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AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

IMPROVING THE WARRIOR PREPARATION CENTER (WPC) AIR CAMPAIGN ANALYSIS CAPABILITY

by

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Disclaimer

Contents

Illustrations

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Abstract

The Warrior Preparation Center (WPC) at Einsiedlerhof AS, Germany provides JTF staff-level computer training. During a recent mission rehearsal, WPC was asked to conduct an air campaign analysis. As a result of this analysis, WPC is looking at ways to improve its current capabilities. Since there is limited data published on this topic, investigation of the air campaign analysis capabilities at key Air Force (AF) sites was the primary source of data. The key AF sites included in this study were WPC, Checkmate, the Command & Control Training and Innovation Center (C2TIC), the Air Force Wargaming Institute (AFWI), and the Air Force Agency for Modeling and Simulation (AFAMS). The research focused specifically on air campaign analysis processes and tools. The findings reveal common themes, innovative processes, and several candidate analysis tools. An analysis of the findings led to the development of a notional air campaign analysis process and a comparison of the existing analysis tools. Subsequently, the notional air campaign analysis process and best tools were combined into real-world applicable air campaign analysis process. Finally, an improvement game plan was recommended, including implementation considerations and potential areas for future research.

Chapter 1

Introduction

The application of air power is profound both in its effects and its potential for loss of human life. It is imperative that the warfighter is given every opportunity to apply air power with maximum effects against our adversaries while keeping friendly losses to a minimum. The actual application of air power is achieved through the execution of the final product from air campaign planning, the Air Tasking Order (ATO). It is essential that when an ATO is carried out, the air campaign is well planned, fully analyzed, and thoroughly rehearsed before a single aircraft takes flight. An air campaign planning process exists today, but is not standardized, often slow, and lacks tools and processes to analyze the quality of the air campaign plan, or ultimately, the ATO. Not surprisingly, several Air Force (AF) organizations currently conduct analysis for certain portions of the air campaign planning process. A few conduct rehearsals of the ATO itself via Modeling and Simulation (M&S) since rehearsals with actual aircraft is infeasible. This research project examines one particular AF organization that does both, the Warrior Preparation Center (WPC), and has subsequently asked for help to improve its current capability.

More succinctly, the goal of this research is to recommend ways for WPC to improve its air campaign analysis capability. To do so, this paper will first lay the foundation of the research. Subsequent chapters will present its findings, analysis of those findings, and then provide conclusions from the analysis. To adequately lay the foundation for this research, this chapter will provide relevant background information and the statement of the problem, the research methodology used, and the associated limitations and assumptions.

Background and Problem Statement

The WPC, traditionally a training organization, recently conducted its first significant air campaign analysis and rehearsal process. The exercise was called Nimble Lion, and the Initial After Action Review briefing concluded: 1) the need to "Grow ability to assess and analyze campaigns," 2) "no robust analysis tools available" as a LIMFAC, and, 3) "Rehearsal is the core of the analytical process."[1] Subsequent queries to WPC regarding potential research topics of interest, resulted in the following request:

> I have an ACSC project for you. We are using our stochastic simulations in an analytical role. Essentially, our models allow us to perform mission rehearsals on ATOs, doing a fly-out for ATO visualization, analysis and feedback into modifying and improving the ATO, and then overall campaign analysis. There's a lot of questions on how to do this better, and we are working projects to implement improvements.[2]

A final testimony to WPC's desire to grow their mission rehearsal capability is their recent four-fold manpower increase in their analysis directorate and subsequent changes to their WPC mission. The latest WPC mission briefing now includes mission rehearsal as one of their four core competencies and it's their first bullet on their WPC After Next slide.[3] Incidentally, initial exploration revealed this in not just a WPC problem, but actually an AF-wide concern. Actually, the Air Force Agency for Modeling and Simulation (AFAMS) has been chartered to develop a roadmap to improve M&S decision support tools for the warfighter. Given the potentially broad scope of this research topic, the project focuses on improvements to WPC's air campaign analysis tools and processes. The methodology is discussed in the next section.

Research Methodology

The following section will outline the fundamental research approach, discuss data sources and collection, and the analysis methodology. Preliminary investigations showed severely limited information published on this topic. So a research methodology that didn't rely on the more traditional method of library data collection was required. Previous experience indicated several sites that also analyzed air campaigns. By investigating their processes and tools, some insights useful to improving WPC's air campaign analysis capabilities were discovered. At the onset of the research, it was believed that at the worst, the result would be a compendium of tools and processes without any meaningful insights. This alone is more information than is currently published. Fortunately, the findings and subsequent analysis provide a synergistic coupling of innovative analysis process ideas with optimum analysis tools. Based on previous knowledge and discussions with CADRE, the sites of interest were narrowed down to AF sites that were "end-users" of M&S analysis tools. They were further narrowed to a list of sites that could be observed in minimal time and least cost. This resulted in the following sites: the WPC itself (as a baseline), Checkmate, the Command and Control Training and Innovation Center (C2TIC) and the Air Force Wargaming Institute (AFWI). AFAMS was subsequently added, although not an "end-user," because of their on-going study efforts of developing a roadmap for improving decision support tools for the warfighter. Interviews were selected over surveys as the primary data collection method based on reading an Air Force Institute of Technology research methods textbook.[4] The interview procedure itself was designed based on this text. Follow-on discussions via email were anticipated, and thankfully occurred. After collecting the data from the sites, a qualitative analysis of the air campaign analysis processes and tools was conducted. Next, a coupling of the process improvements and ideal tools were established. Finally, an implementation strategy to incrementally improve WPC's air campaign analysis capability was developed.

Limitations and Assumptions

It is worth noting some of the limitations and assumptions regarding this research project. A substantial limitation is the lack of published data on the topic. Another limitation is the relatively short time period to conduct the research, the abbreviated nature of the final product, and scare resources. Finally, the inherently human involvement in the air campaign analysis process precludes quantitative analysis of the findings. These subsequently limit the scope of this research in the following ways:

- Data collected from the key AF sites is critically important to the research findings
- The number of analysis processes and tools observed are not all-inclusive
- An analysis of the tools relies heavily on the interviewee and documentation available
- Air campaign analysis and tools focus on operational modeling, excluding logistics modeling
- Analysis is highly qualitative in nature, excluding rigorous performance benchmarking and quantitative tool life cycle cost analysis

It should be noted, that these limitations did not seriously hinder the research and were mitigated whenever possible. There are three major assumptions worth noting. First, it was assumed that the sites interviewed are at least representative and hopefully ahead of, the larger AF. Second, it is assumed the target audience, WPC, has fundamental knowledge of air campaign planning and terminology. This audience includes analysts, wargamers, trainers, and warfighters. Third, it is assumed that WPC desires the ability to perform air campaign analysis autonomously, even though the evolving Expeditionary Aerospace Force (EAF) concept may include centralized, independent planning and analysis.

The background information and statement of the problem, research methodology, and the brief description of limitations and assumptions lays the foundation for this research. The findings will be presented in the following chapter.

Notes

[1] Briefing, WPC, subject: Nimble Lion Initial After Action Review, August 1998.

[2] Email Message, FW: Update (Incorrect Email) to "WPC Assignment/ACSC Research Topics" Email, Mr. Jeff Bradshaw, 26 August 1998.

[3] Briefing, WPC, subject: WPC Overview, no date.

[4] C. William Emory, *Business Research Methods* (Richard D. Irwin, Inc.1985), 160-169.

