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BREAKING THE MISSION PLANNING BOTTLENECK:

A NEW PARADIGM

by

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14. ABSTRACT
Mission planning has come a long way from the days of the Wright brothers first flight in 1903. Today, mission planning has grown into an activity as complex as the machines that carry out the missions. No longer a luxury, automated mission planning systems are vital to the success of current and future air operations. The history of automated mission planning development has been a chaotic combination of official systems and grassroots stovepipes. The Air Force has always leaned towards Unix based mission planning systems, but recent growth in the microprocessor industry has made personal computers a viable option. The Air Force?s continued emphasis on Unix based mission planning systems designed to do everything for everyone has created a bottleneck which may become a critical failure point when examined in light of increasing mission planning requirements. This paper relies on up to date information obtained through interviews and recent publications to analyze this bottleneck from the perspective of F-16 mission planning. As F-16 mission planning requirements grew through the early 1980?s, early mission planning systems progressed along two paths. The larger effort was in the large Unix based systems, which were generally better funded and large scoped projects. The second path was personal computer (PC) based systems, and while smaller in every sense has always been the preferred path by the users. Currently, two members of the Air Force Mission Support System (AFMSS) family dominate mission planning: the Unix based Mission Planning System (MPS) and the PC based Portable Flight Planning Software (PFPS). The size, cost, usability, and portability of the MPS systems have created a bottleneck that threatens the future of mission planning unless a new direction is taken. This new direction must feature heavier use of PC systems, with emphasis on integrated products as opposed to one master mission planner that attempts to fulfill everyone?s needs. Several future projects hold promise to break this bottleneck. The Joint Mission Planning Segment (JMPS) is a cooperative effort between the Air Force and the Navy which will provide a scaleable, tailorable solution for mission planning. CyberWarrior Insights is a PC based add-on program for PFPS designed to provide a virtual scheduling and training shop which will integrate and automate these functions with mission planning. Similarly, the Flight Information Enhancement (FIE) attempts to develop a PFPS add-on that provides virtual base operations functions. All of these take mission planning in the right direction?customizable PC based systems. If the Air Force is going to meet today?s demands for activities such as precision strike and multinational operations as well as meet the challenges of the dynamic changes outlined in Joint Vision 2010?then new directions must be explored in automated mission planning. Continued reliance on inappropriate Unix systems must be abandoned, and the bottleneck broken in favor of PC based solutions.

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Preface

For the past several years I worked at Eglin AFB, Florida testing automated mission planning systems. I was fortunate enough during that period to work with many outstanding personnel, both from the Air Force and civilian contractors. It was through these people that I was made aware of the foibles and follies of Air Force mission planning development. I chose to do this project in the hopes that it may inspire some rational balanced consideration of future efforts in mission planning development.

I would like to thank Major Glenn Carlson of Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama. As my faculty research advisor, he provided invaluable guidance that ensured the research process was both professionally and personally rewarding. Major Carlson allowed me to pursue this project through slightly unconventional means so that this project could be brought to fruition. Hopefully it will be of assistance to those steadfast few out there still trying to breathe common sense into the process.

Abstract

Mission planning has come a long way from the days of the Wright brothers first flight in 1903. Today, mission planning has grown into an activity as complex as the machines that carry out the missions. No longer a luxury, automated mission planning systems are vital to the success of current and future air operations.

The history of automated mission planning development has been a chaotic combination of official systems and grassroots stovepipes. The Air Force has always leaned towards Unix based mission planning systems, but recent growth in the microprocessor industry has made personal computers a viable option. **The Air Force's continued emphasis on Unix based mission planning systems designed to do everything for everyone has created a bottleneck which may become a critical failure point when examined in light of increasing mission planning requirements.** This paper relies on up to date information obtained through interviews and recent publications to analyze this bottleneck from the perspective of F-16 mission planning.

As F-16 mission planning requirements grew through the early 1980's, early mission planning systems progressed along two paths. The larger effort was in the large Unix based systems, which were generally better funded and large scoped projects. The second path was personal computer (PC) based systems, and while smaller in every sense has always been the preferred path by the users.

Currently, two members of the Air Force Mission Support System (AFMSS) family dominate mission planning: the Unix based Mission Planning System (MPS) and the PC based Portable Flight Planning Software (PFPS). The size, cost, usability, and portability of the MPS systems have created a bottleneck that threatens the future of mission planning unless a new direction is taken. This new direction must feature heavier use of PC systems, with emphasis on integrated products as opposed to one master mission planner that attempts to fulfill everyone's needs.

Several future projects hold promise to break this bottleneck. The Joint Mission Planning Segment (JMPS) is a cooperative effort between the Air Force and the Navy which will provide a scaleable, tailorable solution for mission planning. CyberWarrior Insights is a PC based add-on program for PFPS designed to provide a virtual scheduling and training shop which will integrate and automate these functions with mission planning. Similarly, the Flight Information Enhancement (FIE) attempts to develop a PFPS add-on that provides virtual base operations functions. All of these take mission planning in the right direction—customizable PC based systems.

If the Air Force is going to meet today's demands for activities such as precision strike and multinational operations as well as meet the challenges of the dynamic changes outlined in *Joint Vision 2010*—then new directions must be explored in automated mission planning. Continued reliance on inappropriate Unix systems must be abandoned, and the bottleneck broken in favor of PC based solutions.

Chapter 1

Introduction

Since the Wright brothers first flew in 1903, aviators have had to engage in one form or another of mission planning. For Orville and Wilbur, it may have been as simple as tossing a few blades of grass in the air to check the wind. Today's aviators have a far more daunting task when it comes to mission planning.

Mission planning has grown into an activity as complex as the machines of today's skies. Planning is much more involved than the days of old—the new age aviator must factor in communications, weaponry, routing, computer programming, and a myriad of other preflight factors. In order to help the aviator deal with these complexities, automated mission planning systems were developed. These systems rapidly grew from a luxury to a necessity as the demands for premission data processing and transfer increased.

Breaking the Mission Planning Bottleneck

Early attempts at automated mission planning solutions resulted in multiple stovepipe systems, developed to meet the needs of various individual user communities. In the early 1990's, Air Force development was focused on improving and uniting automated mission planning technology. The Air Force Mission Support System (AFMSS) was designed to replace the various stovepipe systems and provide better integration of data. At the time AFMSS was developed, microprocessors found in personal computers were inadequate for the demands of mission planning. AFMSS systems were therefore hosted on Unix based systems out of necessity. Since that time the rapid improvements in the desktop computer industry have made personal computers a viable and logical alternative to larger proprietary systems which try to put everything in one box. **The Air Force's continued emphasis on Unix based mission planning systems designed to do everything for everyone has created a bottleneck which may become a critical failure point when examined in light of increasing mission planning requirements.**

Methodology

This paper will analyze this bottleneck from the perspective of mission planning for the F-16. As a multirole fighter, the F-16 has been at the forefront of mission planning since the early 1980's. It has experienced the full spectrum of mission planning systems, from early stovepipes to the large Unix based systems. Examining the impact of Air Force mission planning development on the F-16 community allows us to draw some conclusions, many of which apply to Air Force mission planning in a larger sense.

