FLIGHT TRANSPORTATION LABORATORY
REPORT R94-3

MANAGEMENT PROCESSES IN U.S. AIR TRAFFIC
MANAGEMENT MODERNIZATION: A STUDY OF GLOBAL
NAVIGATION SATELLITE SYSTEM DEVELOPMENT

JOHN H. SANDVIG

MAY 6, 1994

MIT

DEPARTMENT
OF
AERONAUTICS
&
ASTRONAUTICS

**FLIGHT TRANSPORTATION
LABORATORY
Cambridge, Mass. 02139**

Management Processes in U.S. Air Traffic Management Modernization: A Study of Global Navigation Satellite System Development

by

John H. Sandvig

ABSTRACT

This thesis investigates organization and management issues associated with the Federal Aviation Administration's (FAA) efforts to modernize the nation's Air Traffic Management (ATM) system. Focus is placed specifically on efforts by the FAA to implement a satellite-based navigation system in accord with the ICAO's definition of a Global Navigation Satellite System (GNSS). The US Global Positioning System (GPS) provides much of the capability desired in the GNSS, but enhancements are required to meet full capability required for civil aviation purposes. The research examined the working relationships and the management processes used in the course of major system development and acquisition. The research and analysis discovered a strong functional orientation in the FAA. The research also identified a significant difference in cultural attributes between the two major divisions in the agency: Systems Operations and Systems Development. The combination of these differences serves to impede communication and cooperation among development project participants at the agency and, therefore, to inhibit identification and development of new systems to satisfy airspace users needs. In addition recommendations are made for improvements to the agency's acquisition policy and to system development processes.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION AND BACKGROUND

Introduction

The United States has the safest and most efficient air traffic management
system in the world. On an average day there are about 400,000 aircraft flights
through the nation's airspace including over 30,000 flying hours per day in air
carrier operations out of a total of about 150,000 hours per day for flights of all
types.[1] Most procedures used in this system are, perhaps surprisingly,
essentially those developed during the 1930's in an earlier era, with navigation
and communication technology several generations removed from that
available today. In addition to the procedures, much of the air traffic
management infrastructure in use today, including communications, navigation,
surveillance and control automation features are technically obsolescent.
Considering these facts, that the system functions as robustly and safely as it
does is a strong testament to the skills and motivation of the air traffic controller
workforce.

By the same token, both the procedures and hardware and software
infrastructures in use today in the nation's air traffic management system are
patched together by a combination of technical band-aids, misoriented
technology developments only partially realized and incremental improvements
in hidebound tradition. The capabilities of modern commercial technology often
exceed that being employed and implemented by the FAA in its modernization
programs. More importantly, the FAA, which is responsible for the development
of new systems to modernize the ATM system, does not consistently apply a

---

[1] *Aviation System Capital Investment Plan*, p.1-0-11.

disciplined approach to define operational objectives, operational requirements or functional specification to evaluate and select the best approaches to ATM system modernization. While great efforts have been made within the agency to impose a systematic process for new system development and acquisition, certain organizational and management arrangements serve to preclude successful development of these new systems and procedures. The agency is dominated by its System Operations staff which conducts the daily work of operating the air traffic management system. The character and orientation of personnel in the other major staff contributing to modernization development efforts, System Development, differ significantly from those in System Operations, which tends to impede communication between the staffs. The FAA organizational structure and reward system act to further inhibit dialog between the groups. In addition, the acquisition process in place at the agency omits important tasks required for apt project concept definition. Rigorous implementation of the acquisition policy also remains as a goal yet to be achieved.

Thesis Roadmap

The remainder of this chapter provides background information on air traffic management and airspace system needs, brief description of the US Global Positioning System and a description of the major international coordinating body for civil aviation, the International Civil Aviation Organization (ICAO). This chapter also describes the methods used in the thesis research. Chapter 2 describes the organization and culture of the five groups in the FAA that are the major participants in new system development. Chapter 2 also describes the processes used by the agency to conduct new system development and acquisition, to prioritize among alternative projects and to complete capital

7

budgeting for those projects. Chapter 3 analyzes the functional and cultural differences between system developers and system operators and discusses the implications of strong biases among FAA staffs. Deficiencies in staff effectiveness and in system development and acquisition processes are also identified in Chapter 3 and alternatives proposed, including the consequences of a systems thinking approach. The nature and relevance of interactions between the FAA and the international community are discussed in Chapter 3 as well. Finally, Chapter 4 draws conclusions from the analysis and makes recommendations for FAA organization and management.

Background

Air Traffic Management and the National Airspace

The national airspace is finite, and ATM is the method by which aircraft operations are managed to take maximum advantage of the space available. Current ATM operations and technology are reaching their limits; operations at Newark and La Guardia airports, for instance, now face delays on about 10% of all flights[2]. Aircraft operations have increased 40% in the last decade. During that interval, the FAA has been attempting -- and failing -- to implement a more modern, efficient and higher-capacity ATM system. Traffic is expected to grow a further 30% in the next ten years.[3] It is the task of ATM to develop innovative management concepts that allow more numerous and efficient operations within the limited space available. Airspace system users are clearly signaling their need for more capacity. United Airlines, for example, estimates that various flight operations restrictions cost the airline $647 million each year. RTCA, Inc., a not-for-profit aviation advisory corporation, estimates that capacity benefits enabled by more precise navigation and position reporting than

---

[2] *Review of the FAA RE&D Program*, p 7.
[3] GAO/T-RCED-93-36, p 1.

8

currently in the system would generate airline savings of $13.2 billion between 1995 and 2015[4]. The benefits in efficiency and capacity of better ATM are economically enormous. Realizing these efficiency and capacity improvements is one of the function of the Federal Aviation Administration and is one of its most important objectives. Whether the FAA has the appropriate skills and the organizational structure to achieve these objectives is the subject that will be examined in this thesis.

Global Positioning System (GPS)

The GPS is a satellite-based radionavigation system deployed and operated by the Department of Defense (DOD). When fully operational, GPS provides highly accurate three-dimensional position, velocity, and time to users worldwide. Since its inception, in the early 1970s, GPS was envisioned and has proven to be a significant means of enhancing the war fighting capability of US and allied military forces. GPS initial operational capability was achieved in December, 1993 and full capability is anticipated in summer, 1994.

GPS was conceived, developed, and fielded as a military system; specific civil requirements were not included in it design specifications. Nevertheless civil use of the system has always been an implicit consideration. Civil use is growing in importance and integral to the development of policies under which GPS is operated and made available by the cooperative effort of the DOD and Department of Transportation (DOT).

Widespread civil and military use of the system is occurring. Worldwide civil applications of GPS for navigation, positioning and timing are increasing at a

---

[4] Aviation Week, January 10, 1994, p. 53.

rapid rate. Although not yet widely operational in civil aviation, GPS is generally recognized as having the potential to provide the greatest enhancements to worldwide aviation system capacity, efficiency, flexibility and safety since the introduction of radio-based navigation more than 50 years ago.[5]

ICAO/FAA Interactions

The ICAO is the one worldwide organization whose objective is to coordinate and develop standardized civil aviation policies. Virtually all the world's sovereign nations are members. The formal relationship between ICAO and the United States is managed through the Department of State, which delegates authority to the Department of Transportation, and thus to the FAA, for procedural and technical matters. In practical fact, therefore, FAA is the designated US representative to the one pseudo-governmental international civil aviation agency in the world. ICAO is also affiliated with the United Nations, but operates autonomously.

ICAO is composed of several bureaus including three to deal with its main operations: Air Navigation, Air Transport and Technical Cooperation. The Air Navigation Bureau is responsible for world issues relating to aviation communications, navigation, surveillance and weather as well as airspace operations and airworthiness. Since the founding of ICAO, the Director of the Air Navigation Bureau has been an American and usually a former FAA employee.

There are several standing committees that perform the work of establishing technical standards and procedures. In addition, the organization constitutes

---

[5] Joint DOD/DOT Task Force, p. ES-1.

special committees from time to time as may be necessary to study particular issues that develop. The Special Committee on Future Air Navigation Systems, for example, is one of these. The main connection between FAA and ICAO is these technical committees. The FAA supports the work of the FANS committee, like the standing committees, with experienced working-level people; most of them originate in the Systems Engineering and Development group (ASD). Higher level management participation is generally included only when required.

The main role of ICAO, as described to me by a manager in the Air Navigation Bureau, is to promote common understanding on technical issues and establish standards that can be met and adopted by the world's countries. These are referred to as Standards and Recommended Practices (SARPs). ICAO as a body monitors but does not promote any solution that could be considered either controversial or technically immature. At the same time, ICAO is working on a number of institutional issues that were identified as part of the FANS committee work in 1991, including charging practices for global navigation services, reliability, availability and integrity monitoring, and international control structures. A CNS/ATM committee was created to research these topics and is scheduled to report in the autumn of 1994.

Research Methods

There are many possible explanations for, or contributors to, the FAA's difficulties with its ATM system modernization. A fair body of literature has developed which examines the history and analyzes various factors influencing system modernization. A series of reports prepared to support Congressional testimony, in particular, have commented on management issues relating to the poor overall performance in bring the Capital Investment Plan to fruition. These,

11

and other, reports are reference in the bibliography. These reports, however, are fairly high-level; they do not examine in very great detail the internal management and organizational issues which determine the performance of the agency. In addition to the public records, therefore, direct information is considered to be invaluable to obtain the experience, insight, and opinion of managers most immediately involved with the issues of GPS/GNSS development. Issues to be examined included acquisition process definition and practice, organizational structure both formal and informal working coalitions, workload, cultural orientation, definition of the customer, and availability of relevant development tools and skills.

Preliminary conversations with several managers in government, academia and industry led to a perception of the FAA as embodying several general characteristics:

- safety rules -- no activity is countenanced until its safety is assured.

- very conservative and fairly traditional -- policies and procedures are long-lived and evolve from what has gone before; promotion occurs from within.

- bureaucratic -- not governed to any appreciable extent by the Administrator.

- "gray" collar -- there are lots of technicians in the workforce; over 70% of the workers in the FAA are either air traffic controllers or maintenance technicians.

- Operations tends to rule -- 95% of workforce and 69% of the budget are controlled by the Executive Director for Operations.

- System Engineering & Development people are outsiders -- ASD is located apart from Headquarters and the rest of the agency; most of the rest of the agency is involved with running the air traffic control system.

Research Hypotheses

The characteristics enumerated above constitute only the most general, and in some cases, anecdotal description of the FAA. Nonetheless, along with the rich history of developmental difficulty discussed in the first chapter, the general characteristics lead to a series of hypotheses that may be researched:

1) FAA has at least two distinct cultures within its bounds. The majority of the workforce, and perhaps the power center, is grown from the ranks of the air traffic controllers and maintenance technician staffs. The engineers and scientists who comprise Systems Development, including NAS Development (AND) and Systems Engineering & Development (ASD), form a distinct minority culture, set apart from the rest of the agency.

2) Both cultures are involved in, and responsible for, defining and developing new ATM systems and procedures. Neither group is clearly in charge of this process.

3) Neither group, nor the agency as a whole, has a clear image of who its customer is for ATM modernization, what their needs are or how to contribute to successful accomplishment of a common goal.

4) The organizational structure of the FAA is not arranged to ameliorate the obstacles to effective work performance created by two distinct cultures.

These hypotheses were examined by investigating the public record, the open literature and by private interviews with responsible managers at the FAA and in related organizations.

Data Collection

In addition to the standard literature research, interviews were conducted with about ten executives and managers at the FAA. In addition, seven managers from organizations that work closely with the FAA, such as MITRE, Lincoln Lab, Volpe National Transportation Systems Center, ICAO and the ATA were also sampled for information. The focus of the interviews was to elicit managers' perceptions on several topics:

- how are requirements defined for ATM system modernization?
- how are priorities selected from among competing requirements for scarce resources (both financial and human)?
- who controls the budgets? the people?
- who is responsible for system development at different stages of the process?
- how are system selections determined and who is responsible for bringing the new system to "market?"
- what are the ramifications of needing to operate in an international sphere (e.g. as stipulated by ICAO FANS definition)?

Examples of interview guides for FAA officials and for ICAO managers are attached to this report as Appendix A. Managers were selected for interviews based on their functional involvement in GPS/GNSS system development or operation. In almost all cases, managers made themselves available for face-to-face interviews in their offices. In a few instances, in-person meetings could not be arranged, so interviews were conducted by telephone. In a very few cases, no occasion could be arranged to discuss these issues even by telephone for a couple key managers. In general, however, these busy people

were very willing to spend a reasonable amount of time discussing these matters -- generally one hour. In virtually every case, managers were friendly but candid in their responses -- so far as I could judge.

CHAPTER 2: AIR TRAFFIC MANAGEMENT MODERNIZATION PLANS

This chapter describes the modernization plans that have been developed in the US by the FAA and internationally by the ICAO. Historical perspective is provided to the US plans starting with a description of the original National Airspace System (NAS) Plan and proceeding through the current Capital Investment Plan (CIP). International plans as defined by ICAO are not as detailed at the project level but also define a suite of systems to provide modern ATM services. Finally in this chapter a comparison is drawn of the US CIP with the international ICAO plans.

US ATM Modernization Plans

A short description of the Air Traffic Management (ATM) system is in order prior to any description of the plans to update or improve the system. ATM is composed of "air traffic control" and " traffic flow management". Air traffic control refers to the tactical safety separation service that prevents collisions between aircraft and between aircraft and obstructions. Traffic flow management refers to the process that allocates traffic flows to scarce capacity resources such as airspace, runways and taxiways. Air traffic management, then, is the composite process that ensures safe, efficient and expeditious movement of aircraft from origin to destination. The ATM system requires controllers to communicate with each other and with pilots; requires flight crews and controllers to know their aircraft position and direction of flight with varying degrees of accuracy during different phases of flight; requires both controllers and flight crews to have timely access to relevant weather information. The basic building blocks supporting the ATM system are the communication, navigation, surveillance

and weather reporting functions. In addition, high speed computers are essential to automate of large amounts of data processing required to aid controllers in their performance of ATM duties.

Goals for the future ATM system are:

- maintain and improve the safety of flight operations

- increase system capacity and fully utilize capacity resources as required to meet traffic demands in all visibility conditions

- better accommodate user-preferred flight trajectories

- better accommodate the full range of aircraft types and avionics capabilities

- improve aviation for users, including weather observations and forecasts, traffic congestion and delays, status of NAS facilities and airports, and in-flight situational awareness based on cockpit display of traffic information

- improve navigation and landing capabilities, including curved approach, missed-approach, and departure guidance and eventually a satellite-based capability approaching Category I. Category II precision operations should be supported at all airports serviced by air carriers with Category III provided at the pacing airports[1]

- increase user involvement in decision-making, including computer-based, air-ground negotiation of flight trajectories.[2]

---

[1] Category I is an instrument landing system approach procedure that accommodates landing with 200 foot ceiling and runway visual range of at least 1800 ft; Category II with 100 foot ceiling and runway visual range not less than 1200 ft.; Category IIIa with no minimum (i.e. zero) ceiling and runway visual range of 700 ft; Category IIIb with no ceiling and runway visual range of 150 ft; Category IIIc with no ceiling and no (i.e. zero) runway visual range.

[2] Concepts and Description of the Future ATM System for the US, p. 4.

National Airspace System (NAS) Plan

Pressure mounted in the late 1970's to modernize the nation's air traffic management (ATM) system as the national airspace system became increasingly crowded. The national ATM system had evolved incrementally from the earliest days of air traffic control in the 1930's; most of the procedures and much of the equipment supporting the system was based on the technology of that era. The number and complexity of aircraft operations through the airspace was on the rise partly as a result of the increased number of operations due to airline deregulation and also due the sharply rising number of sophisticated general aviation operations. Many general aviation operations use the full capability of the system to operate in virtually all weather with high performance aircraft. In response to these pressures and in recognition of the availability of new technology, in 1981 the FAA developed and approved a grand plan to modernize the nation's ATM system. The project was entitled the National Airspace System (NAS) Plan and was intended as a coherent approach to the modernization of the nation's aviation airspace-related infrastructure[3]. It incorporated a comprehensive set of projects to address impending obsolescence in all functional areas of the system architecture, including automation, telecommunication, navigation and landing, surveillance, weather and maintenance and operations. These functional areas are defined by the FAA[4] as:

Automation -- Those subsystems that provide assistance to system operators
   to satisfy airspace user needs for service including the accommodation of

---

[3] Other aspects of the nation's aviation infrastructure, notably airports and security-related issues are handled by means of another major program: the Airport Improvement Program (AIP). The AIP deals with airport facilities improvements including runways, taxiways and parking areas, passenger and cargo handling areas and airport and aircraft operations security. Further discussion of the AIP is beyond the scope of this paper.
[4] *Aviation System Capital Investment Plan*, p. 1-0-19.

increasing demand, desire for user preferred routes/altitudes , and delivery of improved weather services.

Telecommunications -- The subsystems that provide the capability for the air/ground and ground/ground voice and data communications, and the inter-facility communications of information such as aircraft surveillance data.

Navigation and Landing --Those subsystems that provide pilots with accurate knowledge of their aircraft position so that they can properly navigate the aircraft in all weather conditions.

Surveillance -- Those subsystems that provide the position data of aircraft in the US airspace, on the airport surface, and over the ocean.

Weather -- The subsystems that provide both pilot and controller with the meteorological information necessary to ensure safe and efficient aircraft and system operations. This includes knowledge of weather phenomena, such as severe weather, windshear, clear air turbulence, microbursts, wake vortex, wind aloft, precipitation, and icing.

Maintenance and Operations -- The subsystems that ensure high quality service and provide continued operation of the various system elements through monitoring, control, maintenance, and testing of hardware and software components.

The NAS Plan originally consisted of 82 separate projects among the functional areas. The plan was expected to require $12 billion (1991 dollars) and ten years to complete. To date 28 have been completed and 1 was canceled. The remaining 53 projects are still under development in various stages of completion. Current estimates at completion exceed $32 billion and a total of 20 years from inception.[5]

Brief descriptions, as detailed in a recent GAO report, of thirteen of the most important projects in the original NAS Plan and still under development follow:

---

[5] GAO/RCED-91-152, p 7.

Automation Projects

Advanced Automation System (AAS) -- The AAS is to provide a new automation system that includes improved controller work stations, computer software, and processors. The AAS will provide: the capacity to handle the projected traffic load and capability to perform the new functions to be introduced into ATC into the 21st century; increased productivity through introduction of new controller workstations and displays; a high degree of reliability and availability; and the capability for enhancement to perform other functions subsequently introduced into the system[6]. The program is to implemented in five phases.

Flight Service Automation System (FSAS) -- This project is intended to improve pilot access to weather information and NOTAMs, simplify flight plan filing, and provide a flight service system that can handle projected increases in demand for flight services without proportional increases in staff.[7] This use of automation is expected to yield significantly increased flight service personnel productivity.

Communications Projects:

Voice Switching and Control System (VSCS) -- This project is to provide a voice communications system between air traffic controllers and flight crews and between different air traffic control segments. The system will provide intercom, interphone, and air/ground voice connections for air traffic control operations in Air Route Traffic Control Centers (ARTCC) and an Area Control Facilities (ACF). The VSCS must satisfy the voice communications

---

6 *Aviation System Capital Investment Plan*, p. 2-1-9.
7 *Aviation System Capital Investment Plan*, p. 2-3-1.

reconfiguration, service, quality, and availability needs of the ARTCC/ACF users. The VSCS is expected to reduce lease costs, increase modularity and growth capability, and increase controller productivity over current services.[8] The system is expected to increase controller efficiency and allow safer handling of anticipated increases in air traffic.

Radar Microwave Link (RML) Replacement and Expansion -- This project will replace and expand the aging RML. The system consists of three major subsystems to manage and transmit voice and data communications between ATC facilities. It is expected to reduce costs and promote safety by providing an effective, reliable voice and data service connecting ARTCCs, long-range radars, and other air traffic facilities.[9]

Navigation and Landing Projects:

Microwave Landing System (MLS) -- In 1978 MLS was adopted by the ICAO as a world standard to replace instrument landing systems (ILS) and to provide precision approach capability where ILS will not function. MLS provides the precision guidance that is expected to satisfy the full range of operational requirements for all types of aircraft in all types of landing. MLS can improve capacity by providing lower landing weather minimums which allows more flight operations in poor weather, and by providing precision approach capability where ILS is not possible. MLS features could be particularly beneficial in multi-airport environments such as Chicago, New York or San Francisco.[10,11]

---

[8] *Aviation System Capital Investment Plan*, p. 2-1-7.
[9] GAO/RCED-93-121FS, p. 22.
[10] *Ibid.*
[11] *Aviation System Capital Investment Plan*, p. 2-4-4.

