# 13th ICCRTS: C2 for Complex Endeavors

"Modeling Impacts of Operational Changes on Joint Campaign Effects"

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## Abstract

Analyses of air mobility capabilities traditionally assess performance across air refueling and airlift capacity over time. Consequently, efforts to improve timeliness and capacity gravitate towards increasing key enablers, (aircraft, C2, etc.). Analytical methods, though, have not adequately applied effects-based protocols to link air mobility execution to impacts on Joint warfighting. This paper describes an integrating approach to applying an effects-based protocol to assess value of air mobility performance (also applicable to other capabilities) to campaign execution.

Programmatic support for capabilities gains momentum when results demonstrate direct benefits to joint warfighting effects. This study uses existing air mobility models with US Joint Forces Command's (USJFCOM) campaign model, Joint Analysis System (JAS), to explore and trace how operational actions improve effects-based operations. The paper expands work from the 12th ICCRTS ("Adapting C2 to the 21st Century," paper 184) to get to the "so what" concerns and focus of the Joint Force Commander (JFC), i.e., how air mobility capability changes can improve the JFC's achievement of campaign objectives. JAS variables provide mechanisms to portray changes in air mobility precision and velocity as more than just improvements in delivery times. This paper examines how different operational and campaign models can be used together to correlate operational changes to campaign effects.



**Keywords:** Capability Based Analysis; DOD Capability Analysis, Assessment, and Development; Airlift Capacity; Airlift Performance; Campaign Modeling and Analysis; Analyzing Joint Effects; Planning, Programming and Budgeting


## Introduction

Capability analysis in the Department of Defense (DOD) air mobility arena has traditionally focused on assessing summarized requirements and resource allocation spread across air refueling and airlift capacity delivered over a phased delivery timeline. Consequently, efforts to assess delivery performance gravitated towards key enablers, including improvements to aircraft platforms and components, command and control (C2) capabilities and responsiveness, including the detailed, near real-time visibility of assets awaiting movement, currently in transit, or already delivered. While the overarching goal has been to improve DOD air mobility capacity and velocity, performance analyses have not adequately applied an effects-based protocol that directly links the results of air refueling and airlift execution to their impacts on war fighting effects along the entire operational timeline.[1] In short, there is little logical effects-based linkage between air refueling and airlift capability planning and programming and the warfighting campaign execution. This paper describes an integrating approach to applying effects-based

[1] For a broader discussion of air mobility analytical methods see Lambert, et al. "A Tabu Search Approach to the Strategic Airlift Problem," Military Operations Research, Volume 12, Number 3, 2007, Alexandria, VA. pp. 59-79.

protocols in analyzing and assessing DOD airlift C2 and execution performance directly related to impacts on campaign execution. The proposed integrating modeling technique will capture outputs from movement requirements produced in standard air mobility models and determine the anticipated delivery profile of those phased requirements using force movement models accepted across DOD. The phased delivery profile of fuel, forces, and sustainment materiel will be analyzed for accuracy and used as the source of warfighting capability in a campaign level warfighting model. This approach enables maximum flexibility to accomplish multiple changes to any variable in either model, providing a scalable analysis of every parameter and its individual or synergistic impact on any campaign by day, phase, or in its entirety.

**Competing Paradigms and Previous Efforts**

The Services are responsible under USC Title 10 responsibilities to "Organize, Train and Equip" forces to support the combatant commanders in execution of their global operational mission, participate in a continuing process of evaluating current capabilities and project the capabilities needed to fulfill future requirements. To accomplish the difficult task of anticipating future capability needs and producing accurate and consistent programming plans for inclusion in the DOD's annual funding plan, the Services must work to include a "Joint" view as they apply Capability Based Planning (CBP) tools and processes. In reality, the legacy of antiquated yet institutionalized Planning, Programming, and Budgeting processes virtually ensures that these institutions continue to operate in an environment where competing requirements, e.g., Service-centric capabilities, dilute their success in producing integrated plans that clearly and tangibly support development of capabilities representing a blended Service-Joint combination of materiel and non-materiel capabilities.

Despite more than a decade of guidance and direction to institutionalize and improve Joint operations[2], progress is slow.