As with most areas in the computer field, things change at such a rapid pace that published sources are oftentimes obsolete by the time they see print. Test reports from mission planning systems provide data on capability and suitability, however this paper is based primarily on interviews with people across the full spectrum of mission planning development. They provide perspectives, which are in tune with the rapidly changing environment of automated mission planning development.

Before beginning a discussion of a new paradigm for mission planning, it is important to understand how the Air Force got to the current point. This paper will begin by examining the rise of mission planning requirements and systems. Following that, an examination of current systems capabilities and limitations will be discussed. Finally, this paper will look forward and propose a new direction for Air Force mission planning.

Chapter 2

The Past - Birth of Automated Mission Planning

The Growth of F-16 Mission Planning Requirements

Automated mission planning for the F-16, as with most aircraft, started out as a luxury. Pilots would spend hours in the planning room with paper, pencil, and charts. The results of these efforts were recorded on various slips of paper such as lineup cards and data sheets, and hand entered into the aircraft for flight. As the F-16 mission grew more complex, the amount of data required to be transferred to the aircraft exceeded the pilot's ability to enter it by hand. Thus was born the data transfer cartridge (DTC) for the F-16C.

DTC's provided the pilot a quick method for loading preflight data into the aircraft, and the history of DTC memory capacity increases provides a quick snapshot of the incredible growth of F-16 mission planning needs:[1]

- Pre-1980: data entered by hand
- 1981: 8K DTC's
- 1987: 64K DTC's
- 1990: 128K DTC's
- 1996: 32 and 72 ***megabyte*** DTC's

Initially, the capacity of the DTC was small enough that the pilot could easily enter the critical data into the aircraft by hand if necessary. Soon the amount of data being loaded into the aircraft exceeded the capability of the pilot to type it in manually. At this point, mission planning systems moved from being a luxury to a necessity.

Early Mission Planning System Development

The explosive growth of F-16 mission planning data requirements led to the need for systems capable of loading these DTC's. The early history of automated mission planning (depicted in Figures 1 and 2) is a tale of two paths. The first taken was that of the officially sponsored Air Force systems. This began in 1980 with the Computer-Aided Mission Planning System (CAMPS). This was soon followed by the Unix based CS2

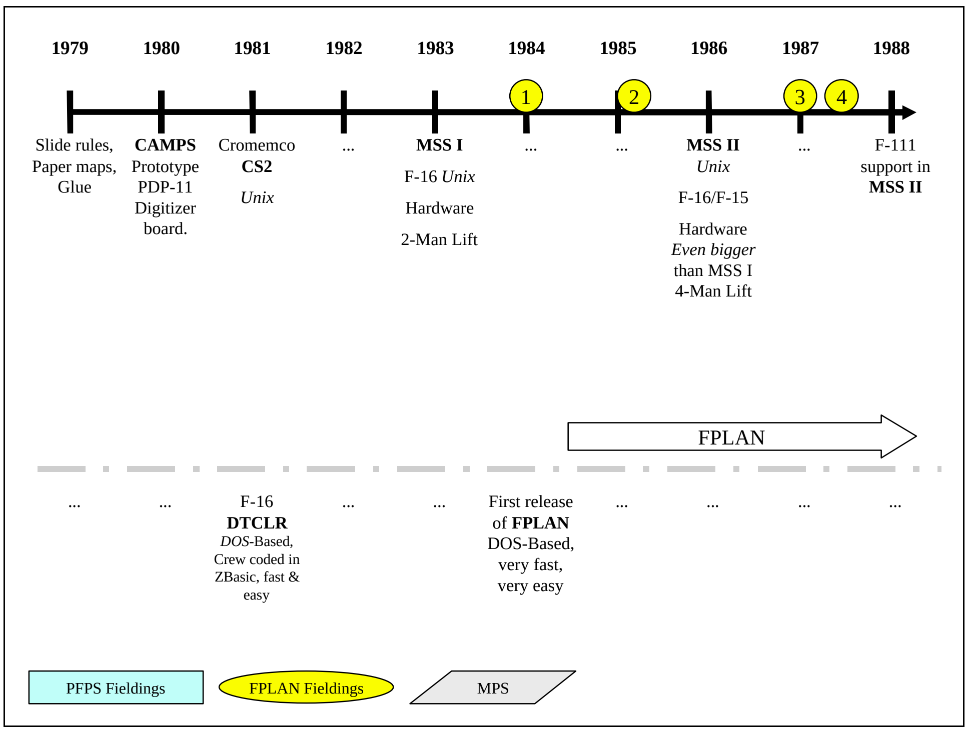

Figure 1. Mission Planning History—Part 1.[2]

system in 1981, which matured into the Mission Support System (MSS I) in 1983.[3] All of these systems were large Unix based computers which provided the capability to do mission planning using a graphical interface with charts, and load DTC's to transfer data to the aircraft. The MSS systems went through several upgrades, finally being replaced by the newer Air Force Mission Support System (AFMSS) in 1992. The AFMSS system was another Unix based computer system, even larger than its predecessor, the MSS II.

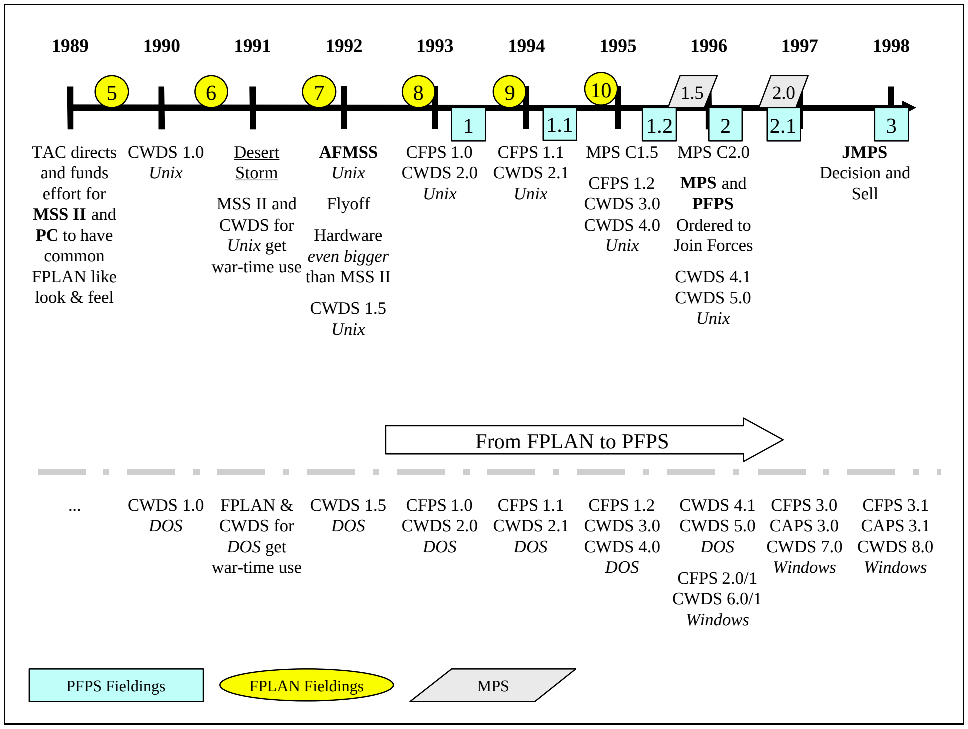

Figure 2. Mission Planning History—Part 2.[4]

