ANALYZING THE AIR OPERATIONS CENTER (AOC) AIR TASKING ORDER (ATO) PROCESS USING THEORY OF CONSTRAINTS (TOC)

Maj Conner, Maj Lambertson, Maj Roberson

AFIT/ISE/ENY/05-J01

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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EXECUTIVE SUMMARY

This thesis examined the Air Operations Center (AOC) Air Tasking Order (ATO) development process using the Theory of Constraints (TOC). TOC defines a constraint as the variable in production in which a local innovation causes significant global improvement [13]. The overall goal of this research was to identify constraints that exist in this development process, both within a single ATO cycle and across five concurrent overlapped cycles.

There has been little documented research on the process of ATO development; much of what is available is either ad hoc, contradictory, or both [1,2,5,8]. Despite this, it is widely agreed that up to five ATOs are concurrently in development at any one time. It is also widely acknowledged that a given ATO from initial conceptualization to execution takes 72 hours, with a daily ATO release occurring every 24 hours. What has not carefully been examined is the lateral interaction between processes within one ATO cycle, nor the vertical interaction between concurrent ATOs under development. Identifying these interactions for possible constraints will focus improvements in this complex command and control process. To this end, we applied TOC using a manufacturing shop-floor analogy [13]. Rather than material goods, our working medium consisted of information flow within a developing ATO and between ATOs. The ATO processes are analogous to the machines on the factory floor. Bottlenecking of information had significant implications and information inventory can be shown to stack up through document completion delays.

Using this model we identified specific locations of lateral constraints that often result in information chokepoints, and therefore reduced quality and/or late delivery of the ATO. We also pioneered identification of non-obvious vertical interaction between ATO cycles. Identification of these constraints will allow AOCs to more effectively plan and control ATO development to ensure accurate and on-time delivery of Air Tasking Orders.

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1. INTRODUCTION

Air Force Doctrine Document 1 (AFDD-1) [8] calls out both the basic principles of war that are accepted as part of any campaign and also the recognized tenets of airpower.

Principles of War	**Tenets of Aerospace Power**
-*Objective*	-*Centralized Control; Decentralized Execution*
-*Offensive*	-*Concentration of Purpose*
-*Mass*	-*Prioritized*
-*Economy of Force*	-*Balanced*
-*Maneuver*	-*Flexible and Versatile*
-*Unity of Command*	-*Persistent*
-*Security*	-*Synergistic*
-*Surprise*	
-*Simplicity*	

Fig. 1: Principles of War and Tenets of Airpower [8]

Any air campaign should be planned with these guidelines in mind. Maximizing them requires an effective planning and command function as well as a means to communicate and execute a given plan.

The command structure and system that we have evolved to prosecute an air war takes the form of an Air Operation Center (AOC) which supports the Joint/Combined Air Component Commander (J/CFACC) [1]. When the AOC is manned and prosecuting a campaign each and every one of the aforementioned principles and tenets is taken into account. The vehicle that the AOC uses to command and execute the war is known as the Air Tasking Order (ATO) [1]. The ATO process is complex by its very nature; this will be the first attempt to better understand its inner workings using the Theory of Constraints (TOC). TOC defines a constraint as the variable in production at which a local improvement causes significant global improvement. This paper models the ATO development process using a "factory floor" analogy [13], in order to determine various constraints which limit maximum realization of intended military effects. Our intent is to reveal areas of the ATO process that may be targeted to increase efficiency and ensure that there are fewer unpleasant surprises during the ATO process.

2. BACKGROUND

2.1 The Air Operations Center (AOC)

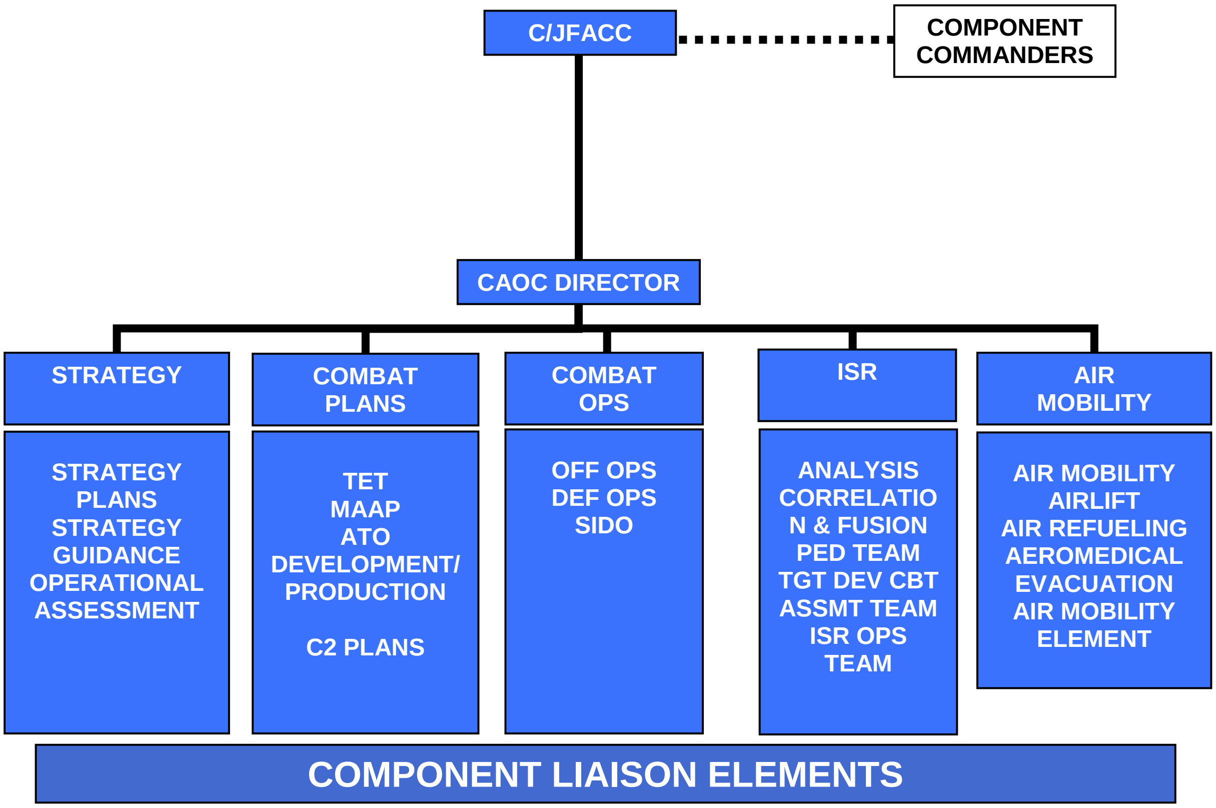


Fig. 2: AOC Organization [9]

As shown in Figure 2, an Air Operation Center (or JAOC/CAOC) is divided into five divisions [1,9]. The Strategy Division (SD) may be thought of as the long range planners, typically engaged with planning for combat activities that are more than 72 hours in the future. This division is the primary conduit between the Joint Forces Air Component Commander (JFACC) and the actual day to day operation of the AOC.

Next is the Combat Plans Division (CPD) [1,9]. This group is tasked with taking JFACC guidance and translating it into a targeting plan and Master Air Attack Plan (MAAP) that will achieve the Joint Force Commander's intent. The third division is the Combat Operations Division (COD). This section will actually execute the war plans that are built by the Strategy and Plans Divisions.

The Intelligence, Surveillance, and Reconnaissance Division (ISRD), is the main source of Intelligence Preparation of the Battlespace (IPB) [1,9]. In effect the ISRD is interleaved throughout the other divisions. A great analogy is to view the ISRD as electricity; it permeates all of the remaining processes and is a prerequisite for their operation, just as electricity is required for factory floor machine operations.

Finally, the Air Mobility Division (AMD) is essentially an AOC-within-an AOC [1,9]. Since not all mobility assets are "chopped" to theater commanders they require a separate planning entity. Now that we've got a top-level picture of how the AOC is organized, let's briefly examine the ATO process before discussing the Theory of Constraints.

2.2 The Air Tasking Order (ATO)

This discussion will provide enough ATO background to set the stage for analysis using the Theory of Constraints. The ATO, historically called the "frag," is an executable snapshot of the Joint Force Commander's (JFC's) intent [1]. It grows from the broad guidance provided by the SD in the form of an Air Operations Directive (AOD), and then matures through the intermediate level Master Air Attack Plan (MAAP) into a fully developed and finalized order. Figure 3 below shows the development process in terms of play of different divisions.

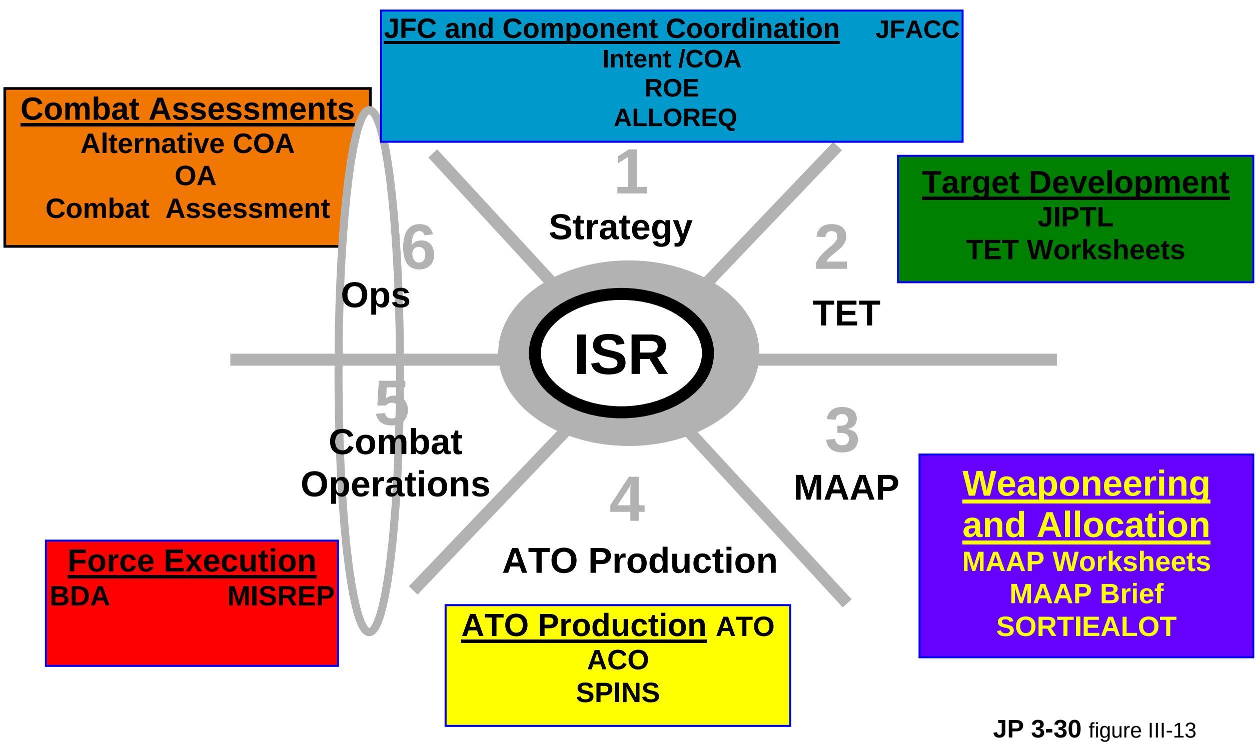


Fig. 3: ATO Process [4]

We focused our research on steps one through four above, and examined what goes on inside the Strategy and Combat Plans Divisions to identify constraints. Figure 4 is an example of one ATO cycle plotted on a 72-hour timeline [1]. Now let's examine the ATO through the lens offered by the Theory of Constraints.

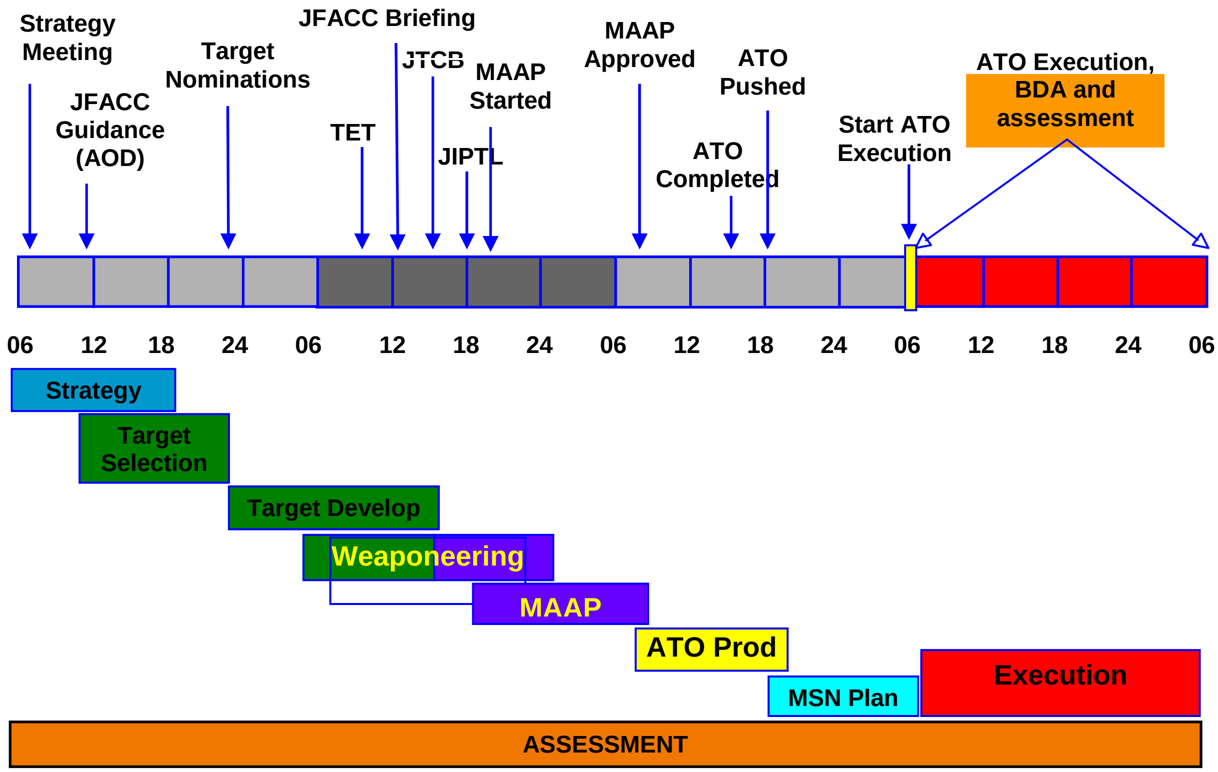


Fig. 4: Generic 72 Hour ATO Timeline [9]

2.3 Theory of Constraints

The Theory of Constraints (TOC), as espoused by Israeli physicist Dr. Eliyahu Goldratt, defines a process in which throughput-limiting constraints can first be identified, then actively managed [13,15]. By identifying the constraints, the process owner/stakeholder is more keenly aware of weak areas within the production chain that require the greatest attention to achieve success. From *Project Management* [17], the *"critical chain is based upon a general improvement methodology called the Theory of Constraints."* To determine where to look for constraints within a project, *The Critical Chain* states, *"the constraint is on the critical path…where most attention should be focused* [16]*."* The critical chain or critical path is defined as the *"longest chain of dependent events where the dependency is either task or resource related [17]."* In *The Goal* and *Its Not Luck*, Dr. Goldratt defines his process through examining a fictitious factory [13,14]. The easiest way to identify the constraints experienced in the lead character's factory was to examine what was occurring on his factory floor. By doing so, he could see where stacks of inventory, such as raw materials and partial assemblies, were piling up – telltale signs of constraints.