<u>Surveillance Projects:</u>

Air Route Surveillance Radar (ARSR-4) -- This project provides for long-range surveillance radar, enroute navigation, air defense, and drug interdiction. The system will reduce costs by substituting unmanned radar for old, hard-to-maintain systems and by reducing the number of site operators required to run the system.[12]

Airport Surface Detection Equipment (ASDE-3) Radar -- ASDE-3 will provide radar surveillance of aircraft and airport service vehicles at high activity airports. This system will enable controllers at busy airports to monitor ground activity of aircraft and other vehicles under all weather conditions. The system can scan the entire airport and focus on particular areas for increased scrutiny. It will increase surface safety and collision avoidance by replacing aging and less reliable radar equipment.[13]

Airport Surveillance Radar (ASR-9) -- ASR-9 provides highly accurate monitoring of aircraft movement and position within a 60 mile radius of the airport terminal. The system will replace aging ASR-4/5/6 systems which are hard to maintain and for which spare parts are in short supply. The system can display aircraft and weather information simultaneously. It should increase safety at busy airports by providing more accurate data to separate and control movement of aircraft in and out of the terminal area.[14]

Mode Select (Mode S) -- Mode S will improve the surveillance capability of the ATC radar beacon system. It will reduce signal interference between aircraft

---

[12] GAO/RCED-93-121FS, p. 22.
[13] *Aviation System Capital Investment Plan*, p. 2-4-15.
[14] *Aviation System Capital Investment Plan*, p. 2-4-13.

and establish a clear message channel between the aircraft and ground facilities. In addition, it provides the medium for a digital data-link which will be used for exchanging information between aircraft, various ATC functions and weather databases. Pilots will be able to access weather information independent of air traffic controllers. It will also improve safety by identifying aircraft location more accurately than with the current system.[15]

Weather Projects:

Automated Weather Observing System (AWOS) -- This project will automatically collect aviation-critical data (such as wind velocity, temperature, dew point, altimeter setting, cloud height, and visibility). The system processes and transmits weather data to pilots upon request, via synthesized computer voice. It will improve safety at small airports without control towers and eliminates or reduces errors at large airports. When integrated with the AWOS Data Acquisition System and the Weather Message Switching System, it will make near real-time weather available to pilots thereby improving safety and efficiency.[16]

Central Weather Processor (CWP) -- This project improves the collection, synthesis, and dissemination of weather information throughout the national airspace to pilots, controllers, traffic management specialists and meteorologists. The system also provides some meteorologists with automated workstations which greatly enhance their ability to analyze rapidly changing, potentially hazardous conditions. The system is intended to reduce weather-related accidents and air traffic delays.[17]

---

[15] *Aviation System Capital Investment Plan*, p. 2-4-12.
[16] *Aviation System Capital Investment Plan*, p. 2-3-8.
[17] *Aviation System Capital Investment Plan*, p. 2-3-2.

The projects described above are only a sampling of the those undertaken in the NAS Plan, but represent a spectrum of the more important systems targeted for creation or improvement. Notably absent from this list is any mention of satellite-based assets. At the time of the development of the original NAS Plan, 1981, mobile satellite communications had already been in use for several years in maritime environments. Significant experimental successes had already been accomplished in civil aeronautical satellite communications as well. Military satellite communications were commonplace at the time. In addition satellite-based navigation had been proven with the Navy's operational Navsat program from the mid-1970s. The US Air Force had been developing its Global Positioning System (GPS) concept since the early 1970s. Both the Air Force and private industry had acquired extensive experience with the prototype constellation of Block I Navstar GPS of satellites from the late 1970s. Indeed, the Air Force had authorized plans and funding to proceed with a fully operational system of Block II satellites with production beginning in 1993. At the time of NAS Plan formulation GPS was expected to be fully operational by 1989.[18] Yet in 1981 the FAA did not identify any satellite-based assets as being important to the NAS Plan.

The Capital Investment Plan

Although the NAS Plan was comprehensive for its day, there was no expectation that the plan should be static. Normal development activities serve to identify needs that had previously been unrecognized, or unlabeled. Similarly technology developments can enable solutions that had not earlier

---

[18] Aerospace America, July 1984, p. 42.

been contemplated. Two examples of projects added in recognition of legitimate needs, or enabled by new technology follow:

Terminal Doppler Weather Radar (TDWR) -- The system is intended to detect windshear, gust fronts, wind shifts, microbursts and precipitation around airports. The main benefit of the system is to promote safety by providing alerts of hazardous weather conditions in terminal areas and of changing wind conditions that influence runway usage.[19]

GPS Monitors -- This project provides a monitor system to enable use of GPS by civil aviation for supplemental enroute navigation and non-precision approaches. This project is, by itself however, insufficient to obtain the benefits that would accrue to GPS from precision approaches if it were enhanced.

While the NAS Plan was very ambitious in its objectives, the FAA quickly ran into problems with development budgets and timelines. Deficiencies uncovered in the course of development of NAS Plan projects identified new projects that would be required to complement the original plan. Other projects would also be required to stop the gaps produced by development delays. By 1990 the NAS Plan was sufficiently behind schedule and over budget that it was renamed the Capital Investment Plan (CIP) to reflect its more expansive scope.

An examination of the thirteen projects in the original NAS Plan which are still included in the current CIP is illustrative of the extent of the problems the FAA has encountered with its various system developments. Table 1 shows the

---

[19] GAO/RCED-93-121FS, p. 22.

differences in key schedule milestones between the 1983 NAS Plan and the
1992 CIP.

Table 1: Delays in Major Capital Investment Plan Projects[20]

	First-site Implementation				Last-site Implementation			
	Year of first-site implementation			Years delayed	Year of last-site implementation			Years delayed
	83 NAS	91 CIP	92 CIP	83-92 plan	83 NAS	91 CIP	92 CIP	83-92 plan
AAS	1990	1991	1991	1	1994	2001	2002	8
ARSR-4	1985	1993	1994	9	1995	1996	1996	1
ASDE-3	1987	1992	1993	6	1990	1994	1996	6
ASR-9	1985	1989	1989	4	1992	1993	1996	4
AWOS	1986	1989	1989	3	1990	1997	1997	7
CWP	1990	1991	1991	1	1991	1998	[21]	20
FSAS	1984	1991	1991	7	1989	1995	1995	6
MLS	1985	1997	1997	12	1999	2008	2008	9
Mode S	1986	1993	1993	7	1993	1996	1996	3
RML	1985	1986	1986	1	1989	1994	[20]	20
TDWR	[22]	1993	1993	[21]	[21]	1996	1996	[21]
VSCS	1989	1995	1995	6	1992	1997	1997	5
Avg. Delay				5				5

But if the schedule delays in Table 1 seem large, consider the magnitude of the
changes in unit costs for these equipment over the same intervals. Table 2
itemizes the relevant unit cost information for these systems.

On some of these project the news continues to deteriorate. In March, 1994 the
FAA again revised its estimate for completion of the AAS project. FAA
managers now expect that the project will require a total of between $6.5 billion
and $7.3 billion and an additional nine to 31 months to finish the project. The
project was originally to achieve its first installation in Seattle in 1990, but the
best guess now is 1998 for that milestone. This represents an increase in unit

---

[20] GAO/RCED-93-121FS, p. 27.
[21] Being reevaluated; don't know last-site implementation date.
[22] TDWR was not included in the 1983 NAS Plan

costs of 214% -- or two-thirds larger overrun than estimated as recently as one year ago[23].

Table 2: Changes in Unit Cost for 11 Major CIP Projects[24]
(in millions of 1993 dollars)

Project	83 F&E cost	83 planned units	83 F&E cost index	93 F&E costs	93 planned units	93 F&E cost index	Percent change in unit cost
AAS	$2070	23 facilities	$90	$4703	23 facilities	$205	127
ARSR-4	426	48 radars	8.9	383	39 radars	9.8	11
ASDE-3	83	21 radars	4.0	191	44 radars	4.3	10
ASR-9	931	96 radars	9.7	840	124 radars	6.8	-30
AWOS	161	700 units	.23	230	737 units	.31	35
FSAS	305	61 stations	5.0	371	61 stations	6.1	22
MLS	1246	1250 systems	1.0	2624	1280 systems	2.1	105
Mode S	487	197 systems	2.5	473	137 systems	3.5	40
RML	264[25]	1000 sites	.26	313	871 sites	.36	38
TDWR	550[23]	102 radars	5.4	351	47 radars	7.5	38
VSCS	259	25 units	10.3	1407	25 units	56.3	444

The FAA also finally added a CIP project in 1993, when GPS was actually approaching initial operational capability, to more fully address the desired capability of GPS for precision approaches and including reliability and availability monitoring and differential signal generation.

---

[23] *Wall Street Journal*, March 4, 1994, p B7B.

[24] GAO/RCED-93-121FS, p. 25.

[25] Cost data from 85 for RML and 87 for TDWR since earlier data are insufficient to calculate index.

ICAO Modernization Plans - Future Air Navigation System (FANS)

The Special Committee on Future Air Navigation Systems (FANS) was established by the ICAO Council at the end of 1983 with the purpose of identifying and assessing new concepts and technology applicable to air navigation. The group purposefully considered satellite technology among the options studied. Recommendations were to focus on developments suitable for international civil aviation air navigation over a horizon of approximately 25 years. In May, 1988 the report of the fourth meeting of the FANS committee[26] identified three basic shortcomings of the current communication, navigation and surveillance (CNS) systems around the world:

- propagation, accuracy and reliability of the world's current line-of-sight systems are severely limited.
- practical impossibility to standardize installation and operations of current CNS systems everywhere in the world.
- lack of digital air-ground data interchange and the limits of voice communication systems insufficient to support the data streams required for a modern automated traffic management system in the air or on the ground.

The committee went on to say that in order to respond to users' needs, new systems should provide for:

- global communication from very low to very high altitudes including remote, off-shore and oceanic areas.
- digital data interchange capability to exploit the automated capabilities of airborne and ground-based systems.

---

[26] Report of the Special Committee on Future Air Navigation Systems, 1988, p. 1.

• navigation and approach aids for landing areas not equipped with precision landing aids (i.e. ILS or MLS).[27]

At the Tenth Air Navigation Conference of the ICAO, in September, 1991, all nations agreed that the future worldwide system of air navigation would be based on CNS capabilities provided by satellite technology. While the specific details of air traffic services would continue to be the responsibility of the sovereign nations using the guidance provided by ICAO standard and recommended practices (SARPs), leaders agreed that all nations would begin to plan the transition to a common global CNS system.[28]

The systems identified for incorporation into FANS are detailed in Table 3. FANS does not include automation, weather or maintenance and operations; these functions are beyond the purview of the Special Committee on FANS. Certainly the communication, navigation and surveillance functions, as well as the procedures used by the controllers need to be standardized throughout the world to obtain maximum safety and efficiency. The communication, navigation and surveillance functions are the most immediately experienced by the flight crews, and therefore the most crucial to seamless worldwide air traffic management.

---

[27] Report of the...FANS/4, p. 1.
[28] National Challenges...for ATM, p 11.

Table 3: Future Air Navigation System Equipment Architecture[29]

	Domestic Airspace	Oceanic Airspace
Air-Ground Communication		
• Voice	• Existing VHF Radio	• New Global Satellite Service • HF Radio to be phased out
• Data	• New Global Satellite Service • Mode S in High Density Terminal Areas	• New Global Satellite Service
Radio navigation		
• Areawide	• Navigation performance req't in lieu of technology standard • GNSS assumed • VOR/DME and NDB to be phased out.	• Navigation performance req't in lieu of technology standard • GNSS assumed
• Precision Approach	• MLS to replace ILS as international standard	
Air Traffic Surveillance		
• Ground	• SSR Modes A, C and S • Supplemental Satellite-based ADS. • Primary radar optional for weather and defense	• Satellite based ADS
• Airborne	• TCAS Assumed	• TCAS Assumed

ICAO did not adopt, nor did the FANS committee recommend, the use of GNSS for precision approaches. The capability of the GPS satellite navigation systems to provide navigation accuracies sufficient to perform these functions -- at least to Category II precision approaches -- is now thought to be practical within a couple years or so. Although questions persist as to the optimal approach to provide the correction signals and integrity monitoring to achieve the required characteristics, since there is substantial experimental data that the capability will be practical and economical it seems likely that if the Air Navigation Conference were meeting today, they would also confirm the use of GNSS for these purposes as well as those stated in Table 3.

---

[29] Ibid., p. 12.

It is apparent that ICAO has made a concerted effort to avoid selecting specific technical approaches to accomplishing the various functions. With the exception of SSR Mode S, TCAS and MLS which are technical standards that have existed for years and are already embodied in hardware, the FANS suite does not specify particular technology. The satellite-based technology is selected to treat the limitations identified in the committee's report from 1988 and still leaves numerous options, as shown in Appendix B to this report.

Comparison of CIP and FANS

The purposes of the CIP and FANS definitions are substantially different. The CIP is a detailed planning document used to define and justify to Congress the hardware development and acquisition projects the FAA manages in order to modernize and operate the ATM system under the continuing stress of daily operations and capacity constraints. The FANS definition, on the other hand, is a more strategic view of the CNS technologies to be adopted in order to reach the next plateau of traffic management capability. Definition of FANS would, of course, require considerable more detail and much finer parsing in order to either appropriate public funds or implement the technical details heretofore undefined.

Nonetheless the approaches that have been adopted under the auspices of the ICAO Special Committee on FANS were known to the US since FAA personnel have been full and active members in that Committee. FAA participation was provided by working-level people primarily out of the FAA Systems Development division. Yet the 1992 CIP, which is the latest complete plan

available, has only three satellite-based system projects (Oceanic Satellite Communications, Satellite Communications Circuits System and GPS Monitors). GPS, while possessing the basic capability required for enroute navigation stipulated in the FANS concept (as well as accuracy suitable for non-precision approaches, which was not specified), does not have the reliability, availability, or integrity assurances that are required for a component of the civil ATM system. The FAA has done nothing (until within the last year or so) to prepare to provide these features to the nation's airspace users. Instead, they have continued to focus on system modernization plans some of which are obsolescent at more than twelve years old -- and they continue to fail even at those modernization projects.

What is wrong with the management and organization of the FAA that this can be so? How is the FAA organized to implement the GNSS provisions of the FANS concept? Is there any reason to believe GNSS projects will fare any better than the CIP projects identified in Tables 1 and 2? What can the FAA and the rest of the community do to ensure the success of GNSS implementation?

CHAPTER 3: ORGANIZATION STRUCTURE AND DEVELOPMENT PROCESSES AT FAA

This chapter describes the organization of the Federal Aviation Administration. There are two main players in the conduct of the FAA's affairs and particularly with respect to its modernization efforts: Systems Operations and Systems Development. Within these two major divisions, there are many other sections and groups that are involved in new development activities. The organization is complex and some effort is required to comprehend the several offices that contribute to ATM modernization as relates to GPS/GNSS. Two key players within System Operations (Air Traffic Service and the Flight Standards Service) and three groups in System Development (NAS Development, Systems Engineering Service and R&D Service) and their roles and responsibilities are discussed in some detail. Several points become evident in the following examination:

- The organization is complex.
- Organizational boundaries are formed along strong functional lines.
- Many participants in development efforts do not understand who the other participants are.
- Many participants do not fully understand the development process nor do they understand their own, or other participants', responsibilities in the process.

This chapter also describes the two important formal processes in the management of new system acquisition: the Acquisition Policy and the Capital Investment Plan determination process. Several observations are drawn from the investigation of these processes:

- The formal acquisition policy is a fairly recent addition to FAA management processes

- Many participants do not fully understand the acquisition policy.

- Discipline in performing according to the acquisition policy is lacking, but is improving.

- A highly formalized planning and budgeting process has been defined to allocate budget to CIP projects and to define new projects.

- The new project definition process separates responsibility for mission needs analysis between the main functional divisions so their is no clear responsibility for Operations to define their needs.

Finally in this chapter discusses the background, education and culture of personnel within the two major divisions of the agency. The examination reveals that

- There are strong cultural differences between the major organizational groups.

- Management culture favors an organizational arrangement that tends to emphasize boundaries between groups.

FAA Organizational Structure, Roles and Responsibilities

This section describes the organizational arrangement of the FAA and the main contributors to GPS/GNSS development activities: Air Traffic, Flight Standards, NAS Development, Systems Engineering, and the R&D Service.

FAA Organizational Arrangement

The FAA organizational structure displays very strong functional bias. The main divisions within the FAA are System Operations and System Development. There are also several other divisions to provide management and business

support services to the agency. These are depicted in the FAA Organization Chart in Figure 1. This is the highest level of functional differentiation in the agency and is profound. The Operations people are predominantly air traffic controllers and operatives of other types; they have few, diffused responsibilities for new developments. System Developers are mostly engineers, scientists and analysts; they have no responsibilities for daily system operations.

System Operations is the much larger of the two major divisions. The major power centers are located one level below the division level Executive Directors -- at the Associate Administrator level. One senior manager likened the Associate Administrators to "feudal lords -- able to pass out resources and perquisites at a whim." Managers at the Associate Administrator level are typically long-time FAA employees and have been in their jobs for several years or more. Officials at the next higher level of management above Associate Administrator, for comparison, are more mobile although those positions are not political appointments. Of course the Administrator and the Deputy Administrator are political appointees and as such they tend to move through their post fairly quickly. One fellow stated that the average tenure of an Administrator is less than 2 1/2 years over the last twenty years.

All the Associate Administrators are either in the Operations or Development Divisions. In other words, the real work of the FAA and most of its employees are subsumed within these two divisions.

Federal Aviation Administration

AOA-1 267-3111
Administrator
David R. Hinson
ADA-1 267-8111
Deputy Administrator
Joe Del Balzo, acting

AGC-1 267-3222
Chief Counsel
Mark Gerchick

ACR-1 267-3254
Assistant Administrator
for Civil Rights
Leon Watkins

AGI-1 267-3277
Assistant Administrator
for Government and
Industry Affairs
George Caudill, acting

AIT-1 267-7203
Assistant Administrator
for Information
Technology
Theron Gray

APA-1 267-3883
Assistant Administrator
for Public Affairs
Bob Buckhorn, acting

ABA-1 267-3721
Assistant
Administrator
for Budget
and Accounting
Nicholas Stoer

ARP-1 267-9471
Assistant
Administrator
for Airports
Quentin Taylor,
acting

ACS-1 267-9863
Assistant
Administrator
for Civil
Aviation Security
Orlo Steele

AHR-1 267-3456
Assistant
Administrator
for Human
Resource
Management
Herbert McLure

API-1 267-3033
Assistant
Administrator
for Policy,
Planning, and
International
Aviation
Dale McDaniel,
acting

AXO-1 267-7111
Executive Director
for System Operations
Monte Belger, acting

AXD-1 267-7222
Executive Director
for System Development
John Burt

AXQ-1 267-7720
Executive Director
for Acquisition
and Safety Oversight
Darlene Freeman, acting

Office of
Accounting

Office of
Budget

Office of
Airport
Planning and
Programming

Office of
Airport
Safety and
Standards

Office of
Civil Aviation
Security
Intelligence

Office of
Civil Aviation
Security
Operations

Office of
Civil Aviation
Security
Policy and
Planning

Office of
Civil Aviation
Security
Program
Management

Office of
Human
Resource
Development

Office of
Labor and
Employee
Relations

Office of
Personnel

Office of
Training and
Higher
Education

Center for
Management
Development

Office of
Aviation
Policy,
Plans, and
Management
Analysis

Office of
Environment
and Energy

Office of
International
Aviation

Europe
Africa, and
Middle East
Office

AAT-1 267-3466
Associate
Administrator for
Air Traffic
William
Pollard

Air Traffic
Plans and
Requirements
Service

Office of
Air Traffic
Program
Management

Air Traffic
Rules and
Procedures
Service

Office of
Air Traffic
System
Effectiveness

Office of
Air Traffic
System
Management

AVS-1 267-3133
Associate
Administrator for
Aviation
Standards
Brooks Goldman
acting

Office of
Accident
Investigation

Office of
Aviation
Medicine

Office of
Aviation
System
Standards

AAF-1 267-8181
Associate
Administrator for
Airway Facilities
Arnold
Aquilane

NAS
Transition and
Implementa-
tion Service

Operational
Support
Service

Systems
Maintenance
Service

AVR-1 267-3131
Associate
Administrator for
Regulation and
Certification
Anthony
Broderick

Aircraft
Certification
Service

Flight
Standards
Service

Office of
Rulemaking

Office of
System
Capacity and
Requirements

AND-1 267-3555
Associate
Administrator for
NAS Development
John
Turner

Program
Manager for
Advanced
Automation

Program
Director for
Automation

Program
Director for
Communica-
tions

Program
Director for
Navigation
and Landing

Program
Director for
Surveillance

Program
Director for
Weather and
Flight Service
Systems

ASD-1 267-8535
Associate
Administrator for
System
Engineering and
Development
Martin
Pozesky

Facility
System
Engineering
Service

NAS Program
Management
Service

NAS System
Engineering
Service

Operations
Research
Service

Research and
Development
Service

ASU-1 267-8513
Associate
Administrator for
Contracting and
Quality Assurance
Carolyn
Blum

FAA
Technical Center
Director
Harvey Safeer

ASF-1 267-9613
Associate
Administrator for
Aviation Safety
Darlene
Freeman

Office of
Integrated
Safety
Analysis

Office of
Safety
Information
and Promotion

Office of
Acquisition
Policy and
Oversight

Office of
Independent
Operational
Test and
Evaluation
Oversight

Alaskan
Region
Regional Administrator
Jacque Smith

Central
Region
Regional Administrator
Jim Haight

Eastern
Region
Regional Administrator
Bill Hendel, acting

Great Lakes
Region
Regional Administrator
Ed Phillips

New England
Region
Regional Administrator
Arlene Feldman

Northwest
Mountain Region
Regional Administrator
Fred Isaac

Southern
Region
Regional Administrator
Ted Beckloff

Southwest
Region
Regional Administrator
Clyde DeHart

Western-Pacific
Region
Regional Administrator
Carl Schellenberg

Mike Monroney
Aeronautical Center
Associate Administrator
Mac McClure

*All telephone numbers are in the 202 area code

FIGURE 1:   FAA Organization Arrangement

36

<u>System Operations Organizations Critical to GPS/GNSS.</u>

Systems Operations is the mainstay of the FAA. It is responsible for all the daily operations of the agency, including air traffic control, control procedures, facilities installation and maintenance, regulation and certification standards for aircraft, airmen and facilities. In a very real sense everyone else at the agency is necessary to help the Operations staff provide effective services to the flying public. Together with the few hundred administrative people at FAA Headquarters, Operations accounts for 94% of the permanent personnel in the agency.