> "As our Nation continues into the 21st century, the guidance in this publication will enable current and future leaders of the Armed Forces of the United States to organize, train, and execute worldwide missions as our forces transform to meet emerging challenges."[3]

The transition to CBP likely exacerbates the Services' evolutionary progress towards a cohesive Joint view because, wedded to old processes and paradigms, planners attempt to understand and apply the CBP process through parochial lenses. Also, because CBP institutes new processes, participants across DOD may tend to focus more on CBP tools than on the application of processes or results. The result of this Service-centric application of the CBP process is DOD ultimately publishes budget plans lacking a truly integrated Joint view of the warfighting effects. The dynamic programming and budgeting environment, complicated by an ongoing Global War on Terrorism (GWOT), may in fact produce less support than the combatant commanders require and expect.

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[2] DOD Joint Publication 3-0, "Joint Operations", 17 September 2006
[3] Ibid., excerpt from Preface by Gen Peter Pace, USMC, Chairman, Joint Chiefs of Staff, September 2006.

When viewed as a process, the Services develop and evaluate combat and combat support capabilities that meet their core mission competencies today. Their efforts often fail to effectively consider the impact of the evolving capabilities in actual Joint operations while executing a concept of operations (CONOPS) produced and executed by a geographical combatant commander. Both the methodology and the tools are missing in the current process to enable the Services to determine how their evolving materiel and non-materiel solutions can perform in a Joint operations environment for the combatant commanders. This lack of methodology is recognized and acknowledged across DOD as a serious shortfall in the continuous CBP process. The shortfall is due in part to a lack of modeling and simulation tools that DOD supports and applies across the Joint community.

Previous efforts conducted to quantify DOD baseline strategic mobility capability targets, like the 2006 Mobility Capabilities Study (MCS 06), have also fallen short in their assessments of the adequacy of strategic mobility by failing to quantify air mobility's effect-based performance as it contributes to the warfighters' campaign plan. For example, how did increased mobility performance improve the combatant commander's operational options? How did more aggressive mobility performance deliver more combat power quicker, and did the increased operational availability of that combat power allow the commander to execute the plan sooner or more efficiently with fewer losses, etc.? Edward Smith highlights the issue of non-combat forces achieving effects when he wrote, "This is especially true because the peacetime tasks of war prevention and crisis/conflict containment constitute the vast majority of what military forces do. In short, we need to begin to think not only in terms of effects-based combat operations, but also in terms of effects-based deterrence, reassurance, forward defense, presence, and containment."[4] Three historical examples of the role that other than combat operations have played are "Flying the Hump" in Burma during World War II (1942-45), the Berlin Airlift (Jun 1948 – Sep 1949), and the Cuban Blockade (Oct 1962). In the first two examples, airlift achieved the effect through air delivery; in the third one, presence and containment achieved the desired effects and all three offered the President crucial options other than war.

Seminal mobility capabilities studies have tended towards producing capability target "windows", reflecting upper and lower control limits that, in a budget constrained environment, have contributed to DOD's acceptance of lower capability targets. In MCS 06, for example, the lowest capability deemed acceptable for global mobility was assessed by DOD as adequate, producing "acceptable risk" to the warfighter. In fact, the MCS 06 assessment process underemphasized operational risk by "assuming" that forces and materiel are delivered in time, even when a percentage of that combat power is delivered late; DOD analysts then fight the war producing successful results which thereby assumes acceptable air mobility risk. Unfortunately, the combatant commanders are generally not included in these analytical processes, as these questions are considered by DOD and the Services to be more in line with the Services' Title 10 roles than in the geographical combatant commanders' purviews.

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[4] Smith, Edward, Jr. *Effects Based Operations: Applying Network Centric Warfare in Peace, Crisis, and War.* Washington, DC: CCRP Publication Series, 2003. p. 409.

Warfighting modeling, analyses and assessments therefore tend to focus on the incomplete analytical equation of simple delivery (port-to-port) profiles compared to static TPFDL[5] requirements. This clearly fails to employ assessment processes following logical protocols clearly supported by real world operational experience. MCS 06 is a prime example. Following publication of MCS 06, Congress directed GAO to assess the study's limitations, which in turn raised questions about its adequacy and completeness. GAO observed that DOD had concluded that US and allied mobility (transportation) assets were in fact adequate to the warfighters' needs but had *failed to assess the operational impact of mobility execution on the warfighters' plan of execution*.