The second path mission planning took was the smaller effort of personal computer (PC) based planning. These efforts were grass roots based development, literally beginning in someone's garage with no funding at all. Computer savvy pilots, frustrated with the size and complexity of the official Air Force systems, set out to create something small, fast, and friendly. In 1981 aircrews wrote DTC Loader Reader (DTCLR). This was a very rudimentary program allowing pilots to load and read DTC's quickly without having to battle the complexities of the large Unix systems.[5] In 1984, a small group of pilots at Myrtle Beach AFB developed Flight Planner (FPLAN) to aid with A-10 planning.[6] This DOS based program provided fast efficient text based flight planning without all the bells, whistles, and complexities of the large systems. The popularity of

FPLAN with the aircrews caused the Air Force to adopt it as a minimally funded effort in the late 1980's.

The two development paths have crossed twice. In 1989, the popularity of the PC based FPLAN products prompted Tactical Air Command (TAC) to direct further efforts at mission planning to have a "common FPLAN like look and feel." This resulted in two changes. First, new MSS II updates became more user friendly as they mimicked the more commonly used FPLAN interface. Second, the unified direction from TAC allowed parallel development on both the Unix and PC platforms for the first time. While the two systems were still separate programs, they were now moving closer together. Beginning in 1990 with Combat Weapons Delivery Software (CWDS), this parallel effort resulted in programs being written for Unix and PC platforms at the same time. This allowed users to go to either platform and see essentially the same interface, as well as share some data files between the two systems.

This direction from TAC also resulted in a bona fide PC development effort. While FPLAN continued on its shoestring budget, a new PC effort began. This new effort produced products, which paralleled the large Unix system functions: Combat Flight Planning Software (CFPS), Falcon View, CWDS, and DTC load software. Originally developed as DOS based programs, these programs moved to the Windows environment in 1996. Collectively referred to as Portable Flight Planning Software (PFPS), they provided more capability than FPLAN, while retaining the overall speed and simplicity that made FPLAN popular.

The direction to develop a common interface worked well for the MSS II system. When the AFMSS system debuted in 1992, however, the automated mission planning systems started diverging again. While the MSS II program was run from TAC (and later Air Combat Command [ACC]), the AFMSS program was run by Electronic Systems Command (ESC). This change in management and vision led the AFMSS in a different direction than the MSS II program. The goals for AFMSS were much more aggressive: "the primary goal of AFMSS is to provide a unit-level mission planning capability for airlift, bomber, fighter, special operations, and tanker aircraft."[7] Additionally, far greater emphasis on the AFMSS as a command, control, communications, computer, and intelligence (C4I) asset[8] added further complexity to the program. The "one box fits all" concept led the AFMSS to diverge significantly from the PC products once again.

In 1996 the mission planning development paths crossed for a second time. Prior to this the Unix and PC efforts were separate projects. After 1996, the two systems were joined under one umbrella - the AFMSS family of mission planning products. The large Unix systems were now referred to as Mission Planning Systems (MPS), and the PC versions as PFPS products. After the initial divergence of the AFMSS and PC products, they were brought back into the same program and a link reestablished between the two systems. While AFMSS had grown too large to adopt the PC look and feel in most areas, efforts were made to increase the interoperability of the two systems through file sharing and data exchange whenever possible.

Analysis of Mission Planning History

The two paths taken in mission planning system development result in some general observations. The path of the Unix based systems is usually a better funded and larger scoped effort. It is pursued using classical acquisition methods, and tends to respond rather slowly to user requests for change. The second path, PC based systems, has traditionally been a much smaller effort—both in funding and scope.[9] The PC systems tend to be developed in incremental steps, and respond quickly to user feedback.

This second path has historically been much more popular with aircrews for several reasons. First of all, the PC systems have always targeted the "80% solution." Instead of trying to implement every function imaginable, the developers of PC systems concentrated on doing the basic functions in a quick and efficient manner. This fit with the inherent limitations of PC systems in terms of storage, display, and computational power—and resulted in a system, which was easy to understand and use.

Second, the PC systems were in a better position for acceptance due to much greater user familiarity. Most users were familiar with PC operations, and could quickly adapt their knowledge to using the PC systems. The Unix based systems, on the other hand, were a foreign environment. Standard keystrokes which pilots used on their home PCs would bring strange results or not work at all on the Unix systems. The introduction of the AFMSS system exacerbated the problem. After years of effort driving the MSS II and the PC systems to use a common interface, AFMSS came along and changed nearly every aspect of mission planning on the large Unix systems. While the AFMSS was a far more capable hardware suite than the MSS II, the methodology used to mission plan was so different from the established systems that it was very difficult for users to operate.

The result of these observations is that there is an inherent advantage to developing mission planning on a PC platform. With ops tempo an issue everywhere, time for training is at a premium. Systems developed with user's inherent knowledge of PC operations as a going in position are going to be useable much faster, and thus accepted quicker and at a lower cost. Leveraging the user's established familiarity with PC operations minimizes any training requirements. The hardware cost of the systems themselves is an issue, which will be addressed in the next section.

Notes

[1] Vance Willsey, Lockheed Martin Tactical Aircraft Systems, Hill AFB, Utah, interviewed by author, January 1998.

[2] Thorn.

[3] Lt Col Jake Thorn, “Why does the Warfighter need JMPS?”, PowerPoint presentation, November 1997.

[4] Ibid.

[5] Ibid.

[6] Doug Poland, 46 TS/OGET (TYBRIN Corporation), Eglin AFB, Florida, interviewed by author, 5 March 1998.

[7] Maj Kenneth L. Cline and Maj Kenneth A Chanin, Air *Force Mission Support System (AFMSS) Block C2.0 Follow-on Operational Test and Evaluation (FOT&E) Test Plan*, ACC Project 97-0303A, (Eglin AFB, Florida: 28th Test Squadron/TOP, February 1997), 1-1.