Chapter 2

Findings

There is the wealth of knowledge that exists in the Air Force (AF) today. By visiting the key AF sites currently engaged in activities similar to the WPC, it is possible to take a broad and objective look at the analysis processes and associated analysis tools. The knowledge gained by visiting the sites through interviews and email is voluminous. In order to provide a coherent overview of this information, findings will be broken into two major areas: Site Summaries, and Description of Analysis Tools.

Site Summaries

A description of the AF sites visited is relevant to this research since the intent is to find insights about their processes and tools and apply them to WPC. Toward this end, a brief summary describing each site, its mission and activities, a list of its analysis tools, and their processes is provided below. A description of the analysis tools listed in the site summaries will be provided in the subsequent section.

WPC[1]

The WPC is located at Einsiedlerhof AS, Germany. It is a joint AF/Army organization that works for United States Air Force Europe Deputy of Operations (USAFE/DO) and US Army Europe Deputy Chief of Staff Operations (USAREUR/DCS OPS). The current WPC mission is:

The Warrior Preparation Center provides commanders and their battlestaffs, a realistic joint and combined, operational level training and exercising environment at any location in the theater or worldwide to maintain mission readiness.[2]

WPC activities include[3]: designing, conducting, and analyzing Computer Assisted Training Exercises (CPX), conducting mission rehearsals, and providing planning and technical support expertise. WPC tools include an entire suite of training/exercise tools called Joint Training Confederation (JTC). The Air Warfare Simulation (AWSIM) is the centerpiece of this suite and will be discussed in more detail in the next section.

The WPC has several processes associated with these activities. However, since this research focuses on the mission rehearsal activity, WPC's recently documented "Mission Rehearsal" process is depicted in figure 1. Notice that the specific steps start with the ATO and Air Coordination Order (ACO) creation followed by model execution and concluding with a briefing. The four major phases assigned to the 12 steps are highlighted in figure 1. They are Preparation, Execution, Analysis, and Production. It should be noted that this process is used primarily for training (JFC staff level) and more recently has been expanded to include mission rehearsal for real-world contingencies.

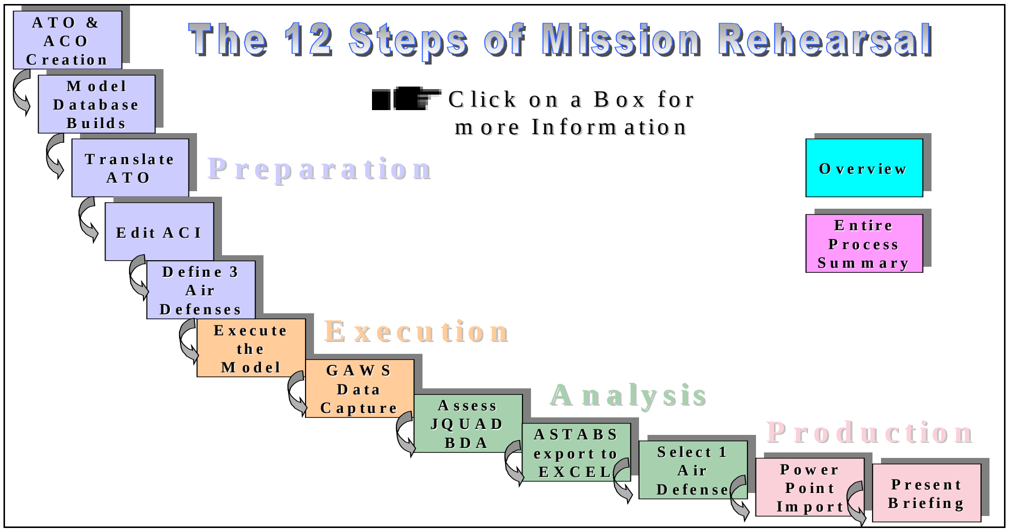

Figure 1. WPC's 12 Step Mission Rehearsal Process[4]

Checkmate[5]

Checkmate is located at the Pentagon, Washington D.C. It is an AF organization that works directly for AF/XO. It works closely with the Air Force Studies and Analysis (AFSAA) organization. The current Checkmate mission is to provide operational assessments as directed by the AF/XO, CSAF and Unified CINCs. Typical Checkmate activities include doctrine and tactics assessments, air campaign development, assessments and analysis, and development of air campaign decision and planning tools. Current air campaign analysis tools include:[6] THUNDER, Combat Forces Assessment Model (CFAM), Operations Planner (OPS Planner), Extended Air Defense Simulator (EADSIM), and ORCA Planning and Utility System (OPUS).

Checkmate analytic processes focus at the multiple ATO-level. They typically don't analyze individual ATOs, although the end result of their analyses can be text formatted ATOs. Their integrated "suite" of EADSIM-centered analysis tools was quite impressive. The tools were designed to be interoperable and lend themselves to a more automated and integrated analysis process. Finally, they rarely perform rigorous campaign-level analyses but do so occasionally in association with AFSAA. They are somewhat unique in that they do more qualitative analyses relying on their exceptional warrior-staff expertise. These analyses focus more on objective/strategy congruence and rely on their hand-selected personnel.

C2TIC[7]

The C2TIC is primarily located at Hurlburt Field, Florida with several CONUS detachments. It is an AF organization that works directly for the Aerospace Command and Control, Intelligence, Surveillance, and Reconnaissance Center (AC2ISRC). As the only AC2ISRC field unit, the C2TIC mission is to provide leadership for AF-wide Command and Control. Typical C2TIC activities include operational assessments of C2 systems; C2 system testing; JFACC-level training; conducting training, operational exercises, and experiments; and baselining/managing Air Operations Center (AOC) systems, processes, and training. Current air campaign analysis tools include: Theater Battle Management Core Systems (TBMCS), Contingency Theater Automated Planning System (CTAPS), the JFACC Planning Tool (JPT), and AWSIM. The last two tools will be described in the next section.

The C2TIC processes focus on training of JFACC staff personnel; and since they've been chartered to standardize AOC (systems, processes, and training) – they closely emulate the processes that are in use or that ideally could be used by the Numbered Air Forces (NAFs). Their training arm, the Command and Control Warrior School (C2WS), formerly the Battlestaff Training School (BTS), includes a classroom portion. The process depicted in figure 2 is a simplified picture of air campaign planning process.