In this study, the extremely complicated ATO process was examined in detail to determine what, if any, constraints existed. Here, the *activities* required to produce the ATO are analogous to *machines* on a factory floor. Each activity performs a task(s) and produces something used later in the process. Machines on a factory floor do the same by producing subassemblies, which are further transformed or integrated into final product. By using this analogy, potential constraints should reveal themselves where ATO process resources build up.

Since TOC is a theory developed for production of tangible goods, there are some difficulties applying it to an information-intensive process such as ATO development. It is not possible to use physical evidence such as raw materials or subassemblies, so Goldratt suggests that you look for other telltale signs or negative effects. These "undesirable effects" are not necessarily the real problem but are indicative or where the constraints may be located. At this level of abstraction, all the major resources were difficult to identify. However, the proximity of processes (and their overlay) did yield a critical path and discussions with Subject Matter Experts (SME) at the 505th and 705th Training Squadrons (schoolhouse) identified numerous problem areas on which to focus our search for constraints. But shouldn't any statistical fluctuations that occur in the output of ATO activities even out across the whole development process? No - because of covariance.

Covariance is a mathematical principle which states, "*in a linear dependency of two or more variables, the fluctuations of the variables down the line will fluctuate around the maximum deviation established by the preceding variables.*" [13] In other words, as we move downstream in a linear process, statistical fluctuations build on one another. Figure 5 demonstrates the principle of covariance. This tabulation came from the famous "match stick" game discussed by Dr Goldratt [13].   Figure 5 is a tabulation of five players rolling through five turns. The game is played by each player rolling his die and moving the rolled number of match sticks to the next player in line. The catch is that a player may only move the number of match sticks he possesses (inventory) at the time of his roll. For example, if player two has three match sticks and rolls a 4, he may only pass his three match sticks. If he rolled a 1, he could only move one of his three match sticks leaving an inventory of two. The asterisks represent the amount each player's transferred match sticks deviates from the average number possible (3.5 average value for the possible outcomes 1– 6). Four moved match sticks would be scored as a change of +.5 while two moved match sticks would be scored as -1.5. The deviations must be cumulative. For instance, Figure 5 shows Andy's first roll of 2 (moving two match sticks), which is a -1.5 deviation from the 3.5 average value. An asterisk at -1.5 marks his first turn. Now move to Ben – he rolls a 4, but can only move his inventory of two match sticks, marked as another -1.5 deviation. As you can see, each name has a group of five asterisks representing their five rolls.

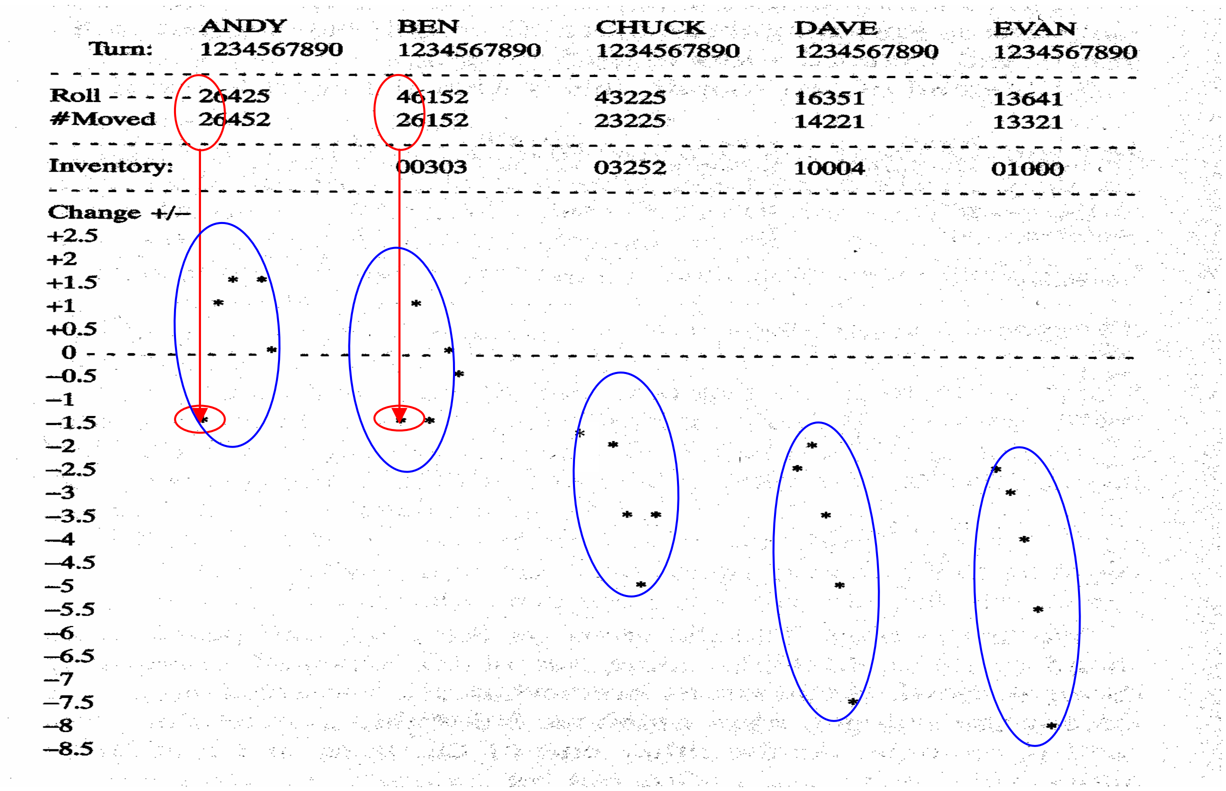


Fig. 5: The Matchstick Game [13]

The best the next player can manage is dependent on the previous player's roll and inventory. These group plots trend downward as the covariant effects take hold. [13]

So how does covariance affect the ATO process? As we've discussed, the ATO development process is linearly dependent along its critical path. For example, the AOD must be released before TNL Development can start: how can you develop targets without knowing commander's intent? If the AOD is late, however, some time may be made up by follow-on processes due to variance within each separate process. In other words, an AOD that is released 30 minutes late may make the TNL Development 30 minutes late or 15 minutes late, depending on how much the TNL process can be expedited. This is unlike strict covariance where two hours lost upstream is effectively non-recoverable. The point is that covariant effects will come into play even if not in their strictest sense

Now, constraints or potential constraints often reside where more tasks exist than resources to perform them – multitasking of resources and careful management becomes necessary. Limited resources are often found in deployed military operations. One very critical area of deployed operations is the AOC. This facility is the "brain" of air operations in any conflict where the United States is involved, with its orders executed primarily through the ATO. Collecting, analyzing, planning, and transmitting a plan which fully informs all applicable units of how they will interact on any given day in any given part of the combined operating area is no small task. The Air Force Operational Tactics, Techniques and Procedures (AFOTTP) publication 2-3.2, that covers the AOC and its ATO process is an extensive 920 pages.

Although the ATO Cycle Model appears "linear" in AFOTTP [5,9,10,11] the process in reality can still be quite chaotic. Throughout the TTP it is repeatedly mentioned how annotated times are notional and how flexible the process must be to meet the needs of each individual conflict. This study built a timeline from those listed notional times with the intent of identifying the critical path, and the potential constraints that arose on that path. Even though these times are notional with much attention given to the flexible nature of the ATO process, applying Constraint Theory might yield some interesting results that are universally applicable to any ATO process.

After much review and direct questioning of members of the AOC "schoolhouse" (C2 Technical Information Group or C2TIG), as well as current and former Master Air Attack Plan (MAAP) Cell Chiefs, it was determined that this timeline did not previously exist [5,11,12]. As stated above, elements of notional times where mentioned in various places throughout the TTP, but no "one-stop" overview of the entire process existed. Therefore, one had to be built. Once the 72 hour timeline was completed, it required overlay with four other timelines to reflect the reality of these ATOs in various concurrent stages of development at any time.

Appendix 1 is the culmination of these efforts. The right column defines the ATO development task with its due time, accomplishment/consumed time and its AFOTTP 3-2.3 reference. The Text column names the document produced at its applicable time. The colors are defined in the lower left corner. The bars' lengths represent the time consumed by each activity in hours. ATO Production team processes are summarized in a 12 hour block in this illustration.

Much of the documented information that we reviewed demonstrated a linear process without much overlaid activity or interaction. In other words, the process depicted in extant literature does not exhibit many parallel tasks or feedback loops and there is little interaction vertically across the ATO cycles. From experience, this is too simplistic a view and this study concentrated on analyzing the overall process in the vertical dimension. For example, how many resources must be shared to conduct the applicable portions of five (not just one) ongoing ATO processes? Completing the overlay essentially defined the factory floor of the ATO process and allowed us to begin our constraint study.

3.0 METHODOLOGY & RESULTS

This section will discuss the overall conduct of our study. We'll start with some necessary assumptions and semantics clarifications, and then look at lateral interaction and vertical interaction in turn. As we discuss each type of interaction we will look at individual methodology and results.

3.1 ASSUMPTIONS

We needed to adopt several assumptions as part of this project, all in an attempt to create a usable baseline that can be modified as the situation dictates. Conversations with different members of the C2 community highlight the fact that all AOCs are different, and indeed that each conflict fought by a given AOC will be different (5,11,12). We definitely recognize this; but we also saw the value in establishing and examining a baseline process that can be modified as the AOR and situation dictate.

- The ATO process that we have defined is a 600 sortie per day "big war." We assumed a normal intermix of sortie types (OCA, DCA, CAS, SEAD, INT, AM, etc.) This means that the AOC is manned 24/7 and that all critical actions must occur on time or there will be a risk of a delayed ATO.
- Currently, AOCs worldwide are experiencing massive technology driven growing pains. Theater Battle Management Core Systems (TBMCS) is still not a mature system, and there is little or no standardization across the community with respect to hardware or software. In our "perfect world," these concerns have been addressed and we assume that all of our C2 systems are fully mission capable.
- Manning is maintained at the requested levels for all segments of the AOC.

- Likewise, all AOC personnel have attended the AOC Formal Training Unit and have had sufficient time In-theater to gain an operational level of proficiency.
- Finally, we concentrated our study on the Strategy and Combat Plans Divisions. These two divisions contain the teams that actually develop the ATO. The Combat Operations, ISR and Air Mobility Divisions do not have direct play in ATO development, with one caveat. The Target Development Cell is a subset of the ISRD that is directly involved in creation of TNLs and the JIPTL. This is the one team from the ISRD that we did directly model as part of ATO development.
- The Combat Operations Division is made up of offensive operations teams (those air and space operations normally conducted in enemy territory) and defensive operations teams (those air and space operations in defense of friendly territory). This is where monitoring of the current ATO, the one being executed, is done and where any changes to the current ATO are dealt with (aborts, impacts to the ATO from weather, mission changes etc). The Combat Operations Division is external to our study since it deals with ATO execution and not development.
- The Intelligence, Surveillance and Reconnaissance Division (ISRD) supports all processes contributing toward planning, execution and assessment. ISRD provides intelligence to support target development, weaponeering, and ATO development. During execution ISRD may provide real time intelligence needed for time critical targeting. And ISRD contributes toward combat assessment with bomb damage assessments, post mission information and collecting mission reports (MISREPs)
- The Air Mobility Division contributes to the ATO through strategic and theater wide mobility missions. Their tasks are accomplished through a parallel cycle which also requires planning, executing and assessing the success of these mobility missions. Since the AMD cycle is parallel it is removed from our overall study.

3.2 SEMANTICS

The list of authors for the latest version of AFOTTP 2-3.2 [9] reads like a list of who's-who from the C2 community. There are 128 individual names listed. Unfortunately this breadth of experience did not lead to unity of effort when it came time to pen the AFOTTP. It seems that each and every AOC does things a bit differently…and this extends down to the level of semantics. It's necessary at this point to clarify the terminology that we will use in this paper.

- **Joint Target List (JTL).** Other names include Combined Target List or Candidate Target List.
- **Targeting Effects Team (TET).** Other names include Joint Guidance, Apportionment and Targeting (JGAT) team, Joint Effects Targeting (JET) team, Combined Effects Targeting (CET) team, and Targeting Effects Translation Team (TETT).
- **Divisions or Squadrons**. Most AOC are divided into divisions and then into teams. 7AF AOC is subdivided into squadrons and then teams.
- **Joint Integrated Prioritized Target List (JIPTL).** Also known as a Single Prioritized Integrated Target List (SPITL).
- **Joint Targeting Coordination Board (JTCB).** Also known as Combined Effects Board (CEB), Joint Effects Board (JEB) and Joint Integration Board (JIB).

3.3 LATERAL INTERACTION: ONE ATO CYCLE

3.3.1 Specific Methodology

As we've mentioned before, prior to this project there simply was no single reference that depicted the chronological flow through one ATO cycle. There are numerous articles in various sources (USAF Weapons Review, USN Top Gun Journal, etc.) about how an ATO process should work. It also turns out that there is just as much guidance in the form of "oral history" or word of mouth [5]. In order to ensure sufficient rigor in the development of an ATO cyclic model that would be a valid baseline for the USAF our team used AFOTTP 2-3.2 [5,9,10]. We resolved conflicting information through the use of several interviews with SMEs.

3.3.2 Results

As discussed, the JAOC ATO cycle is a 72 hour process from concept through production. In this section we'll look at one lateral / horizontal instance of the ATO process. It's important to note that no one ATO cycle stands alone. At any one time five separate ATO's are in work and there is interaction between them in terms of intelligence, assessment and manpower requirements. There are several critical information products that simply must be produced sequentially. These products are [9]:

- The Air Operations Directive (AOD).
- The Joint Target List (JTL).
- The Target Nomination List (TNL).

- The Joint Integrated Prioritized Target List (JIPTL).
- The Master Air Attack Plan (MAAP), which is commonly represented by the MAAP script.
- The final ATO.

3.3.2.1 Potential Constraints

The lateral flow through an ATO's lifecycle is limited at several bottlenecks that are easy to identify and potentially improve. The processes that create the products listed above can be thought of as representing these bottlenecks. The linear flow of one ATO development cycle has connectivity with other ATOs, primarily in the form of manpower constraints and either intelligence or assessment feeds. Manpower issues can cause the bottlenecks that we are about to identify to become full-blown constraints. Despite this, each of the products above must be delivered before the succeeding product can be developed through what is essentially a linear process. In essence, what we will be doing in this section is laying down a narrative of one baseline ATO process. In hopes of making this narrative easier to follow we'll step through ATO development using the above products to delineate sections. Then we will use this chronology to first positively identify potential constraints within the process and then make recommendations on fine-tuning these critical processes to ensure on-time delivery of an accurate ATO. First let's look at the framework that is the overarching reason for all war planning.