Of the several Associate Administrators in this division, one of them controls *over half of the entire FAA workforce* -- the Associate Administrator for Air Traffic.

Systems Operations -- Air Traffic Service

In addition to managing the operational air traffic controllers, this section has groups responsible for Plans and Requirements, Program Management, Rules and Procedures, and System Effectiveness. These are jointly responsible for planning ATM service, managing ongoing and new ATM programs, developing new ATM procedures, measuring and ensuring ATM system effectiveness and actually managing the nation's air traffic. One might jump to the conclusion that these groups, in some combination, would be responsible for all aspects of ATM modernization including GPS/GNSS development. Based on lines of responsibility at FAA, however, ATM system development and operation is much more complicated than this.

There is an important feature in the lines of ATM responsibility among FAA staffs. As one manager within the Air Traffic section of Operations described it

to me -- Air Traffic is responsible for the ground-based components of the ATM system. Airborne assets relating to ATM are deemed to be the responsibility of the Flight Standards Service which is another arm of the Systems Operations Division (refer to Figure 1). It would be more accurate, perhaps, to describe Air Traffic groups as responsible for the communication and surveillance functions (whose equipment and displays are mostly on the ground); Flight Standards is responsible for the navigation and landing functions (whose equipment is also mostly on the ground but whose displays are almost entirely in the cockpit).

Systems Operations -- Flight Standards

Thus it is the Flight Standards group that is logically responsible for defining the need, or being the sponsor for satellite-based navigation systems. Yet this responsibility was evidently not explicitly assigned, nor clearly understood.

The fact that GPS/GNSS did not conform with any one of the traditional system segments as defined by the existing system architecture (i.e. ground-based, vs. cockpit-based), resulted in GPS/GNSS being *essentially ignored* by the agency for years as it was being developed by the DOD and as the civil aviation industry prepared to take advantage of the robust services promised by the system. A key manager in the Flight Standards section described the vigorous demands for satellite-based services originating from the airlines, the international community and other airspace users as stimulating him to *volunteer* to perform the role of GPS system sponsor within the FAA. He clearly felt thrust into the role *by default*, in other words by a clear and glaring need that was not being met by anyone. Although he now regards the territory as his own, it is not clear that he should have understood it to be his responsibility from the outset. The responsibilities of the various groups are simply not stated

38

clearly. Even now, though many people understand Flight Standards to be responsible for GPS, it is not widely understood within the agency that this group is responsible for defining needs related to space-based communication and navigation. Part of the reason is because people at FAA think so much in terms of system technology solutions rather than operational needs. This issue will be discussed more in Chapter 4.

System Development Groups Critical to GPS/GNSS Development

There are two other Associate Administrators from the Systems Development division that play important roles in the development of new systems and in the fielding of GNSS/GPS.

System Development -- NAS Development

The NAS Development section is responsible for acquisition management of those items identified as standard components of the NAS. This group is essentially responsible for managing the acquisition projects that form the Capital Investment Plan (CIP). This group is responsible for defining detailed specifications, qualifying and selecting contractors in concert with other FAA business groups to design, fabricate and install the equipment, and for managing the contractor performance. Interestingly, the GNSS/GPS component which, despite the fact that it is already certified by the FAA for enroute and non-precision approach navigation and thus is a basic piece of the NAS, has no program office in the NAS Development division. The fact that GPS was developed, tested and is today being maintained and operated by the DOD is the explanation managers give for lack of GPS oversight in the NAS Development division.

GPS does not meet all the requirements of GNSS as defined by FANS. The US DOD has no plans for further developments of GPS for purposes of civil navigation. Thus, further development of various assets is required to satisfy the deficiencies of GPS with respect to reliability, availability and integrity monitoring and to enhance navigation accuracy for more robust navigation service. This further development is currently being performed by the other key division in System Development. The System Engineering & Development section is responsible for working with users (i.e. airlines, general aviation, and the flying public) and other agency organizations (e.g., Air Traffic Plans and Requirements, Air Traffic System Management, and Flight Standards Service) to define functional needs, propose alternative hardware, software or procedural solutions, conduct trade studies among the alternatives and recommend an approach to satisfy the need. The work of this section tends to be exploratory; it could be described as applied research or exploratory development rather than system development. Typically, when a project matures to the system development stage and receives formal Facilities and Equipment (F&E) funding authorization it transfers from the Systems Engineering & Development to the NAS Development division.

A GPS/CNS Systems Office was created within the Systems Engineering & Development section in the autumn of 1993. This office was established primarily to be a high-level management coordinating office for all satellite-based communication, navigation and surveillance activities at FAA. GPS is the most urgent and visible of these at the moment, but other initiatives are also moving along. This office does not have responsibility for specific development actions, but works to coordinate the other diverse offices involved at the agency.

The fact that this office was necessary is evidence of the complexity of FAA's organization as relates to new satellite-based ATM systems development.

The essential work of the Systems Engineering & Development section as applied to the details of new system development, such as GPS/GNSS, is accomplished by the Systems Engineering Service and the R&D Service.

System Engineering & Development -- System Engineering Service

The Systems Engineering Service (ASE) is responsible for supporting internal FAA sponsor of new system requirements through the Mission Needs Analysis. The group is essential to the successful completion of engineering trade studies, which it manages in concert with the R&D Service, the sponsor and other offices within the agency. Representation on many of the ICAO committees originates in this group.

System Engineering & Development -- Research & Development Service

The Satellite Navigation Program Office is in the R&D Service (ARD). Since GPS was not a civil development program, the FAA has until quite recently had little influence on GPS specifications or operations although they have been active observers of the DOD developments over the last several years. What little interest was evidenced by the FAA in GPS development was centered in the R&D Service.

Even though GPS has been in development for 15 years, the Dept. of Transportation, of which the FAA is a part, reached an accord with DOD only this year regarding joint operation and access to the system.[1] The announcement of the accord came as a surprise to most of the aviation

---

[1] Aviation Week, January 3, 1994, p. 32.

41

community who expected the DOD to maintain exclusive control over the system. After a six month study, a DOT/DOD task force determined that a joint Executive Board would be the most effective means of balancing civil and military needs. Indications are strong that the clamor from civil, and in particular international, users (who prefer that GPS be managed by an international body), rather than the FAA were deciding influences behind this agreement.

Observations Regarding Organizational Fit and GPS/GNSS

The advent of a new system approach or technology, such as that presented by satellite-based resources, can cause the patterns of organizational responsibility to break down. Some, perhaps many, people at FAA think of the division of responsibilities between sections within the Operations division as based on whether the related systems are on the ground or in the airplane. When the situation develops in which a new system does not conform to these patterns, such as when the displays are in the airplane and the major equipment is in space, ownership and responsibility for the concept can either be neglected or lost entirely. There is strong evidence that the knowledge and expertise of GPS systems resides primarily with the R&D Service rather than in any Operations group. There is further evidence that since there is an · incomplete or imperfect fit between traditional Operations group responsibilities and GPS/GNSS, internal FAA sponsorship of GPS/GNSS was only belatedly accomplished. The expertise that resided in the R&D Service was not effectively shared between Operations and Development. The inference, then, is that if, in the absence of updated formal operational requirements, someone from Operations does not step up to argue forcefully for a particular operational need, there is no program sponsorship and the organization as a whole does not get "switched on" to accomplish anything very purposeful. In other words,

regardless of how sensible or imminent a potential solution might be, *the Operations division is responsible for its own operational needs*; it must be willing and able to stand up for its needs, articulate them persuasively and maintain a commitment to the result.

FAA Acquisition Policy

Confusion originating in organizational responsibility will inevitably have serious consequences for smoothly accomplishing any group's objectives. Any such confusion can only be compounded when complicated procurement actions must also conform to the dictates of the Federal Acquisition Regulations. Many of the CIP projects can be classified as potentially complicated procurements subject to the needs of competitive bidding, rigorous alternatives analysis and multiple reviews by managers and decision makers. Major acquisitions in the Federal government can become complicated to the point of inscrutability if not carefully prescribed and communicated so that all participants in the process understand their roles and the events that must transpire to bring a program to fruition.

The Office of Management and Budget (OMB) has had procedures in place for years to guide the various executive departments through procurement activities. OMB Circular A-109 is the document which provides overarching guidance to the other departments. It is typical for agencies with large procurement activities to tailor the demands of A-109 to the particular circumstances of each agency. The FAA, however, in spite of acquisition actions sometimes stretching into the billion of dollars did not develop an acquisition policy to control their activities until very recently. The FAA was

roundly criticized for years by GAO and Congress[2,3] for not using a systematic

acquisition management process. As FAA managers faced more frequent

frustrations from NAS development projects gone awry and with numerous

recommendations from various stakeholders to develop a rigorous

development process, the agency developed and enacted a formal policy for

acquisition management. In March, 1993 the Acting Administrator signed and

put into effect the FAA's Acquisition Policy -- FAA Order 1810.1F.

FAA Order 1810.1F -- The FAA Version of OMB A-109

The stated objectives of the policy are to achieve:

(1) An integrated management framework for translating well-justified, approved mission needs into stable, affordable acquisitions.

(2) A rigorous, event-oriented management process for acquiring quality systems, supplies and services that emphasizes sound acquisition planning, active involvement of users and sponsors, and effective risk management by both Government and industry.

(3) A disciplined acquisition management structure and process with short, clearly defined lines of responsibility, authority and accountability. This structure should encourage continuity of program management in each acquisition phase.

(4) Active involvement of users and sponsors in the development and evolution of operational requirements and in the planning and execution of operational testing.[4]

The key element of the FAA's policy, Order 1810.1F, incorporates the essential

flow defined in OMB Circular A-109 and consists of five separate phases. The

event-oriented flow is characterized by four key decision points (KDPs) that

---

[2] GAO/RCED-91-152.
[3] GAO/RCED-92-136BR.
[4] FAA Order 1810.1F, p 1-2.

must be transited in sequence for a project to proceed from conception to full

production and on into the field. Key decision points and the general nature of

activities occurring between decision points are outlined in Figure 2.
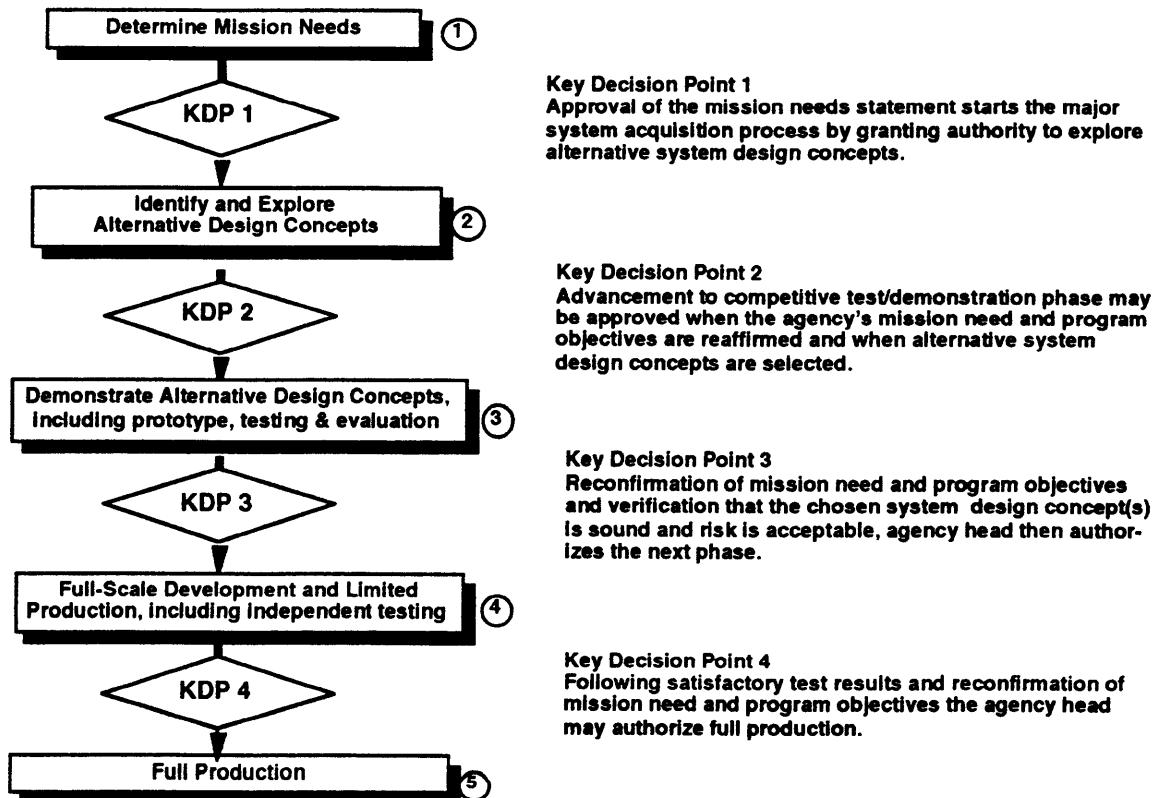
OMB A-109 Major System Acquisition Process

Determine Mission Needs ①

KDP 1

Identify and Explore Alternative Design Concepts ②

KDP 2

Demonstrate Alternative Design Concepts, including prototype, testing & evaluation ③

KDP 3

Full-Scale Development and Limited Production, including independent testing ④

KDP 4

Full Production ⑤

Key Decision Point 1
Approval of the mission needs statement starts the major system acquisition process by granting authority to explore alternative system design concepts.

Key Decision Point 2
Advancement to competitive test/demonstration phase may be approved when the agency's mission need and program objectives are reaffirmed and when alternative system design concepts are selected.

Key Decision Point 3
Reconfirmation of mission need and program objectives and verification that the chosen system design concept(s) is sound and risk is acceptable, agency head then authorizes the next phase.

Key Decision Point 4
Following satisfactory test results and reconfirmation of mission need and program objectives the agency head may authorize full production.

Figure 2: FAA's Major System Acquisition Process is Derived from OMB A-109[5]

The five project phases described here and the purposeful decisions taken

between each step are designed to ensure that appropriate alternatives are

considered and that all reasonable preparations have been accomplished

before proceeding to the next phase. Evolving as it does from the OMB policy

statement, Order 1810.1F takes benefit of the huge body of experience

gathered at the Dept. of Defense and other agencies that have been

---

[5] GAO/T-RCED-93-36.

45

responsible for major acquisition programs over many years. While the origins of the policy do not guarantee trouble-free acquisition programs, they do lend a large measure of credence to the policy as having built upon an accumulation of experience over diverse situations. This is a very thorough and systematic process when conscientiously applied and carefully examined at decision reviews.

The following subsections describe the development process in more detail.

Decision Authority

The decision authority for each KDP depends upon the acquisition "level" defined at project inception. "Levels" are essentially determined by the dollar magnitude and the technical risk inherent in the project. The appropriate project level is one of the issues determined at KDP-1. Level 1 projects, for example, are large scale projects to acquire new or replacement items and often involve development of new technology. Decision authority for all KDPs for Level 1 projects is retained by the Dept. of Transportation Acquisition Executive -- an executive explicitly assigned this duty by the Secretary of Transportation. Decision responsibility for lower level projects is delegated from DOT to FAA and hence, depending on project level, down to the Associate Administrator for the sponsoring or the performing organization . In all cases, though, an acquisition executive at the FAA (FAE)reviews and approves all project milestones before proceeding the Transportation Acquisition Executive.

Acquisition Review Committee

The FAA Acquisition Executive also has benefit of the Acquisition Review Committee (ARC) -- a senior management group responsible for advising the FAE at key decision points concerning the readiness of programs to proceed to

the next phase of acquisition. The ARC is composed of the Executive Directors of System Operations and of Systems Engineering and Development, all the Associate Administrators, and the Assistant Administrators for Information Technology and for Budget and Accounting.[6] The membership of the ARC, thus includes the entire senior management related to system operations or new system development. It explicitly includes all Associate Administrators and thus incorporates the major power centers at the agency.

Interestingly, while the ARC's function is to advise the FAA Acquisition Executive (often the Administrator), it is chaired by the Executive Director of Acquisition and Safety Oversight. The normal duties of the Executive Director of Acquisition and Safety Oversight are to administer the process outlined by the new acquisition policy. This is a program management "watch dog" role in the sense that this group has general management oversight responsibilities. These individuals are responsible for ensuring that the program staffs have the knowledge and tools they need to implement the acquisition policy. They are not, however, responsible for actually acquiring new hardware, or services. Those duties fall to the program managers and their staffs who work in the Directorate for System Development. So we see that the ARC is chaired by the manager with the most general acquisition management responsibilities rather than by any one of the particular agency interests.

This situation is analogous to employing a mediator to manage the acquisition of some new product or service. It insulates the primary developers from the real and intermediate customer. It also removes the internal customer, the internal sponsor, from the urgent need to directly and immediately represent its

---

[6] FAA Order 1810.1F, p 1-28.

need for a new operational capability. The ARC is a comprehensive advisory body that possesses all the functional expertise necessary to advise the acquisition executive on virtually any topic relevant to new system development and acquisition. If this body functions equitably and openly it should be a powerful and positive force in the acquisition process by aiding the acquisition executive in making the best possible decisions with the information available. But it must not diminish the responsibility for the FAA to define and persist in its statement of operational capability.

CIP Planning Process

If the FAA now has formal procedures in place to rationally and economically acquire the new systems needed for maintaining and modernizing the national airspace, how does it decide which systems to acquire? Where are the requirements analyses and trade studies done that substantiate specific acquisition programs? Where are new procedures, rather than new hardware or software systems, considered as alternatives to satisfy an operational requirement? What determines which program make it into the CIP in any given year? These questions are investigated in this section.

The FAA has instituted an integrated Capital Investment Plan planning and budgeting process effective with the 1994 CIP and the FY 1996 budget which is described in detail in a process description document published in September, 1993. The process consumes a full year commencing in June. A flow chart depicting the steps in the process is included as Appendix C. A brief description of the important institutional aspects of the process follows.

"The CIP summarizes Facilities and Equipment (F&E) programs that the FAA intends to pursue over a 15 planning horizon in addressing key concerns of the NAS. The CIP embodies the phased plan for the evolution of the existing NAS through an orderly deployment of new products and technologies to meet mission need. New F&E programs are identified through a continuous process of mission needs analysis which leads to development/approval of a Mission Need Statement (MNS). Approved MNSs then enter the competition with existing programs for F&E funding each year, in the F&E budget process."[7]

It is imperative to have an authenticated Mission Need Statement in order to enter the competition for F&E funds via the CIP planning process.

System Engineering/Operational Analysis Teams (SEOAT)

The CIP planning and budgeting process consists of three phases: (1) policy guidance, (2) system engineering/operational analysis, and (3) resource allocation. Each phase is initiated by a group of managers working together as the System Engineering/Operational Analysis Team (SEOAT). The SEOAT is composed of the managers of the following offices: Facility Systems Engineering, Air Traffic Plans and Requirements, NAS Transition and Implementation, System Engineering, Flight Standards, and Office of Budget.