> "While the MCS concluded that combined U.S. and host nation transportation assets were adequate, in describing the use of warfighting metrics in its analyses, the report does not provide a clear understanding of the direct relationship of warfighting objectives to transportation capabilities. Additionally, the report stated that further analysis is required to understand the operational impact of increased or decreased strategic lift on achieving warfighting objectives."[6]

Additionally, regarding DOD's MCS 06 protocol, GAO reported to Congress,

> "Aspects of modeling and data were inadequate in some areas because data were lacking and the models used could not simulate all relevant aspects of the missions. The report did not explain how these limitations could affect the study results or what the impact on projected mobility capabilities might be. Generally accepted research standards require that models used are adequate for the intended purpose, represent a complete range of conditions, and that data used are properly generated and complete."[7]

As mentioned earlier, DOD has not yet identified an integrated joint operations campaign-level model of choice for use in simulating campaign plan execution; this perpetuates discontinuity among the Services when conducting stovepipe CBP processes. Ironically, DOD has acknowledged the shortcoming, which was also documented in GAO's MCS 06 report, "In addition, the MCS report contains over 80 references to the need for improved modeling or data."[8]

Having established that CBP processes and post analysis results may represent each Service's perceptions of their capability needs without adequately considering the integrated Joint effects on the warfighter, it is clear that DOD must transition to adopting rigorous analysis supported by

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[5] Time-Phased Force and Deployment List found in Appendix 1 to Annex A of the Operation Plan. The TPFDL identifies the types and/or actual units supporting the combatant commander's operation plan and indicates the origin, ports of embarkation and debarkation, final destinations, number of passengers, types and number of vehicles, materiel, etc.

[6] GAO Report to Congressional Committees, Defense Transportation, Study Limitations Raise Questions about the Adequacy and Completeness of the Mobility Capabilities Study and Report, September 2006, pg. 2.

[7] Ibid., pg. 2.

[8] Ibid., pg. 2.

a Jointly-recognized integrated campaign model. The next section proposes how that might be accomplished in the near term.

**Infusing Capabilities Assessments and Programming with Effects-Based Analysis**

One method of incorporating effects-based analyses and results into CBP processes is by applying the very principle of "Jointness" itself. By establishing and maturing Joint partnerships, and leveraging the available modeling and simulation tools and the combined expertise of all participants in synergistic processes, CBP will itself evolve into a protocol that considers Joint effects and offers tangible evidence when preparing future year programming and budgeting plans. Here, we propose a partnership between USJFCOM and USTRANSCOM, who have the analytical expertise and current "best of breed" models capable of producing an end-to-end effects-based analytical outcome.

Current modeling is rarely, if ever, federated to permit real time inputs to flow from one model to another and impact the campaign as changes occur. In "Effects Based Operations," Edward Smith addresses the issue of getting to effects when he wrote, "The challenge we confront when planning an effects-based operation is figuring out what the right stimulus is to produce the response or effect that we seek."[9] Similarly, the difficulty in modeling Joint effects is in determining the stimuli in each model to use to create the change in effects in a campaign model.

The figure below outlines the proposed modeling and analysis protocol. The proposal begins with the insertion of movement requirements into the process. (Initially, this effort should focus on a significantly challenging and previously modeled campaign plan to allow for comparison and validation.) These requirements are then assessed using current mobility modeling tools. The results (outputs from the models) are then linked to selected stimuli within the campaign model, in this case, JAS. Analysts first conduct a baseline JAS run of the campaign fight. Then with the outputs from air mobility models reflected in changes to JAS variables, the analysts complete a second run of the same campaign. Analysis of the deltas between the two runs captures the effects of air mobility on achievement of operational and campaign objectives.