3.3.2.2 Joint War Planning

We will have a plan for any military action that we will undertake [4]. The Joint Staff is constantly creating and updating these plans using the Joint Operations and Execution System (JOPES). In a perfect world, a developing situation will be one that we have already anticipated and executed deliberate planning; if not crisis action planning will be required. In either case, our plan of attack for the air and space campaign will be produced by a subset of JOPES, the Joint Air Estimate Process (JAEP). The JAEP process is iterative throughout the campaign. It begins before the start of hostilities and is repeated in an endless loop until cessation of active conflict. This JAEP continually updates a product known as the Joint Air Operations Plan (JAOP); this is the JFACC's plan for coordinating and integrating joint air activities. The JAOP is a living document that is modified by the Strategy Plans Team (SPT) of the JAOC on a regular basis and maintained to preserve clarity of purpose and unity of effort. Each daily update of this JAOP produces a document known as the Air Operations Directive (see Fig. 6). This is where our narrative begins.

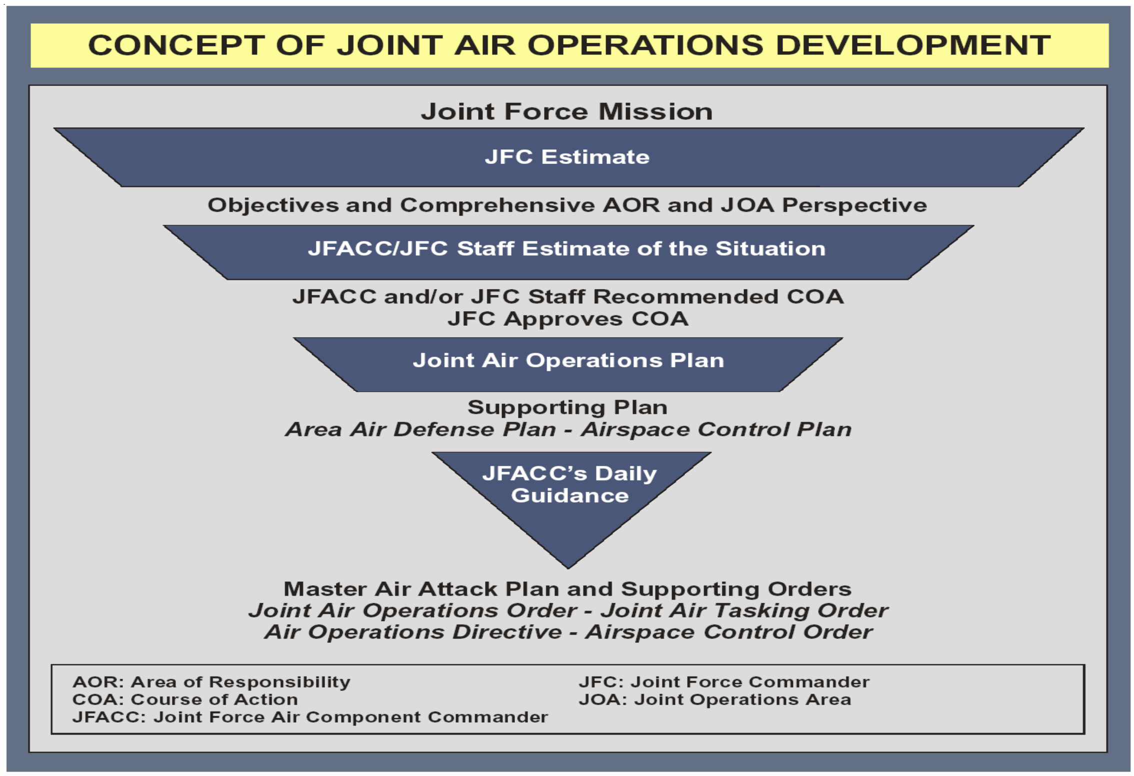


Fig 6: Concept of Joint Air Operations Development [4]

3.3.2.2 The Air Operations Directive (AOD)

As Fig. 7 represents the JAEP is a continuous iterative process. It is executed by the Strategy Plans Team (SPT). This group must have three things in order to function: daily contact with the JFACC, Intelligence Preparation of the Battlespace (IPB), and Operational Assessment (OA) of the past and present conduct of the air war. The SPT produces the JAOP which in effect acts as a method of both communication and continuity with the JFACC. As soon as the JAOP is updated (D-68 hours), the SPT coordinates with the Strategy Guidance Team (SGT) to relay operational guidance from the JFACC. Also at this point the Targeting Effects Team (TET) chief provides a clear picture of the JFACC's targeting scheme for the

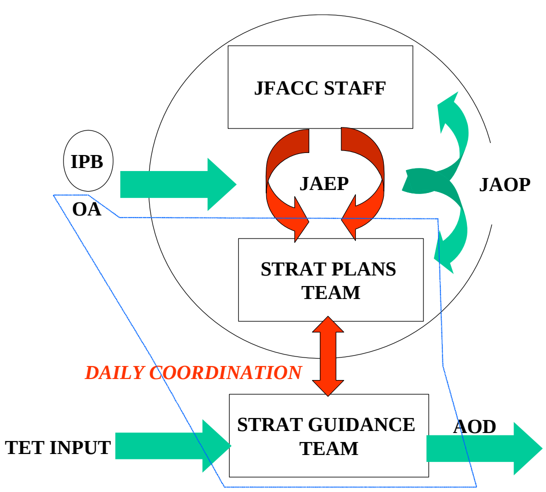


Fig 7: Development of the AOD [9]

day in question. The SGT then produces the Air Operations Directive (D-66 hours). The AOD is the JFACC's guidance for prosecution of the air campaign three days hence and is a precursor to all follow-on activities in the ATO process. *The potential lateral constraint that we find in AOD development is the timely coordination between SPT and SGT.* Publishing of the AOD provides the required guidance for the next phase of the ATO process, which is target list development. Regardless of any chaos that exists in the AOC during the D-68 to D-66 hour span, production of the AOD must be the top priority of the SPT and SGT. If the AOD is late it will be virtually impossible to regain this lost time, and the potential exists for an accordion effect that will result in delivery of an ATO that is hours late [5,9]. This is an example of the covariant effects that we have previously discussed.

As we continue to move along the lateral process, the timely execution of potentially constraining processes and the on time delivery of their critical products will be a central theme. No matter what else is happening, *these critical tasks are potential constraints and must be completed on time.*

3.3.2.3 The Joint Target List (JTL)

At this point, we must step outside the boundary of the JAOC to look at the JTL. This list is a master targets database that is developed as part of deliberate or crisis action planning [1,9]. It contains all of the targets that are considered valid in support of the JFC's objectives. These targets may be struck by aerospace, land, or naval fires by assets from any of the participating services or coalition members in the case of a combined campaign. As you may imagine, the JTL is updated twice daily at 0600 (48 hours from execution of notional ATO A) and 1800 (60 hours from execution of notional ATO B) [9].

A key point to grasp is that the JTL update is done at the JFC level, not the JFACC level. The JTL update is not part of the AOC ATO process. At least theoretically, planning of the air war inside the AOC boundaries can continue…even if the JTL updates do not happen.

3.3.2.4 The Target Nomination List (TNL)

Using the AOD and guidance from the TET, the Target Development Cell (TDC) of the ISR Division (ISRD) develops a Target Nomination List for the air and space component (from D-66 to D-53 hours). Each component air wing is also developing its own component TNL during this phase. At the D-53 hour point, all component TNLs are due to the TDC. Each target on all of these lists must be traceable to a prioritized AOD task. *On time delivery of these component TNLs to the TDC is a potential lateral constraint.*

From D-53 to D-50 hours the TNLs are reviewed by the TDC and the TET for coherency. From D-50 to D-48 hours, component TNLs are merged and then prioritized. The resulting product is the draft JIPTL [9].

3.3.2.4 The Joint Integrated Prioritized Target List (JIPTL)

On time delivery of the draft JIPTL to the TET chief is a potential constraint. By D-47 hours the TET and TDC chiefs have reviewed the draft JIPTL. What follows is a series of three largely redundant meetings (see recommendations).

First is the JAG / Coalition Review of the draft JIPTL for targeting Law of Armed Conflict (LOAC) and multinational issues. Next is the TET Action Officer Meeting, during which component representatives (speaking for component commanders) go over the draft JIPTL to ensure that it achieves objectives and priorities and to address any component issues. Finally, at the Senior Level TET Meeting the draft JIPTL is presented to the Chief of Combat Plans (CCP). Senior component/coalition planners and SD representatives also attend. This is the last scrub of the draft JIPTL to ensure it meets AOD guidance. At this point the CCP approves the draft JIPTL that will be forwarded to the JFACC. This meeting should be completed by D-43 hours.

The JFACC Strategy Update Briefing should occur between D-40 and D-39 hours until execution. At this meeting, the TET Chief presents the draft JIPTL to either the JFACC or the Joint Targeting Coordination Board (JTCB) for approval. After approval, the JIPTL goes firm and is released for further planning. The final JIPTL also goes to the ISR Operations Team to provide updates to the Component Prioritized Collection List (CPCL). *On time approval of the JIPTL is a potential constraint [9].*

3.3.2.5 The Master Air Attack Plan (MAAP)

The MAAP team will synthesize JFACC guidance, desired effects, available resources, friendly and enemy capabilities, and any supported component's scheme of maneuver into the final MAAP. Its process requires the AOD and the final JIPTL. Several meetings will need to occur between delivery of the JIPTL to the MAAP team and the final MAAP decision brief that ends at D-24 hours. We will only briefly discuss these meetings since none are potential constraints, only intermediate steps along the path to the MAAP decision brief.

The first significant MAAP team event is the Pre-MAAP meeting, held at the D-36 hour point. This meeting serves to bring all team members up to speed on current IPB, weather, component/coalition issues, the AOD, and the JIPTL. Next is the MAAP Cell Lead meeting at which the team chief provides macro guidance to the individual cell leads. Individual cells then branch off to perform assigned tasks. A Midcourse Update meeting occurs at approximately D-30 hours.

The last event involved in the MAAP process is the Decision Brief, ending at the D-24 hour point. During this meeting the MAAP Team Chief presents the final Master Air Attack Plan to the JFACC for approval. The finalized MAAP is entered into TBMCS - once this is complete, the electronic entity is the Air Battle Plan (ABP). The ABP is, in effect, the heart and soul of this process' ATO. *Timely approval of the completed MAAP at the MAAP Decision Brief is a potential lateral constraint [9].*

3.3.2.6 Final ATO Production

The ATO Production Team works throughout the ATO cycle to build the shell that will become the final order. Between D-48 and D-36 hours airspace information, Special Instructions (SPINS), and Friendly Order of Battle (FrOB) is imported. Once the ABP is loaded into TBMCS by the MAAP team, all of the respective pieces are in place and the ATO is ready to complete. From D-24 to D-12 hours MAAP Team B produces mission worksheets. Between D-18 and D-16 hours airlift missions are imported and component ABP's are merged and validated. At the D-14 hour point the ATO is subjected to a final check, and then is pushed at D-12 hours. *This final release of the ATO is also the final potential constraint in one lateral iteration of the ATO cycle [9].*

3.4 VERTICAL INTERACTION: OVERLAY OF CONCURRENT ATO CYCLES

3.4.1 Specific Methodology

The previous discussion focused on constraints within a single ATO cycle. The focus of this section is the interaction of multiple overlapped ATOs and how the demands on manpower effect these previously identified constraints.

Maj Lambertson created an MS Project model of the ATO development cycle during his first quarter of conducting this research (SENG 699). Our first step was to verify and update this model by checking the order of the tasks and the task durations. Our initial analysis was of a single ATO cycle derived from the AFOTTP 2-3.2 [9] and supplemented with information from SMEs at the schoolhouse, 7AF KAOC, and the CENTCOM CAOC at Al Udeid [11,12]. Once the updates to task breakdowns and task durations were complete, we added manpower resources to the MS Project model. In order to add manpower resources, as stated in our assumptions, we used 600 sortie per day effort as a model. Again we relied on the AFOTTP for recommended manpower and schoolhouse SMEs for data which was not available from the AFOTTP. Even though we scaled this analysis to the 600-sortie case, it is quite easy to change manpower units (number of personnel assigned to each task) within MS Project and observe the changes to man-hours required to complete tasks. This tool could be modified for analysis of other sized conflicts by linear scaling of the required manpower.

Some explanation of how MS Project performs calculations is required in order to understand how this model was set up to analyze resources. MS Project has three fields which scope the work done on a project; duration, units and work. In our case we used hours for the task duration field, percentages for the units field (100% equals one person assigned to the task, 200% equals 2 people, etc.), and man-hours for the work field. If you enter data for any two of these fields, MS Project then calculates the third value. This data is displayed in the "resource usage" view. This is a very useful feature for most projects because it allows you to observe resource conflicts/constraints which can then be managed by assigning additional personnel, changing task durations, or moving the tasks forward or backwards in time to de-conflict them. MS Project can do this automatically depending on how defaults are set up. Many additional parameters must be set in MS Project in order to accomplish these calculations. For example, the scheduled work hours for the project must be set (in our case a 24 hour day, 7-days per week), and the work hours for each resource must be set (in our case all resources were made available 24-7). In the ATO development case we are very time constrained; meaning the demands of the war dictate that the ATO process must meet the given milestones. Tasks that are short of manpower cannot be lengthened or easily moved to another time. This caused us to "fix" the duration of the tasks, assign the manning derived from the AFOTTP and schoolhouse data, and then allow MS Project to calculate the man-hours expended on each task. This is the main reason that we did not find analogous value in operating expense or throughput, but chose inventory as the metric to evaluate. To create the model, we first created a single ATO cycle and added the resources. We then overlaid multiple cycles at the 24-hour overlap points to create a giant project file. We initially did this for three ATO cycles and plotted total man-hours versus time. On analysis of this data, a clear repeatable pattern did not emerge, as would be expected. This clued us into mistakes on our setup and we then realized that we in fact have five ATO cycles interacting at all times, not three (see fig 8).

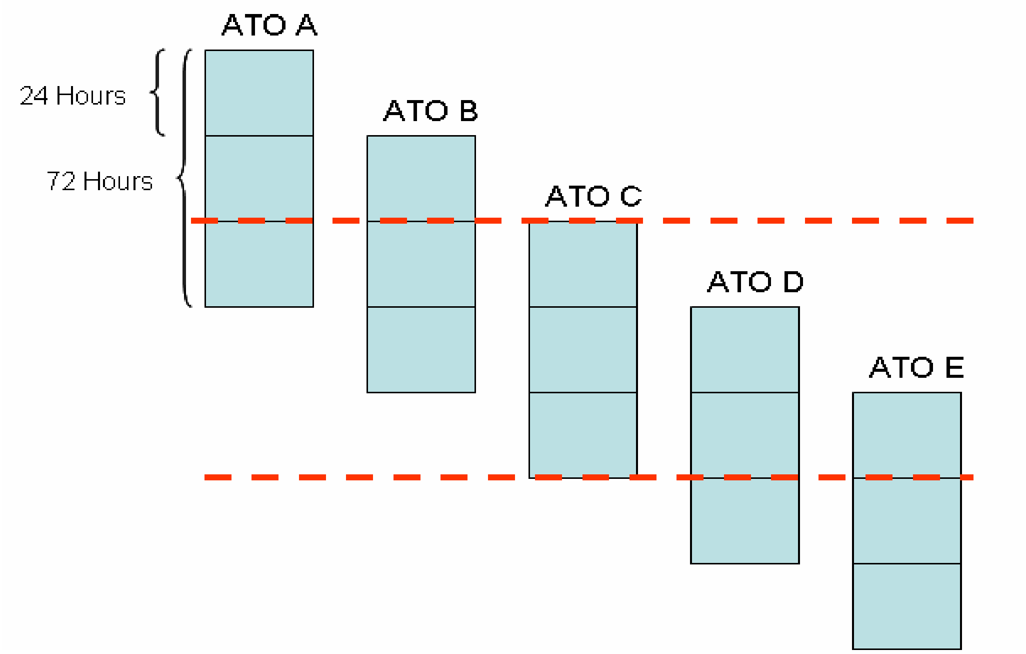


Fig. 8: ATO Overlap

ATO cycle C is affected by cycles A and B during its first 24 hours, by B and D during it's middle 24 hours, and by D and E during the last 24 hours. Being relatively new to MS Project and the complexities of parameter set up, we were having difficulties getting it to behave properly. Ideally it should be able to add the manpower numbers from the multiple cycles by using the "resource usage" view; however, when we attempted this the numbers were blowing up, adding splits to tasks, and otherwise behaving badly. Since we were using an Excel spreadsheet to create our graphs, it just became easier to create multiple sheets (exactly like shown in fig 7) and compile the man-hour data in Excel. Five tables in Excel represent each ATO cycle (A through E) with the columns representing each team and number of man-hours they spent during the 72-hour period. A sixth table was then created which compiled the man-hours spent by each team during ATO cycle C considering overlap from each of the other cycles. Once the spreadsheet was created, we then graphed total man-hours for a single ATO cycle (not affected by other cycles) and for the multiple cycle case. Fig 9 shows the man-hours compiled for the single non-overlapped ATO. You can see that there is no repeated pattern.