[8] Ibid., i.

[9] Thorn.

Chapter 3

The Present—At the Crossroads

Current Automated Mission Planning Solutions

Automated mission planning for the F-16 currently comes in two flavors: MPS and PFPS. The MPS system is the large Unix based system that was last updated in 1997. A typical F-16 squadron would have 2 MPS II stations with 2 planning seats each and two Portable Mission Planning Systems (PMPS). The current PFPS mission planning suite was updated for the Windows 95 operating system in 1997. In order to equip a typical F-16 squadron with the same number of planning stations would take 6 PC computers and 6 Ogden Data Device 3 (ODD-3) cartridge load units.

There are differences between the systems that should be identified. The MPS stations are designed to do far more than the PFPS suite for PC's. According to MPS documentation, MPS is "an integrated, networkable, multiple user, deployable mission planner designed to receive data from various sources to plan a mission and provide both printed and electronic documentation."[1] The scope of operations for MPS is actually far more than just mission planning for the individual aircrew member.

The PFPS suite is a set of tools designed specifically for the individual planner. While they do integrate with each other and will take data from other sources, PFPS is not designed nor equipped to attempt the full spectrum of integrated planning activities that an MPS station is designed to perform. With this basic differentiation in mind, the problems of the status quo can be examined.

Problems With Current Situation

There are several problems with automated mission planning as it exists today. They can be summed up in four areas: size, cost, usability, and portability. The first of these is the physical size of the systems and the associated demands on a squadron. The MPS systems are very large, far larger than their predecessor MSS II systems.

Figure 3. MPS I Two Station Layout[2]

Depending on the specific configuration and layout, an MPS I system takes approximately 75 square feet to set up each station. Figure 3 shows the layout of a typical two seat station. Due to the nature of some mission planning data the MPS stations must be set up in a secure location. The demands of these systems for floor space can cause problems with available secure locations, which is at a premium in most F-16 squadrons. This problem is more pronounced in a deployed situation

In contrast, the PFPS systems can be as large or as small as the user desires. The CD-ROM based software can be loaded on any system running Windows 95—from a large desktop system to a portable notebook. Figure 4 depicts a laptop computer based PFPS system ready to flight plan and load cartridges for an F-16. The ODD-3 device used to load cartridges is roughly the size of half a loaf of bread. In contrast to the MPS systems that require specific space intensive hardware, these systems are scaleable. The requirements for floor space are a far cry from those of the MPS systems.

Figure 4. Typical PFPS System for F-16 mission planning.[3]

Cost disparity is the second problem with current systems. The cost to equip a squadron with MPS systems is shown in Table 1:

Table 1. MPS Cost per F-16 Squadron

	Cost per Item	Items per Squadron	Cost per Squadron
MPS II	$ 170,000	2	$ 340,000
PMPS	$ 40,000	2	$ 80,000
		TOTAL COST:	**$ 420,000**

Source: Maj Tom Martin, HQ ACC/SMO-P, Langley AFB, Virginia. Interviewed by author, March 1998.

Any planning capability the squadron desires above and beyond the 6 stations would raise the cost significantly. Users have no option other than purchase the expensive Unix based MPS stations to expand mission planning capability to support operations. For example, a unit may desire to have additional mission planning hardware packed and ready for rapid strategic mobility as envisioned in *Joint Vision 2010*.[4] Purchasing one additional MPS II station and two PMPS units to enhance mobility will cost the squadron a quarter million dollars—not a very enticing motivation to be prepared for rapid reaction.

The cost to equip a unit with this PC hardware is shown in Table 2:

Table 2. PFPS Cost per F-16 Squadron

	Cost per Item	Items per Squadron	Cost per Squadron
Computer	$ 2,500	6	$ 15,000
ODD-3	$ 2,500	6	$ 15,000
		TOTAL COST:	**$ 30,000**

Source: Vance Willsey, Lockheed Martin Tactical Aircraft Systems, Hill AFB, Utah, interviewed by author, January 1998.

Again, this provides planning capability for 6 stations. Additional planning stations may or may not require any more outlay of funds by the squadron. Since the software is written for any Windows 95 platform and is free to the users, it can be loaded on any compatible computer. This means that not only can the squadron set up additional planning stations in the squadron, but that aircrews can also plan at home on their personal machines if desired—all at no cost to the squadron.

The third area of difficulty is that of usability. As previously mentioned, the large Unix based MPS systems operate very differently than the PC systems which most users are accustomed to using. This lack of familiarity with Unix type systems causes significant frustration amongst users, and substantially increases the learning curve for efficiently operating the system. The PC systems have been designed with one central design theme: "make it work like Microsoft Office."[5] Any user who is even remotely familiar with Microsoft Office (Air Force standard software) can most likely operate the PFPS software "out of the box." One ACC headquarters officer was introduced to PFPS during a mission planning meeting in 1997. He had just completed a two week course learning how to use the MPS system. After 15 minutes using PFPS installed on a laptop he commented "I've learned more in 10 minutes on my own with this software than I did during two weeks of training on the MPS."[6]

The final problem area is portability. With the current MPS beddown of two 2-seat stations and two PMPS systems per squadron, you are limited in how many locations you can plan. If a squadron is deploying to a forward location with airlift, they have the option of taking an MPS II that will take a full pallet, or a PMPS stored in two small suitcase units. If they do not have airlift support (especially likely in the event of a small deployment) the squadron can take a PMPS in an aircraft mounted travel pod. This assumes that one or more aircraft will have a travel pod with enough space to stow the two suitcases. If the squadron is deploying aircraft without airlift or travel pod space, then neither MPS nor PMPS can support the operation unless it is prepositioned through some other method. The PFPS system is much more portable. A user can take a notebook computer and an ODD-3 and have the capability to plan, load, and read DTC's at any location. If the deployed location will have any computers available, the notebook computer could even be left behind, and just an ODD-3 and the PFPS software carried and set up at the new location.

Why Current Air Force Direction Is Inadequate

The Air Force's major mission planning effort is still currently the Unix based MPS systems. There are two primary factors that led to the current state of Air Force mission planning systems: technological state of the art and the desire to create the ultimate planning machine. Examining each of these reveals why continued emphasis on systems such as MPS would not serve the warfighter's needs in the future.

Abandoning The Unix Paradigm

The MPS systems were initially designed in early 1991[7]. In this time frame, most PC systems were running 386 microprocessors and DOS; Windows 3.0 had been out for less than a year[8]. At this time it made sense to develop a mission planning system on a machine which had the processing and graphics power to support mission planning. PC systems were not advanced enough to handle the requirements levied on the MPS. The PC software that did exist was DOS based and textually driven. The situation has changed dramatically since that time, however.