[9] Ibid. p. 113

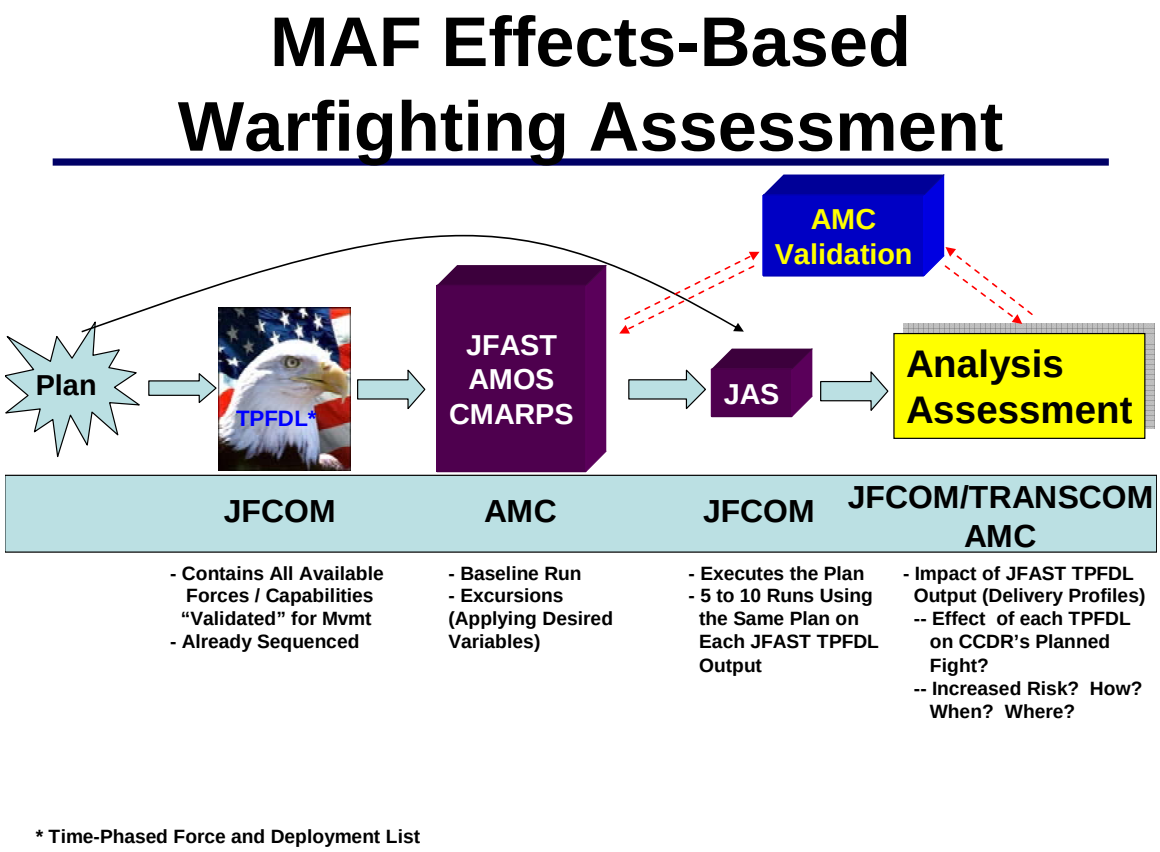


Figure 1. Modeling & Analytical Process Flow

**Results of Adopting This Approach**

While we have not yet performed actual runs of a campaign model based on the ideas in this paper, initial results are very promising and revealed the potential of the approach at describing Joint effects. With the cooperation of the JAS modeling team at USJFCOM/J9, we were able to structure how the modeling effort would link outputs from air mobility-proven models with the JAS campaign modeling capability. Additionally, similar investigations with air mobility modelers in Air Mobility Command and USTRANSCOM have substantiated that the methods described in this paper are valid to implement a campaign-level assessment. Furthermore, this is true even if a Joint model lacks the acceptable level of functional modeling, as with transportation modeling within the JAS model. (Although JAS has a transportation execution module, JAS analysts rely on proven Joint Flow and Analysis System for Transportation (JFAST) modeling to represent the transportation segment.) JAS can thereby capture the changes in air mobility performance and develop an assessment of the impacts of air mobility on the warfight. By employing proven functional models (e.g., Air Mobility Operations Simulation (AMOS) or JFAST) to run the analysis of operational performance changes in that capability area, that community's accepted model's results are assessed as valid, thereby producing credible outputs to feed into the Joint campaign model. These outputs stimulate variables within the Joint campaign model, reflecting the outputs of the functional model and thereby driving the Joint model to fight the war with these new inputs. The Joint model captures the impacts on the

campaign resulting from changes in the stimuli based on accepted functional model outputs; a detailed and analytical comparison with a baseline run portrays the delta on the campaign and value of the capability, in our case, air mobility.

The findings identify the potential for substantive gains in capability-based planning value weighting for investment strategy development based on contribution to achievement of Joint warfighting objectives. With air mobility, for example, not only could the case be made for how much more fuel, cargo, and passengers could be delivered, but the rationale could be linked to how increased delivery could enhance achievement of the campaign objectives. Cross-domain analysis could then be established to link enabling capabilities to warfighting and provide valued-focused analysis of changes of performance on achieving Joint effects.