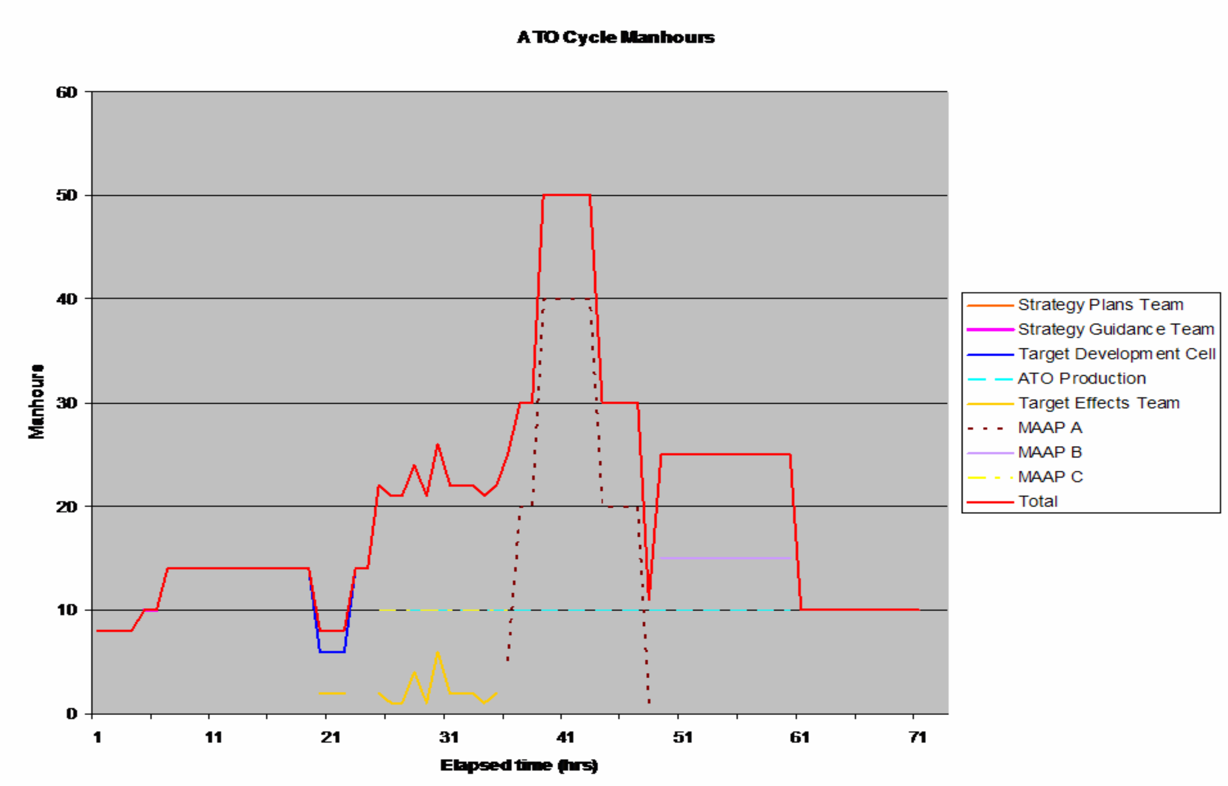


Fig. 9: Single ATO Total Man-hours Expended

However; when all of the ATOs are overlaid a 24-hour pattern, which is a result of the 24 hour stagger between starts, became apparent (fig. 10) and you can readily see the interaction and impact on total man-hours expended.

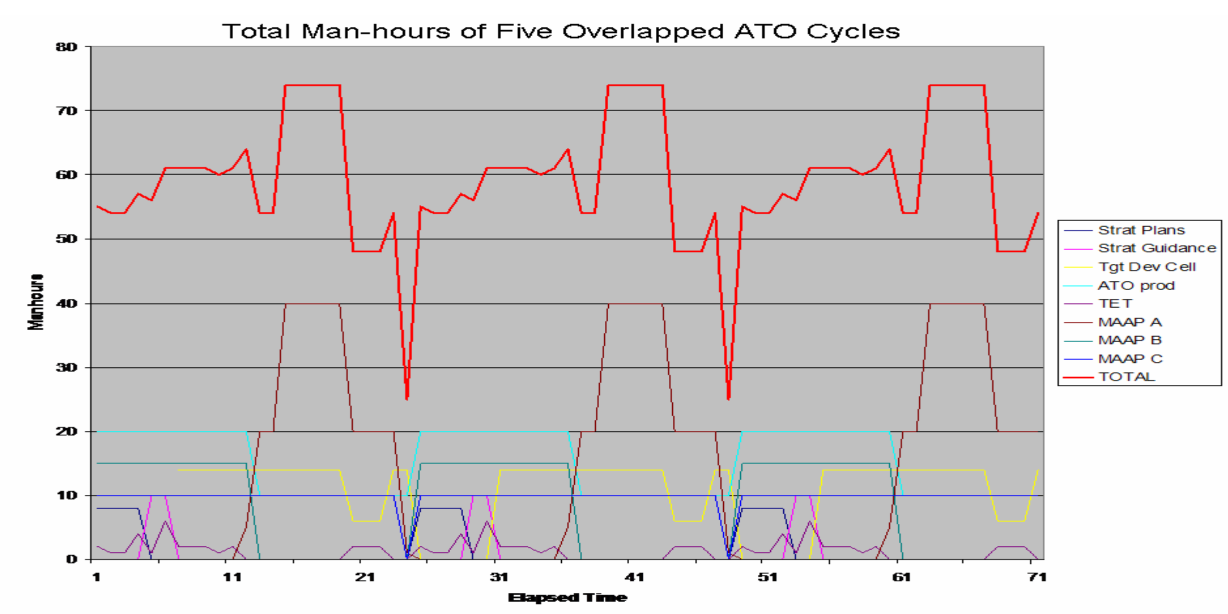


Fig. 10: Total man-hours expended for Five Overlapped ATO Cycles.

3.4.2 Results

It is important to remember from our earlier discussion of the AFOTTP that all of the task durations given are notional, thus the man-hours depicted are notional at best. This is where we run into difficulties applying TOC, a theory for manufacturing which tends to have much more normally distributed durations for tasks, to an information-dependent process. In other words, information systems have a much higher task variance than a true shop floor tasks with the same name often are wildly variable in levels of difficulty or complexity. Since the tasks depicted in our graphs are extremely variable there could in fact be much more overlap than shown, and these graphs should be considered to show order of magnitude effects only. Covariant effects are present, but due to this task variance they are much easier to qualify that to quantify precisely.

Several observations were made from examining the plotted man-hour charts. First we noted from fig. 11 that interaction between the multiple ATO cycles caused the man-hours required for both the ATO Production Team and the MAAP A team to be double that of the allotted manning.

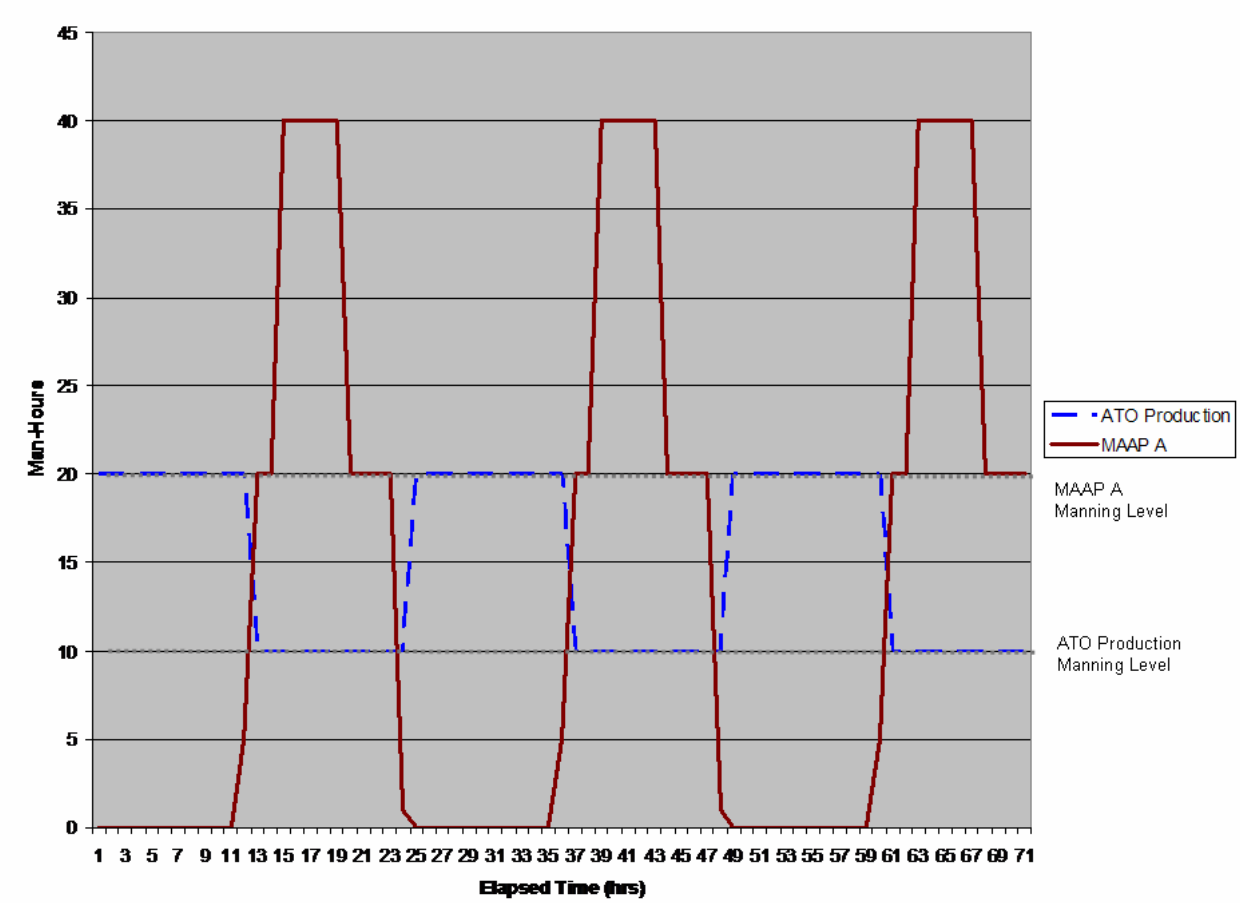


Fig. 11: Team manning overages with five overlapped ATO cycles.

For the ATO Production Team the spikes are caused by overlap of the tasks "ATO Production Imports TNLs, Airspace, FrOB, SPINS" and "ATO Production Inspects MAAP, Receives and Final Worksheets" from the overlapped ATO cycles. For the MAAP A team the spikes are caused by the overlap within a single cycle by the tasks "MAAP Cell Mtgs" and "Mid Course Update Prep" (at D-30 to D-34 hours). Obviously these overlaps would cause you to subdivide your personnel or worst case to multi-task them, but it does indicate periods of excessive demand.

The value of the tool is the visibility provided into interaction between the multiple cycles. Next we transferred the constrained critical tasks identified during the horizontal analysis and discussion with schoolhouse SMEs to fig. 12, which shows man-hour requirements from the overlapped ATO cycles. This readily showed work peaks at or prior to each of the six identified critical tasks (Publish AOD update, TNL development, Merge TNLs, JFACC strategy update meeting, Decision brief and MAAP B shows, and Publish ATO). This confirmed the SME feedback about bottlenecking at certain tasks.

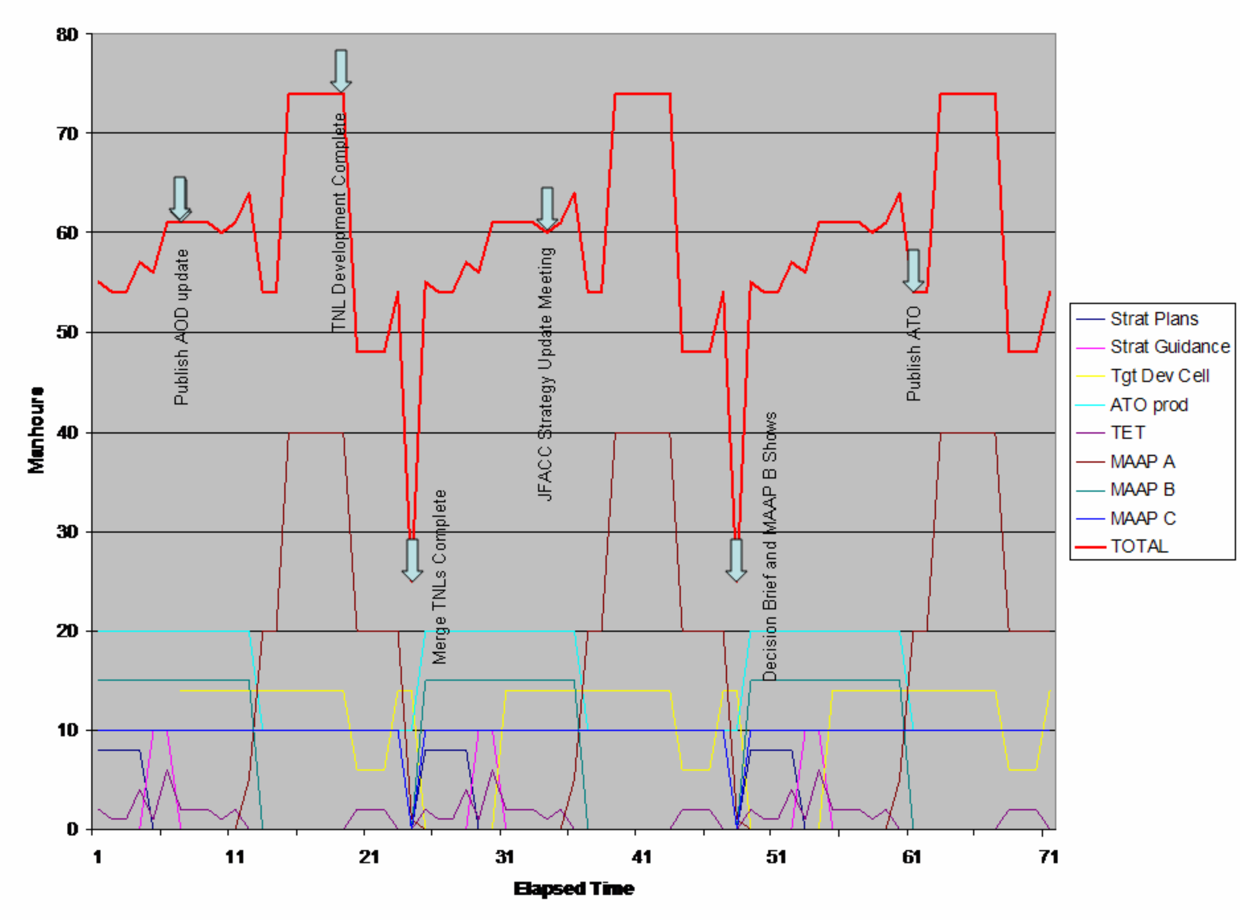


Fig. 12: Milestone tasks on Multiple ATO Cycle man-hour chart

4.0 FINDINGS AND RECOMMENDATIONS

4.1 Critical Events

- No matter what happens in the JAOC, the critical events in each lateral cycle (listed below for clarity) must occur on time.