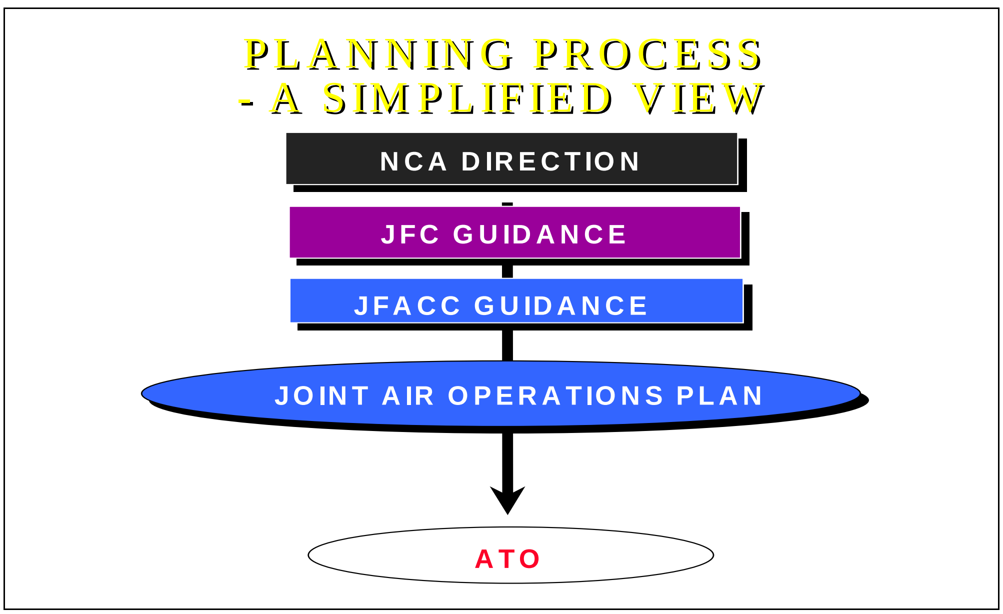

Figure 2. C2WS' Simplified Air Campaign Planning Process[8]

More specific C2TIC activities, including analysis tools, used for training and exercises, are depicted in figure 3. Although it doesn't depict creation and execution of the ATO, these activities do occur via the CTAPS network. So, in essence the C2TIC is executing the ATO like

WPC and also performing higher level analyses like Checkmate. Notice the Master Air Attack Plan (MAAP) as an intermediate step between the JFACC staff and the actual ATO. The MAAP essentially pairs specific weapons against specific targets. This step is critical to developing a detailed ATO, and many trade-offs are made and analyzed in the process of narrowing broad resources and target priorities down to weapon/target pairing. Finally, it should be noted, however, that the C2TIC's ATO execution is geared toward training and experimentation and not meant to assess real-world air campaigns.

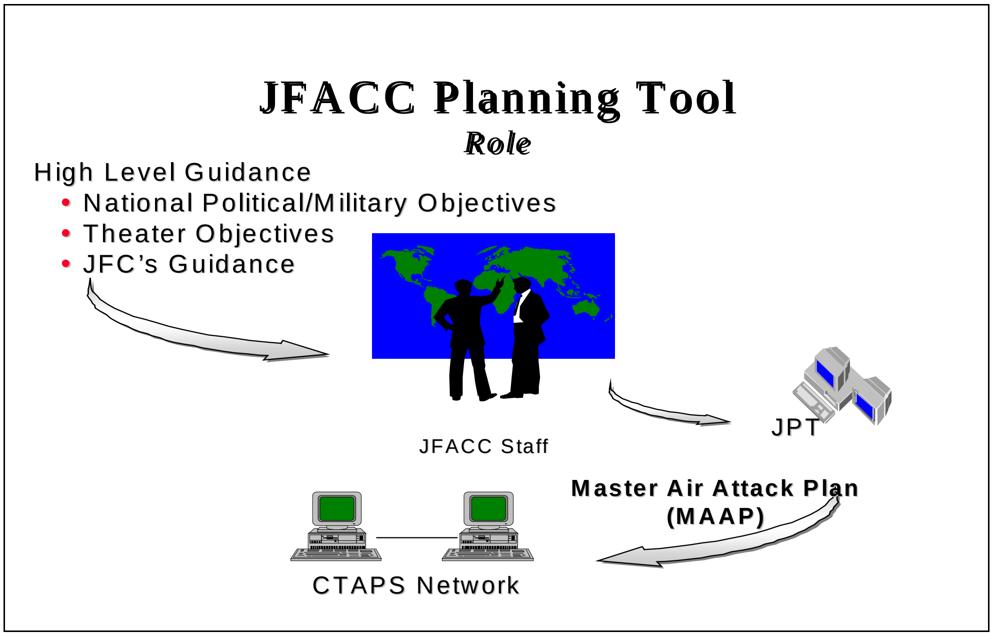

Figure 3. JFACC Planning Process[9]

AFWI[10]

The AFWI is located at Maxwell AFB, Alabama. It is an AF organization that works directly for the Air University (AU). The current AFWI mission is to provide wargaming and education to the AF, primarily the Professional Military Education (PME) organizations. Typical AFWI activities include conducting wargames for education purposes, supporting other service wargames and using, assessing, and developing modeling & simulation (M&S) and analysis tools. Current air campaign analysis tools include the ACT ATO Generator (AAG) – described in the next section, THUNDER, TACWAR, and EADSIM.

The AFWI processes are mainly aimed toward education purposes. They do however support major exercises like Prairie Warrior and create an education environment. This process takes students from NCA level objectives down to creation of ATO level – thus encompassing the entire air campaign planning process. Although they have air campaign analysis tools such as THUNDER and EADSIM, they have developed AAG specifically for this purpose. It enables students to execute an entire air campaign and see the results of their decisions. This is unique from the other sites, which have several tools that span only portions of the air campaign planning process.

AFAMS[11]

Although AFAMS is not an "end-user" of air campaign analysis tools, they work closely with all the organizations listed above. They were added as a site for this research because of an on-going study of Decision Support Tools for the Warfighter - closely paralleling this research. The AFAMS is located in Orlando, Florida. It is an AF organization that works for the Director of Command and Control (AF/XOC). The current AFAMS mission is to implement AF/Joint/DOD M&S policy and standards, coordinate and manage major M&S programs and initiatives, support corporate AF M&S operations, and promote M&S technology improvement and innovation. Since AFAMS is not an "end user," typical activities and a list of analysis tools are omitted. However, examination of the on-going study, includes relevant information regarding the subject with specific information about the air campaign analysis process and many analysis tools.

Although not an "end user", AFAMS has been chartered to develop a roadmap to provide Warfighters decision support tools. A potential set of decision support tools and the associated process are depicted in figure 4.

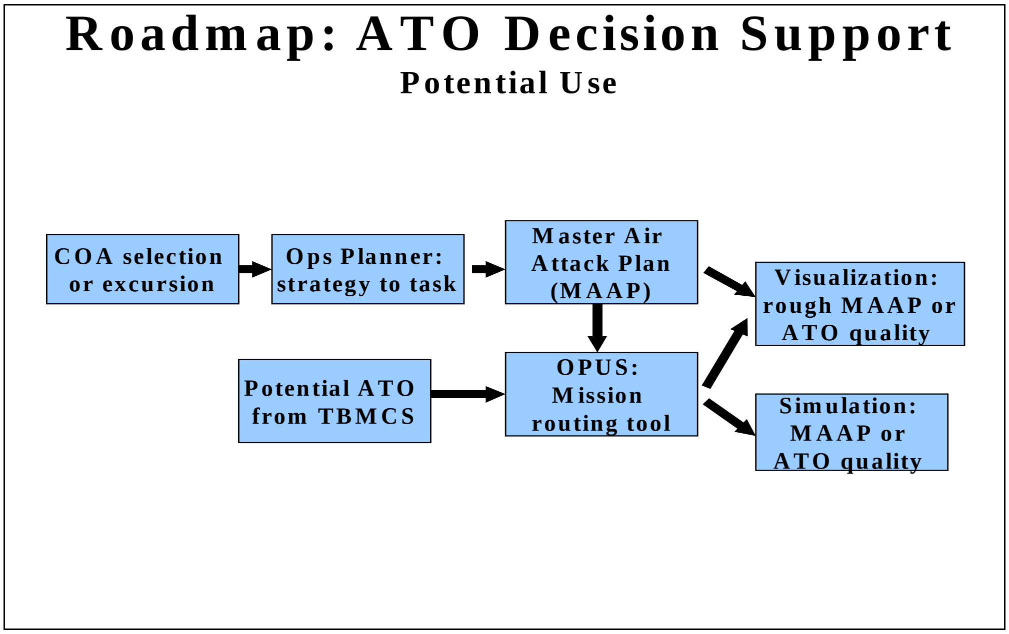

Figure 4. Road Map: ATO Decision Support Process[12]

Notice that this process starts with either a Course of Action (COA) or an ATO. Using the first process, the COA is converted into a MAAP using Ops Planner, and ends with a visualization. The second process starts with an ATO, which is then route-planned using OPUS, and ends with a simulation. Realize the intended users of the above process are real-world JFACC staff and more specifically AOC personnel.

