost of service reductions in relation to alternative technologies.

NAS modernization architecture and project designs have been consistently subverted by requirements growth, development delays, cost escalations and inadequate benefits management. But all these things were symptomatic of the fact that FAA didn't think it needed to reduce operating costs. Strong aviation growth and excise tax revenues provided sufficient resources for infrastructure modernization and increasing operation appropriations, allowing increased service costs to aviation users from the way FAA provided air traffic control services.

The FAA's future growth assumptions may be flawed, its operating cost could exceed future aviation revenue unless taxes are raised, and it is likely that most of the claimed cost avoidances could actually have been achieved in a less expensive way. Our data show the enigmatic character of claimed per capita productivity that resulted from modernization. The connection between available trust fund revenue and the growth of FAA operating cost increases is pervasive. And the variations in FAA facility costs per operation have been exacerbated by modernization expenditures of FFP and the automation program, creating unrealized capacity in the wrong places.

The FAA claims cost avoidances from NAS modernization the way the NAS plans did; it makes assumptions about aviation growth and controller work force staffing, allocates the resulting benefits among modernization projects deemed necessary to allow growth, and continues to provide aviation services as it has in the past. It has held down controller employment and reformulated its controller work force classification to increase productivity. Unlike the early NAS plans, however, FAA is trying to modernize its infrastructure rather than its services.

NAS modernization must produce more efficient FAA operations. Traffic may not double every 15 years if FAA cannot contain its operating costs, further depressing aviation demand and causing trust fund revenues to continue to decline. The same trust fund uncommitted balances and appropriating mechanisms that made it unnecessary for FAA to achieve savings from NAS modernization and operations could suddenly require them. If, for example, the Congress refused to increase or create new excise taxes simply because FAA operating costs continue to exceed revenues, FAA's operations budget would constrain its capital spending on modernization. Operating costs would crowd out infrastructure modernization, forcing the FAA to prioritize its investments. Economists might even consider this a virtuous cycle. Alternatively, all that is required for this virtuous cycle to occur, is anything that slows economic growth, like the WOT.

The real cost of failing to achieve savings from NAS modernization is moral and at the heart of public service. Until we demand an alternative to NAS infrastructure modernization, an open-ended liability will continue to consume all resources and revenues that excise taxes and the General Fund allow. This is not responsible management of the public's resources.

References

SPIRE. The Simplified Program Information Reporting System, developed to support project baseline establishment and management as part of the FAA acquisition management system. According to FAA, the CDM project will produce $85 million in "Other" cost savings. SPIRE access: http://172.27.70.61/spire/overview/DE2004/Optional_Link_1.xls

NASP. The first compendium of Communication-Navigation-Surveillance (CNS) modernization and automation projects with established project baselines was published in the Spring of 1983 and every year thereafter as the National Airspace System (NAS) Plan until the Capital Investment Plan (CIP) replaced them in 1990. Earlier versions of the 1983 NAS Plan, called "Brown Book" projects as part of FAA's Facilities and Equipment (F&E) budgets, were printed in 1981 and 1982. The schedule and cost baselines for the Brown Book projects were re-done for the 1983 NAS Plan edition. See: *National Airspace System Plan: Facilities and Equipment Development*, Federal Aviation Administration, April, 1983; *Executive Summary*, 1983, pp.I-3 to I-5; 1983, pp. II-19, 67-69, III-17.

Benefits. When the 1983 NAS Plan was created it identified $21.5 billion in modernization benefits, but no one knew exactly how benefits would be achieved, or how valuable they might be. After subsequent architecture designs and benefit studies by FAA's Systems Engineering and Integration Contractor in 1986-87, the agency identified $66 billion in potential modernization benefits, $42 billion of which were user benefits and about $24 billion FAA benefits.

CBO/Trust Fund. See: A*irport and Airway Trust Fund*, Briefing, Federal Aviation Administration, May 7, 2004; and, *Status of the Airport and Airway Trust Fund*, A Special Study, Congressional Budget Office, December 1988.