Critical Events in Lateral Process

-Publish AOD
-Develop TNL
-Merge TNLs
-JFACC Strategy Update (Publish JPITL)
-MAAP Decision Brief (Publish MAAP)
-Publish ATO

Fig. 13: Critical Events

If this does not happen, each delay will ripple downstream as covariant effects take hold. Despite the complexity, development of a single ATO is a sequential and linear process. There is, however, interaction between ATO cycles in the form of IPB and Operational Assessment, as well as manpower requirements. Manpower crises can elevate any critical event to the level of a constraint. Once this fact is recognized it is apparent that the critical events must be carefully monitored and kept to a very strict timeline. The MAAP Decision Brief, for example, simply must be completed by 24 hours. If it is allowed to happen late, then this slip will only propagate through the sequential process and quite likely result in late delivery of the ATO to warfighters.

- Not only are manpower requirements critical interlinks between cycles, they are also extremely variable. Figure 12 clearly shows the significant fluctuations that take place as a result of concurrent ATO development cycles. This variability must be recognized, and when able mitigated by proper allocation of manpower and tasks.

- Further breakout of each division and their teams as well as recommended baseline manning is required to improve and validate the model developed here. As the resources and activities that each team accomplishes are mapped out on the timeline, more accurate and specific constraint identification will be enabled. This paper may also serve as a proposal for further, more in depth study into this subject.

- As our research progressed we discovered that the 705th and 505th TRS, and indeed most of the worldwide AOCs are critically undermanned and underfunded.

- AFOTTP 2-3.2 (approval draft) is very inconsistent and incomplete, as shown below. These figures show a nice, convenient flow of information and products between each process, starting with figure 14. Figure 15 takes this gross inaccuracy further, indicating that each process fits perfectly in its place horizontally and vertically. At the depicted level of abstraction, the figure is accurate. But when you drill down into what actually is occurring, this figure loses much credibility.

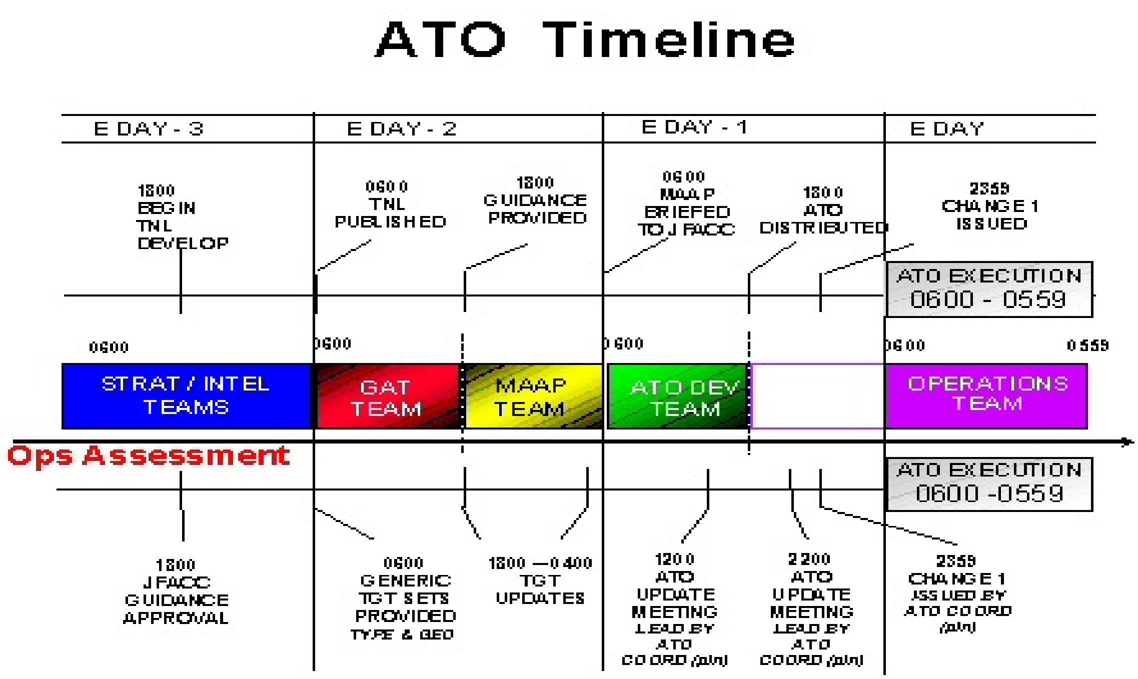


Fig. 14: Notional ATO timeline from AFOTTP 2-3.2

Repeated analysis of these processes made it painfully obvious that there was no fully vetted ATO Process Timeline so that's where this project had to concentrate before any constraint analysis could take place.

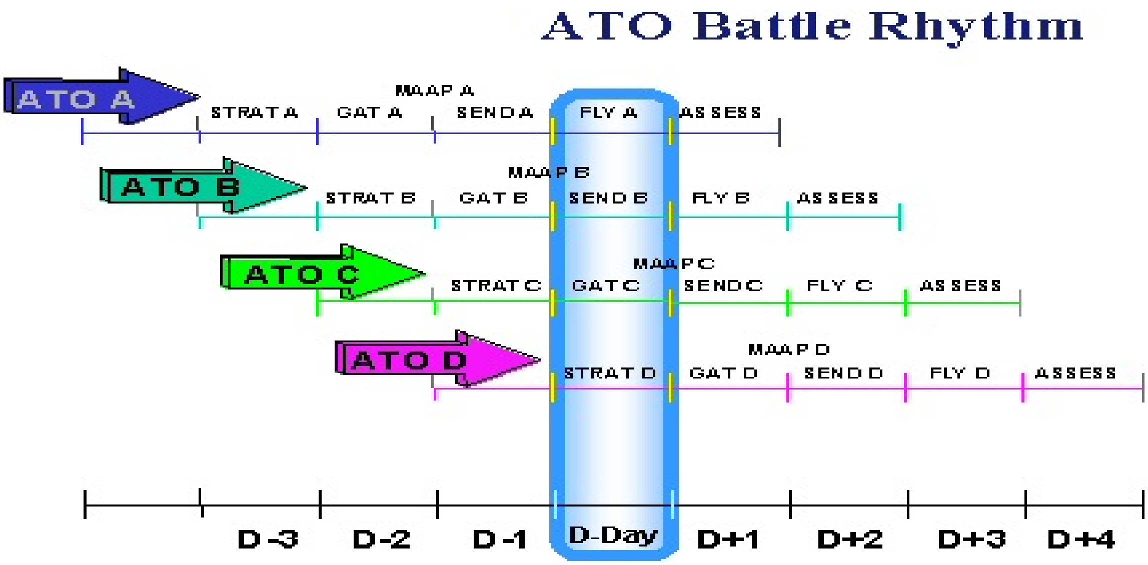


Fig. 15: Notional battle rhythm from AFOTTP 2-3.2

- It is a fact that each AOC must be a bit different. Operational factors will dictate that a given AOC will evolve to handle the specifics of a given Area of Responsibility. Having said this, extant literature does not adequately baseline the ATO process. Different divisions in AFOTTP 2-3.2 are covered in varying degrees of depth. The discussion of TET functions, for instance, is detailed and very specific, while the ATO production process is nebulous and lacking detail. The AFOTTP needs to be rewritten by a much smaller cadre of professionals than the current list of contributors to incorporate changes as the Falconer weapons system comes on-line. We recommend that the SME's at the C2TIG should be the first stop in this effort [19]. Also as part of this effort the C2 community must agree on a single set of terminology. The model developed by this project should be included in the next edition of AFOTTP 2-3.2.

- The process of target list development and prosecution is cumbersome and needlessly repetitive. Development of a finalized JIPTL currently involves eight steps:
    1) Update JTL
    2) Develop Component TNLs
    3) Merge and Prioritize these TNLs to produce a draft JIPTL
    4) TET Chief Review of the draft JIPTL

5) JAG Review of the draft JIPTL

6) TET Action Officer Review of the draft JIPTL

7) Brief draft JIPTL to the Chief of Combat Plans

8) Brief the draft JIPTL to the JFACC for approval

There certainly appears to be room to improve this process. This general area of ATO development is a very target rich environment for business process reengineering. Specifically, we recommend that:

- The JTL become the master list for all targeting. All target planning and weaponeering should be done at the JFC level, and target assignment should then be passed down to the individual components, facilitating both more efficient processes and more "jointness". This means that some ISRD and TET personnel will need to move to the JFC level to conduct target planning at this higher level.
- There should be one mid level meeting at the AOC to allow JAG, TET and Combat Plans review of the portion of the JTL to be serviced by a given ATO. Once this is complete then that portion of the JTL will be forwarded to the JFACC for approval, and then released to the MAAP Cell.

- An excellent task for a future SENG 798 project could be to make the multiple-ATO MS Project file user friendly so it could be used for sensitivity analysis. The first benefit of the tool is that it allows you to identify which tasks across the multiple cycles are interfering with each other from a manpower perspective. Secondly the process could be streamlined through careful analysis of the overlapped tasks at critical points. It may be possible to "un-fix" some task durations in MS Project to allow them to proceed longer, or move them to an earlier time to relieve work overload. By scaling the model based on the sortie estimate, the tool could be used to scale the manning for an AOC for future conflicts. And finally, it could be used to identify work intensive critical tasks to target for future automation as part of the Falconer weapons system.

4.2 MITRE Specific Recommendations

This study has taken written guidance from the AFOTTP and developed a one-stop Timeline capturing the ATO processes for a 600 sortie per day war. As part of the literature review we researched MITRE Architecture and uncovered some interesting problems. First, we must discuss the elements that are involved. These elements are:

- Previous AOC Colored Petri Net (CPN) Team thesis work
- MITRE AOC Architecture
- 505th / 705th TRS / MITRE 51 AOC processes
- This thesis project

The previous AOC analysis team developed a CPN for the AOC utilizing MITRE Architecture and the 51 AOC processes that MITRE in conjunction with the 505th and 705th TRS' identified. Once the CPN shell was complete they were forced to "make up" arbitrary durations for each of these processes. The assumption was that all 51 processes, when added, would sum to 72 hours and that all 51 processes applied to any ATO cycle. This assumption determined individual process durations according to perceived difficulty. These durations were required to allow CPN simulation.

Our research uncovered significant room for improvement. Our first recommendation is to trace the MITRE Architecture to the 51 processes (which are used in the CPN) and then in turn trace said processes to the actual timeline that we defined by reference to the AFOTTP. These processes do not match one for one but the functionality should still be traceable.

Once the 51 processes are matched to the timeline, the actual durations can be substituted for the "guessed" durations used to simulate the CPN AOC model. These factual durations will create a CPN based on AFOTTP durations, something that could not be previously accomplished.

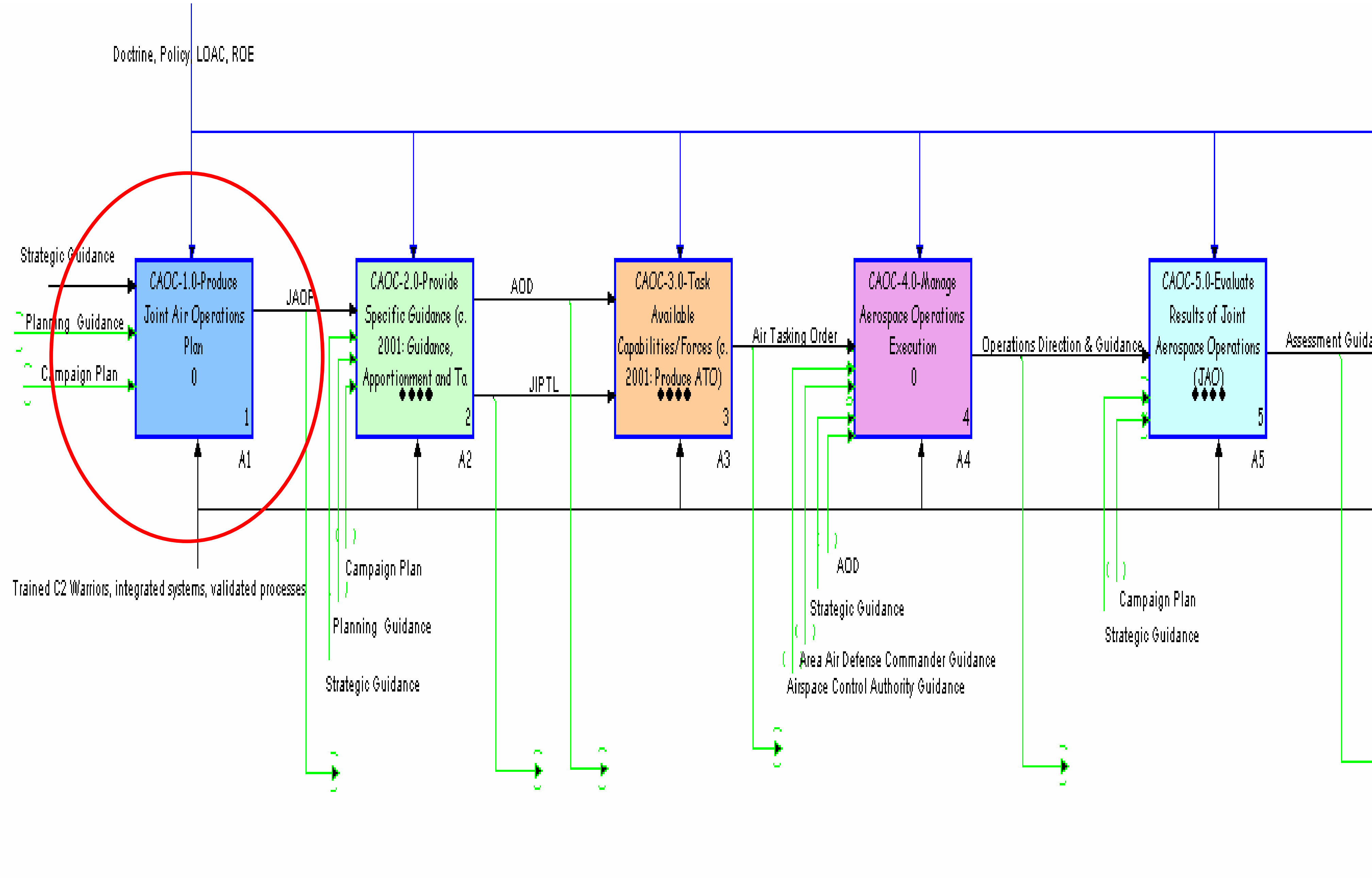
Our second recommendation addresses the MITRE Architecture itself. We will show that the 51 processes – the bridge between 505th / 705th TRS', MITRE and the AFOTTP – are in the MITRE Architecture (nearly verbatim), but not at the same level of decomposition throughout. Further work will also need to occur in order to address what ATO processes are parts of the 51 and which are not.