The next sections provide air refueling and airlift examples that demonstrate the results of the proposed modeling linkage in order to connect air mobility capabilities to Joint warfighting effects.

*Results: Air Refueling Methodology*

Today, air refueling assessments using the Combined Mating and Ranging Planning System (CMARPS) normally investigate issues of sufficiency in terms of amount of fuel offloaded and the number of receivers air refueled. Resource inputs to this model include fleet apportionment, number of possible missions per day, flight characteristics with range and fuel burn rates, and receiver requirements containing information on amount of fuel, time, and the air refueling track coordinates and altitude where the fuel is required. Outputs of the model include amount of fuel the air refueling tankers passed to the receivers, number and type of receivers refueled, and remaining fuel onboard the tanker.

Both CMARPS and the JAS models can conduct “What-if” drills with varying force structures. As an example, the baseline run could have a tanker aircraft apportionment of 100 aircraft and the second run could increase the apportionment by 20 aircraft. CMARPS would report the change in fuel offloaded (total and by aircraft mission) while JAS would provide that same information as well as how the added air refuelings increased fighter target coverage. Since JAS is a campaign-level model, the analysis results would also describe the changes on achievement of objectives connected to the increased tanker fleet size. This added information would help quantify the value of the increased number of tankers to the Joint Force Commander achieving campaign objectives. The calculations would then support investment decisions for future tanker funding.

An alternative study could be run that seeks to quantify the value of conducting air refueling closer to the fight (higher threat environment) on the fighter aircrafts’ ability to strike more targets. A method to get to this issue would involve relocating tanker air refueling orbits closer to where the fighters are engaging enemy forces. JAS would track the increased tanker fuel burned and time to reach the new air refueling point and the risk and threat factors to the tanker aircraft from any ground or air threats. CMARPS would be able to provide validation of the tanker flight information relating to fuel burned and amount of fuel offloaded with tankers operating at different air refueling points (anchor areas or tracks) but it would not be able to link

to the effects on fighter aircraft missions or the tanker losses from operating in a contested environment. It again would not be able to assess the impact on the overall warfight.

As one can see, the JAS model can accommodate some degree of fidelity in modeling the air refueling mission, but it does have its limitations. One such example would be its lack of ability to model refueling using both a boom and a drogue on the same mission to offload fuel to aircraft with different type refueling systems. However, CMARPS could capture the changes in offload amount and number of receiver aircraft air refueled based on boom and drogue capacities and the outputs would then be used to adjust JAS air refueling data accordingly. In that way, the Joint effect from a change in an air refueling capability could be measured in terms of its contribution to the warfight, not solely offering how much fuel was offloaded, or fighter aircraft were air refueled, or even the number of targets struck. The connection to campaign modeling that analyzes effects on the campaign gets to the justification for increasing or decreasing funding of air refueling capabilities based on contribution to achieving campaign objectives.

*Results: Airlift Methodology*

As described in Figure 1 above, airlift performance modeling will be accomplished using one of two tools. The first, the Joint Flow and Analysis System for Transportation (JFAST), is used throughout DOD's Joint Planning and Execution Community (JPEC), including USTRANSCOM and the unified combatant commanders, in accomplishing transportation feasibility analyses. JFAST is a multi-modal transportation model that includes several tools to enable changes to the TPFDL such as movement re-phasing, and the ability to create re-supply requirements and append them to the TPFDL using the editor module. The benefits of employing JFAST include its familiarity and acceptance in the JPEC, and the ability to convert results into media easily shared with other models.

The second, the Air Mobility Operations Simulation (AMOS), is used by Air Mobility Command. AMOS specifically focuses on airlift and aerial refueling and provides a detailed, individual aircraft-level view of the ability of a fleet of aircraft to satisfy user-input requirements for airlift, and air-refueling orbit and escort missions.

Similar to the air refueling methodology above, JFAST or AMOS tools allow multiple iterations of movement execution to determine the airlift fleet's performance in delivering the required equipment and troops when and where specified. This supports assessment of the impact on the TPFDL timeline from single or multiple adjustments to materiel (number and types of aircraft used, etc.) and non-materiel (changes to doctrine and procedures) variables. By feeding the TPDFL delivery performance output into JAS and executing those variable adjustments in the campaign model, analysis can then determine availability of combat forces and key enablers. JAS can highlight when forces would become operationally available for employment by the warfighter to support execution of the overall campaign and determine the overall impact of those arriving warfighting capabilities on the campaign by phase or in its entirety.