In the policy guidance phase, based on their review of FAA strategic planning documents and other source material, the SEOAT drafts preliminary guidance papers to orient the numerous project sponsors and other process participants to the global and strategic objectives of the agency. After review and resolution of controversial issues by the Administrator, approved guidance is passed back to the SEOAT, which initiates the next phase -- system engineering and operational analysis.

---

[7] FAA Capital Investment Planning Process, p. 1.

The major work of the system engineering and operational analysis phase is accomplished by the SEOAT and the Functional Work Groups (FWG). The SEOAT explains and interprets the CIP planning guidance to the Functional Work Groups. The SEOAT also develops rating criteria to be used in evaluating the relative merits of various projects. The Functional Work Groups use the evaluation criteria to rate all projects within their functional area. FWGs are established in each of seven functional areas: automation, communications, surveillance, weather, navigation/landing, facilities, and mission support. The FWGs are comprised of representatives from Air Traffic, Airway Facilities, Regulation and Certification and Systems Engineering. FWGs are responsible for rating projects in terms of their mission objective, system engineering coherence, benefit/cost, and operations impact. The functional rating provided by the FWGs are then used by the SEOAT, along with the planning guidance, to produce a relative ranking of all the projects in the CIP. The planning process description defines the SEOAT is the final determinant of project rankings: "The SEOAT will be responsible for the overall rating of the various projects and their contribution to the corporate guidance and issue resolution provided by the [Administrator]."[8] The second phase ends with the approval of the SEOAT overall evaluations and ratings by the CIP Steering Committee, which is composed of the senior executive management of the agency.

In the budgeting phase the Functional Work Groups are given functional target levels they are required to meet. Relevant financial and program data is provided to the FWGs and the SEOAT to assist them in allocating budget. Budget is allocated based on the ability to execute the project in a given year consistent with the priority recommendations of the SEOAT. Project Work

---

[8]FAA Capital Investment Planning Process, p. 6.

Breakdown Structures must be modified in accordance with any budget revision that occurs as a result of this process. Finally the SEOAT compiles the individual functional baselines from the separate FWGs into a final CIP financial baseline for review by the CIP Steering Committee.

Reference to Appendix C shows that the planning cycle continues through June with the submission of the budget for two years hence to the Office of the Secretary of Transportation. One of the last parallel events is approval of Mission Need Statements, which is a curious design since we saw in Figure 2 that the MNS should be the *first* step in the acquisition process as prescribed by Order 1810.1F. That is, an authenticated MNS is required to proceed at any stage of CIP planning. The Planning Process document is quite explicit on this; "MNSs that have not been authenticated will not be assigned an MNS number and, as such, will not be included as workload for the MNA [mission needs analysis] team."[9] What could the explanation be for this apparent contradiction? The terminology used on the chart for Appendix C is imprecise; the cut-offs at the end of the planning cycle and just before submittal to the Secretary of Transportation refer to Key Decision Points, rather than Mission Need Statements per se, that must be passed before a given project can move into the next phase and for which its future budgeting might depend. In other words, every project needs an approved MNS to enter the CIP, and some projects need to transit a subsequent decision point in order to proceed through the process. Those projects must pass through the relevant decision gate by the time indicated or fall out of the system.

---

[9]FAA Capital Investment Planning Process, p. 12.

Mission Needs Analysis Teams (MNATs)

Each of the five phases of activity outlined in and required by FAA Order 1810.1F in Figure 2 are crucial to the successful completion of a complex acquisition program. The objectives, activities and products of each phase of the process are described in detail in the Order.

Consideration of Non-Materiel Solutions

The first phase, i.e. Phase 0, which occurs before the first decision milestone is particularly important in initiating any ATM modernization project. Note that it is Phase 0 that establishes and authenticates the Mission Needs Statement which then becomes the cornerstone of all subsequent acquisition activities. It is also in this phase that non-materiel approaches, such as revising air traffic control procedures, are considered to satisfy any given need. The stated objectives of Phase 0 are:

- Identify needs in terms of deficiencies or shortfalls in existing mission capability or in terms of technological opportunities to perform assigned tasks more effectively.

- Determine if deficiencies can be resolved with low-cost, non-materiel means that do not involve a new development or acquisition program.

- If the need cannot be satisfied by low-capital, non-materiel means, develop and quantify mission need for a new acquisition in a mission need statement that is validated and sponsored by an FAA user organization.[10]

It should be noted that while Phase 1, Concept Exploration and Alternatives Analysis, also requires consideration of "all reasonable alternative

---

[10] FAA Order 1810.1F, p 2-3.

approaches," the emphasis is clearly on potential hardware and software solutions, rather than other non-materiel forms, such as new or revised procedures. Thus Phase 0 activities are particularly important in determining the type of project that should be instituted to satisfy a need.

Definition of a Project Sponsor and MNAT Composition

There are several key people required to effectively accomplish a Phase 0 Mission Need Development phase in addition to the obvious "Originator." The process requires, for example a "Sponsor' from the cognizant group within FAA with operational oversight responsibility of the area. In the case of GPS/GNSS as we discovered earlier in the chapter, the appropriate sponsor is the Flight Standards Service. The other members of the group that must perform in order to produce an authenticated MNS are from System Engineering and Development (ASD) and include representatives from Facility System Engineering (AFE), NAS System Engineering (ASE), and Operation Research (AOR). Together, this group comprises the Mission Need Analysis Team (MNAT). The MNAT is intended to provide the appropriate people, skill mix, tools, data and expertise to bridge from the Sponsor's preliminary description of mission need, to a more precise description of required operational capability, functionality, performance characteristics and performance attributes appropriate for initiating system concept development activities after KDP-1 approval.

Composition of the MNAT varies to some extent depending on the nature of the preliminary need defined by the Sponsor and depending on the analyses accomplished by the Team. Nonetheless it is significant that another group within ASD -- the Research and Development Service -- is not typically included

in the initial MNAT. This omission of R&D personnel, who are most familiar with emerging technology and who can most realistically judge technical capabilities, can bias a program, either toward or away from advanced technology solutions, during the critical mission need determination phase.

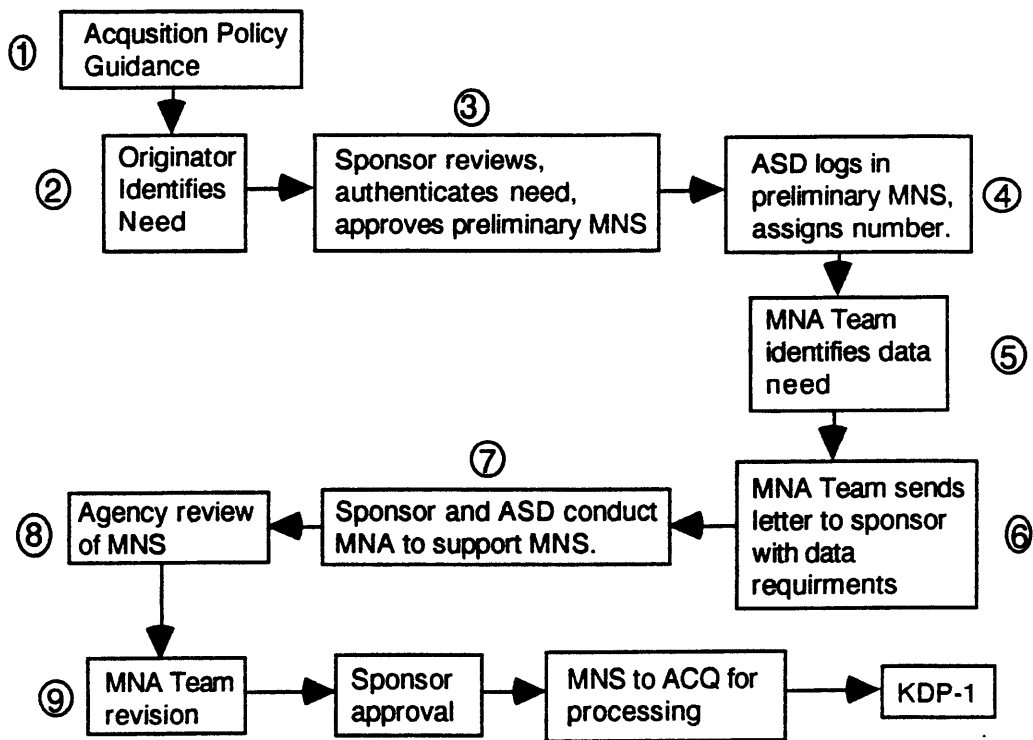The activities to be conducted during Phase 0 are depicted in Figure 3.

① Acqusition Policy Guidance

② Originator Identifies Need

③ Sponsor reviews, authenticates need, approves preliminary MNS

④ ASD logs in preliminary MNS, assigns number.

⑤ MNA Team identifies data need

⑥ MNA Team sends letter to sponsor with data requirments

⑦ Sponsor and ASD conduct MNA to support MNS.

⑧ Agency review of MNS

⑨ MNA Team revision

Sponsor approval

MNS to ACQ for processing

KDP-1

Figure 3: Mission Need Statement Development and Approval Process[11]

Several features of the MNS development process bear discussion. First, while the MNAT will accomplish the needs analysis, it is obvious that the responsibility for acquiring the basic data with which to perform the analysis is the responsibility of the Sponsor. This arrangement places the burden for proceeding with any program on the shoulders of the organization with the need. On paper at least, this arrangement tends to ensure "ownership" of the

[11] FAA Capital Investment Planning Process, p. 13.

process by keeping responsibility for the moving the process along with the internal FAA using group, i.e. the Sponsor. Secondly there is an evident transfer or work responsibility after the basic data requirements have been satisfied by the Sponsor; the bulk of the needs analysis is shifted to the various groups from Systems Engineering & Development. They become the "actual" needs analysts and they are often overworked. The CIP Planning Process document actually explicitly defines procedures for resolving conflicts and prioritizing analyses among projects when analysts can not accomplish their backlog of work. A large backlog is the normal state of affairs for these analysts as evidenced by the standing procedure for dispute resolution. One manager in Systems Engineering told me that the manpower available for performing these functions is about *half that required* to do a competent job on all the analyses requested.

The partitioning of work between Systems Engineering & Development (ASD) and the various sponsors is on the face of it sensible but perhaps unnecessarily divides the group's activities. In the seventh box of Figure 3 the process requires Sponsor and ASD to conduct mission needs analysis. But the *Sponsor and ASD are the MNAT*, yet they are not referred to as a team. The suggestion is strong that teamwork breaks down at this stage (and perhaps never existed to begin with). Given that personnel in ASD working Mission Needs Analyses are overloaded and that the sponsoring organization takes little responsibility after developing an initial statement of need, it is evident that System Engineering & Development takes over responsibility for subsequent development phases. Systems Operations personnel are not major participants in subsequent stages in spite of their sponsorship role. The planning and

budgeting process document does not name the MNAT members, nor identify the team leader. *The MNAT may be a team in name only.*

Education and Culture

The staff of System Development , including NAS Development (AND) and System Engineering & Development (ASD) includes a large fraction of engineers and scientists as well as other analytic and professional disciplines. Most of these people have some higher education and many have baccalaureate degrees, or better. The staff of the Systems Operations directorate, however, is derived from the ranks of air traffic controllers and systems maintenance technicians. These people have much less frequently experienced higher education and seldom possess college degrees. An FAA executive described to me a recent management search case: a person was sought to fill a Senior Executive Service (i.e. a high-level, executive management) position from the ranks of the System Operations directorate. Of the 16 applicants, only two had any college experience; *none had a degree* of any kind.

In addition, the headquarters staff of System Operations is often populated by field personnel on a three-year tour of duty. The lack of continuity in maintaining mission needs and the need for time to understand current developments-in-process and to develop working relationships with R&D personnel inhibits or prevents efficient progress in system development activities.

Personality surveys can also reveal something about the nature of the organization. The Myers-Briggs personality survey, for example, characterizes

personality types along four different dimensions: 1)introvert (I) - extrovert (E) relationship style; 2) sensing (S) - intuition (N) information gathering style; 3) thinking (T) - feeling (F) decision making style; and 4) perceiving (P) - judgmental (J) priority preference. Myers-Briggs surveys conducted at the FAA Management Training Institute discovered that 70% of managers at the FAA are:

- Introverts -- rather than extroverts   (I vs. E)
- Sensing -- rather than intuitive   (S vs. N)
- Thinking -- rather than feeling   (T vs. F)
- Judging -- rather than perceiving   (J vs. P)

This is a remarkably high percentage. No greater than 5% of the general US population is categorized in this category although nearly 24% of the 849 managers attending business short courses in one study possessed these characteristics.[12] Individuals with ISTJ characteristics are frequently practical, orderly, matter-of-fact, logical, realistic and dependable. They make up their own minds as to what should be accomplished and work toward it steadily, regardless of protests or distractions.[13]

Organizational structure has been shown to correlate with the personality types dominant in an organization. Kilmann and Mitroff[14] summarized their findings on managers' Myers-Briggs personality types and preferred organizational structure, which is tabulated here.

---

[12] Margerison & Lewis, p 15.
[13] Myers.
[14] Margerison & Lewis, p. 17.

Table 4: Organizational Preferences for Various Personality Types[15]

Areas	Types			
	Practical (ST)	Social (SF)	Idealistic (NF)	Theoretical (NT)
Structure	Practical bureaucratic, well-defined hierarchy, central leader	Friendly, Hierarchical but open	Completely decentralized, no clear lines of authority, no central leader	Complex organization flexibility, changing authority, task forces
Emphasis in Interactions	Task orientation, complete control, specificity, fixed rules	Human qualities of people doing work as individuals	Humanitarian, general concem for development of employees	Goals, clients, effect of environment
Organizational Goals	Productivity work flows	Good interpersonal relations	Personal and humanitarian	Macro-economic, theoretical

Margerison and Lewis synopsize these results with the following remarks that are relevant to the majority of personality types in the FAA:

"...ST's prefer an authoritarian and bureaucratic organization with a well defined hierarchy and central leadership. The reasons for this stem from the nature of the work preference types. The NF person requires a high degree of autonomy and freedom in order to exercise his preferences and feeling. He prefers making contact with people regardless of their level and organization before he can work effectively. The ST type on the other hand, prefers a well defined structure because this enables him to get on with what he enjoys doing -- practical, everyday matters at hand. Discussions with people about feeling and intuition are often seen by ST people to be a waste of time and barriers to getting the task done."

In considering the FAA it may be asked not whether talking about feeling and intuition in necessary or important, but whether the preponderance of ISTJ types might not create overwhelming favor for a centralized organizational structure that is governed by fixed rules and that actually inhibits dialog across group boundaries. An organizational environment can easily be fashioned in

---

[15] Kilmann & Mitroff after Margerison & Lewis, p. 18.

which individuals become so directed toward their immediate job, they do not stop to converse with their customer. Kilmann and Mitroff conclude that:

"To summarize ST's can be characterized as real-time, operational-technical, problem solvers; NT's are future-time, strategic-technical problem generators; and SF's are real-time operational-people problem solvers. Compared to intuitives, the planning horizon of sensing people is extremely short. In the extreme sensing people are not interested in planning at all. They do not believe that one can talk sensibly about the future because one can not sense it directly."[16]

The contention here is not that FAA managers do not plan but that their preferences are for other sorts of work and that the organization and attitudes within the organization value other work, specifically technical problem solving, more highly than strategic planning, modernization planning or even needs analysis. One easily forms a vision captured in the caricature of a software development group in which the group manager intones, "You all start coding and I'll go upstairs and see what the customer wants"!

Summary

The FAA has a diverse and complicated set of responsibilities and requires the talents of skilled people of various sorts. The tasks of safely operating the busy national airspace, certifying and regulating equipment and personnel that operate in the system and continuously modernizing and improving the system are daunting tasks that require the services of personnel with very different functional orientation. The agency has organized along functional lines in an effort to manage the activities of this diverse community. The combination of organizational arrangement and personnel bias represented by culture and background tend to reinforce the divisions between groups in the organization. Formal processes recently instituted to improved system development

---

[16] Ibid, p. 19.

performance, including the 1810.1F Acquisition Policy and the CIP Planning Process, are intended to force the development process to flow through the system. This approach is only partially successful because it is primarily authoritarian in nature; it works only to the extent that the policies are rigidly enforced. The processes are not rigorously enforced. The FAA needs to find a better way to manage new system developments.

CHAPTER 4: ANALYSIS OF ORGANIZATION AND MANAGEMENT PROCESSES IN SYSTEMS DEVELOPMENT AT FAA

Chapter 3 described both the organizational arrangement of the key offices of the FAA relating to ATM system modernization and the major formal policies and procedures prescribed for major system planning and development. This chapter presents an analysis of the functionality of the agency's organizational arrangement that was described in Chapter 3. An expansion and discussion of processes used in system definition and development are covered in this chapter.

This chapter makes several points:

- The combination of organizational boundary and difference in cultural orientation make communication across functional divisions very difficult.

- There is no ethic for cross-functional teamwork at the FAA.

- Cross-functional teamwork is essential to successful implementation of most development tasks.

- The allocation of resources and influence is unbalanced in regard to new development activities, but the organizations with the most influence have the least commitment to specific development goals.

- The formal acquisition policy does not adequately emphasize crucial needs analysis that should occur early in the life of a potential project.

- The FAA leads the world in most development activities. ICAO represents the interests of the worldwide aviation community whose priorities can differ from the FAA's. The FAA serves the nation well by also accommodating the needs of the international community.

FAA Organizational Orientation

The Federal Aviation Administration is organized along very strong functional lines. The main constituents of the agency are the directorates of System Operations and System Development (refer to Figure 1). The organizational arrangement of these major divisions and some of the key offices within them were described in Chapter 2.

Systems Operations and the FAA's Dual Mission

The FAA has a dual mission: the continuous augmentation of aviation safety, and the promotion of civil aviation. There is no need for these two mission features to ever be in conflict, for certainly if aviation is not perceived as safe it will be impossible to promote it. At the same time, there are activities that might be contemplated which could promote aviation and which could be, either in fact or perception, damaging to safety which would not be countenanced by the public, or by the agency. Thus we can conclude that, of the two sub-missions assigned to the FAA, the enhancement of safety is the more imperative.

The Systems Operations directorate operates the air traffic management system (Air Traffic), develops and administers rules, regulations and standards governing aircraft, airmen and aeronautical operations (Regulations & Certification, and Aviation Standards) and installs and maintains the federal aviation infrastructure (Airway Facilities)[1]. Two of these groups, Air Traffic and Regulations & Certifications (more particularly Flight Standards Service) are key players in development of GPS/GNSS for civil aviation use as we saw in Chapter 3. They are also responsible for the safety of the flying public.

---

[1] FAA Annual Report, p. 3.

Whenever there is a potential conflict between development and safety, the issue must be decided on the side of safety.

Safety is like a mantra everywhere within the FAA (as it should be) and within Systems Operations it takes on the character of the holy grail. After all, people in this organization are directly and most immediately responsible for ensuring public safety in regard to aviation. Certainly any new system development that improves safety may be considered urgent. On the other hand, every no product or procedure involves an element of uncertainty which can be interpreted as compromising safety. In other words, unless a new development is positively proven to improve safety, there is a tendency to consider it potentially damaging to safety. The national airspace system has been developed to guarantee safety. Commercial air transport in the US is by far the safest mode of mechanized transport devised by man. Any change that could remotely endanger that enviable record is subject to intense scrutiny and potential opposition -- particularly from the people charged with the most direct responsibility for system safety.

System operators, then, are most directly responsible for system safety since they are responsible for operating the system everyday. They define the certification standards for aircraft, and airmen, for air traffic controllers and air traffic control procedures and for all airway facilities. These people depend on carefully crafted procedures that are so thoroughly coordinated and tested they can legitimately be called "certified." System operators have a common characteristic of depending upon rules, rule books and procedures to accomplish their jobs. They are the masters of rule-making and change the

rules only after the most careful consideration. These people make the "fully certified" system work.

Systems Development and the FAA's Dual Mission

The System Development division also contributes essential services to the promotion of safe aviation in the US. This group provides system engineering and research and development services to prepare for the future, to safely expand the capacity of the system, and to exploit emerging technology to improve system safety.

System developers are a different breed than system operators. They seek improvements in system capacity, reductions in cost and the application of advanced technology for the variety of other benefits it can bring -- in addition to searching out possible advances in system safety. As key players in the FAA mission they are also bear some responsible for system safety as well as for "promoting US aviation." Many of their developments are primarily intended to improve airspace system safety. Certainly the vast majority of the Capital Investment Plan projects make reference to improved safety as fundamental justification -- and in most cases the claims are legitimate even when safety is not the primary objective of the project.