Once these updates are made (entailing a considerable amount of work) the USAF will have:

- A more accurate AOC Architecture

- An actionable CPN AOC model easily used for simulation and further study
- An error-checked process coalescing good work from numerous areas and basing the results in USAF regulation.

Figure 16 below shows the A0 level of MITRE AOC Architecture. From this level we must drill down through the architecture decompositions in order to locate the 51 processes. As you can see, we traced one process, "Develop C/JFACC air and space estimate of situation", through the architecture to where it resides. The steps went from A0 down two levels (A1.3.8) to find the *process* as an architecture *activity*. Figure 18 shows this meeting place. Notice that only activity A1.3.8 is a matched process. None of the other processes from Figure 19 match to the A1.3 level of decomposition activities. As stated previously, a follow-on group should match the 51 processes to their MITRE Architectural activity brethren. Once done, the 51 processes that relate to ATO development can be accurately matched to the AFOTTP from our Timeline. Then, our AFOTTP Timeline durations can be substituted into the CPN Team's model. Since they broke the 51 AOC processes down to a 72-hour timeframe, the improvements over their model are obvious. With the accurately referenced Timeline the real 72 hour process can be determined. More research must be accomplished to discover where the other processes fit by matching the remaining architecture activities to their TTP sources.



Doctrine, Policy, LOAC, ROE
Strategic Guidance
Planning Guidance
Campaign Plan
CAOC-1.0-Produce Joint Air Operations Plan
0
1
A1
JAOP
CAOC-2.0-Provide Specific Guidance (c. 2001: Guidance, Apportionment and Ta
2
A2
AOD
JIPTL
CAOC-3.0-Task Available Capabilities/Forces (c. 2001: Produce ATO)
3
A3
Air Tasking Order
CAOC-4.0-Manage Aerospace Operations Execution
0
4
A4
Operations Direction & Guidance
CAOC-5.0-Evaluate Results of Joint Aerospace Operations (JAO)
5
A5
Assessment Guida
Trained C2 Warriors, integrated systems, validated processes
Campaign Plan
Planning Guidance
Strategic Guidance
AOD
Strategic Guidance
Area Air Defense Commander Guidance
Airspace Control Authority Guidance
Campaign Plan
Strategic Guidance

Fig. 16: A0

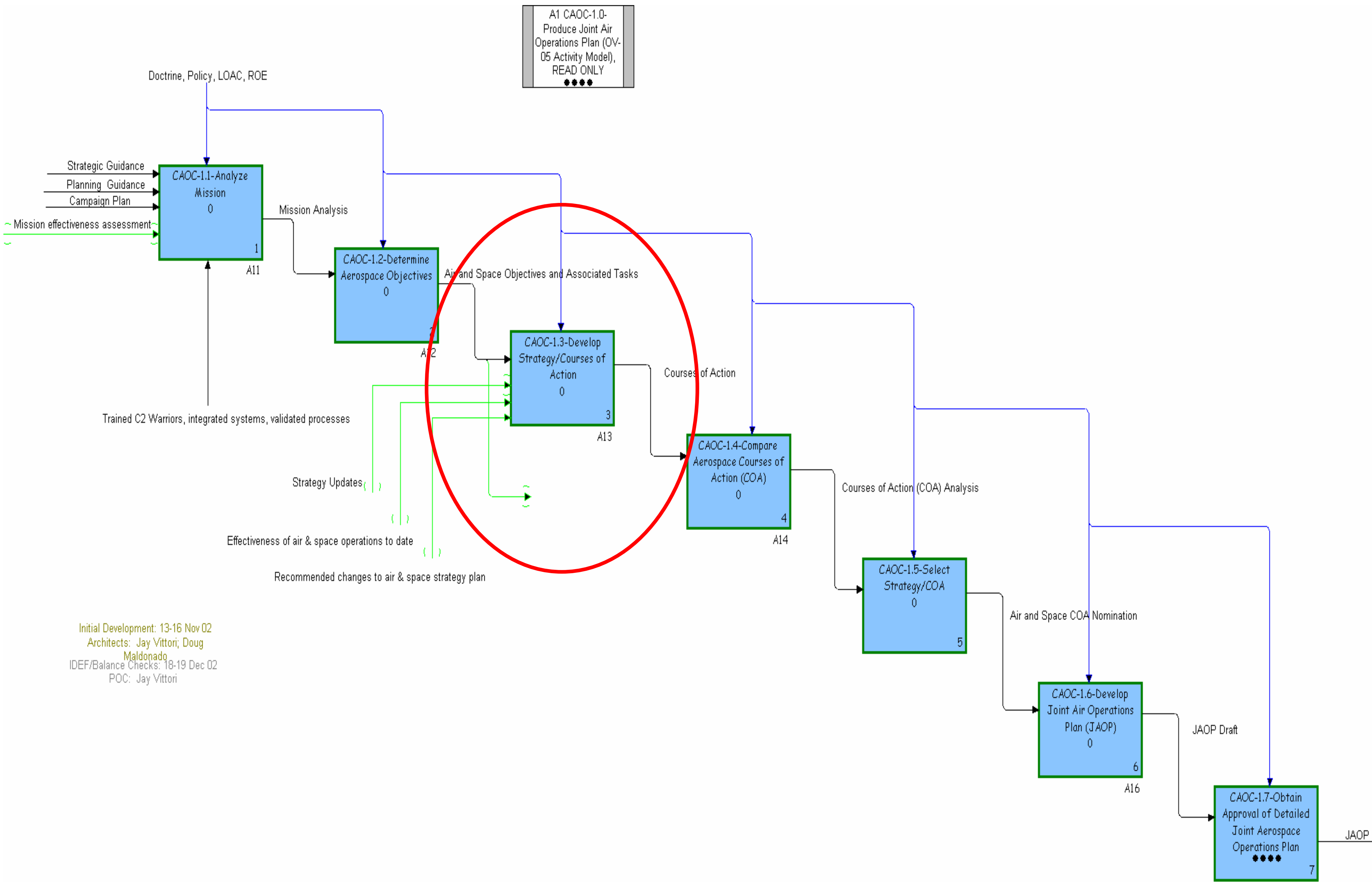


Fig. 17: A1 - Produce JAOP

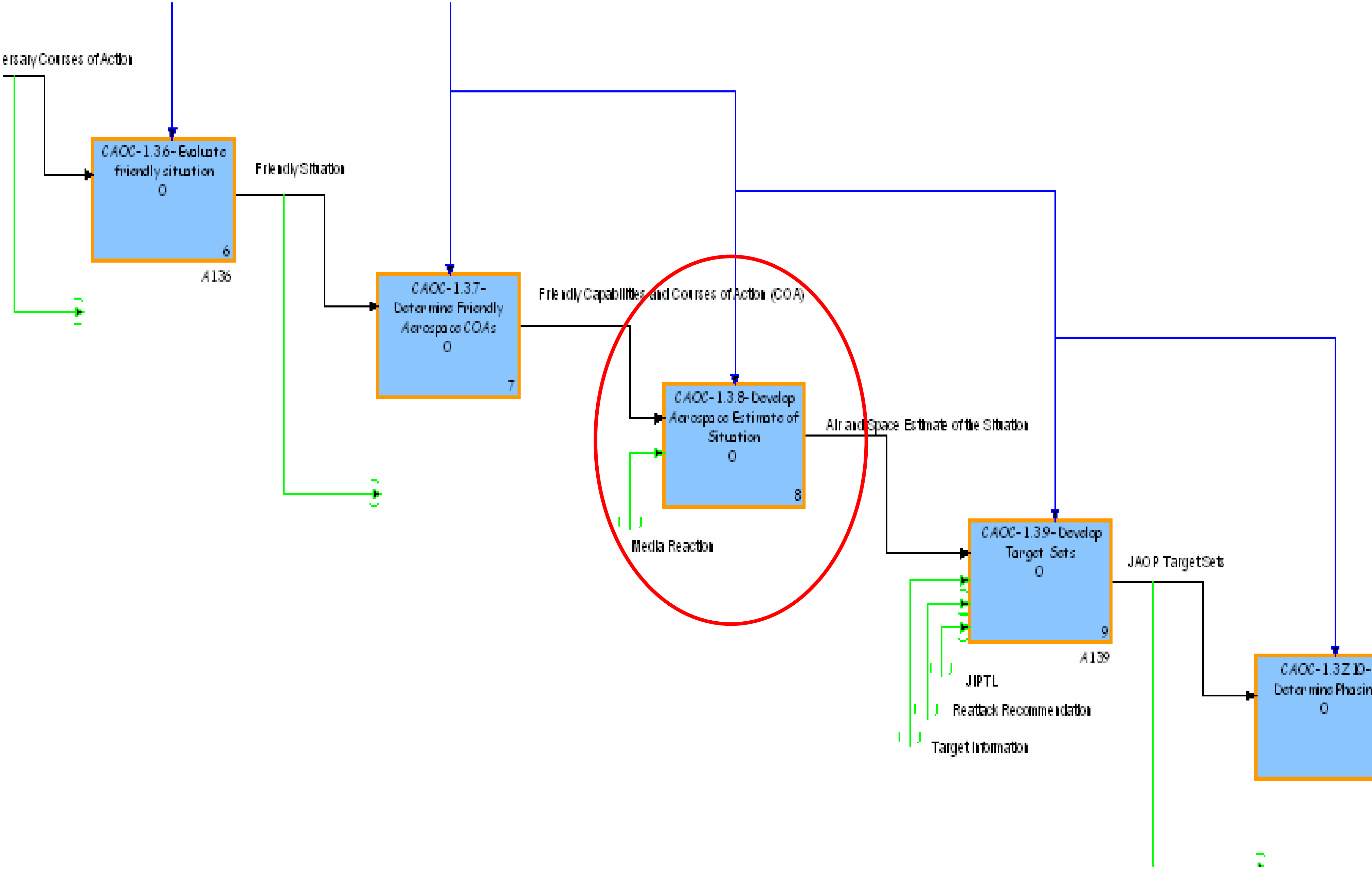


Fig. 18: A1.3 - Develop Strategy/Courses of Action

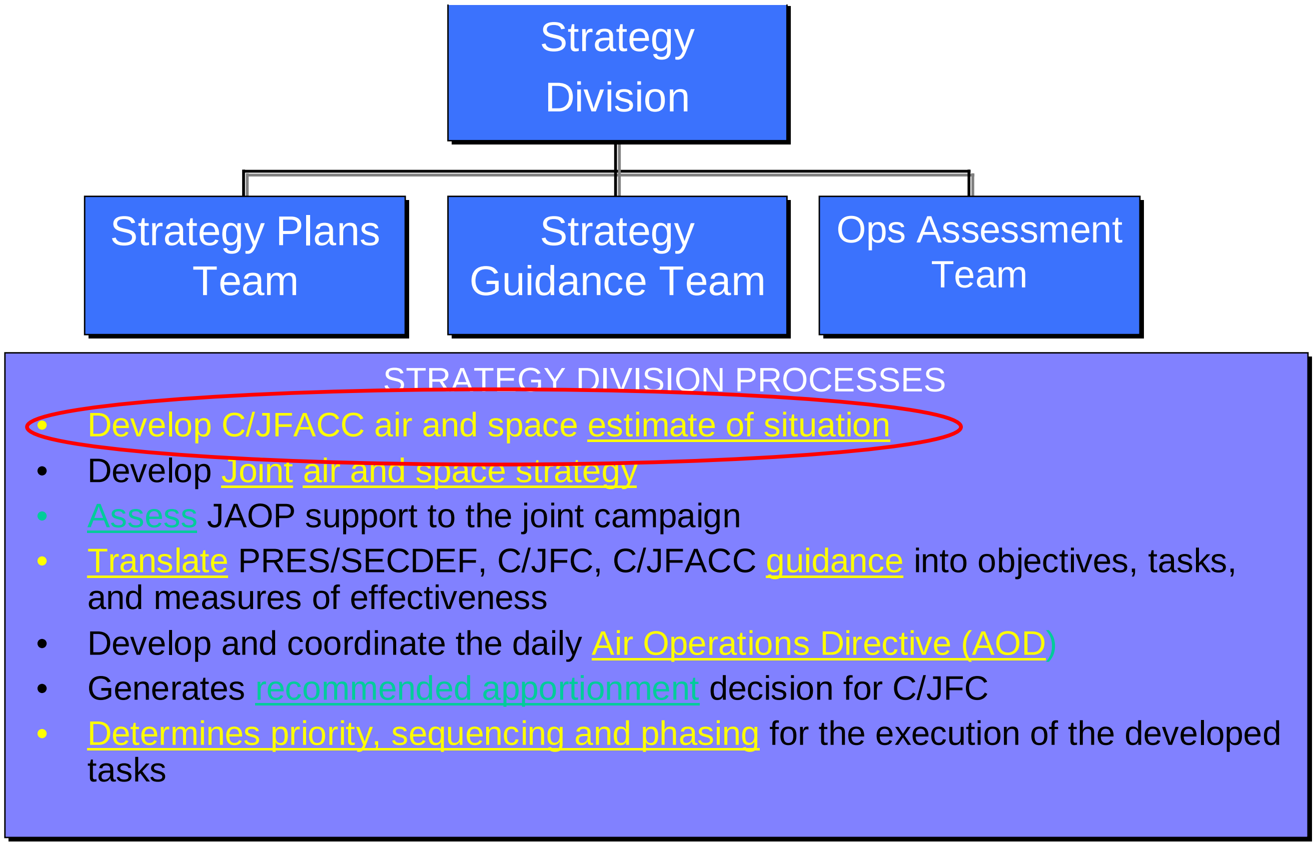


Fig. 19: Strategy Division Processes

5.0 SUMMARY

This project examined the ATO development process that is an integral part of the AOC. For the first time, this vital process was examined using the Theory of Constraints as proposed by physicist Eliyahu Goldratt. At this time there is no unified written guidance on this process, and when we set out there was no single existing chronological model of the 72 hour ATO process.

Our first task was to build such a model. Using best-available publications and personal interviews we constructed and verified such a model that included sub-processes, manning, and duration. This model allowed us to identify critical events that had to happen sequentially and on-time in order to produce an accurate and on-time ATO. We were also able to identify redundancies in both products and processes which will be targets for future study and potential targets for business process reengineering.

Next we used manning and duration information from the first step as inputs to Microsoft Project. Project allowed us to overlay five concurrent ATO cycles and look at man-hour requirements. We found that our required AOC manning fluctuated over very wide bounds throughout an ATO cycle. More importantly, we discovered that peaks in the required man-hour plots coincided with problem areas identified in our lateral analysis of the process and represented potential constraints. If these man-hour spikes were not properly managed they could easily elevate many critical tasks to constraint level and make on time ATO delivery impossible.