The distinction between the Unix based workstation and modern Pentium based PCs boils down to one thing: price.[9] Today's PC's far outperform the current MPS architecture (at a far smaller price tag)—and are projected to continue to get more powerful at a rapid pace. During a March 1998 trade fair in Germany, Intel demonstrated their new 700 Megahertz Pentium II PC.[10] Scheduled for consumer release in 1999, these new processors will have the same performance as the world's fastest supercomputer only a few years ago. The new Intel Merced processor, also due out in 1999, will run even faster than the Pentium II.[11] This explosion in inexpensive microprocessor technology shows that the initial justification for developing automated mission planning on the Unix based SunSPARC platform has long since been eclipsed. Future efforts should be aimed at the PC platform, where market forces will continue to produce more "bang for the buck."

Dangers of "Joint-Think" and Feature Creep

The second factor that has led to the inadequate state of Unix systems today is a combination of misguided joint emphasis and feature creep. The multiple stovepipe systems of the late 1980's and early 1990's suffered from an almost total lack of compatibility. When development began on the MPS systems in 1991, the concept was good—to eliminate the problems of the multiple stovepipes that couldn't talk to each other and create systems which would enable joint planning. The problem, which still plagues mission planning, is that few understood what "joint planning" really meant.

The joint movement was just gaining momentum during this time period, and words such as joint, unification, integration, and interoperability were used without truly understanding their impact. What was not fully understood was that the problem of the multiple stovepipe systems was ***not*** that they were separate, but that they couldn't communicate with each other. What should have been an effort to enforce *interoperability* and *integration* of systems became a quest for *unification* of systems in the name of "joint mission planning." According to Joint Publication 1-02, interoperability is:

> The ability of systems, units or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. 2. The condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. The degree of interoperability should be defined when referring to specific cases.[12]

The emphasis is on exchange of data and the ability to work with each other. This does *not* mean all systems must be operated with common software or interface. Unfortunately, early efforts were directed towards eliminating stovepipe systems and combining them in one system. This problem continues to threaten development of future systems.

The impact of this artificial emphasis on "jointness" is dilution of the capabilities of a mission planning system under development. The focus shifts from meeting the needs of the users of the system to meeting the myriad requirements levied in the name of joint mission planning. Many times these joint requirements take developers deep into the region of diminishing returns. An example is recent guidance to incorporate collaborative planning into systems to support joint operations. This type of requirement is not necessary for the user to plan his basic mission, but the additional time and money needed to incorporate this technology may keep the system from providing the basic functions in a timely manner. The risk of delaying system delivery and not meeting current needs far outweighs the benefits of the desired future enhancement. The end result is that instead of trying to develop systems that are interoperable and tailored to the user's need, systems are developed to be unified and serve no one in particular. This problem is amplified by a phenomenon known as feature creep.

Feature creep is essentially the difference between trying to design the 80% solution versus the 110% solution. The MPS systems of today suffer from a common flaw. During development, they failed to keep in mind that there is a significant difference between the needs of a tactical level mission planner, and a unit or higher level tool for coordinated planning. The MPS was loaded down with numerous bells and whistles that allow for data exchange with a plethora of outside sources, graphics displays to show the big picture and other features that aid in centralized planning. All well and good, but in the process the machine became so complex to operate that the tactical level planners have trouble simply planning from point A to point B. Developers, or more accurately those who controlled the requirements, failed to grasp that the tools for centralized planning (operational and higher) may not be the same tools needed for decentralized execution (tactical planning.) This continued hunt for features to include in the system often results in the systems diverging from the needs of the users it is supposed to be servicing. The result is often an end product that is laden with features users neither want nor need—a phenomenon known in the commercial industry as "bloatware."

This tendency to try and "put it all in one box" is one that must be addressed in any future automated mission planning system development. Not only does this problem dilute any efforts aimed at providing the basic functions for the planner; it also contributes to the bureaucratic phenomenon labeled here as the "coordination threshold." This is seen often in organizations that begin small and rapidly expand. While the organization is small, group decisions are easily made since few people are needed to reach a consensus. As the group grows it becomes more difficult to reach a decision with the ever expanding interests of the group. In essence the group hits a threshold at which the coordination required to make any decision becomes prohibitive. At this point the project generally will continue along its current path, regardless of whether it is still the logical one, simply because it is near impossible to get the group to agree on a change. Keeping the project broken into smaller, simpler parts avoids the "coordination threshold" trap. It not only makes coordination and decision making easier, but smaller tasks are technically easier to accomplish as well.[13]

Controlling the complexity of current systems is not unique to Air Force systems. During the time that the Air Force was developing the MPS systems, the Navy had a parallel effort developing the Tactical Automated Mission Planning System (TAMPS). Another Unix based mission planning system, TAMPS has experienced many of the same problems Air Force developers have run into with the MPS systems. Rear Admiral Cook touched on the problem of TAMPS complexity when he identified the need to work towards "even less time required for warfighters sitting at a machine, planning missions."[14] The Navy's TAMPS and the Air Force's MPS are currently investigating migration towards a common system which may help solve some of today's complexity problems for both systems.[15]

The Next Step

Future Air Force direction in mission planning must keep in mind that joint planning requires interoperability of systems, not unification of those systems. Just as each service has unique requirements for their aircraft, mission planning systems also have unique requirements based on their user base. Systems should be designed and tailored so that they can meet the requirements of both users and aircraft, ranging from the basic planning requirements of the T-38 to the advanced planning and data loading demands of the B-2. Additionally, these systems must start with the basic features, and make sure those features are not sacrificed in a mad rush to make it bigger and better.

Automated mission planning has moved from a luxury to a necessity for many aircraft, not just the F-16. It has reached the point that the mission planning system is as critical a part of the aircraft as the engine or flight controls. For aircraft such as the F-16 Block 50, without a mission planning system to plan the mission and load the DTC the mission cannot be flown effectively. There is far too much preflight data processing and transfer required to even attempt to do it without a mission planning system. In light of this, the problems identified become particularly troublesome. Continuing to rely on the MPS systems tie us to the limitations and difficulties of size, cost, usability, and portability. This de facto bottleneck in mission planning capability can only be addressed by examining why we are at this juncture, and what the proper direction should be from this point to best serve our mission planning needs of the future.

Notes

[1] Cline, i.

[2] An MPS I is pictured. The second generation system, MPS II, has reduced the footprint to approximately 50 square feet per two station system.

[3] PFPS can be run on any Windows compatible machine. It can be as small as the notebook shown here with built in CD and ODD-3 loading device; or it can be a much larger desktop, tower, or network server machine. It is the user's discretion to configure the system to meet their needs.

[4] *Joint Vision 2010*, Joint Staff Study, 1996, 5.

[5] Dave Medeiros, TYBRIN Corporation, interviewed by author, March 1998.

[6] Major Tom Martin, HQ ACC/SMO-P, interviewed by author, January 1998.

[7] Ibid.