Description of Analysis Tools

The amount of data available for the analysis tools is also enormous; so only a brief summary of relevant information for each tool will be provided. At a minimum, this summary will include the tool's primary user and OPR, its operating environment, the tool's main purpose, typical inputs/outputs, some qualitative observations, and known future plans/transitions. The presentation sequence of the tools is not arbitrary. Their sequencing will become clear in the next chapter.

AAG[13]

The ACT ATO Generator (AAG) is used exclusively by AFWI, who is also the tools OPR. It is PC-based and its primary purpose is to facilitate education of the entire air campaign planning process. Typical inputs include broad objectives initially, with weapons and targets as intermediate inputs. Intermediate outputs include text-formatted ATOs and actual execution of the ATO followed by final outputs in statistical and tabular forms. Output information includes aircraft losses, history trends and overall combat effectiveness. The tool has inherently analytic properties but limited excursion flexibility. The tool uses unclassified data and algorithms; thus isn't valid for analyzing real-world air campaigns. It is very timely to operate, modeling a 30 day air campaign in only a few hours, and has a Graphical User Interface (GUI), making it relatively user-friendly. Some degree of expertise is needed to use AAG and although it does "fly-out" the ATO, it doesn't visualize it. There is no replacement in the known future, and being a new tool it will likely mature over time.

THUNDER[14]

THUNDER is used by Checkmate (via AFSAA – who is also the tool's OPR) and AFWI, but is widely used throughout DOD analysis shops. It runs best on fast SUN workstations using a Solaris operating system. Its principal purpose is to examine air and space power effectiveness in a theater-level joint warfare environment. It can be run in either analytical or wargame modes. In its analytical mode, attrition rates; readiness; sustainability; force structures; alternative courses of action (ACA); and evolving capabilities and operational strategies can be examined. In its wargaming mode, it provides a rudimentary visualization (FLOT movement, etc) and is used to facilitate senior staff education and training. Inputs are voluminous and typically include friendly/enemy joint forces, geographic and weather data, logistics, etc. Since there is no GUI, data input is tedious taking literally months to prepare a single theater. However, once the databases are populated, excursions and large numbers of runs can be accomplished in a timely manner. Outputs are user selectable and are in text file/tabular formats. Typically outputs include campaign outcome information, equipment inventories, planned, executed, and cancelled sorties, etc. The tool is validated and has a wide user base but requires a fairly high-level of personnel expertise to operate. The planned replacement for THUNDER is the Synthetic Theater Operations Research Model (STORM) which will operate in conjunction with the National Air and Space Model (NASM) and will interface with Joint Warfare Simulation (JWARS).

CFAM[15]

CFAM was created for AFSAA who is the tool OPR. It was created primarily as a quick, albeit less powerful, alternative to THUNDER. Checkmate, AFSAA, ACC/SAS, and OAS are primary users of CFAM. It is PC based and relies on a fast linear program to optimize aircraft-weapons-target pairings. Its primary purpose is to analyze operational tradeoffs, with the goal of optimizing one (of five) air campaign objectives, like minimizing attrition, for example. Typical inputs include weather, attrition limits, budget and cost data, aircraft and target data, etc. Although it requires a high level of input data initially, it does have its own GUI and does interface with several already existing models. Outputs are text files that can be manipulated using analytic tools such as Excel, Access, and Statistical Analysis Software (SAS). CFAM can be used to quickly explore large areas of interest. Critical points, i.e. the ‘knee’ of the curve, can then be explored in detail with THUNDER. Future enhancements anticipated include a “back-end” GUI to increase utility and an interface to OPUS.

OPS Planner[16]

Ops Planner is primarily used by Checkmate, who is the tool OPR, as a replacement to JPT. It is PC based and its purpose is to facilitate the strategy to task process. Typical inputs include theater-level objectives, tasks, and measures of merit and targets. Output is a text MAAP, but the model's unique ability is to look at critical linkages between the tasks and the final air campaign plan. The output MAAP is then input into OPUS for routing and EADSIM for high fidelity attrition analysis and combat rehearsal. This is a relatively new tool currently in beta testing; its scheduled Initial Operational Capability (IOC) date is April 1999.

JPT[17]

JPT was born from Checkmate's Air Campaign Planning Tool (ACPT) and is intended for AOC staff use. Of the sites visited, the C2TIC is the primary user. It currently runs as part of CTAPS and is primarily used to facilitate weapons/target pairing. Typical inputs include Commander's guidance; objectives and tasks; Intel analysis; targets; and aircraft/munitions available. Some of this data must be inputted manually. Primary outputs include a prioritized list of air tasks, a candidate list of targets, and weapons/target pairing. Some outputs are in AOC standard formats, like Candidate Target Lists and MAAPS. JPT performs its functions well, given an "air smart" operator. However, it is not user-friendly enough to be widely accepted by AOC staffs and is not a good tool for multiple excursion analysis. Hopefully, as JPT transitions to the TBMCS and as AF-wide AOC standardization continues, JPT will mature into the tool it was originally intended to be.

AMASS[18]

AMASS is still being developed, but is intended to be used by AOC personnel. ESC is currently the tool's OPR. AMASS is TBMCS-based, primarily using an SGI environment, however, some components have been ported to Windows NT and Sun environments. Its purpose is to parse ATOs and provide some rudimentary simulation capability of the ATO to perform physics checks and error checking. The later capability currently uses EADSIM as its simulation engine. Typical inputs include EADSIM characteristics data; some of which can be gleaned from ATO and ACO messages. The ultimate intent is to get all input data from existing TBMCS or EADSIM databases. Outputs include typical EADSIM outputs for the simulation component and ATO error log information. AMASS is still being developed and thus it is too early to make qualitative assessments.

EADSIM[19]

EADSIM is widely used throughout the DOD, to include both Checkmate and AFWI. It runs primarily using an SGI environment, but can be run using a SUN environment. EADSIM is an analytic model used for a wide range of applications focusing on air and missile warfare. It is unique in that it models individual platforms and models interactions between C2 processes and intelligence activities. Checkmate uses it primarily to conduct attrition analyses of alternative war plans. Their inputs include loading enemy Integrated Air Defense System (IADS) primarily and an already developed MAAP with large-scale aircraft routes generated from OPUS. Data input is somewhat of an art. However, given semi-processed data, i.e. from OPUS, or warfighter-interpreted data, a single ATO can be entered in a day. Laying down an Iraqi size IADS from scratch, however, takes several weeks. Outputs are user selectable, but typically include attrition data and a visualized fly-out of the entire ATO (or MAAP/OPUS Routes). Once the database for an AOR is entered, excursions are relatively easy; for example a Desert Fox type operation was fully analyzed in 2-3 days by 2-3 experts. The model is validated and interfaces well with several Checkmate created (or enhanced) tools. A PC version of EADSIM may be available in a few years.