These people by their nature, and due to the obligations of their jobs, are experimenters. They explore new technology, conceive of new applications of the technology, experiment with alternate designs to evaluate relative strengths and weaknesses and create new hardware or software approaches to satisfy users' needs. These people turn the unknown into the "fully certifiable."

Organizational "Stovepipes" and Cultural Differences

The FAA has been reorganized several times since its establishment in 1958 as the successor to the Civil Aviation Agency. According to one long-time FAA manager, the FAA has been restructured 11 times since 1960 in efforts to focus on key issues and make the agency more responsive to particular needs. The strong functional orientation, however, has persisted throughout these rearrangements. It is reasonable to speculate that the strong functional orientation is a result of the significantly different tasks that must be performed to accomplish the agency's diverse responsibilities. One could speculate that the organizational boundaries were originally drawn expressly in an effort to provide focus and assign responsibility for these major tasks. An unintended effect of this division of responsibility is to differentiate and separate people with various skills and with various intellectual orientations. This sort of separation results in a strong senses of group identity that can be less than ideal for operation or improvement of the ATM system.

Chapter 3 discussed the organizational arrangement and group responsibilities of the main players in GPS/GNSS system development activities. This chapter includes a discussion of the cultural attributes of each of the participating groups. The implications of the compounded effects of functional and cultural orientation is also included. We start with the two System Operations groups, Air Traffic and Flight Standards and proceed to the Systems Development groups, Systems Engineering, R&D Service and NAS Development:

<u>Air Traffic (AAT)</u>

The Air Traffic Service, perhaps not surprisingly, is made almost entirely of air traffic controllers. There is a strong social norm within the service to promote worthy workers, and to promote from within the service. As one manager said "there is a strong cultural norm at work: *everyone* needs to be promoted." So the managers and executives within this arm of the agency are former controllers. On the one hand, it may be necessary that competent managers in this area have experience as controllers, but other background and experience is also probably necessary to be good managers. Controllers often do not have the educational background that might be expected for, and which would be advisable for, management positions in the area.

Managers in this group have a reputation for being particularly insular and inward looking. They are experts in the historical ways of air traffic control procedures since they usually are among the best controllers in the crowd which currently numbers more than 17,000. As a generality it might be said that managers in Air Traffic are comfortable with the procedures with which they worked as active controllers and are much more hesitant than developers to experiment. One FAA manager said "they insist upon holding onto their security blankets -- and are not comfortable with any of the candidate changes that might be desirable in the agency." At the same time they are desirous of improvements in their system that will provide "more reliable hardware, better software tools to help them control traffic, better weather information and forecasting, better communications, clearer, more flexible displays and a better working environment." But as a senior executive in the division said, "unfortunately, controller-defined improvements often do not improve the airlines' capabilities or productivity. This is not serving the customer!" One

comes away with a strong feeling that the controllers, or more accurately, the Air Traffic Service as defined by its management, seek incremental improvements in the way they accomplish well-established procedures. They may be eager to adopt advanced technology solutions that are offered to reworking their procedural tasks, but their orientation is toward the procedural status quo. Indeed, managers in the Air Traffic Service have been vilified for their inability to commit to a given system (hardware or software rather then procedural) requirement. One manager closely associated with the group described Air Traffic people as wanting "maximum flexibility in their system definition activities; they can not be held to a fixed, or even stable, requirement."

We are left with an impression of the Air Traffic group at Headquarters as very conservative, dependent upon existing procedures and hesitant to change them, strictly oriented toward its functional hierarchy for rewards, fiercely loyal to that same functional hierarchy, and undisciplined and unimaginative in its approach to new system requirements. The combination of functional orientation and particular culture in this group makes it difficult for personnel to focus on the large objectives of system improvement and to work with other more distant groups in Systems Development to accomplish these objectives.

Flight Standards (AFS)

The Flight Standards group is a component of the Administration for Regulation & Certification, another arm of the System Operations directorate. This group, in addition to having very different functional responsibilities from Air Traffic, seems to have a decidedly different character in regard to innovation of the National Airspace System. Flight Standards is responsible for the communication navigation and landing equipment used in the national

airspace. As mentioned in Chapter 3, this equipment is sometimes confused with "equipment in the airplane," but is more aptly conceived as equipment required for the aircraft and flight crew to operate safely within the National Airspace System. Flight Standards is also a very functionally oriented group. The scope of the activity appropriate to the group is tightly bound; these people operate strictly within the domain of definition and certification of equipment necessary to operate the airplane.

This group is responsible for representing the interests of the users (i.e. airlines and general aviation) in regard to communication, navigation and landing systems. Flight Standards is the sponsor for mission needs in these areas; they must form the foundation for everything that comes after in the FAA's acquisition process.

Personnel from this group possess much more varied backgrounds than those from Air Traffic. They often spend their entire careers with the FAA, but many have worked in industry, including the airlines, avionics manufacturers, other semi-government agencies such as RTCA, ARINC and the Dept. of Defense. A more varied staff might help make for a more flexible and adaptable organization. Bailyn suggests that it is not clear that there is an identifiable organizational advantage to diversity; it might provide greater creativity and innovation, but implementation and action are probably made more difficult. By the same token, when an organization is inherently diverse, as is the FAA, attempting to homogenize the organization can have negative repercussions[2]. Learning from diversity can help produce organizational learning yielding a more innovative, creative and flexible organization.

---

[2] L. Bailyn, Personal Communication, Oct, 1993.

Their contact with advanced technology and the cycle of new system development in this arena is also more rapid than in Air Traffic. The cycle time on airborne aeronautical equipment, particularly avionics, is more rapid than for most of the ground based infrastructure. Advanced technology transmitters and receivers and in flight management computers are introduced on a cycle of only a handful of years rather than the twenty years or more for ground-based system. This rapid cycle time makes the Flight Standards group more responsive to the possibilities of advanced technology and more in tune with the National Airspace System users.

The Flight Standards group, then, also has a strong functional bias, but since the group is more diverse and the cycle time for new projects so rapid, the group maintains a more experimental, open attitude than Air Traffic. The strong functional orientation and the organizational boundaries tend to inhibit communication across functional lines, but it this case the culture does not compound the effect to stifle communication as in the case of Air Traffic.

Three key groups from the System Development (AXD) organization are responsible for performing new development activities relating to GPS/GNSS. Two of these are active in the current R&D phase: Systems Engineering Service and the R&D Service. The third is the NAS Development organization.

Systems Engineering (ASE)

Systems Engineering is a relatively new group at FAA and has a key role to play in the definition of the mission need statement and in all that occurs after the initial preliminary MNS in the acquisition process. The main function of

system engineering is to develop system level requirements from the definition of an operational need or requirement. The initial task should be to consider procedural and other technical solutions to satisfy the need, then to conduct "trade studies" to determine the best compromise in satisfying the needs according to specific performance and cost criteria. This is a crucial activity for any complex new developmental situation and must also consider non-materiel solutions, such as revised or new ATC procedures to be robust. This function is sensibly a part of System Development since it is entirely a new system concept analysis function and has no operational aspect to it. At the same time, competent accomplishment of the system engineering discipline can only be accomplished by very close cooperation between this group and the Mission Needs Statement (MNS) sponsor. In the case of GPS/GNSS, the Mission Needs Statement is Flight Standards. System Engineering is also responsible for coordinating diverse development projects.

When I asked a manager in the Systems Engineering group to identify the "owner" of the GPS MNS , I was told that prior to Key Decision Point #1 (KDP-1) the Operations Research Service (AOR), a close companion organization in Systems Development, had responsibility for the MNS. After that decision point, responsibility transitioned to Systems Engineering. In other words, the understanding is that AOR bears responsibility for defining the need and developing the initial Mission Need Statement. Operations is presumably also responsible for pushing the need through the initial gate, KDP-1, to authorize an exploratory project.

After a project is authorized at KDP-1, Systems Engineering takes on more responsibility and shepherds the project through the rest of the process. A key

manager in the group told me that "Systems Engineering operates more like a program management agency than like a system engineering outfit." But if this is so, who works with the sponsoring organization (Flight Standards) to do the early trade studies that are so critical to determining the path of a project? Who helps decide if an ATC procedural solution is acceptable rather than some other approach? Who conducts the detailed trade studies that are crucial to the Key Decision Point #1 milestone? Something is being left out.

The System Engineering group apparently feels a clear responsibility for any given project after KDP-1, that is, after the point at which a conceptual need is clearly authorized as a developmental project. The group is ready and willing to work diligently trying to satisfy a stated mission need. But ASE does not speak for the user -- nor even the internal FAA user, i.e. the sponsor. They are ready to proceed only with the engineering implementation of an approach that has been authorized at KDP-1. At this point, there is also a clear intuitive chain of responsibility to the Associate Administrator for System Development and Engineering and thence to the Executive Director for System Development. But the Acquisition Policy Order 1810.1F does not describe responsibilities this way. It clearly states that a mission needs analysis shall be performed at the behest of an FAA user organization that sponsors the Mission Need Statement. It further states that within a specified time of KDP-1, a single program manager be designated to organize and direct the program and that he in turn develop a program management team and program directive(s) to coordinate the activity with other organizations. Program managers are typically selected from the R&D Service for R&D projects not from System Engineering. Program managers for CIP projects are from the NAS Development Administration. So who is doing the trade studies? One high level executive who is close to the

FAA described the acquisition process as practiced at FAA as "bogus". He went on to say that the FAA does not have the proper social structure to enable or accomplish complex system development. Perhaps *nobody* does the required trade studies. More often, it is left to the program manager to acquire the skills to conduct these trade studies form whatever cranny he can discover. At best, we can conclude that they are poorly coordinated and roles and responsibilities are not well understood.

Systems Engineering, then, is oriented toward coordinating development projects. They have major responsibilities in determining CIP priorities and analyzing mission needs, but the group is compromised between the need to perform trade studies for requirements determination and the need to coordinate projects already underway. Its culture is the most open of any of the groups but the accountability is to System Development rather than Operations. Systems Engineering represents the user's need only by proxy; the organizational barriers tend to make this relationship problematic. Much of the work of this group requires the contributions of many other functional players but the work flows are sequential rather than concurrent because of organizational barriers and cultural biases, particularly among other groups.

R&D Service (ARD)

The fourth is the R&D Service (ARD). It is the hard-core technology development arm of the System Engineering & Development section. Personnel in this group are mostly engineers and scientists. They posses both the education and inclination to pursue advanced technology solutions to what they perceive as various mission needs. In fact, when a program manager is assigned from ARD it is fair to infer that an advanced system development approach has been selected. There is a very strong functional orientation

within this group and a responsiveness to the Associate Administrator for System Engineering & Development. Most of the people in this group have no counterpart elsewhere in the agency, with the exception of the FAA Technical Center (FAATC). Much of this group are now located at a leased building several blocks from FAA Headquarters, which is where most of the other organizations are located. R&D personnel have a strong technology orientation and are removed both physically and organizationally from the real users and the internal FAA users.

In summary we can say that the R&D Service is a rigorous, traditional technology development outfit. It is also segregated from the rest of the agency, physically because it is in a difference location, intellectually because it has no counterparts or companions elsewhere in the agency and organizationally because is has no organizational connections with other groups outside ASD. Managers from a group with such liabilities would need to work particularly diligently to integrate their contributions into the rest of the agency.

NAS Development (AND)

The fifth group to consider is the Administration for NAS Development (AND). It is the major organization that typically handles the acquisition of CIP development projects. It has no responsibility for R&D projects, such as most of the current GPS/GNSS projects. Surprisingly, despite the fact that there are now approved GPS/GNSS projects in the Capital Investment Plan, responsibility for GPS/GNSS has not shifted from ASD to AND. But it is not apparent that shifting responsibility to this organization would necessarily have a beneficial effect. NAS Development manages the several projects discussed in Chapter 1 that are over-spent and behind schedule. It appears that in spite of

the greater major system acquisition experience that AND possesses compared to any other group within the agency, there are still many opportunities for learning in this complex arena. A senior manager within AND characterized the organization as more matrix-oriented than ASD with a trend toward work-teams and integrated development activity. He also described how AND essentially inherits most of its work from ASD, and he stated that team work practices are not yet developed at ASD. They are also not yet well developed within AND the manager opined that there needs to be a much more integrative approach to system development. He amplified by saying that the FAA bureaucracy is very functionally oriented and is a remnant from another era. The moves toward integrated product development are positive in this view but are too slow and have not yet been adopted by all the necessary players. He says the SEOAT, for example, needs more of a system engineering orientation. While one might have thought the SEOAT's *main* task was system engineering, the suggestion is that it makes CIP project decisions on criteria other than the FAA planning guidance and hard trade studies of performance and cost for various system alternatives.

While that manager seemed to have a clear view of what needed to change within NAS Development, he was also clear that the changes have not yet occurred and that the organization was highly oriented along functional lines. We further see that the two major organizations in System Development both take major responsibility for system development after a project reaches the authorization stage (i.e. Key Decision Point #1); NAS Development works the CIP projects, Systems Engineering and Development works R&D projects. Before authorization, however, no one has clear responsibility to take charge of

a mission need. The transition from the sponsor to one of the development groups is confused and incomplete.

Summary of Function and Culture Impacts of Development Performance

Strong functional orientation and distinct group culture serve to isolate groups from one another. Responsibility and accountability among line personnel is clearly directed along the organizational, function chain. Potent cultural differences is some organizations, such as in Air Traffic and R&D, serve to inhibit communication. One group sees another as unfriendly since "they're not like us." These two forces combine to produce powerful constraints on individuals' ability or proclivity to actively communicate across organizational boundaries. Cross-functional communication is necessary to effective development.

Complex ATM Functional Interactions

The foregoing analysis points out the disconnects that are apparent in the most basic and straightforward of the acquisition projects. The strong functional orientation, different and perhaps incompatible culture exhibited by the two major divisions with the agency, and the poorly understood, imperfectly practiced acquisition policy all serve to make the sharing of responsibility impaired as a project moves through the process. The discussion so far has been relevant to projects that are conceived as all within the domain of a single function, as for example the case of the Microwave Landing System which is limited in its functional applications to landing guidance and would be presumed to be entirely within the domain of the Flight Standards functional responsibilities. The tortuous history of this project points out the procurement difficulties that can be encountered. What is likely to happen to projects whose

aims cross functional boundaries, even at the outset? There are several examples of goals, or operational needs, that are addressed by GPS/GNSS and which cross the functional boundaries at the FAA sponsor level. A brief discussion centers on the synergistic simultaneous benefits enabled by GPS/GNSS but which were not recognized because of insufficient cross functional communication between agency sponsors with one another and with Development personnel. The needs that GPS/GNSS addresses for three of these, Automatic Dependent Surveillance and Direct Flight Plan Routing and Precision Approach Capability are discussed in the following sections:

Automatic Dependent Surveillance (ADS)

ADS is a process through which controllers are able to determine precisely the location of aircraft in the airspace based on data available in the aircraft alone. The process is based on the idea that surveillance can be accomplished by the controllers if they are able to acquire the precise data that is already available in the aircraft (i.e. position, altitude, velocity, direction, turn rate, etc.) thereby obviating the need for an independent surveillance system (i.e. ground-based radar). The data can be datalinked to ATC facilities either through line-of-sight VHF datalinks or through satellite communication links. The surveillance is automatic because the aircraft transmits its navigation data to the air traffic control system without intervention of either the flight crew or any controllers. It is dependent upon the accuracy and reliability of the aircraft navigation and flight management systems and upon the existence of a suitable datalink.

There are many potential benefits to world-wide ADS, including the ability to monitor aircraft location over oceanic and desolate areas thereby reducing oceanic separation standards and increasing airspace capacity, the potential to

eliminate the extensive ground-based, maintenance intensive ATC enroute-radar network, and the potential to develop collision avoidance systems for all aircraft based on ADS.

ADS crosses the functional boundaries between several System Operations groups. The surveillance function is a prime responsibility of Air Traffic but the navigation source of the data is the domain of Flight Standards. These two groups have adopted the concept of ADS an objective for the ATM system, but until recently the main objective has been to reduce reliance on ground-based radar systems.

The approach has centered on the need to develop a communications datalink to transmit airplane-determined position to the controllers. The additional benefit of potential airspace capacity increases enabled by more accurate position, velocity and time information which is possible with GPS/GNSS has only lately been recognized. This is a case in which people in the R&D Service has long recognized the potential of GPS/GNSS to provide more accurate data and where that knowledge was not effectively communicated to the potential sponsors in a way that could stimulate the sponsors to demand the capability. For a long period, the statement of ADS need has presumed only the availability of current generation navigation sources such as VOR/DME and inertial navigation systems. Thus, while the sponsors had cooperated to state a need for ADS capability, they demanded only part of the utility that could be available thanks to the new satellite technology. While this additional utility is now recognized and planned for, the restrictions on cross-functional communication in the agency help explain why it was recognized so late.

The salient problem here is that the system evaluation and improvement process does not even commence, let alone progress, without a clear and vigorous sponsor from within the FAA. Many examples are mentioned in Chapter 2 of NAS system needs that are not effectively satisfied partly because there is no operational sponsor that stands up, clearly defines the need, evaluates potential solutions, monitors development against some agreed statement of work, and pays the bills. These are basically the dynamics of the successful enterprise in which customers contract for goods and services. This dynamic is completely missing within the FAA for even the most dedicated projects in which the customer is eager and clearly identified. In the case of ADS, the sponsors only demanded part of the feasible capability because they did not understand the technology nor did they understand who was responsible for demanding it.

Direct Routing/Optimal Trajectory Flight Planning

Direct routing shares many of the characteristic of ADS. The desire for direct routing is to traverse more efficient, economical and rapid flight paths. It frees airspace users from the constraints of ground-based navigation systems for flight path planning. Most current flight paths are coincident with the airway system defined by the existing VOR network. The airways reduce to some extent the controllers need for precise position data by concentrating aircraft in relatively small proportion of the airspace (in other words, the controller does not have to inspect all segments of the airspace if he knows where the traffic is at the outset). This approach obviously has the adverse consequence of jamming the users together and unnecessarily limits airspace capacity and the users' ability to operate the airplane most efficiently.

Direct routing capability would provide the ability to navigate with sufficient accuracy to ensure precise flight tracking according to an arbitrary flight plan filed before departure. This approach allows trips to navigate direct from origin to destination and at optimal altitudes. It is dependent upon precise 4-D navigation capability everywhere in the airspace as well and on air traffic control's ability to monitor aircraft navigation performance, or conformance to plan. The capability will probably also depend upon a significant amount of automation to process the numerous, potentially conflicting, flight paths. The benefits of direct routing would begin when a large percentage of the civil fleet has developed this capability. This requires foresight, and a long term commitment to ubiquitous adoption of such on-board capability.

Much like ADS, direct routing implies the sponsorship of more than one Operations group. The history of sponsorship on this need, however, is one of *no* sponsor, rather than joint sponsorship. There are serious demands to be placed on communications, navigation and automation resources for such a capability. Controllers would also very likely need to adopt new procedures to accommodate the diversity of flight paths that would be present. But there is no doubt that the airspace users need this capability. Cross functional sponsorship along with the contribution of the R&D service is required to effectively even state this need, let alone develop the capability.

Precision Approach Capability

Precision approach capability is the ability to provide lateral and vertical flight path guidance to near the touchdown zone of a runway that approximates the capability of an Instrument Landing System. Formally, the FAA planning documents cite the Microwave Landing System as the means to this capability.

The agency has had plans to implement MLS for more than a decade, but these plans are now obsolete. GPS has already been certified for non-precision approaches to thousands of airports and with wide area differential enhancements GPS is expected to provide precision approach guidance to thousands of runways around the world by 1996. When the wide area differential enhanced GPS is certified, other precision approach aids, such as Category I MLS will be unnecessary. Further enhancements are likely to make higher precision aids unnecessary.

The case of Precision Approach Guidance is clearly a case of the technology getting ahead of the FAA system development process. The tardiness in creating a GPS Mission Needs Statement (which was not created until summer of 1992 -- only 18 months before initial operational capability) occurred because R&D, which held the expertise and interest in GPS, and Flight Standards, which is responsible for navigation and landing needs, were not communicating

The facts are that ADS, Direct Routing and Precision Approach Capability are now implicit needs in the GPS MNS although none is emphatic.[3] GPS has been in development for more than fifteen years; its initial operational capability was originally anticipated before 1990 and was actually achieved in December, 1993. The ICAO identified the need for satellite-based ADS in the late 1980s and the entire body confirmed the need in September, 1991. The FAA only accomplished a GPS mission need statement in June, 1992.

---

[3] NAS Program Initiative #0050, p. 5.