[8] Ken Polsson, "Chronology of Events in the History of Microcomputers." On-line, Internet, 11 December 1997, Available from http://www1.islandnet.com/~kpolsson/comphist.htm.

Notes

[9] Poland.

[10] " Intel puts PC industry on notice at CeBIT fair," On-line, Internet, 19 March 1998, Available from http://cnn.com/TECH/computing/9803/19/intel_cebit.reut/

[11] Ibid.

[12] Joint Pub 1-02, *DoD Dictionary of Military and Associated Terms,* 23 March 1994, 352.

[13] Poland.

[14] Thorn.

[15] "Briefs from 2/12 JMPS meeting." On-line, Internet, 17 February 1998, Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

Chapter 4

The Future—Breaking With Tradition

On The Horizon…

Automated mission planning is going to be a critical part of any future aerial undertaking. Hopefully, future efforts can learn the lessons of the recent past and better serve the needs of the aircrews who need these systems to accomplish the mission. In that vein, there are currently three efforts which hold some promise for the future of automated mission planning: Joint Mission Planning Segment, CyberWarrior Insights, and Flight Information Enhancement.

Joint Mission Planning Segment

The Joint Mission Planning Segment (JMPS) is a cooperative development effort between the Navy and the Air Force to migrate the Navy Tactical Automated Mission Planning System (TAMPS) and the Air Force Mission Support Systems (AFMSS) into a common family of mission planning systems.[1] The primary objective of JMPS is to provide a scaleable product that allows users to configure systems tailored to their specific needs. It should concentrate on enabling exchange of information at the unit, wing, and higher headquarters levels for collaborative interservice planning. Above all, JMPS designers want to achieve “an end-user perception of a high performance system.”[2]

This project holds great promise to break with the problems of the past for several reasons. First, the development effort is focusing on the customer's needs. The target user of JMPS will be an aircrew member from an operational unit—the warfighter who will use the system.[3] This in itself will avoid the problem of feature creep that the MPS systems exhibited. Reinforcing this positive approach is the strong push from the operational communities to limit the scope of initial JMPS releases to unit level roles and responsibilities.[4] Once the system has proven the ability to do the basics, then and *only* then will higher command features be added to the system.

The problems of cost and hardware dependence are also being addressed. The JMPS concept calls for platform independent software, so it can be installed on a Windows NT PC or a Unix machine. If the concept survives as envisioned, JMPS will be a family of mission planning systems. The systems can then be configured as small as a flight planner on a notebook system, or as large as a full mission planning system on a networked workstation. The user decides the level of complexity, cost, and features they desire. The JMPS concept does an excellent job of providing a hardware independent scaleable solution to today's problems.

CyberWarrior Insights

CyberWarrior Insights is an initiative spearheaded by the Air National Guard and Air Force Reserves to develop automated tools for squadron level scheduling and training functions.[5] These tools are intended to be add-on modules for the PC based PFPS software which will provide a "virtual scheduling and training shop" for the squadron. These tools will help alleviate the current operations tempo problems by automating some of the more time consuming tasks, either freeing members up to perform other duties or allowing them more time home with families.

There are four major areas targeted under the CyberWarrior Insights project. First, it is attempting to automate the links between the flight planning system (PFPS) and the squadron scheduling system. This will give planners access to real time changes in their sortie data such as what length sortie they are planning for, what ranges are available, and other data pertinent to planning operations. The automated links will inform the planners of changes without having to constantly return to the scheduling shop to get the latest updates.

The second area under CyberWarrior Insights development is a link between the schedule and currency/training tracking. This will allow the schedulers automated access to currency and training requirements of the pilots so they can more efficiently build a schedule that meets squadron requirements. It also automates the process of updating the currency and training data; thus removing the need for time consuming human tracking. The third area under development, similar to the training and currency tracking, is integration of "bean counting" for the weapons shop. This is another feature that replaces time intensive human tracking with an automated function that will track weapons event accomplishment.

The final area being studied under CyberWarrior Insights is methods to enhance training opportunities. The most promising of these is a PC system that will produce not only fly-throughs of a planned mission, but will also allow for free roam simulation while planning. This will allow pilots to better visualize "what if" scenarios when planning a mission, and will better familiarize them with mission variables.

The combination of the CyberWarrior Insight initiatives will allow for automation of many of the time consuming tasks scheduling and training personnel currently perform manually. This virtual training and scheduling shop will use tools that integrate with PFPS software and provide warriors with the means to more effectively use their time and better prepare for missions.

Flight Information Enhancement

Flight Information Enhancement (FIE) is similar to CyberWarrior Insights. Where CyberWarrior Insights is working towards developing virtual scheduling and training functions, FIE is exploring the virtual base operations concept. It will also be an add-on package that integrates with the PFPS suite. FIE is currently exploring three functional areas, all of which center around linking Air Force mission planning to data available on the World Wide Web (WWW).

The first area is integration of weather information. The ultimate goal of FIE is to allow pilots to link a PFPS route to WWW weather information, with data flowing both directions. This will allow not only review of weather status along the route, but will also feed wind information back into the flight planner to produce a winded flight plan. The initial operational capability (IOC) of FIE is scheduled for the summer of 1998, and will allow uploading of a PFPS route to the WWW to display weather along the route. The feedback of data to allow for recomputation of a winded flight plan will be incorporated into future releases.

The next FIE function is automated Notices to Airman (NOTAM) retrieval. The 1998 IOC release will only allow for retrieval of NOTAMs by input identifier. Future releases will utilize smart logic to examine the PFPS route, extract pertinent identifiers and areas of interest, and provide the pilot with comprehensive NOTAM information for the entire route of flight.

The final area FIE seeks to automate is the filing of flight plans (DD-175). Eventually, FIE will provide the means to generate and electronically file the DD-175 through the WWW. The IOC release will generate the DD-175 and provide it to the pilot in a hardcopy format.

All three of these functions are traditionally base operations activities that are time consuming. Base operations is normally not in the squadron facility, requiring additional travel time to accomplish these tasks. By automating weather, NOTAM, and flight plan filing FIE seeks to establish a virtual base operations capability which will reduce mission planning time for the aircrews.

Emerging Trends

The preceding discussions highlight some emerging trends that hold promise for future mission planning systems. First, the course is away from Unix based systems and towards PC systems. This will help alleviate the earlier discussed problems of cost, size, usability, and portability. The second trend is towards systems and software that are modular. Instead of trying to build all possible functions for all users in one large package, the new approach is towards a mix and match philosophy. Part task tools such as CyberWarrior Insights are being developed which specialize at doing certain subtasks efficiently. The emphasis is shifting from one of *unification* of the various systems towards the *integration* of these systems. Finally, new development is attempting to avoid the pitfalls of current systems such as AFMSS by striving for incremental development of capabilities. FIE is a good example of this trend, with the summer 1998

IOC release targeting only a subset of the eventual capabilities of the project. By doing the basics correctly first, then adding the "bells and whistles" in later releases, FIE has much better odds at early success and user acceptance. These trends are not universally accepted as the correct path to take. There are arguments against some of the new directions in mission planning development.