OPUS[20]

OPUS is primarily used by Checkmate. It is PC based and its purpose is to autoroute large numbers of aircraft through enemy IADS. The primary input is a MAAP. Outputs include aircraft routing (for EADSIM) and the "fly-out" can be visualized. In the future it will get imports from CFAM and OPS Planner. Thus OPUS, plus CFAM and EADSIM offer an integrated "suite" of tools that collectively form a formidable analysis tool set. OPUS should not be considered on a stand-alone-basis, unless only autorouting large numbers of aircraft through enemy IADS is needed.

AWSIM[21]

AWSIM is primarily used by the C2TIC and WPC. ESC is the tool OPR, although the AFAMS controls the configuration. It runs using a SUN environment. The primary purpose is modeling the ATO execution for training, and less so, for wargaming purposes. Inputs include the ATO, directly from CTAPS, and enemy threat data. Outputs include visualization of the ATO "fly-out" and other information for training critiques. AWSIM interfaces with many models including ground and naval models. Thus to really reap the full utility of AWSIM, the AWSIM "suite" of models, or the JTC, should be used. AWSIM executes ATOs and interfaces with other models extremely well, however, it was not designed for analytical purposes; and has very limited excursion flexibility. The model has been calibrated for training and has a stable user base. Once the databases for an AOR are populated it can be run faster than real time. Unlike most of the other models, there is considerable government expertise in operating

AWSIM. The future of AWSIM is limited since it's scheduled to be replaced by Joint Simulation (JSIMS) in the next few years.

A lot of information concerning air campaign analysis activities was presented. Dividing the information into site summaries and tool descriptions was done in order to make the information more understandable. Based on this information, some meaningful analysis can be performed and is introduced in the following chapter.

Notes

[1] Mr. Edward Ballanco (et al), WPC, interviewed by author, 15 December 1998.
WPC Website, available from http://www.wpc.af.mil.
[2] Briefing, WPC, Subject: WPC Overview, no date.
[3] Ibid.
[4] Mr. J. Puckett, Nimble Lion Study,(WPC Study, no date), 1-15.
[5] Major Douglas Fuller, Checkmate, interviewed by author, 29 December 1998.
[6] Briefing, Checkmate, Subject: Checkmate Analysis Tools, 22 July 1998.
[7] Mr. Don Neal (et al), C2TIC, interviewed by author, 29 January 1999.
[8] Briefing, C2TIC, Subject: Joint Air Planning, no date.
[9] Briefing, C2TIC, Subject: JFACC Planning Tool, no date.
[10] Dr. E.L. Perry, AFWI, interviewed by author, 5 February 1999.
[11] AFAMS Website, www.afams.af.mil.
[12] Briefing, AFAMS, Subject: Improving Modeling and Simulation Decision Support Tools for the Warfighter, Dr. Flash Gordon, 24 January, 1999.
[13] Dr. E.L. Perry, AFWI, interviewed by author, 5 February 1999.
[14] Email Message, FW: THUNDER Info, Mr. Roger Weissflog, 4 February 1999.
THUNDER Website, available from http://www.s3i.com/tug_home.htm.
[15] Briefing, Checkmate, Subject: Checkmate Analysis Tools, 22 July 1998.
Major Douglas Fuller, Checkmate, interviewed by author, 29 December 1998.
"CFAM, Combat Forces Assessment Model, Training CD", CD-ROM, ASI Systems International, 31 July 1998.
[16] Major Douglas Fuller, Checkmate, interviewed by author, 29 December 1998.
[17] Mr. Clay Olschner, C2TIC, interviewed by author, 29 January 1999.
[18] Email Message, RE: AMASS Info, Mr. Jonathan Prescott, 19 February 1999.
[19] Facsimile Message, no subject, Mr. Jim Hingst, 25 January 1999.
Email Message, RE: EADSIM Overview, Mr. Jim Hingst, 28 January 1999.
[20] Briefing, Checkmate, Subject: Checkmate Analysis Tools, 22 July 1998.
[21] Email Message, Subject: AWSIM User's Manual, Lt. Joseph Hernandez, 29 January 1999.
AWSIM Website, available from http://www.wg.hanscom.af.mil/AWSIMR/.

Chapter 3

Analysis

The findings showed some useful process insights and potentially promising tools for WPC's use. It is important to synthesize these findings into a coherent and meaningful way. To do so, this chapter will first look at the various processes in use by the sites and develop a notional air campaign analysis process. Second, the individual tools will be assessed based on common factors deemed important by the various tool users. Third, the two analyses will be fit together into a coupled process and then applied to a WPC-specific example.

Analysis of Processes

Several trends are observable based on the sites' activities and the specific functions of their analysis tools. Ideally, air campaign analysis occurs during and throughout the air campaign planning process. Using the air campaign planning process depicted in figure 2 as a basic framework, and the sites' activities, tools, and processes, two major trends emerge. First, there is an increasing level of specific knowledge about the air operations; going from broad objectives to a very specific ATO. Second, there is a sequentially narrowing of alternatives from multiple courses of action to a single air campaign plan. These two trends provide the two major axes for a notional air campaign analysis process, depicted in figure 5. This first major trend will be defined as "**Air Operations Specificity**," which **increases** as the process advances. The second major trend will be defined as "**Analysis Flexibility**," which **decreases** as the process advances.

Having framed the continuum of the air campaign analysis process, discrete subprocesses need to be defined to make the process practical. Discrete subprocesses will be defined with three key factors in mind: the functions performed, the tools used, and the organization responsible to perform the function. The predominance of activities, analysis tools, and organizational missions center around three analysis levels. The lowest level, analyzing the effectiveness of individual aircraft missions against specific targets will be defined as "**ATO-Level Analysis**." The next higher level, evaluating the effectiveness of alternative target sets and weapons and/or specific aircraft type to target type (or in some cases an actual MAAP) will be defined as "**MAAP-Level Analysis**." Finally, the highest level of analysis, starting with joint objectives and comparing multiple COAs against those objectives will be defined as "**Campaign-Level Analysis**." Naturally, there can be overlaps between the levels, degrees of independence, and two way iterations between them. However, for a simplified conceptualization of the entire process, the three discrete levels defined above capture the entire spectrum of the air campaign planning analysis. Also segregation of the levels lends itself to organizational separation of analyses and more manageable subprocesses.