I contend that the main reasons for the agency's apparent tardiness in initiating a serious GPS/GNSS program was the lack of operational sponsorship within the FAA. Recognition of the need was under-emphasized for a combination of reasons:

- In many functional respects, GPS/GNSS was perceived by Operations people as duplicating navigation systems already in place within the National Airspace System (if not generally in the world). System Operations people are generally hesitant to change the status quo as we have seen.

- Many of the needs that GPS/GNSS can satisfy cut across functional boundaries within Operations, as in the cases of ADS and direct routing discussed above, so there was no sponsor for change within an FAA user organization.

- Communication between Operations and Development groups was incomplete so Operations people did not appreciate, until recently, the added benefits of GPS.

- GPS is a DOD system, so the presumption may have been that FAA only need to monitor its continuing development at the hands of the other agency. The particular needs of civil aviation users for assured availability, reliability monitoring and improved accuracy were not recognized as crucial to operational improvements.

<u>Implications of Cross-Functional Communication</u>

In the early 1990s, the rest of the world was gearing up to take advantage of the services offered by GPS. In the US, National Airspace System users began to shout for an upgrade of GPS to full GNSS capability -- and more. Flight Standards reacted and sponsored a MNS and today stands as the principal sponsor of GPS/GNSS capability. Air Traffic is still apparently out of the loop.

The R&D Service, technology proponents to the core, are still the main drivers of the GPS/GNSS capability. The process works best, though, when a user is the main impetus behind a project. GPS, perhaps like many ATM improvement projects, cuts across traditional functional boundaries. But needs which should have several sponsors thereby obtaining increased sponsorship and vigor, end up with no clear sponsor resulting in more diffused and ineffectual support. This is a clear problem for management at FAA.

Resource Allocations

The application of resources is a powerful indicator of influence in an organization. Examination of the use of human and financial resources reveals that Operations is by far the most influential of the two major division at the FAA. The following sections will consider both dollar and human resources.

Funds

Major categories of spending for the FAA over the last 13 years are shown in Figure 4. The categories of spending are Airport Improvement Program (AIP) which is directed toward improvements in runway, taxiway and terminal improvements at public-use airports around the country; Facilities and Equipment (F&E) which is almost entirely spending on CIP projects; Research and Development (R&D) which is directed toward advanced technology investigations that could provide potential solutions in the future to National Airspace System needs; and Operations and Headquarters activities necessary to perform the ongoing aviation safety regulation and general management of the agency.
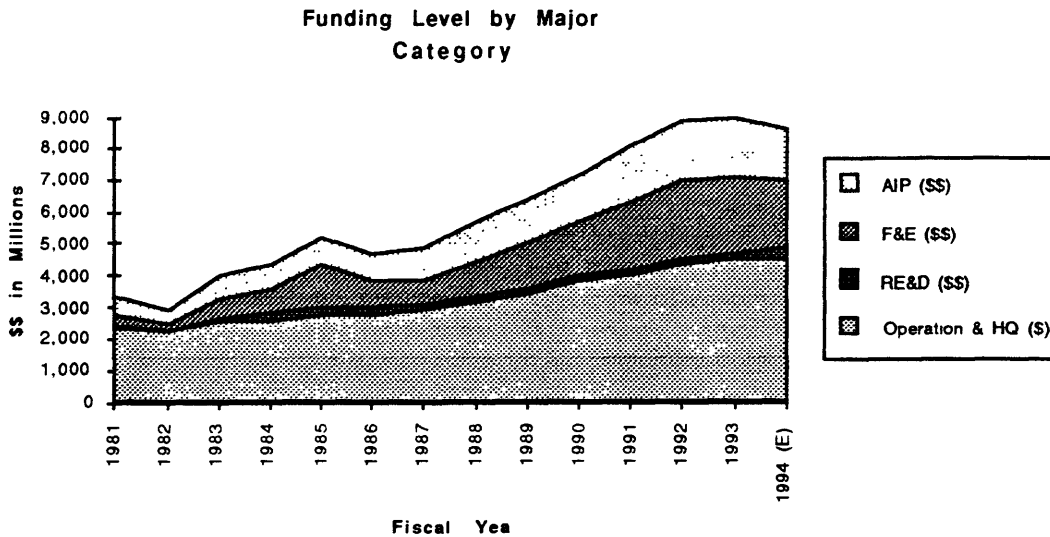
Funding Level by Major Category

Figure 4: Major Funding Categories in FAA Budget.

The figure depicts the large increase in F&E budgets which accompanied the original NAS Plan. A significant retrenchment in National Airspace System F&E activities in fiscal 1986 was later reversed and F&E activities have grown dramatically as a fraction of agency budget. In recent years there has been a greater reluctance on the part of DOT and the Administration to continue the large increases in F&E spending despite continuing difficulties with CIP implementation. That gravy train may have finally by running out, but at magnitudes of over $2 billion a year could not be considered small.

It is also worth noting that the PATCO strike in 1981 which resulted in massive firings of the controller workforce, had a smaller impact on Operations budgets than might be suspected. In fiscal 1983 Operations and HQ budgets were up only 17% compared to the year before. By comparison, during the interval between fiscal 1985 and 1992 the F&E budget increased 5.2 times, or 420%!

In fiscal 1994, Operations and Headquarters activities are expected to consume $4.58 billion out of an agency budget of $9.19 billion, or 50%. At $254 million and $2.12 billion the R&D and F&E budgets represent 3% and 23% respectively of the total agency budget.

It should be noted that both F&E and R&D funds described in these data are generally for contracted goods and services, rather than agency personnel. But the distinction is not perfectly clear since both F&E and R&D accounts are used to procure contract services to support in-house activities related to various acquisition projects. Thus some of the F&E and R&D funds identified in the figure above are used to provide surrogate FAA personnel.

Personnel

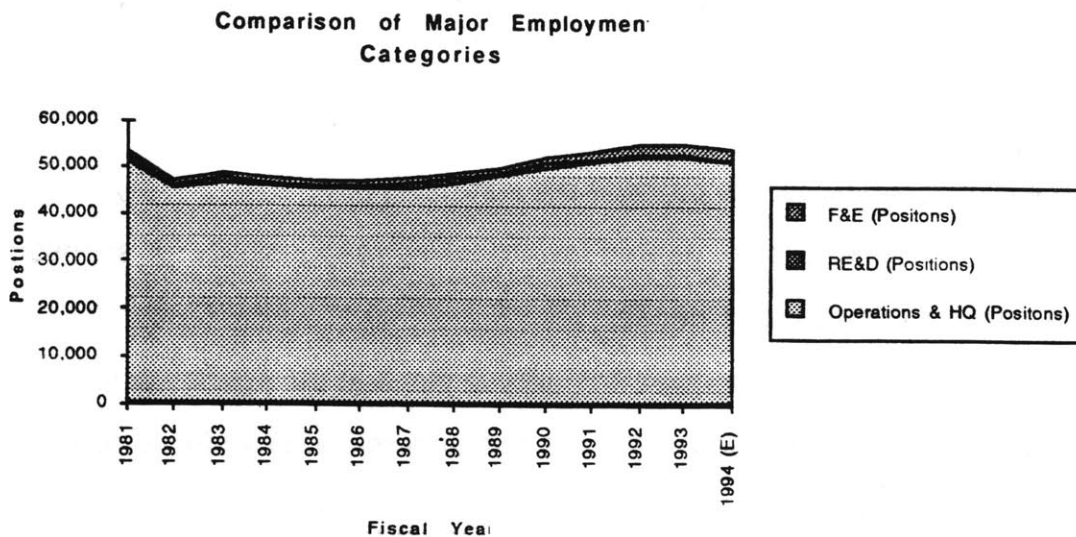The permanent FAA human resource allotments are depicted in Figure 5.

Figure 5: Major Employment Categories at FAA

There is no mystery in these data. The FAA staff is ruled by Operations. In 1984, 94% of the permanent allocated positions are in Operations and Headquarters areas. Out of slightly more than 54,000 positions in the agency, R&D areas are allocated 645 (1.2%) and F&E dedicated areas 2504 (4.6%) people. The effect of the PATCO strike is much more apparent in these data than the funding data. As mentioned above, there are other people hired on contract to support F&E and R&D activities, so the numbers reflected here in those areas are perhaps not as severe as they appear.

The background and culture of the FAA are clearly evident in these data: The permanent employment at the agency is directed toward ongoing operations; the role of system development as evidenced by F&E budgets in particular and to a lesser extent by R&D budgets did not exist as a major activity at the agency before fiscal 1983. The large increase in F&E spending and the realignment and expansion of agency responsibilities occurred as a result of the grand NAS plan.

Recognizing these facts, it is perhaps not surprising that:

- System Operations is not geared toward taking responsibility for sponsoring and defining new system needs.
- there was not a formal acquisition policy in place at the agency until very recently and that the policy is still not well understood or widely practiced today.
- there is *not* a strong sense of teamwork, communal purpose and cooperation between the major divisions in the agency.

Roles, Responsibilities and Rewards

The first sections of this chapter described the functional and cultural orientation of the key players relating to GPS/GNSS. This section reviews key aspects of the interactions between these players and highlights some of the difficulties encountered in modernization activities.

Understanding Functional Roles

There were several occasions in the interviews when I received contradictory or conflicting data about who was responsible for what during the mission needs analysis and the rest of the acquisition process. In most cases, these conversations were with senior managers . One wonders what confusion would have been evidenced if the regular workers had been queried for a description of the process. I was frequently greeted with the comment that when I had figured it out, would I please let the respective managers know how the system was supposed to operate. While this sort of remark is frequently encountered in large organizations working complex tasks, it was startling to find so frequently among senior managers. Interestingly, the people who seemed most confident of their comprehension of the system were those who had been in their jobs only a relatively short time. It was apparent to me that they had studied the formal procedures and had paid attention to the process briefings they had received as a normal part of taking a new assignment. They were not yet confused by the way things really worked around the agency!

Understanding functional roles of the various groups both in Operations, and Development is clearly deficient at the FAA. This situation arises from practices of senior management. There is good reason to suspect that the strong functional orientation of the agency is hurtful to its work since people do not look

"sideways" to the other functions, but concentrate on the "vertical" aspects of their chain of command. It is very difficult for them to get coordinated with this frame of mind and many issues must be elevated to high levels that should be decided at the working level. What's more, that one group does not clearly understand the commitment of another group in this environment is a prescription for disaster; everyone can easily assume that someone else is taking care of the problem when, in fact, no one is paying attention.

Ownership of the Need

The key to the acquisition process as defined in FAA Order 1810.1F is the development of a Mission Need Statement at the behest of an FAA sponsor. The sponsor is expected to work in the interests of one of the National Airspace System users. The entire approach to system development depends upon a sponsor who has a definite need, is committed to communicating that need and struggles to obtain the resources to satisfy the need. Once those resources are available it is the sponsor who should maintain some leverage over the quality of the solution to be implemented. The sponsor of a project can not be a bit player in this process or be relegated to observer status once it is initiated.

FAA management must strengthen the commitment of the various Operations groups to their responsibility to sponsor system modernization. This commitment should consider procedural as well as new system approaches. It should be clearly understood by everyone involved in the development process that the Operations groups are the sponsors of the projects and that they work in behalf of National Airspace System users. Project sponsors should appreciate the influence they have over development priorities and they responsibilities

they hold to an effective development process. They must be disciplined and committed to system modernization developments and a rigorous development process. This is the message defined in 1810.1F, but it must be reinforced and clarified to the entire agency.

Cross-Functional Team Activities

FAA management must work to reduce the functional orientation of the staffs if it has any intention of continuing to perform system development activities -- as surely it must to maintain an efficient, safe and productive airspace system. Concentration should be placed on improving teamwork and cooperation between staffs. This weakness is recognized by many at the FAA and the recommendation presented here was made by many of those managers; it is not universally held, however, and some at the agency would see their influence and territorial control diminished. The latter applies particularly to managers in the Air Traffic.

There are indications that purposeful team activities are being initiated at the agency in light of the recognition to promote teamwork. In February, 1994 the Executive Directors of System Operations and of System Development initiated two experimental development projects to be performed with integrated product development teams. The teams will be comprised of fully dedicated people from relevant groups in each of the divisions with a single team leader that will report to both Executive Directors. Each individual team member will maintain his functional duties, but will contribute them in a full-time team setting rather than as a task worker separated by functional walls. The first of the projects is expected to commence in March, 1994.

However, one issue that is yet to be resolved is the personnel evaluation and appraisal process that will apply in integrated product team settings. It is necessary that workers be responsible to the team for the quality of their work, but the human resource process at FAA is firmly entrenched along functional lines. The reward system is one of the most effective ways of communicating overall organizational objectives. If the rewards continue to be distributed by functional management, the transition to a product orientation will be upset, incomplete or nonexistent. On the other hand, if rewards are determined by solely project management, functional competence can perhaps suffer. Some combination of evaluation factors is probably best, but the dominance of functional management in this process should be revised. These procedures must be changed to give the program manager, as the agent of the sponsor, more control over appropriate rewards to development team members.

Requirements Definition

The acquisition policies recently authorized at the FAA attempt to impose a systematic and rigorous process on new development activities. The following analysis of these policies point out:

- significant confusion in particular process definitions including operational need, operational requirement and system concept.

- an omission, or under-emphasis, in the acquisition policies to conduct mission needs analysis to properly consider non-materiel procedural solutions.

- the potential for simulation as an integral part of the early needs analysis process.

Mission Needs or Operational Requirements?

The FAA Acquisition Policy, Order 1810.1F, requires that an operational

requirements document (ORD) be published during Phase 1, Concept

Exploration and Alternatives Analysis, of a new program. The ORD

> "establishes system-level performance thresholds and objectives and defines
> the planned life cycle of the product. It shall be updated during subsequent
> acquisition phases to reflect the results of trade-off studies, engineering
> development, and testing...A performance threshold is the value for a
> performance parameter that is necessary to satisfy mission need. An [sic]
> performance objective is a parameter value beyond the threshold that could
> potentially have a measurable and beneficial impact on capability. These
> performance objectives and threshold vales shall be developed from and
> remain consistent with the statement of operational need in the mission
> need statement. The ORD is the bridge between operational and functional
> requirements in the mission need statement and the performance
> specification that will govern development of a product. It provides the basis
> for performance thresholds and objectives in the acquisition program
> baseline and for the initial test and evaluation master plan."[4]

The ORD, like the Mission Need Statement, is a critical contributor to any new

system acquisition process since it established the most basic requirements for

a new system. What is meant here by requirements and how are they different

than need? What is an operational requirement and how is it different from a

functional requirement? Operational concepts are not mentioned in the

paragraph above but are often mentioned is such discussion -- what are they?

How is a performance specification different than a technical specification?

These questions are not answered in the FAA Acquisition Policy, or in any other

FAA policy that I have been able to discover. The differences between these

terms is significant although many of them are used synonymously which often

confuses the development process.

---

[4] FAA Order 1810.1F, p 1-19.

There is another issue that warrants discussion, which is that the ORD prescription defined above has an obvious predilection toward new system -- either hardware or software -- development. Non-materiel items, such as new procedures development, while not explicitly prohibited, are also not particularly encouraged during this phase. The supposition seems be that a comprehensive and orderly approach to mission needs analysis, which is accomplished in Phase 0, before KDP-1, is the stage at which non-materiel solutions should be considered and that once into Phase 1 an ORD is required only to manage "system-level performance...and the planned life cycle of the product." This presumption is hazardous and will be examined in the following section.

System Development Definitions

It is imperative that system developers, including the end-user and the sponsor within the FAA as well as the engineering developers and contractors, understand the requirements and specifications that are defined in any process improvement activity. There is great latitude for misunderstanding in this area unless the terms are clearly defined. Opposing views of the best approach to be used in ATM system improvement exist and are certainly legitimate, but many disagreements might well be the result of semantics due to imperfect communication or misuse or poor understanding of common terminology. In the absence of explicit definitions in FAA's acquisition literature, I offer the definitions below to facilitate further discussion:

Functional Requirement -- a statement of the necessary capability to be provided by the system in terms of separate functional aspects of a total task.

Functional Specification -- synonymous with functional requirement above.

Operational (or Operations) Concept -- a vision of a future approach to satisfy an operational need, including procedures, hardware and software and logistics support. There could be many operational concepts that would satisfy a particular operational need to varying degrees and at different cost.

Operational Need -- a statement of the necessity to perform a high-level task that can not currently be performed. Operational needs must be stated in operational terms (i.e. in terms of the task that must be accomplished) rather than in terms of specific procedures, hardware or software so that useful alternatives analysis may be performed.

Operational Procedure -- a description of how equipment and information are employed in order to accomplish a particular task. Operational procedures can be very detailed, down to the individual operator level; in the aggregate they define how the system is used to satisfy an operational need.

Operational Requirement -- a description of the roles to be performed by an element in an operational concept. The needs for each element of the operational concept, whether procedure, hardware or software, are defined in operational terms at this level. Collectively, description of all elements in an operational concept are the operational requirements and are gathered into the ORD.

Performance Specification -- a specific criterion to be achieved by a new system component. Applies to procedures, hardware and software. Performance

92

specs may be defined at any level of system definition, from the smallest identifiable system component up to the integrated system. Performance specs must be appropriate to the level of aggregation and are selected to be relevant to the particular function(s) to be accomplished by the component.

Technical Specification -- also referred to as design specs, is the detailed physical description of a development item. Applies to hardware and software. In the case of software, the spec. defines the structure of the software component, interfaces and data flows. This spec. also often includes manufacturing or production process definition.

These commodities flow into one another in a sensible pattern as development progresses. Figure 6, which follows, shows the flow of the items described above at a fairly global level. The acquisition policy defines the process in considerably greater detail although it differs in important ways as will be discussed below.

The FAA Acquisition Policy does not fully agree with the requirements development process defined in Figure 6. This gap is important. In particular, it leaves out the Operational Concept Analysis and Development activity altogether. Initially, one jumps to the logical conclusion that it would be included in the Phase 1 activity as part of Concept Exploration/Alternatives Analysis, but the consideration of non-materiel solutions for all practical purposes is left behind at Phase 0, Mission Needs Analysis. The "concept" that is understood in the FAA's parlance is a new hardware/software solution. The language in the description of the ORD quoted above is testimony to the fact

that operation procedures, for example, are not normally considered as part of the Concept Exploration phase.
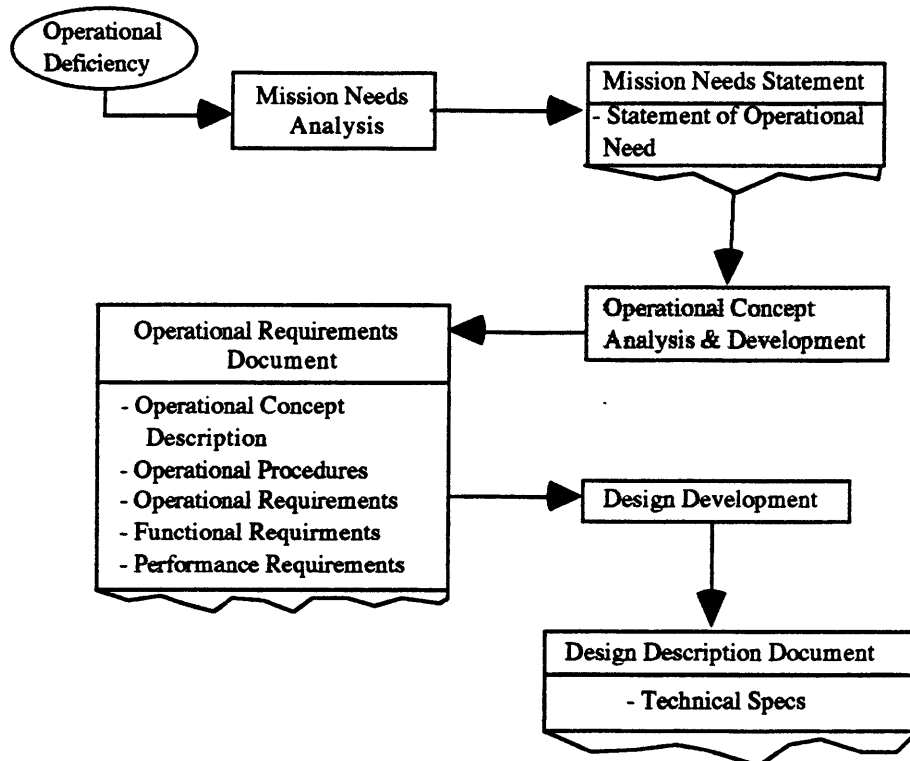
Figure 6: Requirements Development Process

I propose here that an Operational Concept Analysis and Development phase be inserted in the place of the Concept Exploration phase. At the very least, the FAA policy should be rewritten to emphasize the operational aspects of the development process rather then quickly focusing on new systems developments as the current approach does.