Counter Arguments

Those who aren't satisfied with current trends in mission planning development cite four main arguments. The first two are arguments against expansion of mission planning on the PC platform: security and performance capacity. Both arguments are essentially outdated. The first proposes that Windows based PCs cannot offer the same security as Unix systems. While this was true in the past, Windows NT 4.0 and beyond offer security features just as robust as Unix based systems.[6] Similarly, opponents argue that only Unix systems can offer the multi-level security required by some mission planning functions. The PC architecture is physically capable of the same multi-level security features, and current developments in encryption are dating this argument weekly.[7]

The second counter to the PC mission platform is performance capacity. This was discussed earlier, and is essentially an obsolete argument. In fact, the development of Intel Pentium microprocessors is providing exponential leaps in performance for a fraction of the cost of other comparative systems such as the SunSPARC stations currently used for MPS systems.[8]

The third argument against *any* change in mission planning development is the substantial cost of rewriting all legacy code. While at first this may seem to be a valid point, further consideration shows that it is a hollow argument. Not all legacy code needs to be rewritten. Each system should be examined to see if it meets the needs of the users, and how much longer the system will need to be maintained. There are several options when considering what to do with legacy code. If the code is still doing the job for the user, then all that may need to be done is write interface code to integrate the old system with the newer systems. Even if the decision is made to migrate the code into the newer systems, the tools for automatic code generation have significantly reduced the effort required to move to the new system. If the legacy code no longer meets the needs of the users, then the code will need to be updated in any case. Again, automated tools can help migrate to newer systems.

The last major argument against current mission planning trends is the attitude that "the new system can't meet our requirements." This argument is generally made without a full understanding of the facts. As an example, the Navy was hesitant to even consider PFPS as a tool to supplement their TAMPS system.[9] They initially felt that the PC based PFPS couldn't possibly handle the requirements for Naval mission planning. Once they sat down and were shown the capabilities of a PFPS system, however, they immediately incorporated it into their mission planning roadmap as a major component carrying them into the future.[10]

Notes

[1] Thorn.
[2] "Briefs from 2/12 JMPS meeting."
[3] Poland.
[4] "Briefs from 2/12 JMPS meeting."
[5] Thorn.
[6] Poland.
[7] Ibid.
[8] Ekman.
[9] Poland.

Notes

[10]Capt Ted Spilman (USN) “Naval Mission Planning Systems: A Look Ahead.” On-line, Internet, 17 February 1998, Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29

Chapter 5

Conclusion

Those who cannot remember the past are condemned to repeat it.

—George Santayana

Automated mission planning is no longer a luxury. Without the proper systems to support mission planning at the tactical level, the aircraft are just as ineffective as if the engines are removed. Future development must consider the path mission planning has taken in the past and actively try to avoid the same pitfalls. Both hardware and software issues must be addressed.

Past justification for using large Unix based systems is no longer valid. Unix systems are no longer required for the data processing needs of the user, and are difficult to use in today's PC prevalent society. The cost in dollars, floor space, and training can no longer be justified.

Software development is particularly susceptible to the problems of the past. The rush to provide marginal capabilities sometimes tramples the bottom line need for the basics. Future systems should emphasize providing the basic mission planning features first - the 80% solution. Once this has been provided, new features can be added in later releases. Due to the rapid pace of technology growth today, the hunt for the 110% solution may even result in development paralysis. Releases are constantly held up for "one more feature" and never get completed—as there is always one more carrot to delay for on the horizon. Beyond the individual planner, the system should concentrate on interoperability with other systems. This will emphasize the sharing of data and files to improve the mission planning process, but does not mean that all systems are locked into one master configuration—nor that all users inherit the overhead of unneeded features found in other systems. Emphasis on the PC platform provides the opportunity for numerous commercial off-the-shelf (COTS) solutions and significantly increases competition for those contracts. Dollars previously used in the development of expensive Unix solutions can be directed elsewhere.

The danger of not heeding the lessons of the past will be a failure to meet current and future operational needs. In the near future mission planning systems must be smaller, cheaper, easier to use, and PC based to meet the needs of the warfighter. Smaller systems are needed to support current operational employment concepts such as the Aerial Expeditionary Force (AEF). Current AEF plans include reducing the airlift requirement as much as possible to enable quick reaction. Current MPS systems require one to two pallets to airlift each into the theater of operations. Switching to PC based systems reduces airlift requirements substantially for an AEF movement. Cheaper systems are needed to support the lean logistics concept. The MPS systems are larger and more expensive to repair than PC hardware, which are almost disposable. A much smaller logistics footprint can be maintained through utilization of PC systems, and any necessary repairs will be both cheaper and easier to obtain.

Mission planning systems must also concentrate on ease of use. Today’s battlefield is a more mobile and lethal arena than ever before. The shift towards precision strike on almost all platforms puts a larger burden on the mission planning systems since they become the pacing function in joint precision interdiction timeliness.[1] It is also becoming increasingly obvious that the United States will rarely, if ever, fight a purely unilateral operation. This means that our mission planning systems will have to take into consideration interoperability with not only US systems, but those of our multinational partners as well. Many nations have already approached the United States to purchase mission planning technology. The preponderance of interest has weighed heavily in favor of PC based planning, due to its low cost.[2] Moving US mission planning in this direction will substantially increase our chances of interoperability with our allies.

Mission planning development will also have to consider the implications of the future battlespace. *Joint Vision 2010* lists five areas of dynamic change as we move towards 2010: multinational operations, enhanced jointness, information superiority, technological advances, and potential adversaries.[3] The first four of these directly impact mission planning systems. As discussed above, increased multinational operations will require the ability to integrate with allies' mission planning systems—most likely PC based systems. Enhanced jointness will require the same integration among our own services, emphasizing the need for systems that are not *unified*—but *integrated*. Information superiority will require the ability to sort, process, and share data between multiple systems. Technological advances will have to be embraced and leveraged to further improve our capabilities. This means being willing to let go of past paradigms such as Unix based mission planning and seizing the advantages of new technology such as recent growth in the PC industry.

If the lessons from the past are heeded, the Air Force will produce a system that is easy to use, cost effective, portable, and scalable. It will provide mission planning capabilities to support today's joint and multinational operations as well as the battlefield envisioned in the future in *Joint Vision 2010*. Past problems will teach us how to better provide the warfighters the tools they need to accomplish the mission, and the mission planning bottleneck will at last be broken.

Notes

[1] Spilman.

[2] Based on the author's experience from 1993 through 1997 working development and testing of foreign military sales mission planning systems.

[3] *Joint Vision 2010*, 6.