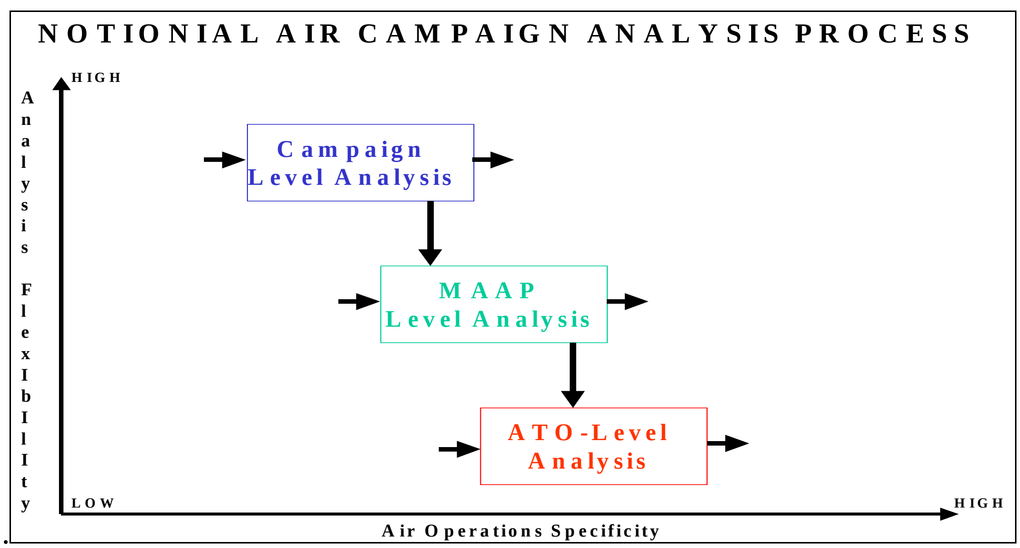

Figure 5. Notional Air Campaign Analysis Process

Notice in figure 5 the basic framework of this notional process rests on the two axes defined earlier: Analysis Flexibility, which decreases over time, and Air Operations Specificity, which increases over time. Next, notice each of the three analysis levels, Campaign, MAAP, and ATO, has individual inputs and outputs, thus can be performed independently. Also notice, the three levels are arranged sequentially and include arrows between them, symbolizing the potential interlinkage of each higher level analysis feeding the next lower level. This notional process will be more applicable once specific inputs/outputs for each of the three analysis levels and specific analysis tools are identified. But before doing so, an analysis of the tools described in the previous chapter must be accomplished.

Analysis of Tools

Given the concept of three distinct, but interrelated and overlapping analysis levels, the tools observed can be more appropriately assessed. No one tool, with the exception of AFWI's AAG, can meet the needs of the entire spectrum of air campaign analysis. However, based on interviews with the various sites and their selection, creation, and refinement of the tools they use, some common criteria are apparent. These criteria are qualitative in nature, and thus a quantitative assessment or comparison of the various tools is unfeasible. Nonetheless, these criteria are relevant and, at a minimum, invoke a meaningful thought process when assessing the tools for consideration. Common criteria for assessing the utility of the tools include:

- Powerfulness and Breadth of Tool Application
- Experiment Design and Excursion Flexibility
- Tool User Base (there's safety and efficiency in numbers)
- Input Database Compatibility/Ease of Data Entry
- Output Data Compatibility (to next process input)/Format Specific Outputs
- Tool Interfaces to Other Tools and Models
- Timeliness in Using the Tool (How long to set up, run, and iterate)
- User Friendliness of the Tool/Personnel Expertise Required
- Modeling Fly-Out and Visualization

The relative importance of each criterion varies by individual organizational tastes and needs. But, a common perceived trend is that the importance of these criteria correlates with the air campaign analysis level. For example, for Campaign-Level Analysis, the tool's breadth and excursion flexibility are critical; but the need to fly-out and visualize individual aircraft is much less important. At the other end of the air campaign analysis spectrum conversely, fly-out and visualization are paramount while the tools' ability to perform broad analysis functions isn't. The notional analysis sublevels, Campaign, MAAP, and ATO and the tools reviewed are interrelated. To meaningfully compare the tools, they must first be put into the framework of the notional air campaign analysis process. Further, the tools need to be grouped into the three analysis levels. However, just as the individual analysis levels overlap, so do the tools. A graphical depiction of the tools grouped by analysis level is provided in figure 6.

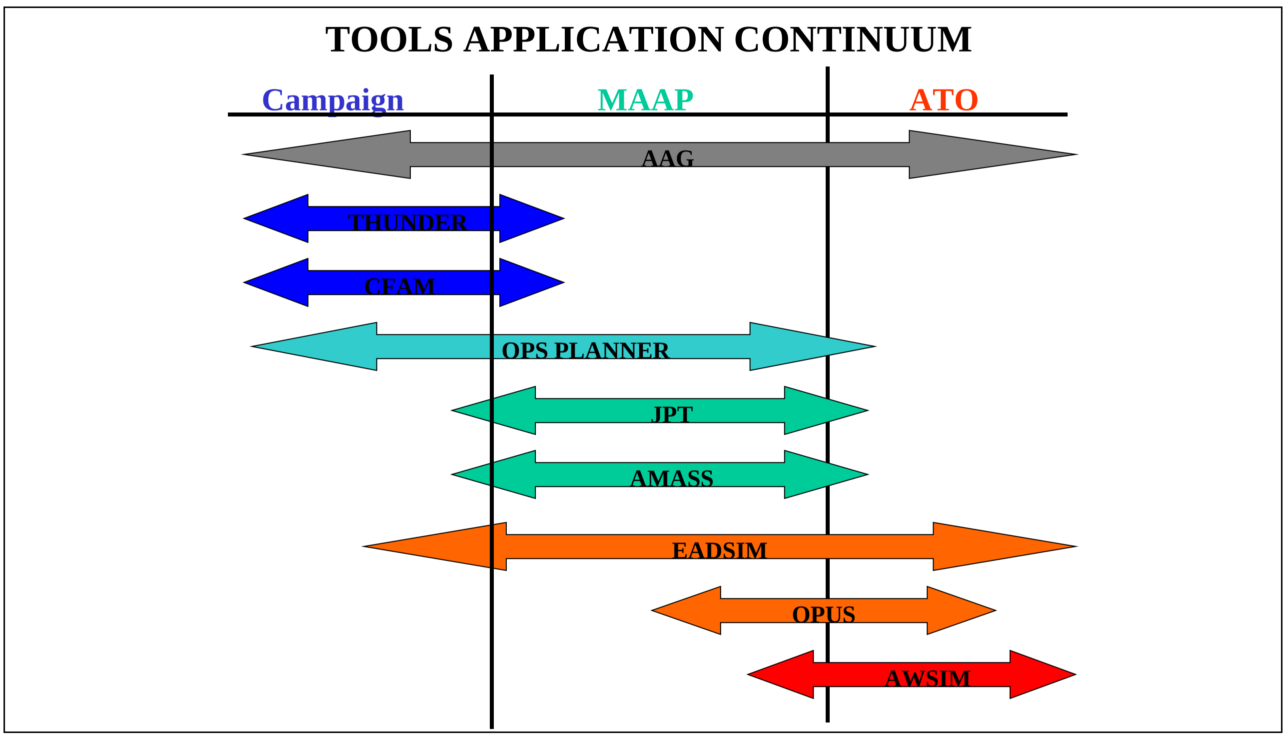

Figure 6. Tools Application Continuum

In figure 6, notice the tools cascade from left to right starting with Campaign-Level tools toward ATO-Level tools. Also notice that no tool fits exclusively into one analysis level; thus emphasizing the overlap between the three analysis levels themselves. Discussing the relative utility of each individual tool can now be meaningfully done using both the tool criteria described in the previous section and the three groupings depicted in figure 6.

The tools will be compared within the three analysis levels. However, since AFWI's AAG extends to all levels of analysis it will be discussed separately. Using a tool that performs analyses across the entire spectrum seems ideal. However, AAG is used predominantly for education purposes; and not real-world operations. Also, since it uses unclassified algorithms and databases, significant modifications are required for it to be fully useful to WPC. However, the ability to go from high-level campaign planning to individual ATO fly-out and see the results of planners efforts from start to finish is unparalleled.