Simpson describes the current "inverted" development process in which a set of technical specifications are let to a contractor to produce a prototype system as one of the first development activities. In this approach expected benefits can

94

usually be vaguely stated in general terms of safety, cost reductions and capacity, but there is often no attempt actually to examine the operational problems. It is often at the point of prototype evaluation that the real needs of the system become apparent, which may require extensive parallel development in other areas or extensive redesign when a simple operational solution could have solved the problem.[5]

Operational Requirements & Operational Procedures

It is imperative that FAA revise its approach to systems improvement processes to take account of the proper consideration of procedural modifications early in the needs analysis phase.

Even if the current policy statement does not preclude the approach described in Figure 6, at also does nothing to either require the approach or even clarify its desirability. This is a major failing and points out the lack of a disciplined system engineering approach to ATM modernization. Certainly the advent of Order 1810.1F is helping to instill a measure of systematic discipline to development processes, but the policy itself is flawed with its obvious predilection for new system procurement as the expected outcome of every operational need. This attitude is misguided and renewed emphasis must be placed on consideration of operational procedures.

Nor are operational procedures in lieu of new systems the only issue. Even when new hardware or software elements are required in the ATM system there are certain to be procedural implications. If new procedures are not considered from the outset, many of the gains that could be provided by new systems will

---

[5] Simpson, June, 1993, p 4.

95

be squandered. In some cases potential benefits will not even have been discovered without some creative consideration of alternative procedural approaches.

One of the difficulties the FAA apparently encounters in considering procedural innovation is the cultural orientation of the operators, i.e. air traffic controllers, which is discussed earlier in this chapter. Standard operating procedures are the bedrock of Air Traffic's approach to operating the ATM system. While there may be many individual controllers who would eagerly consider procedural innovation, from an institutional perspective modification of certified procedures is a high-risk proposition. There are many risks and the benefits can be both ill-defined and uncertain. The culture among management at Air Traffic recognizes very little reward for this sort of innovation. The agency needs a way to lower the perceived and actual risk of procedural innovation.

Operational Simulation Capability

One approach to facilitating innovation of air traffic management procedures as well as lowering the risk of the innovation is through simulation. Simulation for air traffic control task has long been recognized as an essential tool to understand the human factors aspects of control operations and controller workstation design. In fact the Review Panel of the FAA RE&D Advisory Committee recommended that simulation capability be given a high priority by the agency to "streamline the transition of new technologies and concepts into the nation's air traffic system."[6]

Partly as a result of the Panel's recommendation, the FAA now has two separate simulation facilities. The National Simulation Capability (NSC) which

---

[6] R&D Plan Review Panel, p 36.

is located at MITRE and the FAATC, and the National Airspace Management Facility (NAMFAC) is at Oak Ridge, TN. The objective of both systems is to provide simulation capability of air traffic control tasks. Beyond that the distinction between these systems is unclear. On the one hand, it is encouraging that FAA has taken the guidance to heart so emphatically. On the other hand, the question is raised if the resources would be more effective if they were concentrated in a single facility.

In any event, it will not be sufficient to use the simulation capability to examine new technologies, new hardware and new software approaches. The simulation capability should also be applied to new procedures development. It should be an explicit goal of the simulation capability to develop new procedures for ATM modernization independent of other system developments. In other words, procedural innovations should be actively investigated in a simulation facility with both the current infrastructure and with new systems explorations. Such a task should be an essential element of the Operational Concept Analysis & Development phase of every project.

Systems Thinking Approach

Since the publication of Forrester's book, *Industrial Dynamics*, in 1961, a field has grown up that examines the performance of processes determined by complex systems of interrelationships. The field is now generally referred to as "System Dynamics" and focuses on problems that are characterized by *dynamic* behavior and in which that behavior is determined by *feedback* in a process. The dynamic nature of the performance means that it changes over time; the notion of feedback implies that an "output" of a process will also be an "input" to that same process.

The virtue of systems dynamics analysis is that it provides a powerful and unique way of modeling the complex features and interactions in virtually any process. It allows an examination of the effects of some hypothetical policy shift on the *entire* system, which is likely to be too complex to analyze by sequential exposition or by intuition. Indeed, one of the main benefits of the systems thinking approach is to reveal how inaccurate intuition can be in predicting behavior to a change in system management policy. Many problems related to ATM modernization, for example, are too complex to analyze intuitively; the application of management actions in one area can have totally unforeseen consequences in another are. Process that are determined by complex interactions, as are ATM modernization processes, are ideal for systems dynamics analysis.

A preliminary attempt at creating a definition of the key parameters, relationships and influence structures for one important sub-process is included in this thesis as Appendix D. The sub-process selected for this work is the conduct of the Mission Needs Analysis discussed elsewhere. Several variables determine the performance of that system including, number and skills of system engineering and operations research personnel, level of commitment of system engineering and FAA sponsor personnel, work load, and many others. The definition in Appendix D is, perhaps, incomplete, but could provide a nucleus to initiate future work.

Impact of ICAO on FAA

ICAO is the spokesman for the international civil aviation community. It is the only organization that represents the diverse aviation interests of governments and industry around the world. The FAA, which manages the largest, most

complex and most capable civil aviation system in the world, is usually far in advance of the rest of the world's aviation community. This situation produces a tendency on the part of FAA management to discount or ignore the issues raised at ICAO. Occasionally, though, ICAO stakes out a position that differs substantially with the FAA position and which proves to be superior. FAA management would do well to upgrade its interaction with ICAO.

As I initially planned this research, I assumed that the ICAO would be a powerful force influencing the actions and activities of the FAA in its ATM modernization endeavors. Similarly, I expected that the FAA, in turn, would have considerable influence over the international agency. In other words, I expected that the two organizations would be *roughly equal partners* in conceiving and developing global air traffic management plans and processes. The research in this area was directed at understanding where the centers of power lie for various issues, including institutional issues such as ownership, control, and charging for services of a global asset such as GPS/GNSS. Interviews with managers at ICAO and FAA contradicted my expectations in several important areas which are discussed below.

The general attitude among managers at FAA is that the agency leads ICAO. Both technical developments and air traffic procedural matters are assumed to be so far advanced compared to the rest of the world that little consideration is normally given to developments outside the US. Several people at FAA explicitly stated they felt ICAO would eventually adopt policies and plans initiated at FAA and that interactions with ICAO were essentially political in nature. In other words, FAA managers recognized that it would be necessary to form political coalitions with other countries or other international players in

order to smoothly promulgate FAA developed plans and procedures throughout the rest of the world, but that, with the least bit of common sense, FAA's plans were essentially de facto world standards. The hubris associated with the dominance of the US in post-WW II civil aviation is extensive in the FAA.

Despite the fact that there are some recent cases (albeit few) of standards or technology being instigated from outside the US, or by some agent other than FAA, at ICAO there is also begrudging acknowledgment that FAA policy, once firmly set, is essentially unassailable. An interesting historical example is the case of Microwave Landing System (MLS) standards. The UK was the strongest proponent of MLS initially because of their need for frequency allocation that did not conflict with other aeronautical radio and commercial FM broadcast uses, as well as for other reasons. The British were largely responsible for promoting MLS as the preferred approach to future precision landing-aid needs. But there was a significant difference of opinion about the signal pattern that should be adopted as the international standard for MLS. The US and UK each had a different preference. In the end MLS was adopted, but with the US-recommended signal pattern.

This decision presumably was made on the basis of technical merit. It is significant to observe that in this case the concept was initially promoted to the international community from outside the US, but US interests determined the outcome of establishing a technical standard. Perhaps this example is more typical of the pattern for development of international standards and recommended practices (SARPs).

Consider GPS/GNSS, as another example. While the US DOD had been developing GPS since the 1970s, the FAA had no more than an observer role

and as recently as 1990 (less than three years before initial operational capability) asserted that GPS would neither be mature enough or certifiable for civil navigation until after the turn of the century. The FANS committee, which had been considering the use of space-based resources since the mid-1980s, recommended a complement of satellite systems to support future ATM systems in 1988. This position was adopted by the ICAO membership in 1991 as described earlier. There can be little doubt that the commitment to satellite navigation evidenced by the ICAO decision had some influence with the FAA to increase its activities in development and promotion of GPS/GNSS. Finally, as we have seen, in the FAA 1992 turned on the Satellite Navigation Program in a serious way. Domestic users, particularly the airlines, were also influential in stimulating the FAA to initiate the Satellite Navigation project. There can be little doubt that the advanced position established by ICAO stimulated both the airlines and the FAA to adopt the satellite approach. The details of the GNSS implementation process remain to be determined, but it is clear that the FAA is now moving rapidly to accomplish the objectives of the FANS recommendations, and more, using enhanced GPS.

It seems probable, now that FAA is committed to GPS/GNSS, that they will develop and adopt technical processes and procedures that accomplish the FANS objectives. Indeed plans are well along to enhance GPS sufficiently to do more than even the FANS concept allocates to GNSS -- for example to use GPS/GNSS for non-precision approaches at virtually every suitable certified airport in the world; with wide area differential capability, for precision approaches with Category I capability to suitable runways; and with local area differential, for precision approaches with Category III capability to suitable runways. Excepting the possibility of technical "show stoppers," which are not

considered likely, it is virtually certain that these capabilities will be implemented by the FAA. Plans for wide area differential capability commit to full operational capability by 1998 but managers believe it will be available by the end of 1996. No approved plans yet exist for local area differential, but it is expected before the end of the decade. The US government has also offered the world community free, unhindered access to GPS signals for a minimum of ten years and into the foreseeable future (with a minimum of six years notice for a change in this policy) Given these facts, there is little doubt that the enhanced GPS will become the system ICAO envisioned for GNSS. In addition, the enhanced GPS will have more capability than originally identified by the FANS committee for a satellite navigation system.

FAA is proceeding along this development path satisfied that it is meeting domestic user needs and assuming that the resulting system will also meet the international community's needs as well. But there are some issues that continue to be concerns to GNSS users around the world such as:

- who pays for maintenance and upgrades of the system after it meets the basic needs?
- how will charges be imposed by the US on system users, if at all?
- how can the world community be assured that, in times of world crisis, the US will not restrict or eliminate access to navigation signals for security reasons?

These are legitimate concerns and loom larger in the consciousness of users outside the US than those inside. It is conceivable that a commercial venture providing assured access to satellite navigation would be viable if a robust and reliable revenue collecting scheme were developed. Some people claim that a dedicated civil navigation system could be fielded for less then half the cost of

GPS that would have greater accuracy, and as much coverage and reliability since it would not need the provisions dictated by national security. At $10 billion, GPS is not a good example of the costs of civil navigation satellite development costs. (The economic analysis of this proposition is beyond the scope of the current work.) Even if it is only a remote possibility, the prospect of a commercial satellite navigation system energized by the issues enumerated above could complicate and confuse a world standard approach to permanent GNSS. The Joint DOD/DOT Task Force on GPS management and operation also recognized the desirability of addressing these international concerns early when it recommended to the Secretaries of the two departments that DOT should initiate new activities to "enhance international acceptance of GPS."[7]

ICAO is the obvious body in which to debate and decide these issues and FAA would serve the nation and the world by addressing these concerns early. Senior management at the agency seems to be uncertain of the magnitude or importance of these issues by the international community. They project the attitude that once GPS is in place with the appropriate enhancements these concerns will evaporate. While US officials can be smug in their confidence that GPS services will always be available, they should appreciate that the rest of the world is not convinced and that further negotiations culminating in relevant policy commitments may be necessary to perpetuate a satisfactory world standard for GNSS.

Summary

There are several lessons for FAA management in the analyses discussed in this chapter. For one, executive management should recognize that the

---

[7] Joint DOD/DOT Task Force, p ES-4.

background, experience and culture of different parts of its staff tend to reinforce, rather than diminish, the divisions between groups. These forces work to seriously inhibit communication and cooperation between groups, which can be fatal to complicated development projects. Secondly, the agency has no experience and thus no ethic for teamwork. The "feudal fiefdoms" that one manager described captures the essence of the agency work ethic, which is inimical to teamwork. Cross-functional sponsorship and team work is essential to the crucial task of needs identification and analysis, but the agency has no regular mechanisms to facilitate cross-functional interaction. Thus critical activities are left unfinished or are never identified as necessary.

It is also evident that power and influence are unevenly distributed between the major player in development activities. It is sensible that Operations, which has the much larger job in the overall context of FAA responsibilities, receive the allocation of resources as currently allotted. It is not sensible that the Operations managers not be held to rigorous standards for needs identification and accountable for disciplined approach to development of new operational capabilities. This is not a responsibility that can be delegated to system developers without the crucial sponsorship and intense involvement of the internal user.

The development process does not properly define the necessary needs analysis to consider procedural approaches. The agency also lacks the simulation resources both to properly examine the procedural alternatives and to develop management confidence in procedural modifications.

Finally, ICAO represents legitimate and informed world aviation interests. FAA management would do well to remain vigilant to international ATM system concerns.

CHAPTER 5:   CONCLUSIONS AND RECOMMENDATIONS

The FAA is now moving along briskly with its plans to enhance GPS for civil aviation purposes. The satellite-based navigation capabilities the agency is preparing to provide are more extensive than those identified initially by the FANS committee and adopted by ICAO. Except for the possible exception of some institutional issues discussed in Chapter 4, the enhancements planned for GPS will provide all the capability identified for GNSS -- and more. The agency has approved a Mission Need Statement, created a Program Office and appointed a Program Manager for Satellite Navigation. The Program Office has developed an approved Satellite Navigation Master Plan and produced a Operational Requirements Document. The record seems to indicate that a disciplined system development process is applied to GPS enhancement efforts and the program is proceeding without difficulty.

Despite the current progress and indications of future success, the fact is that the GPS capability that exists today has been implemented entirely by the DOD, with essentially no contributions from FAA. While the plans for GPS enhancements are strictly positive and there is no indication of problems in implementing them, it is important to remember that GPS enhancements are still only plans. It remains for the FAA to place the enhancements in the field (or as may be, in space). There is no reason to believe that FAA's plans for GPS enhancement are faulty, but there is definite reason to believe that *the process for formulating plans and managing system development* leaves much to be desired.

We have seen that there are two major organizational groups within the agency and each is characterized by a distinct culture. System Operations people tend to be air traffic controllers and technicians; System Development people tend to be engineers and analysts. The experience base and the intellectual orientation of these two groups are significantly different; both are valid. Indeed both perspectives are *necessary* to successful ATM modernization or to any ATM system development. The extent of the cultural homogeneity within each group, and the disparity between groups serve as effective obstacles to information and goal sharing by the two groups.

The two groups are also very functionally oriented; power and authority are now directed along functional axes. The organizational structure of the FAA is partially a result of preferences in work style and orientation that are determined by remarkably similar personality types among agency managers. The strong functional bias of the organizational structure and the disposition to concentrate on inwardly motivated, problem oriented tasks further inhibits dialog across functional boundaries. The structure of the organization at the FAA and its reward system, in other words, actually work to aggravate the cultural and personality biases that, in combination, make cooperative project performance very difficult.

Cultural boundaries that prohibit communication and cooperation should be attacked by changing the agency organizational structure and reward system. The current model for development is an incremental, functional approach in which each person performs a particular task and "throws the work over the wall" to the next person in the chain. This process concentrates on the *boundaries* between participants rather than on the *customer oriented goal* of

the process. Integrated process/product development (IPD) teams are a better approach to accomplishing development activities. In the IPD approach, personnel with all the relevant skills are dedicated to the team activity. An IPD team would, of necessity include people from both the current System Operations and System Development divisions as well as other divisions as might be germane to the project. Responsibility becomes product, rather than function, oriented. At the same time individuals are responsible to both the team and their functional leadership for technical expertise. The main measure of success and the main determinant of rewards is the success of the team pursuit of new system development. IPD team structure gives development groups the human and financial resources they need to accomplish their job, the authority to decide from among relevant alternatives, and the commitment to a common goal. The influence of the functional leadership should be substantially reduced and vastly more influence given to IPD team leaders to select and reward team members. Influence of functional managers on personnel rewards should not be eliminated since they continue to be responsible for performance to functional standards of excellence. Personnel rewards are a key to success of this approach and will be the most difficult for the FAA to institute. Several organizations have now successfully adopted the IPD team approach with good effect and the prospects for FAA in their development, if not all, activities are favorable.

In addition other more "tactical" issues could be addressed by FAA management immediately. For one, there is a confused definition of concept exploration activities that fails to properly account for analysis of potential procedural innovations in combination with new hardware solutions to an identified need. Emphasis on non-development and non-materiel solutions to

satisfy emergent needs is deficient and the prescription for appropriate trade studies occurs too late in the development process (Phase 1, Concept Exploration rather than Phase 0, Mission Needs Analysis) to have significant impact. This deficiency could be quickly solved by amending the Acquisition Policy to redefine mission needs analysis to include this imperative. The more considerable effort would be to undertake a training task to educate both developers and operators in the need to conduct appropriate trade studies during the needs analysis phase. Needs analysis is the key to the entire remainder of the development process; if it is not conducted thoroughly and systematically any project is likely to encounter difficulty along the development path.

For another, there is no clear assignment of responsibility for engineering and operations trade studies. The System Engineering group (ASE) is employed as a super-program management function. Much of their effort is apparently expended coordinating the activities of the various projects vying for resources within FAA. While this activity is undoubtedly legitimate, there are questions as to its effectiveness and efficiency. This is not systems engineering in the traditional sense. More important are questions are raised about who manages and who supports systems engineering and operations trade studies. As practiced at the agency today, each individual program manager is left to his own devices to compose a project team with the appropriate skills to accomplish necessary project tasks. Instead FAA management to ensure that a functional group is tasked with responsibility to develop and maintain a skilled body of system engineers -- people who are expert in the disciplines of requirements analysis and allocation. This is a unique technical discipline and requires specific training and experience to become expert. Program managers

should know that their needs for system engineering skills can be satisfied in some particular place.

It is heartening to appreciate that FAA management has already recognized the possibilities of IPD team development even if they have not fully adopted it as the preferred management process. Two experimental developments are to be initiated at the agency with this process in 1994. IPD is not a process that can be implemented half way; a full commitment by management including appropriate human resource and business support procedures are necessary for it to be successful. For these experiments to be valid, therefore, management must ensure that the teams receive appropriate instruction to reorient them to the new axes of responsibility and accountability and to the basis of a common purpose. It must also be especially vigilant to the establishment and maintenance of appropriate incentives to team members that do not conflict with the rest of the agency. These will be major challenges but with proper care can be overcome.

The enhancements the FAA plans for GPS will make it a fabulously powerful navigation source for the world's airspace users. The capabilities provided will reach way beyond that envisioned in the FANS GNSS definition. It the FAA can accommodate the institutional issues that are still concerns to many aviation groups around the world it will become the standard GNSS and could do so even in spite of those concerns. When integrated into successful accomplishment of the rest of the agency's Capital Investment Plan, GPS/GNSS will provide a more modern, dramatically improved ATM system. Several organizational and management changes at the agency will ensure those plans are enacted sooner rather than later, or not at all.

LIST OF ACRONYMS

1810.1F	FAA Acquisition Policy document
A-109	Office of Management & Budget circular on acquisition policy
AAS	Advanced Automation System
ADS	Automatic Dependent Surveillance
AFS	FAA Flight Standards Service
AIP	Airport Improvement Program
ALR	Alerting Services
AND	FAA NAS Development Orgnization
AOR	FAA Operations Research Service
ARD	FAA Research and Development Service
ARINC	Aeronautical Radio, Inc.
ASD	FAA Administration for System Engineering and Development
ASE	FAA NAS System Engineering Service
ASM	Air Space Management
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATM	FAA Office of Air Traffic System Management
ATN	Aeronautical Telecommunications Network
ATP	FAA Air Traffic Rules & Procedures Service
ATR	FAA Air Traffic Plans & Requirements Service
ATS	Air Traffic Services
AVR	FAA Administration for Regulation & Certification
CIP	Capital Investment Plan

CNS	Communication, Navigation and Surveillance
COSPAS	SARSAT from former-Soviet Union
COTS	Commercial Off-The-Shelf
DOD	Department of Defense
DOT	Department of Transportation
F&E	Facilities and Equipment
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIS	Flight Information Services
FOP	Future Operational Procedure
FOR	Future Operational Requirement
FSAS	Flight Service Automation System
FTC	FAA Technical Center
FWG	Functional Working Group
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
IGIA	Interagency Group for International Aviation
ILS	Instrument Landing System
KDP	Key Decision Point
MLS	Microwave Landing System
MNS	Mission Needs Statement
NAMFAC	National Airspace Management Facility
NAS	National Airspace System
NASPAL	National Airspace System Precision Approach & Landing
NCS	National Simulation Capability

NDI	Non-Developmental Item
NOTAM	Notice to Airmen
OAP	Oceanic Automation Program
ODAPS	Oceanic Display and Planning System
OTS	Operational Training System
PET	Pacific Engineering Trials
RAIM	Receiver Autonomous Integrity Monitoring
RD&E	Research, Development and Engineering
RML	Radio Microwave Link
RNAV	Area Navigation
RNP	Required Navigation Performance
RTCA	Radio Technical Commision for Aeronautics
SARP	Standard and Recommended Practices
SARSAT	Search and Rescue Satellite
SEOAT	System Engineering Operations Analysis Team
SOIT	Satellite Operational Implementation Team
SSR	Secondary Surveillance Radar (i.e. with radar beacon transponder)
TCAS	Threat Alert & Collision Avoidance System
TMS	Traffic Management System
VOR/DME	VHF Omnidirectional Range/Distance Measuring Equipment

BIBLIOGRAPHY

Allison, Graham T., *Conceptual Models and the Cuban Missile Crisis*, The American Political Science Review, Vol. 63, No. 3, September, 1969.