To more clearly illustrate the effects-based relationship between strategic airlift performance and campaign plan execution refer to Figure 2 below. The strategic airlift flow of forces displayed on the bottom of the slide outlines the deployment timeline for major combat units. Comparing the JFC's campaign execution plan shown on the top portion illustrates how airlift performance

can either expand or restrict the JFC's operational options and overall risk. In this particular example the JFC plans on executing Phase 2, Consolidate and Extend Operations, on D+10, but assessments done by the staff show that executing Phase 2 at D+7 will reduce casualties and destruction. To enable earlier Phase 2 execution the JFC requires the delivery and operational availability of at least 50 percent of the 25th Infantry Division (25th ID). Note below that although the 25th ID has been moving for 4 days, strategic airlift has yet to deliver even 25 percent of those forces. When compared to the campaign plan it is clear that not only will Phase 2 not execute early as the JFC had hoped, but execution of Phase 2 on the original date, D+10, may now be in jeopardy. End-to-end modeling and assessment can clearly demonstrate how air mobility performance can produce positive or negative effects for the combatant commander.

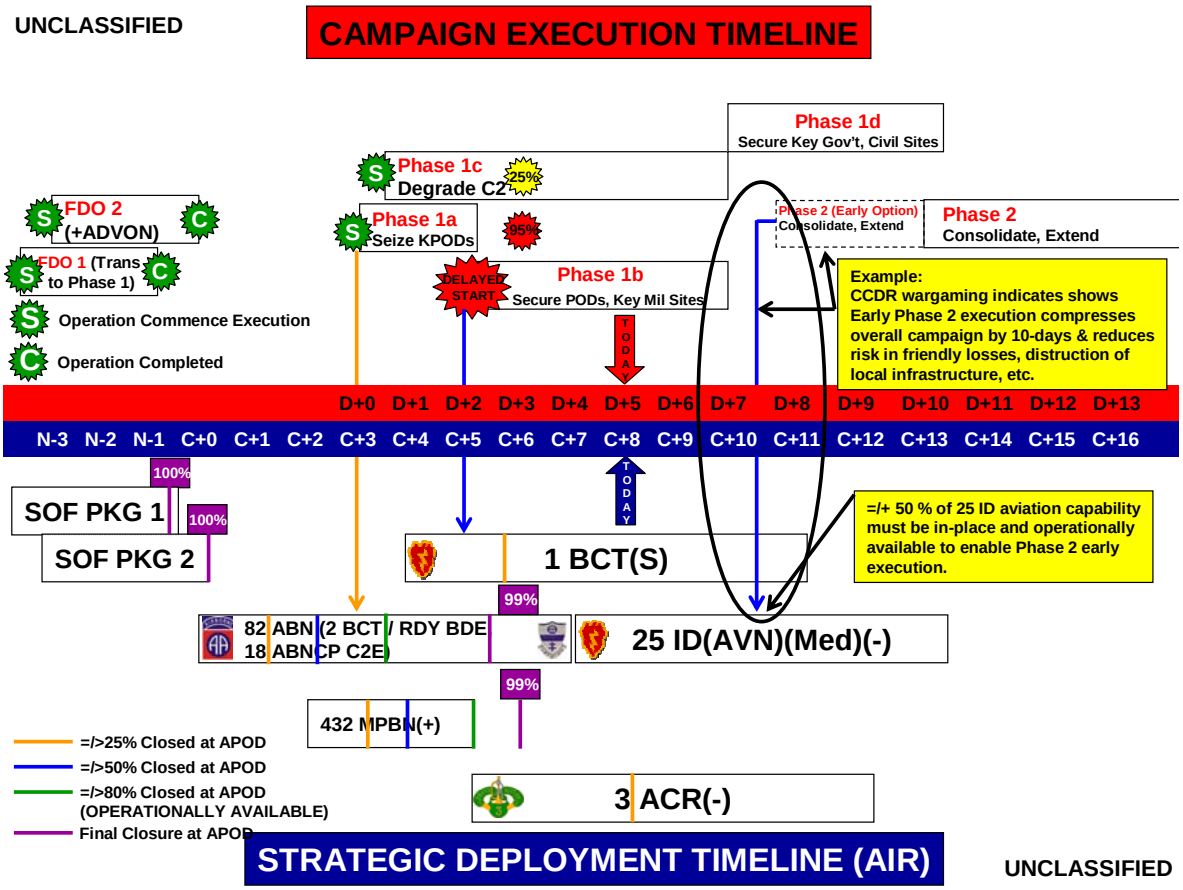


Figure 2. Effects-Based Assessment Modeling

Using JFAST or AMOS with JAS, it is possible to determine the impact of changes to key airlift variables like Allowable Cabin Load (ACL) and Aggregation. ACL describes the maximum amount of payload that mobility aircraft can carry given a specific routing, and aggregation describes the principle of consolidating materiel and personnel in place and time. Refining the transportation model to reflect a higher minimum ACL ensures that all requirements failing to meet the minimum threshold will not move. The next step is to aggregate the requirements so that they meet the minimum ACL threshold and hence are airlifted.

Historically, airlift operations during contingencies and emergencies tend to result in very poor overall ACL utilization; this inherently limits the volume of materiel moved over time and does

so at very great cost as aircraft depart with unused capacity. By adjusting the minimum ACL threshold and aggregating variables, analysts can determine whether the increase in cargo volume delivered and the improved velocity will produce positive effects for the JFC while subsequently proving a more efficient use of the available airlift capacity, e.g., it is not only possible but smarter to move the same amount of materiel on 35 missions versus 50 over a shorter time period. This improvement in delivery may prove significant enough to enable JFCs additional operational options as would have been the case in the example in Figure 2.