CDM. Collaborative Decision Making projects, are part of the Free Flight Program in the automation program and are an exception to only cost avoidance benefits. SPIRE data show CDM projects would generate $85 million in direct savings to the agency by 2025.

NGATS. See for example, Brown, Steven, and Gisele Mohler, Loretta Martin, and Andy Andregg, *Evolving the National Airspace system for a New Era of Growth,* NBAA Annual Meeting, October 13, 2004, FAA; and, "A Statement of The Problem", Chapter One, *An integrated Plan for the Next Generation Air Transportation System*, Joint Planning and Development Office, Federal Aviation Administration, December, 2004.

Helms. Former Administrator J. Lynn Helms' vision of the synchronous implementation of enhanced systems operating throughout the national airspace gave rise to the description of the Plan as a "system of systems". Early criticisms of the Plan within the agency took issue with this characterization from engineering claims that the 100 CNS and automation program project acquisitions didn't represent a system, to management concerns that all these projects would be too difficult to simultaneously acquire and implement on schedule, to outright opposition based on air traffic controllers', service technicians', and flight specialists' fears that the plan was designed to replace their jobs. All were prescient.

Helms initiated the NAS Plan to allow the FAA to operate the air traffic control system in a changed, post-strike environment. He was the most decisive force behind the Plan and expected that the size and scope of the effort to develop and implement a 100 new, air traffic control-related systems in the understaffed facilities would provide so many new capabilities to operators that they would change procedures and transform air traffic control services to overcome the shortage of air traffic controllers.

SEIC. The FAA's Systems Engineering and Integration Contractor (SEIC) warned the agency that without a sophisticated architecture design, unrecognized and unacknowledged development and implementation changes to project baseline requirements would increase costs, extend schedules, and jeopardize benefits. The SEIC was tasked with developing a system level architecture capable of tracking project benefit requirements and created a 4-level design for an integrated system, made up of systems (automation, communication, surveillance, navigation, etc.), each comprised of projects, that were allocated development and interface requirements based on the overall architecture.

GAO/OIG. *FAA Has improved Management of its Acquisitions, but Policies and Oversight must be Strengthened to Help Ensure Result*, GAO-05-23, January 2005, US Government Accountability Office, Washington, DC, pp. 24-33; and, *Status of FAA's Major Acquisitions*, AV-2003-045, June 26, 2003, Office of Inspector General, Department of Transportation, Washington, DC, pp. 1-27.

FAA99. *FAA Acquisition Program Baseline Stability: Comparison between growth rates for programs conducted prior to acquisition reform and those conducted under acquisition reform*, NAS Configuration management and Evaluation Staff Program Evaluation (ACM 10), Report #1999-05, September 27, 1999, Federal Aviation Administration, Washington DC, pp.5-6.

Komons, Knick A, *Bonfires To Beacons: The Federal Civil Aviation Policy Under the Air Commerce Act, 1926-1938*, Smithsonian Institution Press, Washington, DC, 1989 (Reprinted from FAA, 1977.

GAO/Costs. *"FAA Appropriation Issues"*, Statement of Kenneth M. Mead, Director-Transportation Issues, GAO, March 22, 1988.

CIP. *Aviation System Capital Investment Plan,* Report to the Congress, Federal Aviation Administration, US Department of Transportation, December, 1990; and *Capital Investment Plan*, Report to the Congress, Federal Aviation Administration, Department of Transportation, December, 1993, pp. 1-0-13-14.

ffp. See: *Free Flight Phase 1 Background*, at http://ffp1.faa.gov./about/about_ffp1.asp

FAA/CATS. http://www.nas_architecture.faa.gov/costs/View_Financial/Program

FAA/03frcst. http://apo.faa.gov/forecast03/Tables

FAA/04frcst. http://apo.faa.gov/forecast04/Tables

Brown, Steven, *Building Today to Ensure Our Future*, Presentation to RTCA Forum, June, 2004, vy Vice President of Operations Planning, Air Traffic Organization, FAA.