Glossary

ACC	Air Combat Command
AEF	Aerial Expeditionary Force
AFMSS	Air Force Mission Support System
C4I	Command, Control, Communications, Computer, and Intelligence (C4I) asset
CAMPS	Computer-Aided Mission Planning System
CFPS	Combat Flight Planning Software
COTS	Commercial Off-The-Shelf
CWDS	Combat Weapons Delivery Software
DOD	Department of Defense
DTC	Data Transfer Cartridge
DTCLR	Data Transfer Cartridge Loader-Reader
ESC	Electronic Systems Command
FIE	Flight Information Enhancement
FOT&E	Follow-on Operational Test and Evaluation
FPLAN	Flight Planner
GTRI	Georgia Tech Research Institute
IOC	Initial Operational Capability
IPT	Integrated Product Team
JMPS	Joint Mission Planning Segment
MPS	Mission Planning System
MSS	Mission Support System
NOTAM	Notice to Airmen
ODD-3	Ogden Data Device (version 3)
PC	Personal Computer
PFPS	Portable Flight Planning Software
PMPS	Portable Mission Planning System

TAC	Tactical Air Command
TAMPS	Tactical Automated Mission Planning System
USAF	United States Air Force
USN	United States Navy
WWW	World Wide Web

Bibliography

Interviews

Brandon, Jeff. Lockheed Martin Tactical Aircraft Systems (LMTAS), Fort Worth, Texas. Project Software Manager for Joint Strike Fighter and F-16 Mission Planning Systems. He has worked on both MPS and PC mission planning system development. Interviewed by author, November 1997 through March 1998.

Cosby, Lt Col Mike. Selfridge Air National Guard, Selfridge, Michigan. Worked on operational development of mission planning systems while on active duty, continues to consult on mission planning system development. Interviewed by author, November 1997 through March 1998.

Martin, Maj Tom. HQ ACC/SMO-P, Langley AFB, Virginia. Works development of current and future mission planning systems for the Air Force. Interviewed by author, November 1997 through March 1998.

Medeiros, Dave. TYBRIN Corporation, Eglin AFB, Florida. As PFPS Integrated Product Team (IPT) Lead, he works development of current and future PC mission planning software. Interviewed by author, November 1997 through March 1998.

Poland, Doug. 46 TS/OGET (TYBRIN Corporation), Eglin AFB, Florida. Mission Planning IPT Director and a part of the working group developing next generation mission planning software. Interviewed by author, November 1997 through March 1998.

Pyles, John. Georgia Tech Research Institute (GTRI), Atlanta, Georgia. Heads up the GTRI team that develops *Falcon View*, the map display software for PC mission planning. Interviewed by author, November 1997 through March 1998.

Smith, Maj Mark. HQ ACC/SMO-P, Langley AFB, Virginia. Worked testing, development and operational issues for Air Force mission planning systems. Interviewed by author, November 1997 through March 1998.

Thorn, Lt Col Jake. 46 TS/OGET, Eglin AFB, Florida. As Deputy Director CAF C2 SPO and PFPS Program Manager he coordinates development of mission planning system development for Air Force and Navy. Lt Col Thorn was also one of the originators of FPLAN. Interviewed by author, November 1997 through March 1998.

Willsey, Vance, Lockheed Martin Tactical Aircraft Systems, Hill AFB, Utah. As Mission Planning Test Director, he has worked mission planning test and support for over 10 years. Interviewed by author, November 1997 through March 1998.

Documents

"Briefs from 2/12 JMPS meeting." On-line. Internet, 17 February 1998. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

"Intel puts PC industry on notice at CeBIT fair." On-line. Internet, 19 March 1998. Available from http://cnn.com/TECH/computing/9803/19/intel_cebit.reut/.

"JMPS Acquisition Strategy Update." On-line. Internet, 13 January 1998. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

"JMPS Frequently Asked Questions as of 26 June 97." On-line. Internet, 26 June 1997. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

"JMPS Status Update." On-line. Internet, 15 December 1997. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

"PMA-233 Brief from 2/12 meeting." On-line. Internet, 17 February 1998. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

Air Force Mission Support Systems (AFMSS). *Product brochure.* 46th TS/OGET, Eglin AFB, Florida. No date.

Cline, Maj Kenneth L. and Chanin, Maj Kenneth A. *Air Force Mission Support System (AFMSS) Block C2.0 Follow-on Operational Test and Evaluation (FOT&E) Test Plan.* ACC Project 97-0303A. Eglin AFB, Florida: 28th Test Squadron/TOP, February 1997.

Ekman, Kenneth. "The Intel road map in short." On-line. Internet, 9 March 1998. Available from http://home1.swipnet.se/~w-10554/tech.html.

Forrester, Erinn. "Joint Mission Planning Segment." On-line. Internet, 12 March 1998. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

Gillott, Capt Mark A. *Mission Support System (MSS) IIA, Annex B, Version 6.1 Software Suite Follow-on Operational Test and Evaluation (FOT&E).* ACC Project 92-045T. Eglin AFB, Florida: 28th Test Squadron/TXAP, September 1994.

Joint Pub 1-02. *DoD Dictionary of Military and Associated Terms.* 23 March 1994.

Joint Vision 2010. Joint Staff Study. 1996.

Keep, Christopher. "IBM Compatible Computers." On-line. Internet, 1995. Available from http://jefferson.village.virginia.edu/elab/hfl0108.html.

Lightning: Mission P1anning System - III. *Product brochure.* Sanders Information Systems Division, Nashua, New Hampshire. September 1997.

Manship, Lt Col Mark M. *AFMSS C1.0 QOT&E(1) Test Report.* TR-96-007. Eglin AFB, Florida: Air Force Operational Test and Evaluation Center, Detachment 2, June 1996.

Polsson, Ken. "Chronology of Events in the History of Microcomputers." On-line. Internet, 11 December 1997. Available from http://www1.islandnet.com/~kpolsson/comphist.htm.

Portable Flight Planing Software (PFPS). *Product brochure*. 46th TS/OGET, Eglin AFB, Florida. No date.

Smith, Maj Mark R. *Air Force Mission Support System Follow-on Operational Test and Evaluation (FOT&E), Final Report.* ACC Project 94-047TF. Eglin AFB, Florida: 28th Test Squadron/TOP, February 1996.

Spilman, Capt Ted (USN) "Naval Mission Planning Systems: A Look Ahead." On-line. Internet, 17 February 1998. Available from http://www.herbb.hanscom.af.mil/info.asp?rfp=R29.

Thorn, Lt Col Jake. "Why does the Warfighter need JMPS?" PowerPoint presentation. November 1997.

Weller, Clemens. “Timeline of important historic computers.” On-line. Internet, 14 Dec 1996. Available from http://ourworld.compuserve.com/homepages/computer_museum/gallery.htm.

Air Command and Staff College
Maxwell AFB, Al 36112