From both the lateral and vertical play in ATO development we were able to produce numerous findings and recommendations that included definite areas for further study, targets for both information technology improvement and business process reengineering, and most importantly a baseline understanding of where and why the ATO process can breakdown. We hope that this project will result in many offshoots that will further improve the ATO development cycle, and that it will provide seminal understanding of one of the most crucial command and control activities in today's Air Force.

6.0 REFERENCES

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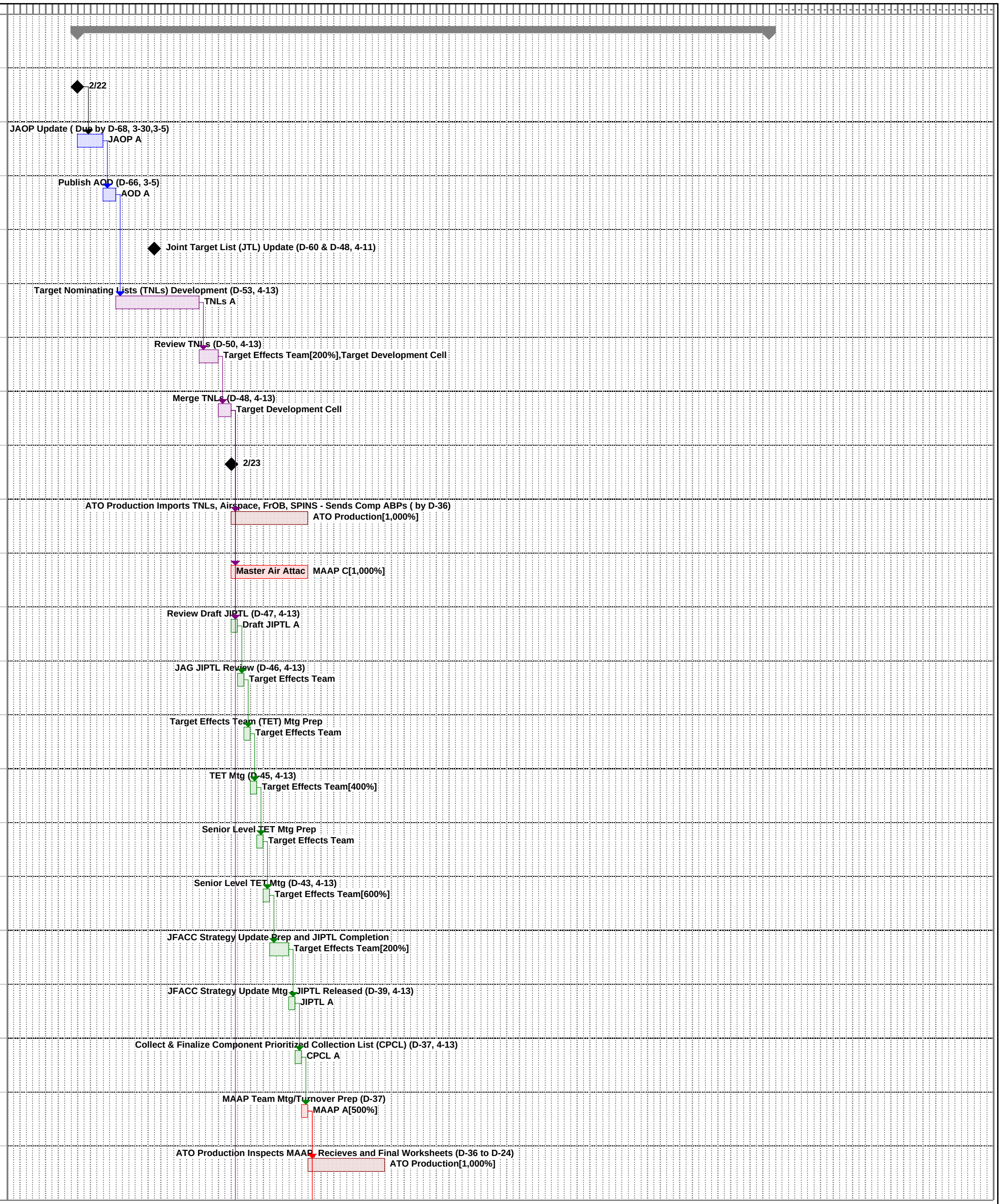
APPENDIX 1: Air Tasking Order Schedule

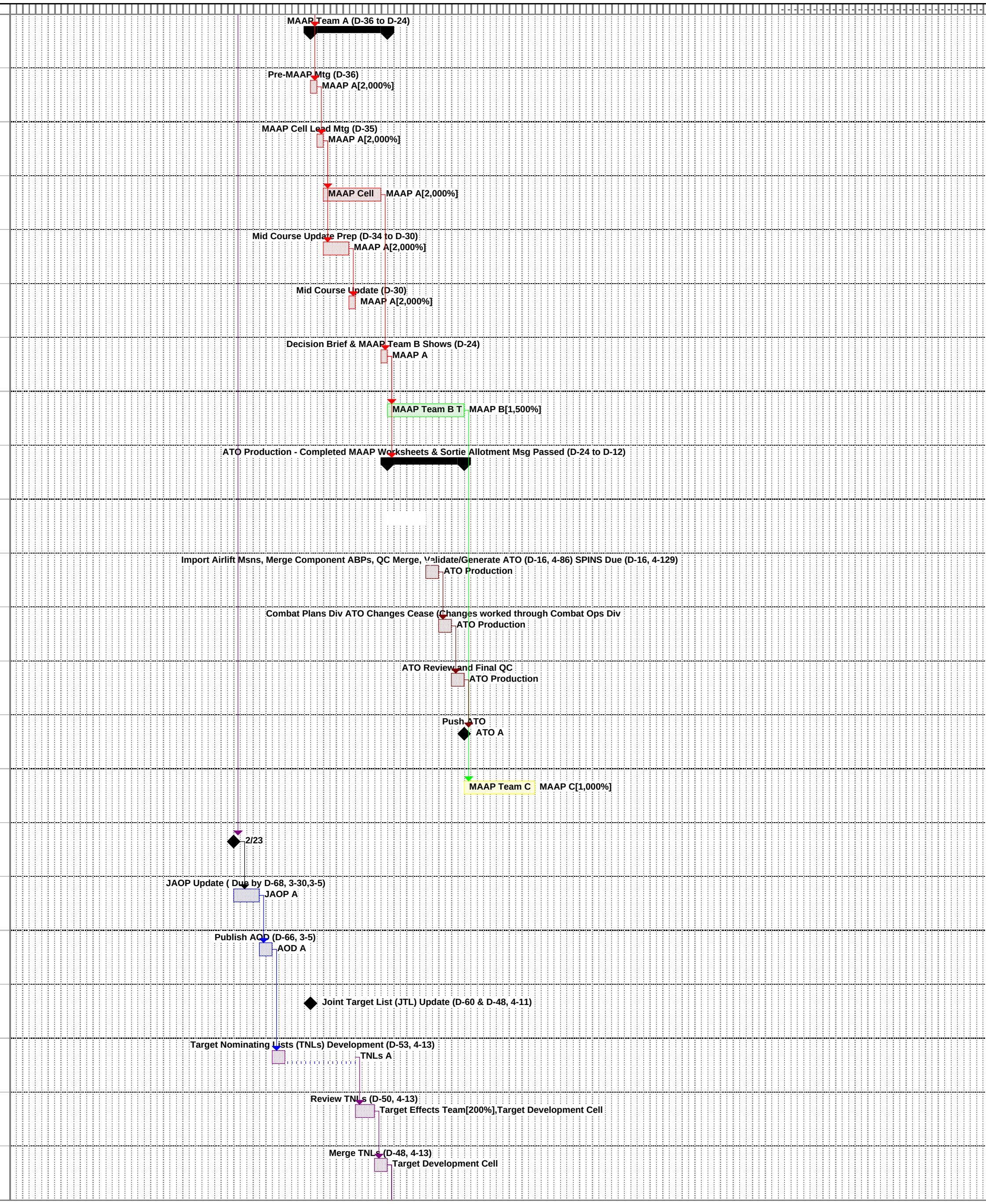
ID		Task Name	Duration	Text1	Predecessors
0		**kevin ato2**	**4.5 days**		
1		ATO A Start (D-72)	0 days		
2		JAOP Update (Due by D-68, 3-30,3-5)	4 hrs	JAOP A	1
3		Publish AOD (D-66, 3-5)	2 hrs	AOD A	2
4		Joint Target List (JTL) Update (D-60 & D-48, 4-11)	0 hrs	JTL A	
5		Target Nominating Lists (TNLs) Development (D-53, 4-13)	13 hrs	TNLs A	3
6		Review TNLs (D-50, 4-13)	3 hrs		5
7		Merge TNLs (D-48, 4-13)	2 hrs		6
8		Joint Target List (JTL) Update	0 days		
9		ATO Production Imports TNLs, Airspace, FrOB, SPINS - Sends Comp ABPs (by D-36)	12 hrs		7
10		Master Air Attack Plan (MAAP) Team Prep (D-48 to D-36)	12 hrs		7
11		Review Draft JIPTL (D-47, 4-13)	1 hr	Draft JIPTL A	7
12		JAG JIPTL Review (D-46, 4-13)	1 hr		11
13		Target Effects Team (TET) Mtg Prep	1 hr		12
14		TET Mtg (D-45, 4-13)	1 hr		13
15		Senior Level TET Mtg Prep	1 hr		14
16		Senior Level TET Mtg (D-43, 4-13)	1 hr		15
17		JFACC Strategy Update Prep and JIPTL Completion	3 hrs		16
18		JFACC Strategy Update Mtg - JIPTL Released (D-39, 4-13)	1 hr	JIPTL A	17
19		Collect & Finalize Component Prioritized Collection List (CPCL) (D-37, 4-13)	1 hr	CPCL A	18
20		MAAP Team Mtg/Turnover Prep (D-37)	1 hr		19
21		ATO Production Inspects MAAP, Recieves and Final Worksheets (D-36 to D-24)	12 hrs		20



Project: kevin ato2
Date: Wed 6/22/05

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

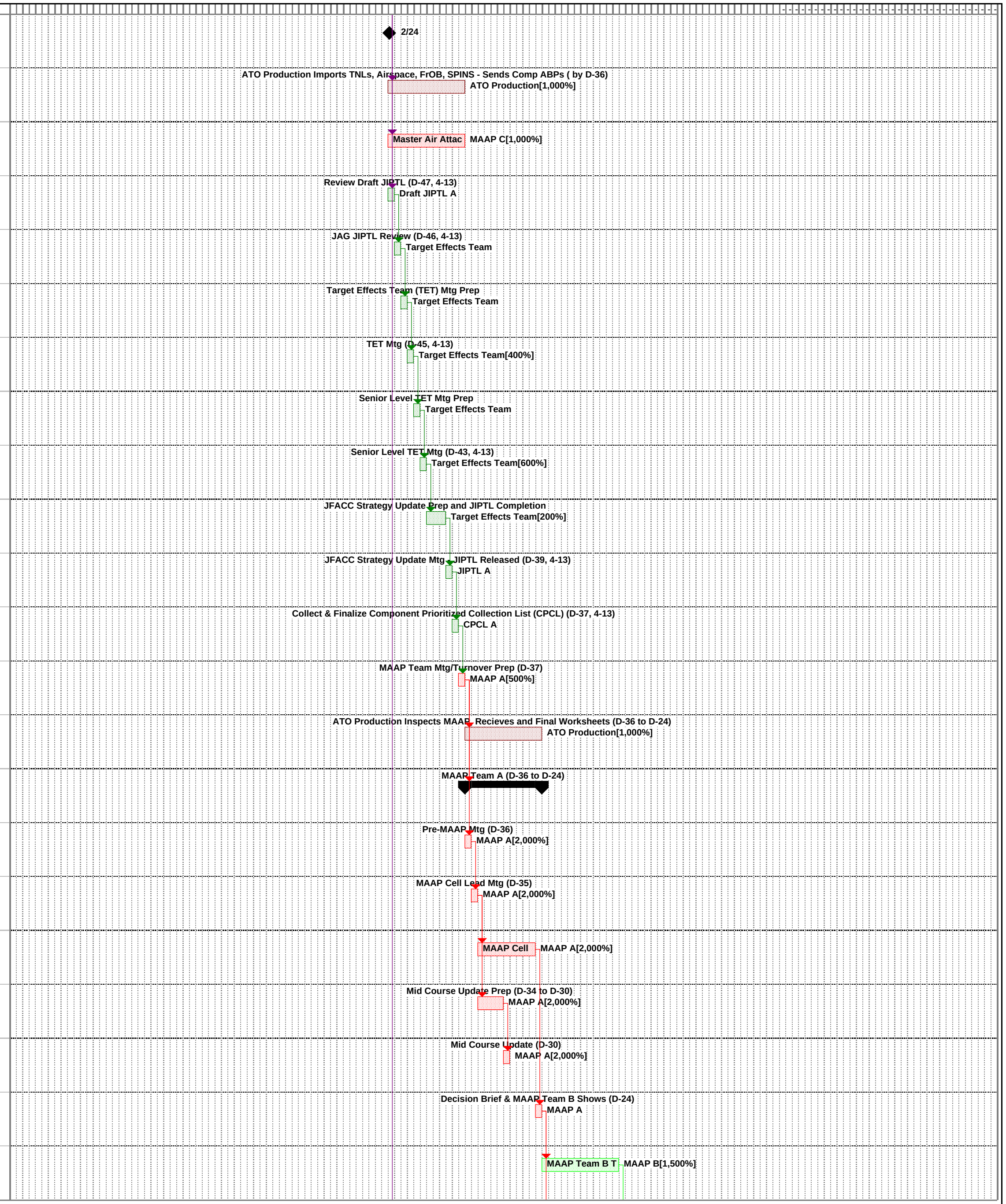
ID		Task Name	Duration	Text1	Predecessors
22		**MAAP Team A (D-36 to D-24)**	**0.5 days**		**20**
23		Pre-MAAP Mtg (D-36)	1 hr		20
24		MAAP Cell Lead Mtg (D-35)	1 hr		23
25		MAAP Cell Mtgs (D-34 to D-24)	9 hrs		24
26		Mid Course Update Prep (D-34 to D-30)	4 hrs		24
27		Mid Course Update (D-30)	1 hr		26
28		Decision Brief & MAAP Team B Shows (D-24)	1 hr		25
29		MAAP Team B Tasks (D-24 to D-12)	12 hrs		28
30		**ATO Production - Completed MAAP Worksheets & Sortie Allotment Msg Passed (D-24 to D-12)**	**0.5 days**		**28**
31		Not ATO Process *** timeshift to allow next function at right time ***	6 hrs		
32		Import Airlift Msns, Merge Component ABPs, QC Merge, Validate/Generate ATO (D-16, 4-86) SPINS Due (D-16, 4-129)	2 hrs		31
33		Combat Plans Div ATO Changes Cease (Changes worked through Combat Ops Div	2 hrs		32
34		ATO Review and Final QC	2 hrs		33
35		Push ATO	0 days	ATO A	34
36		MAAP Team C Tasks (D-12 to Execution)	11 hrs		29
37		ATO B Start	0 days		7
38		JAOP Update (Due by D-68, 3-30,3-5)	4 hrs	JAOP A	37
39		Publish AOD (D-66, 3-5)	2 hrs	AOD A	38
40		Joint Target List (JTL) Update (D-60 & D-48, 4-11)	0 hrs	JTL A	
41		Target Nominating Lists (TNLs) Development (D-53, 4-13)	13 hrs	TNLs A	39
42		Review TNLs (D-50, 4-13)	3 hrs		41
43		Merge TNLs (D-48, 4-13)	2 hrs		42