Campaign-Level Analysis tools include THUNDER, CFAM, and OPS Planner. THUNDER is predominantly a campaign level analysis tool and has little overlap into the MAAP level. Of the three, it is the most powerful, has the widest breadth of use, and is conducive to experimental designs with high volumes of excursions. It is, however, difficult to use and requires high levels of expertise to operate and is best used by skilled analysts. CFAM, conversely is PC-based, easier to use, but less powerful than THUNDER. However, it can quickly explore large areas of interest, finding the 'knee' of the curve. It does overlap into the MAAP level of analysis and will eventually provide outputs compatible with OPUS, and indirectly, EADSIM. OPS Planner is also PC-based, but is a relatively new tool. It promises to replace JPT and its output MAAP can be input directly into OPUS.

MAAP-Level Analysis tools include OPS Planner, JPT, AMASS, and EADSIM. OPS Planner, as previously described, is relatively new, but is PC-based and extends well into Campaign-Level Analysis. The JPT is currently available on CTAPS and will be available on TBMCS; both platforms are intended for AOC and planning cell staff use. It has very specific inputs and outputs and is a good tool for creating MAAPs from task, targets, and resource lists. To be fully embraced by its current users, however, JPT needs some major refinements but may mature over time. AMASS, may eventually replace JPT, and is likewise intended for AOC and planning cell staff use. It will be incorporated into later versions of TBMCS and is envisioned to provide ATO error/reality checks. Finally, EADSIM is a workhorse that spans between high level analyses down to individual aircraft modeling and visualization. It assesses attrition rates, models individual entities (joint) and provides a visual display at campaign levels down to ATO levels. It is validated and has a wide user base. It is, however, difficult to populate and requires a moderate level of expertise to operate. It does, none the less, have a user-friendly interface specifically designed to allow non- analysts to use it.

ATO-Level Analysis tools include EADSIM, OPUS and AWSIM. EADSIM, as described previously, is a powerful tool extending well into MAAP-Level Analysis; but requires a moderate level of expertise. It does, however, offer analytical capabilities well beyond OPUS or AWSIM, and interfaces to several other tools (CFAM, OPS Planner, AMASS, OPUS). OPUS is really a mission-planning tool for large-scale operations. It interfaces with EADSIM, CFAM, and OPS Planner. It does provide visualization and fly-out, but models friendly aircraft survivability more than combat effectiveness. It has been suggested[1] that before a meaningful simulation of an ATO can be accomplished, optimized routing is needed to provide a more realistic assessment of friendly attrition through enemy IADS. Finally, AWSIM is intended for training and exercise purposes, and has little analytical capability. However, WPC, recognizing this, used it for Nimble Lion as the best tool available at the time. It does provide some overlap into MAAP, but is really best suited for individual ATO modeling and fly-out. It has the widest user base of all the models investigated and interfaces well to other joint models; allowing analysis of other than air operations.

Application of Process and Tools Analyses

Using the above tools' assessment, specific tools and representative inputs/outputs can be added to each analysis level. This expansion to the notional air campaign analysis process is applicable to a WPC-specific example and is depicted in figure 7.

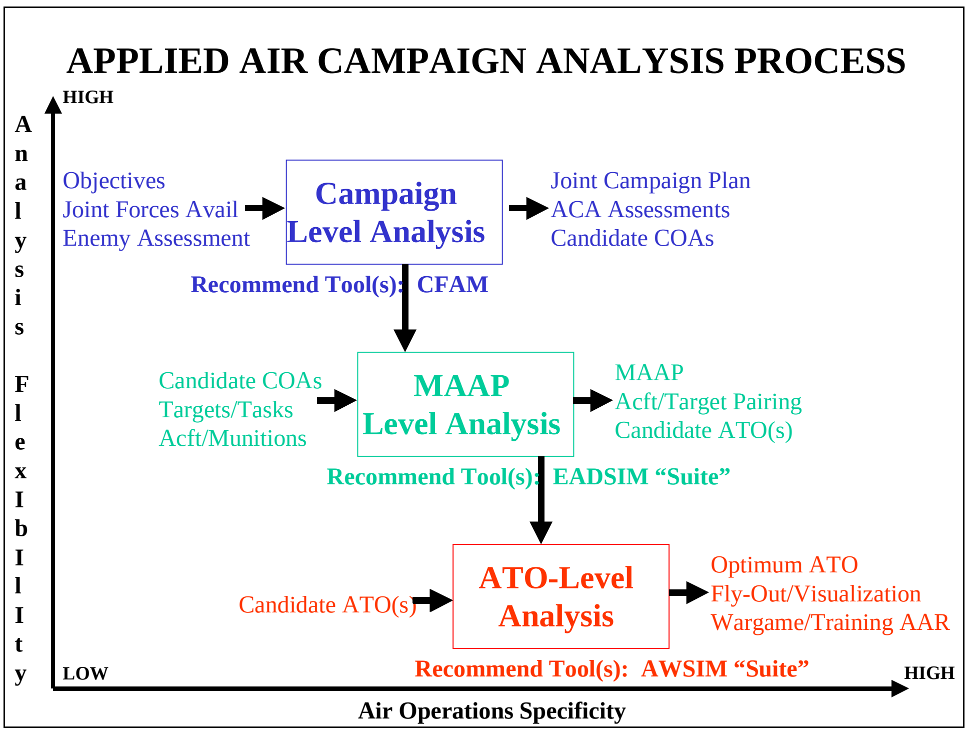

Figure 7. Applied Air Campaign Analysis Process

Notice in figure 7 the two major axes, Air Operations Specificity and Analysis Flexibility still frame the process. Also, the specific inputs/outputs for each analysis level correspond to the tools recommended and are intended to be representative, but not all encompassing.

To demonstrate the application of the notional air campaign analysis process, a hypothetical example will walk-through figure 7. Imagine WPC is tasked to assist USAFE in Crisis Action Planning (CAP) for a real-world contingency. First, the Campaign-Level Analysis begins with CINC-level joint objectives, apportioned joint forces, and some information about the AOR and the enemy capabilities. Potentially, other information, like multinational forces available, assumptions, Commander's Intent, a Mission Statement, and specific JFACC and/or J3/J5 guidance is provided as well. WPC analysts gather experiment design information, especially desired decision factors such as attrition rates, combat effectiveness, etc and then determine the types and numbers of excursions needed. This would facilitate populating, or at least bounding, the solution volume; precluding tedious and time-consuming rework later. Using analysis tools, like CFAM, results in broad-level analysis; identifying "knee" in the curve critical points of interest. These activities segregate the airpower portion from the overall joint campaign plan, assess ACAs, and ultimately result in several candidate COAs.

Next, the MAAP-Level Analysis starts with these candidate COAs; which could be provided to WPC (directly from USAFE or from a centralized planning cell). WPC analysts gather information in addition to the COAs, such as JFACC-prioritized tasks, prioritized target lists and apportioned airpower resources. At this point, the desired decision factors and excursions are narrower, having "modeled-out" undesirable or less feasible alternatives. Using analysis tools, like the EADSIM "suite" of tools accomplishes assessments of specific weapon/target pairings, comparisons of candidate COAs and ultimately provides candidate ATOs. These candidate ATOs could be either the initial day of the air campaign or could be progressive multiple-day ATOs. The ATOs associated with each COA, or an optimum COA, is then provided for the next level for analysis.