An additional excursion can also test the impact of changing an established practice of scheduling mobility aircraft to pick-up TPFDL requirements at airfields in the vicinity of the home base of the deploying units. This might include determining the impact of a phased airlift operation where mobility aircraft pick up requirements at deploying units' locations for a period of time, e.g., 15-days. After that, all deploying units would travel via surface transportation (e.g., truck transport, rail, convoy) to a specified air deployment platform (military airfield) for aggregation and movement via mobility aircraft. By feeding the TPFDL delivery profile from the transportation model into JAS, analysts can determine if the practice of bringing the cargo to the aircraft and aggregating the requirements at a limited number of locations would produce significant improvements to warfighting capabilities and over a shorter time. Those improvements would then drive changes to the Required Delivery Dates (RDDs) in JAS and allow changes to the force employment date based on the new flow. Comparing results would indicate how changes in delivery variables improved or hurt the JFC's options and/or reduced operational risk. One other consideration planners must consider is how an earlier delivery profile expands options for the development of Courses of Actions. Without this reassessment, the effect of a more aggressive delivery profile might simply be that the forces arrived in country earlier but just waited for the original execution day to engage. Finally, positive results here can then lead to additional analysis to determine a more comprehensive picture of the time (prepare, transport, stage deploying assets at the platforms) and cost (surface transportation, fuel, travel) necessary to apply this non-materiel solution variable.

Our next steps include identification of a Joint model and application of the concept of effects-based assessment in future analysis and Wargaming.

## Conclusion

Modeling Joint capabilities' effects on Joint operations' objectives will better support future programmatic decisions. The Joint Capability Areas are postured to implement an analysis of those capabilities, but inertia is needed to move to full effects-based analysis to clearly identify contributions and interdependencies across capability areas. When models are truly federated, the relationship between lower level actions that cascade into other effects can be traced through direct interaction among the models. This paper presented a methodology that would permit the analysis of the linkage today. The results of the research indicate that the proposed methodology for air mobility is a valid approach to assess impacts on campaign-level objectives even when the campaign model lacks the fidelity to accurately portray the performance of a capability area. To accurately to reflect the level of impact and value to the warfight, the approach uses existing modeling tools that are accepted for functional areas (air refueling and airlift) and then demonstrates methods to take outputs from those models and stimulate relevant factors in a Joint campaign model. Results from the Joint model can then be analyzed to validate that the changes

correlate with the new inputs. For air mobility, air refueling and airlift capabilities can both be assessed within the Joint Analysis System (JAS) model to analyze their impacts on Joint effects. Our findings demonstrate improvements in value-focused thinking analysis when capabilities are assessed at both the functional and Joint warfighting levels.