Aviation System Capital Investment Plan, Federal Aviation Administration, Washington, D.C., December, 1991.

Beukers, John M., Global Radionavigation - Heading Towards a United States Monopoly?, International Omega Society Annual Meeting, Amsterdam, August 4, 1992.

Beukers, John M., *Institutional and Financial Alternatives for Global Satellite Navigation*, GPS World, October, 1992.

Beukers, John M., Politics, Economics and Implementation of Global Radionavigation Systems, Royal Institute of Navigation Nav 91 - Satellite Navigation Meeting, London, November 6-8, 1991.

Beukers, John M., The Window of Opportunity for A GNSS, Buekers Technology, Vero Beach FL, January 29, 1993

Concepts and Description of the Future Air Traffic Management System for the United States, Federal Aviation Administration, Washington, D.C., April, 1991.

Del Balzo, Joseph M., *US Air Traffic Control Modernization: Lessons Learned*, Journal of ATC, Oct-Dec, 1992.

FAA Annual Report - Fiscal Year 1992, Federal Aviation Administration, Washington, D.C., 1993.

FAA Capital Investment Planning Process for FY 1996, Federal Aviation Administration, September, 1993.

FAA Order 1810.1F, Acquisition Policy, Federal Aviation Administration, Washington, D.C., March 19, 1993.

FAA Satellite Navigation Program Master Plan, FAA R&D Service, Satellite Program Office, Washington, DC, February 15, 1993.

GAO/IMTEC-91-25, Air Traffic Control: FAA's Advanced Automation System Contract, General Accounting Office, Washington, D.C., March 5, 1991.

GAO/RCED-91-152, Meeting the Aviation Challenges of the 1990's: Experts Describe Key Problems and Identify Emerging Issues, General Accounting Office, Washington, D.C., July, 1991.

GAO/RCED-92-136BR, Air Traffic Control: Status of FAA's Modernization Program, General Accounting Office, Washington, D.C., April 3, 1992.

GAO/RCED-92-180, Aviation Research: FAA Could Enhance Its Program to Meet Current and Future Challenges, General Accounting Office, June 3, 1992.

GAO/RCED-93-121FS, Air Traffic Control: Status of FAA's Modernization Program, General Accounting Office, Washington, D.C., April 16, 1993.

GAO/RCED-93-55, Air Traffic Control: Justification for Capital Investments Need Strengthening, General Accounting Office, Washington, D.C., January 14, 1993

GAO/T-RCED-92-34, Air Traffic Control: Challenges Facing FAA's Modernization, General Accounting Office, Washington, D.C., March 3, 1992

GAO/T-RCED-93-68, Aviation Research: Issues Related to FAA's Research Activities, General Accounting Office, Washington, D.C., July 29, 1993.

Gellman Research Associates, Inc., Cooperation and Coordination in Federal Aviation Research, OTA Contractor Paper OTA RFP #92-SET1, Draft, August 27, 1992.

Joint DOD/DOT Task Force, The Global Positioning System: Management and Operation of a Dual Use System, Washington, DC, December, 1993.

Kane, F.X. & Sheerer, J.F., The Global Role of Navstar, Aerospace America, July 1984.

Margerison, C. & Lewis, R., Mapping Managerial Styles, International Journal of Manpower, Vol. 2, No. 1.

Morgan, Ron, et al, FAA System Engineering Management: Renewed Emphasis on User Needs and System Evolution, MITRE Document No. MP 92W0000037, August, 1992.

Myers, I.B., The Myers-Briggs Type Indicator, Princeton: Educational Testing Service, 1962.

NAS Program Initiative No. 0050, Application of Satellite-Navigation Capability for Civil Aviation, Federal Aviation Administration, Washington, DC, June 30, 1992.

National Challenges Concerning a Global Satellite-Based Environment for Air Traffic Management, Draft, Volpe National Transportation Systems Center, April 20, 1992.

Nyhart, J.D., The Elements of Negotiation Management: Using Computers to Help Resolve Conflict, Negotiation Journal, Spring, 1989.

Operational Requirements Document, <u>Application of Satellite Navigation Capability for Civil Aviation</u>, Federal Aviation Administration, Washington, DC, September, 22, 1993.

OTA-SET-392, <u>Safe Skies for Tomorrow: Summary - Aviation Safety in a Competitive Environment</u>, Office of Technology Assessment, Washington, D.C., July, 1988.

Perry, James L. & Kenneth L. Kraemer, <u>Public Management: Public and Private Perspectives</u>, Mayfield Publishing, Palo Alto, CA, 1983.

Pfeffer, Jefrey, <u>Managing with Power: Politics and Influence in Organizations</u>, Harvard Business School Press, Boston, 1992.

Pfeffer, Jefrey, <u>Power in Organizations</u>, Pitman Publishing, Marshfield, MA, 1981.

Poole, Robert W., Jr., <u>How to Spin Off Air Traffic Control</u>, The Reason Foundation, Los Angeles, August, 1993.

R&D Plan Review Panel of the FAA RE&D Advisory Committee, <u>Review of the FAA Research, Engineering and Development Program</u>, Federal Aviation Administration, Washington, D.C., November, 25, 1991.

<u>Report of the Special Committee on Future Air Navigation Systems - Fourth Meeting, FANS/4</u>, International Civil Aviation Organization, Montreal, May 20, 1988.

Simpson, Robert W. <u>Co-operation in ATM - 1993</u>, Presentation to ATCA 1993 International Technical Program, MIT, October 28, 1993.

Simpson, Robert W., <u>Using ATC Operational Requirements to Guide FAA R&D and Procurement Activities</u>, (Prepared for Office of Technology Assessment), MIT, June, 1993.

Sutton, Oliver, *FANS to Rescue 21st Century Air Traffic*, <u>Interavia Aerospace Review</u>, December, 1989, pp1171-74.

The Navstar Global Positioning System, <u>Aviation Week & Space Technology</u>, January 10, 1994, p 67.

Transportation Research Board, <u>Winds of Change: Domestic Air Transport Since Deregulation</u>, National Research Council, Washington, D.C., 1991 .

Transportation, Defense Depts. Reach Accord on GPS Use, <u>Aviation Week & Space Technology</u>, January 3, 1994, p. 32.

Interview Outline for ATM Modernization Thesis:
GNSS Development

Proposed interview topics for: **FAA Managers**

The US has the best Air Traffic Management system in the world - indisputably. The interview contemplated here is directed at understanding the management processes used in the recent past, and planned for the future, to continue improving the nation's ATM system. The following questions indicate the sort of information sought. Some questions are general in nature but all are presented in the context of GNSS development. All interviews will be confidential - not for attribution; but the final thesis, which distills data from many interviews, will be published in unrestricted form per MIT policy.

New System Development Processes

What are your organization's responsibilities relative to the definition of requirements for the GNSS component of the FANS concept? How have these responsibilities changed within the last ten years in comparison with previous air traffic CNS resources?
- relative to GNSS development, test and evaluation?
- relative to GNSS acquisition?
- relative to GNSS operation?

Who do you regard as the stakeholders in determining the configuration of the future ATM environment in the US? in the world?

In your view, are all stakeholders fairly represented? What recommendations would you make for improving the development process for new CNS systems? For improving development of new operational procedures?

Do you consider new CNS system developments, particularly GNSS, vital to improved productivity in the ATM system? If not, what do you consider the major needs to be?

Budget and Domestic Political Considerations

How effective is the current budgeting process at supporting the obligations of your organization? Are your responsibilities and obligations reasonably balanced with the human and capital resources available to you? How long is the sensible planning horizon for your resource needs? Does the budget process allow adequate continuity to plan to this horizon?

To what extent would you say your organization suffers from the vicissitudes of Congressional action, compared to other parts of the FAA? Compared to a public corporation? Compared to a private company?

What is your opinion of the time required to reach decisions?

Do you have the authority to make decisions within your field? Who can countermand your decisions?

Who is accountable for decisions that have been made?

International Political Considerations

How does your organization interact with ICAO? What responsibility do you have to help lead development of ICAO plans regarding both system development and operations?

To what extent are your operations influenced by the need to coordinate with other nations or establish international standards?

Interview Outline for ATM Modernization Thesis:
GNSS Development

Proposed interview topics for: ICAO Managers

The US has the best Air Traffic Management system in the world but the need to continue system improvement is relentless and unremitting and the need to coordinate ATM operations worldwide is imperative. The interview contemplated here is directed at understanding the management processes used in the recent past, and planned for the future, to continue improving the US ATM system. The following questions indicate the sort of information sought. Some questions are general in nature but all are presented in the context of GNSS development. All interviews will be confidential - not for attribution; but the final thesis, which distills data from many interviews at the FAA and ICAO, will be published in unrestricted form per MIT policy.

New Capability Definition Processes

What are your organization's responsibilities relative to the definition of requirements for the GNSS component of the FANS concept? How have these responsibilities changed within the last ten years in comparison with previous air traffic CNS resources?
- relative to GNSS development, test and evaluation?
- relative to GNSS acquisition?
- relative to GNSS operation?

Who do you regard as the stakeholders in determining the configuration of the future world-wide ATM environment?

In your view, are all stakeholders fairly represented? What recommendations would you make for improving the development process for new CNS capability? For improving development of new operational procedures?

Do you consider new CNS system developments, particularly GNSS, vital to improved productivity in the ATM system? If not, what do you consider the major needs to be?

How does the FAA contribute to definition of new CNS capabilities? What are the major relationships and what data flows between FAA and ICAO relating to GNSS capability? What problems are recognized in these relationships or data flows?

Who are the other major contributors to ICAO processes (i.e. what nations or international entities)? Are relationships between ICAO and other entities similar to those with FAA? What differences between relationships with FAA and the others, if any?

Budget and Political Considerations

How is ICAO funded? Is the ICAO budget process supportive of the planning required to coordinate new capability definition and development? Are budget resources adequate to the needs of the organization?

How does ICAO enforce/compel member states to comply with ICAO-adopted plans? How is schedule discipline imposed on member states? How are technical standards enforced or maintained?

To what extent would you say your organization suffers from the vicissitudes of US government policy? To what extent does it suffer from changeable policy in other member states?

What is your opinion of the time required to reach decisions?

Do you have the authority to make decisions within your field? Who can countermand your decisions?

Who is accountable for decisions that have been made?

GNSS OPTIONS AND ASSOCIATED IMPLICATIONS

Notes. —

1. The five options (satellite and augmentation as required) will all provide GNSS service in accordance with RNP requirements up to and including precision approach, and provided that the respective institutional issues are resolved and safety regulations are satisfied, could serve as a long-term GNSS.

2. Options 1 through 5 can be an evolutionary progression. Therefore, failure to reach any particular option will still provide acceptable GNSS service as long as the respective institutional issues are resolved and safety regulations are satisfied.

3. The material in this table is not exhaustive. It is expected that further analysis will modify and refine the table contents.

Option	Satellite	Satellite Ownership/ Control	Augmentation for Integrity and Accuracy Assurance	Cost Items to Navigation Service Provider	Cost Recovery for Cost Items to Provider	Transition Issues	Institutional Factors
1.	GPS or GLONASS	US government (GPS) Government of Russia (GLONASS)	RAIM Ground monitor (where required for a particular phase of flight) Differential (for precision approach)	Ground monitor station(s) Differential	Route charges or other cost recovery method of charging		No charge for satellite use. Satellite availability per ICAO commitments (Tenth AN Conf. & 29th Assembly)
2.	GPS and GLONASS	US government (GPS) Government of Russia (GLONASS)	RAIM Ground monitor where required Differential (for precision approach)	Differential Ground monitor station(s), if implemented	Route charges or other cost recovery method of charging	Receivers capable of GPS/ GLONASS operation	No charge for satellite use. Satellite availability per ICAO commitments (Tenth AN Conf & 29th Assembly)
3.	GPS/ GLONASS + Overlay	US government (GPS) Government of Russia (GLONASS) 3rd party (eg, for Inmarsat overlay)	RAIM Ground monitor where required Differential (for precision approach)	Differential Ground monitor station(s), if implemented Overlay	Route charges or other cost recovery method of charging for ground systems State reimburses overlay provider. Costs recovered via route charges.	Receivers capable of GPS/ GLONASS operation Overlay compatibility with GPS and GLONASS	No charge for (GPS/ GLONASS) satellite use. Satellite availability per ICAO commitments (Tenth AN Conf. & 29th Assembly)

Option	Satellite	Satellite Ownership/ Control	Augmentation for Integrity and Accuracy Assurance	Cost Items to Navigation Service Provider	Cost Recovery for Cost Items to Provider	Transition Issues	Institutional Factors
4.	GPS/ GLONASS + several civil GNSS satellites	US government (GPS) Government of Russia (GLONASS) Other States and/or parties for GNSS satellites and control	RAIM Ground monitor if required Differential (for precision approach)	Differential Ground monitor station(s), if implemented GNSS satellite launch and operation	Route charges or other cost recovery method of charging for ground systems States, groups of States or international GNSS satellite consortium funded by various sources. Costs partially recovered via route charges and other user charges	GNSS compatibility with GPS and GLONASS	Cost sharing mechanism among States for GNSS (US and Russia participation to be GPS & GLONASS) User free to operate with any satellites
5.	Civil GNSS satellites	3rd party (or parties) for GNSS satellites and control	RAIM Ground monitor if required Differential (for precision approach) if required	Differential GNSS satellite launch and operation	Route charges or other cost recovery method of charging for ground systems States, groups of States or private entities or international GNSS satellite consortium funded by various sources. Costs recovered via route charges and other user charges.	GNSS compatibility with GPS and GLONASS Means to transition GPS and GLONASS to international satellite consortium	Cost sharing mechanism among States for GNSS User free to operate with any satellites

PHASE 1 | PHASE 2 | PHASE 3

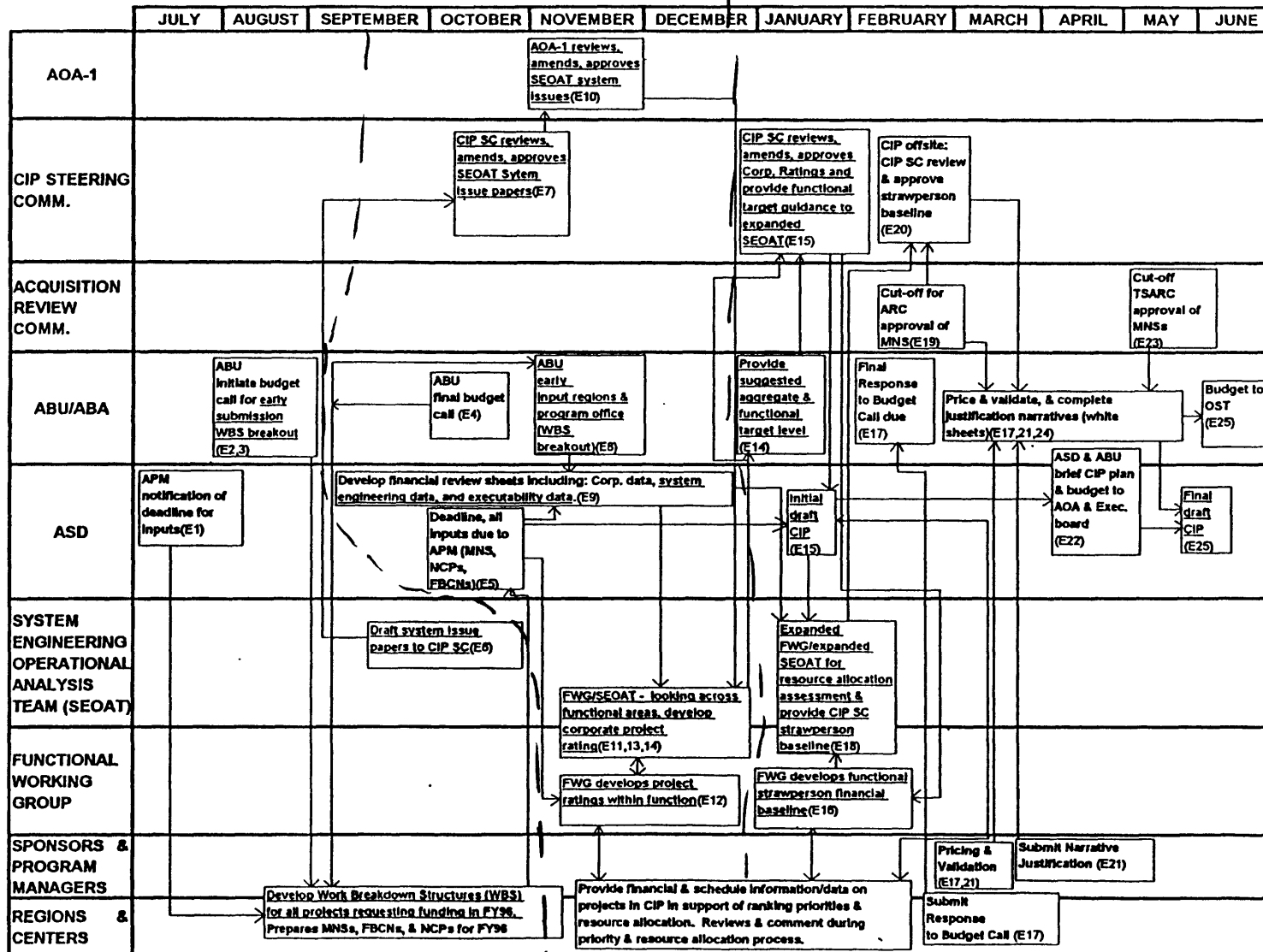|	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
AOA-1					AOA-1 reviews, amends, approves SEOAT system issues(E10)							
CIP STEERING COMM.			CIP SC reviews, amends, approves SEOAT Sytem issue papers(E7)			CIP SC reviews, amends, approves Corp. Ratings and provide functional target guidance to expanded SEOAT(E15)	CIP offsite: CIP SC review & approve strawperson baseline (E20)					
ACQUISITION REVIEW COMM.							Cut-off for ARC approval of MNS(E19)		Cut-off TSARC approval of MNSs (E23)			
ABU/ABA		ABU initiate budget call for early submission WBS breakout (E2,3)	ABU final budget call (E4)		ABU early input regions & program office (WBS breakout)(E6)	Provide suggested aggregate & functional target level (E14)	Final Response to Budget Call due (E17)	Price & validate, & complete justification narratives (white sheets)(E17,21,24)		Budget to OST (E25)		
ASD	APM notification of deadline for inputs(E1)		Develop financial review sheets including: Corp. data, system engineering data, and executability data.(E9) / Deadline, all inputs due to APM (MNS, NCPs, FBCNs)(E5)				Initial draft CIP (E15)		ASD & ABU brief CIP plan & budget to AOA & Exec. board (E22)	Final draft CIP (E25)		
SYSTEM ENGINEERING OPERATIONAL ANALYSIS TEAM (SEOAT)			Draft system issue papers to CIP SC(E6)		FWG/SEOAT - looking across functional areas, develop corporate project rating(E11,13,14)		Expanded FWG/expanded SEOAT for resource allocation assessment & provide CIP SC strawperson baseline(E18)					
FUNCTIONAL WORKING GROUP					FWG develops project ratings within function(E12)		FWG develops functional strawperson financial baseline(E16)					
SPONSORS & PROGRAM MANAGERS								Pricing & Validation (E17,21)	Submit Narrative Justification (E21)			
REGIONS & CENTERS			Develop Work Breakdown Structures (WBS) for all projects requesting funding in FY96. Prepares MNSs, FBCNs, & NCPs for FY96		Provide financial & schedule information/data on projects in CIP in support of ranking priorities & resource allocation. Reviews & comment during priority & resource allocation process.		Submit Response to Budget Call (E17)					

Figure 1: FAA CIP Planning Process Cycle for FY 1996

Note: (E#) Located in boxes indicates event number (see Appendix H)
Red & Underlined events are new to the process this year