Project: kevin ato2
Date: Wed 6/22/05

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone		

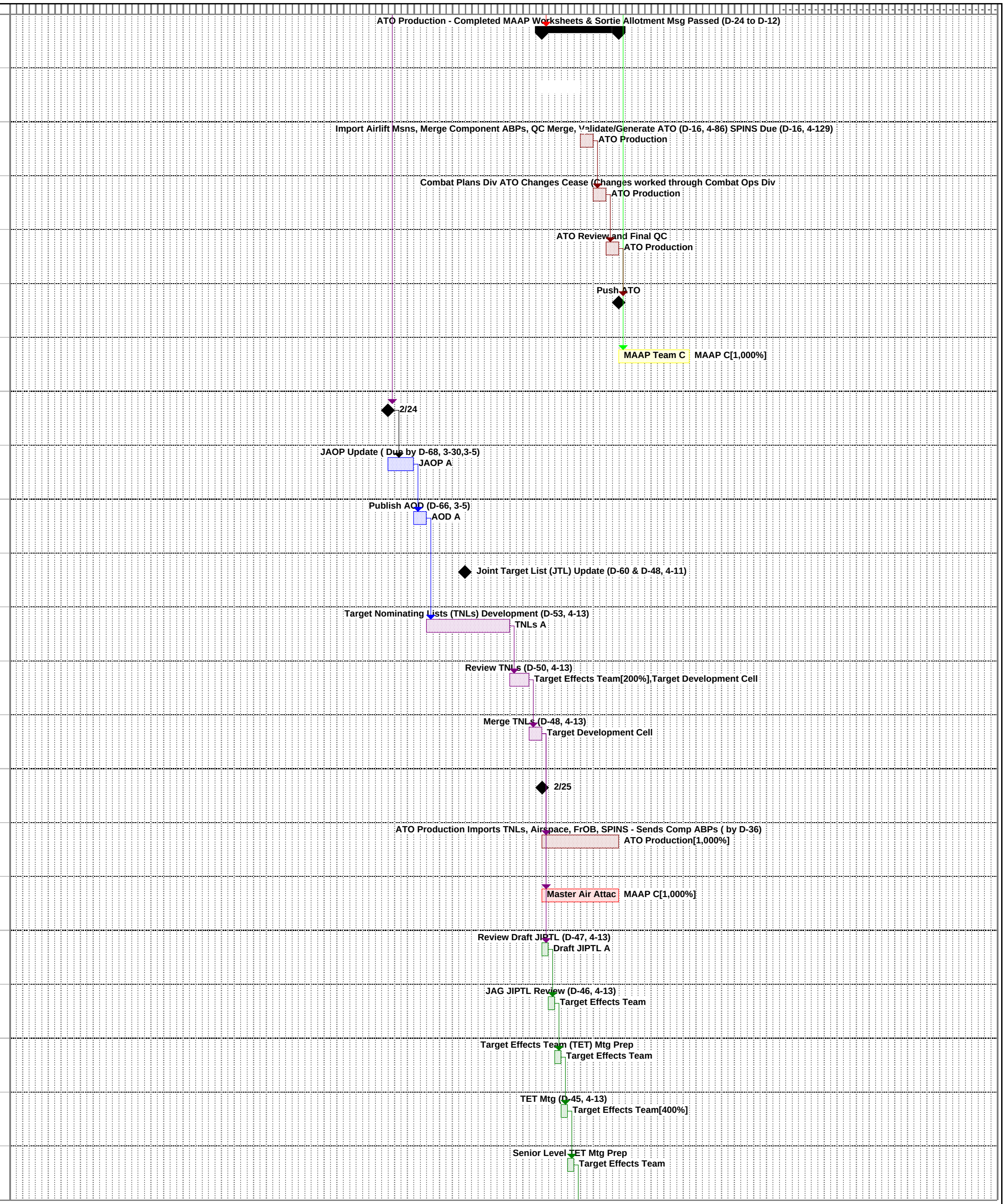
ID	Indicators	Task Name	Duration	Text1	Predecessors
44		Joint Target List (JTL) Update	0 days		
45		ATO Production Imports TNLs, Airspace, FrOB, SPINS - Sends Comp ABPs (by D-36)	12 hrs		43
46		Master Air Attack Plan (MAAP) Team Prep (D-48 to D-36)	12 hrs		43
47		Review Draft JIPTL (D-47, 4-13)	1 hr	Draft JIPTL A	43
48		JAG JIPTL Review (D-46, 4-13)	1 hr		47
49		Target Effects Team (TET) Mtg Prep	1 hr		48
50		TET Mtg (D-45, 4-13)	1 hr		49
51		Senior Level TET Mtg Prep	1 hr		50
52		Senior Level TET Mtg (D-43, 4-13)	1 hr		51
53		JFACC Strategy Update Prep and JIPTL Completion	3 hrs		52
54		JFACC Strategy Update Mtg - JIPTL Released (D-39, 4-13)	1 hr	JIPTL A	53
55		Collect & Finalize Component Prioritized Collection List (CPCL) (D-37, 4-13)	1 hr	CPCL A	54
56		MAAP Team Mtg/Turnover Prep (D-37)	1 hr		55
57		ATO Production Inspects MAAP, Recieves and Final Worksheets (D-36 to D-24)	12 hrs		56
58		**MAAP Team A (D-36 to D-24)**	**0.5 days**		**56**
59		Pre-MAAP Mtg (D-36)	1 hr		56
60		MAAP Cell Lead Mtg (D-35)	1 hr		59
61		MAAP Cell Mtgs (D-34 to D-24)	9 hrs		60
62		Mid Course Update Prep (D-34 to D-30)	4 hrs		60
63		Mid Course Update (D-30)	1 hr		62
64		Decision Brief & MAAP Team B Shows (D-24)	1 hr		61
65		MAAP Team B Tasks (D-24 to D-12)	12 hrs		64



Project: kevin ato2
Date: Wed 6/22/05

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

ID	Indicators	Task Name	Duration	Text1	Predecessors
66		**ATO Production - Completed MAAP Worksheets & Sortie Allotment Msg Passed (D-24 to D-12)**	**0.5 days**		**64**
67		Not ATO Process *** timeshift to allow next function at right time ***	6 hrs		
68		Import Airlift Msns, Merge Component ABPs, QC Merge, Validate/Generate ATO (D-16, 4-86) SPINS Due (D-16, 4-129)	2 hrs		67
69		Combat Plans Div ATO Changes Cease (Changes worked through Combat Ops Div	2 hrs		68
70		ATO Review and Final QC	2 hrs		69
71		Push ATO	0 days	ATO A	70
72		MAAP Team C Tasks (D-12 to Execution)	11 hrs		65
73		ATO C Start (D-72)	0 days		43
74		JAOP Update (Due by D-68, 3-30,3-5)	4 hrs	JAOP A	73
75		Publish AOD (D-66, 3-5)	2 hrs	AOD A	74
76		Joint Target List (JTL) Update (D-60 & D-48, 4-11)	0 hrs	JTL A	
77		Target Nominating Lists (TNLs) Development (D-53, 4-13)	13 hrs	TNLs A	75
78		Review TNLs (D-50, 4-13)	3 hrs		77
79		Merge TNLs (D-48, 4-13)	2 hrs		78
80		Joint Target List (JTL) Update	0 days		
81		ATO Production Imports TNLs, Airspace, FrOB, SPINS - Sends Comp ABPs (by D-36)	12 hrs		79
82		Master Air Attack Plan (MAAP) Team Prep (D-48 to D-36)	12 hrs		79
83		Review Draft JIPTL (D-47, 4-13)	1 hr	Draft JIPTL A	79
84		JAG JIPTL Review (D-46, 4-13)	1 hr		83
85		Target Effects Team (TET) Mtg Prep	1 hr		84
86		TET Mtg (D-45, 4-13)	1 hr		85
87		Senior Level TET Mtg Prep	1 hr		86



Project: kevin ato2
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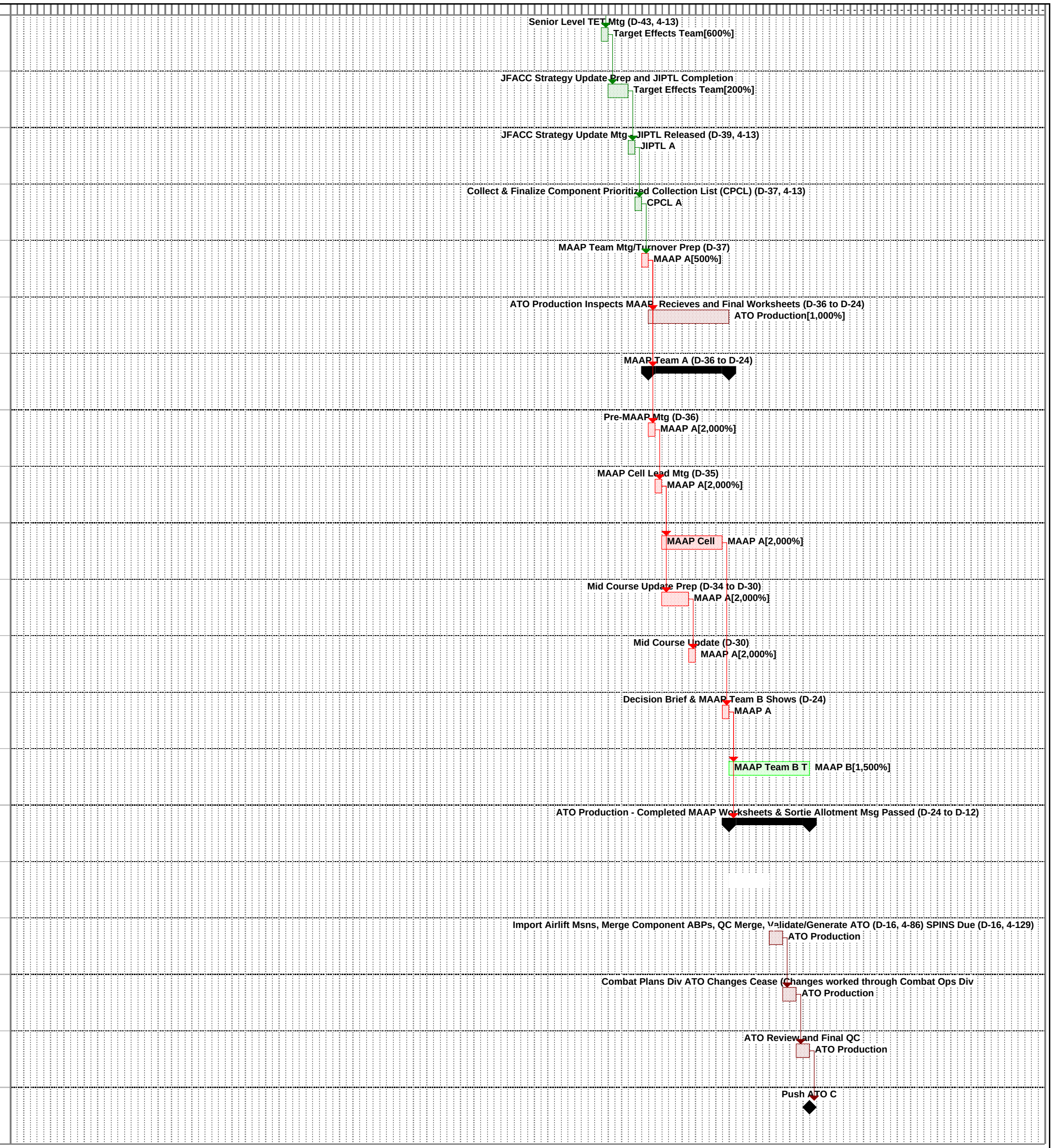
Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

ID		Task Name	Duration	Text1	Predecessors
88		Senior Level TET Mtg (D-43, 4-13)	1 hr		87
89		JFACC Strategy Update Prep and JIPTL Completion	3 hrs		88
90		JFACC Strategy Update Mtg - JIPTL Released (D-39, 4-13)	1 hr	JIPTL A	89
91		Collect & Finalize Component Prioritized Collection List (CPCL) (D-37, 4-13)	1 hr	CPCL A	90
92		MAAP Team Mtg/Turnover Prep (D-37)	1 hr		91
93		ATO Production Inspects MAAP, Recieves and Final Worksheets (D-36 to D-24)	12 hrs		92
94		**MAAP Team A (D-36 to D-24)**	**0.5 days**		**92**
95		Pre-MAAP Mtg (D-36)	1 hr		92
96		MAAP Cell Lead Mtg (D-35)	1 hr		95
97		MAAP Cell Mtgs (D-34 to D-24)	9 hrs		96
98		Mid Course Update Prep (D-34 to D-30)	4 hrs		96
99		Mid Course Update (D-30)	1 hr		98
100		Decision Brief & MAAP Team B Shows (D-24)	1 hr		97
101		MAAP Team B Tasks (D-24 to D-12)	12 hrs		100
102		**ATO Production - Completed MAAP Worksheets & Sortie Allotment Msg Passed (D-24 to D-12)**	**0.5 days**		**100**
103		Not ATO Process *** timeshift to allow next function at right time ***	6 hrs		
104		Import Airlift Msns, Merge Component ABPs, QC Merge, Validate/Generate ATO (D-16, 4-86) SPINS Due (D-16, 4-129)	2 hrs		103
105		Combat Plans Div ATO Changes Cease (Changes worked through Combat Ops Div	2 hrs		104
106		ATO Review and Final QC	2 hrs		105
107		Push ATO C	0 days	ATO A	106



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Conner, Kevin, Major, USAF
Lambertson, Paul, Major, USAF
Roberson, Matthew, Major, USAF

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7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

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505th Training Squadron
142 Hartson Street
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14. ABSTRACT

This thesis examined the Air Operations Center (AOC) Air Tasking Order (ATO) development process using the Theory of Constraints (TOC). TOC defines a constraint as the variable in production in which a local innovation causes significant global improvement. The overall goal of this research was to identify constraints that exist in this development process, both within a single ATO cycle and across five concurrent overlapped cycles. There has been little documented research on the process of ATO development; much of what is available is either ad hoc, contradictory, or both. Despite this, it is widely agreed that up to five ATOs are concurrently in development at any one time. It is also widely acknowledged that a given ATO from initial conceptualization to execution takes 72 hours, with a daily ATO release occurring every 24 hours. What has not carefully been examined is the lateral interaction between processes within one ATO cycle, nor the vertical interaction between concurrent ATOs under development. Identifying these interactions for possible constraints will focus improvements in this complex command and control process. Using our model we identified specific locations of lateral constraints that often result in information chokepoints, and therefore reduced quality and/or late delivery of the ATO. We also pioneered identification of non-obvious vertical interaction between ATO cycles. Identification of these constraints will allow AOCs to more effectively plan and control ATO development to ensure accurate and on-time delivery of Air Tasking Orders.

15. SUBJECT TERMS

Air operations, command and control, air tasking order, Theory of Constraints

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					Lt Col John Colombi
a. REPORT					**19b. TELEPHONE NUMBER** *(Include area code)*
U	U	U	UU	44	937-255-3636 x3477 john.colombi@afit.edu

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