The ATO-Analysis Level starts with ATOs developed from the MAAP-Level Analysis; which could be provided to WPC (directly from USAFE or from a centralized planning cell). WPC analysts gather information in addition to the ATOs, such as specific AOR or the latest enemy threat assessment for realistic ATO modeling. At this point the decision factors and number of excursions should be narrowest. Using analysis tools, like the AWSIM "suite" of tools, specific ATOs are assessed, compared, and optimized. Ultimately, a final, optimum ATO is provided to the warfighter/training audience.

This chapter synthesized the abundant findings from the various sites in a coherent and meaningful way. This was accomplished by first looking at a notional process framework across the entire spectrum of the air campaign analysis process. Next, the individual tools' were grouped into the three analysis levels and then compared. Coupling the notional process and evaluated analysis tools resulted in an applied air campaign analysis process with a WPC-specific example. The utility of this analysis culminates with specific recommendations, presented in the next chapter.

Notes

[1] Email Message, FW: Decision Support Tools Briefing, Dr. Flash Gordon, 11 February 1999.

Chapter 4

Conclusions

The information gathered from the various Air Force sites and subsequent analyses have provided great insight into improving the WPC air campaign analysis process. Although each site has unique missions, there is ample commonality and many great ideas to be useful. Based on these observations, recommendations for improvement, with some implementation considerations can be made. Finally, since this research was by no means comprehensive, there are several potential areas for future research identified.

Recommendations

First and foremost, consider the Applied Air Campaign Analysis Process depicted in figure 7 as a framework capturing the entire spectrum of analysis. Once the varying analysis levels are segregated, tools and processes become more manageable, vice finding a single tool or process to do everything. WPC currently does ATO-Level Analysis, using AWSIM primarily, but needs some improvement. However, instead of concentrating on improving this, adding the other analysis levels would greatly expand WPC current capabilities over the entire air campaign analysis spectrum. Although there are several tools in development, WPC should not wait, but should instead expand its capabilities now, but do so incrementally. The incremental approach recommended below uses WPC's self-recommended analytical improvement approach of "CRAWL—WALK—RUN."[1]

CRAWL: Add the ability to do MAAP-Level Analysis. AWSIM is not the right tool for this, but EADSIM is well suited for the task. Including the EADSIM "suite" of tools provides even greater capability. Adding this intermediate step between Campaign-Level and ATO-Level analysis would allow greater flexibility in a Nimble Lion type activity. It would provide broader analyses, with visualization, and help WPC to bound the solution volume with more excursions. Most importantly, it would result in narrowing down the ATO candidate(s) considerably, easing and greatly accelerating the ATO-Level analysis, especially AWSIM set-up and execution time. Although EADSIM "suite" can do some Campaign-Level analysis, this function could also be done by outside agencies or manually until WPC expands its capabilities to include Campaign-Level Analysis. Finally, EADSIM extends into ATO-Level Analysis and provides analytical tools well beyond current AWSIM capabilities. This CRAWL step alone would be a significant improvement to the current WPC air campaign analysis process!

WALK: Add the capability to do Campaign-Level analysis. If WPC finds outside help in this area inadequate, or wants greater self-sufficiency, this would capture the full spectrum of analyses. Although this could be done by expanding the MAAP-Level analysis, a more thorough Campaign-Level analysis capability is ideal. In order to provide broader and more far-reaching analysis, a tool, such as CFAM should be considered. As before, there are other tools in development (STORM, and/or JWARS), but this tool is available now and used by several AF organizations. Full implementation would require higher levels of statistical analysis and greater rigor in experiment/excursion design.

RUN: Seamlessly and interactively accomplish all three levels of analysis. This will take experience, refinements to the WPC analysis process and greater interoperability between the various tools. During the Crawl and Walk periods, the AF will continue to develop decision support tools, perfect the TBMCS/GCCS tools, and continue to standardize AOC processes and training. A growth path toward these is optimal, since it will allow, at a minimum, compatibility with 1) real-world products like ATOs, MAAPs, etc, 2) tools like JPT, AMASS, JOPES, etc, and 3) standardized AOC processes. Also, during this timeframe, a transition from the current AWSIM to the NASM and ultimately the all-service model, JSIMS, should be planned and implemented as WPC's ATO-Level Analysis capability evolves. Ultimately, this RUN phase will allow WPC to train using the same tools used in the field; and to the degree desired, replicate those processes.

By incrementally implementing and segregating the varying levels of air campaign analysis, adding the analysis tools and processes becomes more achievable. Doing so, will ultimately, give WPC the full-spectrum of air campaign analysis and make Nimble Lion type activities easier, more timely, repeatable, and ultimately, more meaningful.

Implementation Considerations

Implementing the recommendations above is an extensive effort but would comprehensively add to WPC's current capabilities. Detailed processes for each analysis level need to be defined and further developed.

Before implementing, reflection about WPC's relationship with outside organizations may be warranted. For example, the USAFE planning cell and/or the AOG may be better suited to do some or all of these analysis functions. Or further from home, consider collaborating with other organizations, such as the still evolving Air Expeditionary Force planning cell, ACC, AFSAA, or Checkmate, for higher level analyses. In that case, WPC need only to define the relationship and product formats to be exchanged. However, if WPC wants the capability to perform the entire spectrum of the air campaign analysis process, an integrated suite of tools, like Checkmate's, precludes the CRAWL and WALK steps and jumps immediately to RUN.

Also, WPC should consider the relationship and relative importance between its training mission and its mission rehearsal mission. If the two are inseparable and/or of nearly equivalent importance, the analysis process should consider, and be integrated with, the training process. Furthermore, selection of tools in use AF-wide, or at least by WPC's training audience, should be selected (as recommended in RUN) to be more fully integrated with training. However, if the training mission and mission rehearsal mission are not as interdependent, more stand-alone and more powerful analytic tools should be selected, perfected, or created.

Finally, realize the AF at large continues to wrestle with this very problem. As seen at several AF sites, there seems to be some "stove-piping" of solutions. Although the recommendations include tools currently in use by at least two AF sites, WPC should keep abreast of the AF-wide plan. Toward this end, WPC could get on the current TBMCS/GCCS "train", when convenient, skipping the intermediate CRAWL and WALK steps.

Potential Areas for Future Research

This research, albeit limited, answered the immediate question of improving the current WPC air campaign analysis capability. However, in addition to the implementation considerations above, there are two potential areas for future study, and may be of use to WPC, and/or the AF at large. First, the sites where limited to AF sites currently performing activities similar to WPC's. A more extensive survey, especially to the NAFs would likely find even more tools, processes, and innovative ideas. Second, a more comprehensive look at the analysis tools described herein may be warranted. The tools in this study could be researched more extensively. Certainly, a more hands-on examination of the tools in operation should be conducted. Also, more data on the tools' life cycle costs such as tool training, operating costs, etc may be needed. Further, a deeper look at related tools such as logistics (deployment, sustainment rates, beddown etc) or specific related analysis tools (statistical tools, databases, GUIs, etc) may be helpful. In any case, the future research areas suggested would not substantially change these conclusions, but they are a logical extension to this initial research.

The author hopes this research paper helps WPC improve its air campaign analysis capabilities. At a minimum, the information gathered and subsequent analyses have provided an objective assessment of WPC's current capabilities and some thought-provoking ideas. At best, the research results in a tangible product for improving WPC's growing mission. Ultimately, this newly characterized air campaign analysis process will provide warfighters thoroughly planned air campaigns that are fully analyzed and rehearsed well before the wheels are in the well.

Notes

[1] Briefing, WPC, subject: Nimble Lion Initial After Action Review, August 1998.

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