ADAPTIVE MISSION PLANNING:

Squeezing Out Greater Combat Capability

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No war has ever been fought according to plan. Commanders who have witnessed or studied the dynamics of military conflict are acutely aware of the difficulty in looking beyond the first encounter. Rigid planning for the application of land, sea, or aerospace power against a predictably unpredictable enemy achieves randomly successful results. Given the high-tech, highly mobile military forces of today, adaptive mission planning, or lack thereof, is a crucial force multiplier (or Achilles' heel) in determining the ultimate victor in a conflict. Adaptive mission planning is a viable means for managing forces during a battle--a means for squeezing greater combat capability out of our forces. We must be prepared to fight outnumbered and win. That prospect requires effective employment of limited military resources, which demands the kind of leverage available from adaptive planning.

Policy

The mandate for adaptive mission planning is clear. Initially spelled out in presidential directives, there is an absolute requirement--whether in peacetime or at war--to make our war-planning systems more responsive to changes in policy and direction, in the threat, or in friendly forces.[1] These directives indicate that enemy perceptions about our warfighting capabilities are likely influenced by the demonstrated agility of our planning system and that we must be viewed as being adaptive--that is, capable of rapid and effective planning of a dynamic force against a dynamic enemy target system. Faster and better mission planning constitutes a force multiplier that enhances deterrence.

Adaptive Mission-Planning System (AMPS)

An adaptive mission-planning system (AMPS) is defined as an end-to-end, man-machine system for planning missions in a dynamic, and in some cases, time-compressed environment. A mission-planning system is adaptive if it provides timely and effective responses to changes in policy and direction, in the threat, or in friendly forces. An AMPS could respond to an order received from the highest civilian or military command authorities down to the executing unit, crew, or soldier. An AMPS should be viewed as an on-the-spot hedge against the unexpected, whether the unexpected occurs during peacetime or in military conflict.

The data transmissions depicted in the accompanying AMPS model are both end-to-end and interactive. The end-to-end, one-way arrows indicate how planning data flow clockwise from functional element to functional element for AMPS processing. The interactive, two-way arrows indicate how AMPS functional areas (situation assessment, mission planning, and system employment) crossfeed real-time information to effect adaptive planning outcomes. Thus, the transmission of data between the AMPS functional elements constitutes the adaptive planning process (not unlike any planning process); and the transmission of data between the AMPS functional areas constitutes the modification of the process (or the update of the system's knowledge base).

The functional areas and elements shown in the AMPS model are representative of all military mission-planning systems. Depending on the planning system modeled, information flow can be entirely manual or mostly automated, but people are always involved. To replan a weapon system, the mission-planning system must first assess the situation. It must collect information on both enemy and friendly forces and constantly correlate it with policy and direction received from higher levels of command authority. There must then be intelligence production in which all pertinent information derived from the collection/ direction function is tailored for the intended user. Within the functional area of mission planning, the system constructs target aimpoints to optimize weapon effectiveness and selects and routes weapon delivery systems with appropriate employment tactics to help ensure mission success. During weapon system employment, the battle unit operates and monitors the weapon system that executes the mission. Reconnaissance to measure mission results updates the situation assessment functional area, recycling the planning system.

A mission-planning system may accommodate either deliberate (scheduled) or ad hoc (unscheduled) planning and may operate in either a benign or hostile environment. Mission planning can occur at a headquarters or in a unit on the ground, in the air, in space, or at sea. Mission planning systems must interact with other mission planning systems. For example, the deployment of a B-52 bomber to the theater for conventional weapons employment requires the linkage of Strategic Air Command and theater mission-planning systems. Even though traditional and adaptive mission-planning system architectures have quite similar functional areas and elements as well as operating environments, the military strategies these planning systems are capable of supporting (and hence their respective information flow requirements) are remarkably different.

A traditional mission-planning system plods methodically and sequentially from functional element to functional element and is usually adequate for peacetime, schedule-driven, detailed, a priori planning that responds periodically to changes in policy, threat, and forces. Unfortunately, the rigor in the traditional planning process that promotes standardized mission planning and quality control during peacetime also discourages interaction between the functional areas, and thus inhibits system responsiveness to battlefield dynamics. The AMPS, however, can be highly interactive. The ability of its functional areas to adapt quickly, both to new planning data entering the system and to real-time information generated by the other functional areas, allows the system to be the best that it can be. In general, a degree of quality control may be sacrificed to achieve speed on the grounds that a good, timely plan is much better than a perfect plan that is too late to accomplish its intended purpose.

Requirement for AMPS

Adaptive planning, however desirable, may not be appropriate or cost-effective in every mission-planning situation. As just discussed, the scheduled development of a major plan such as the single integrated operational plan (SIOP), produced annually by the Joint Strategic Target Planning Staff (JSTPS) at Headquarters SAC, should be accomplished with traditional end-to-end planning methodology. JSTPS planners typically receive early forecasts about impending changes in the planning parameters (policy, threat, and forces), giving them ample time to effect necessary changes to the SIOP. High standards for quality control are set and achieved throughout the SIOP planning cycle. Conversely, whenever an unexpected change occurs in one of the strategic parameters and the change is of sufficient priority to dictate prompt action, traditional planning methods may be inadequate. Without an AMPS, untimely mission replanning could portend the specter of defeat on the battlefield unless we possess overwhelming superiority over the enemy. For example, target data bases may not reflect the latest position of relocated enemy forces, or our attacking weapon systems may suffer an unacceptable level of attrition. We could well end up applying the wrong measure of force against the wrong targets at the wrong time. The more rapidly the crisis unfolds, the greater the need for adaptive mission planning.

Principles for Developing an AMPS

When developing an AMPS, the vital system attribute we seek is flexibility, which can be achieved by applying the following principles.

Design an"Expert System"

An "expert system" is a computer program that uses knowledge and inference procedures to solve difficult problems that require significant human expertise for their solution. The knowledge necessary to perform at such a level, plus the inference procedures used, can be thought of as a model of the expertise of the best practitioners of the field.[2] Knowledge-based technology is an attractive engineering approach to complex problems that require time-urgent solutions. Adaptive planning is fertile territory for practical application of this technology. By allowing the diverse intellect of the mission-planning community (intelligence specialists, logisticians, targeteers, tacticians, communicators, unit plans officers, and crew members/soldiers) to define the data bases and rules for an AMPS, there is far more confidence in the practical worth of the ultimate product. The idea is to project the "experts" into the weapon system (e.g., the cockpit), not to usurp the responsibilities of the weapon system operator but to enhance his timely execution of those responsibilities. A knowledge-based AMPS increases speed with minimum loss of efficiency. By allowing the system to make certain inferences, data bases and system logic can be streamlined. Such data compression also allows for more compact systems and therefore greater system mobility--a definite plus for a battlefield planning element.

An interesting side benefit of applying knowledge-based technology to adaptive planning is the resulting adaptability of the system itself. Military experts--the users more than the engineers--must continuously inject their knowledge into an AMPS by designing and updating the system rules for situation assessment, mission planning, and system employment. Their efforts are expected to pay great dividends. As the AMPS is tested and operated in a battlefield environment, user understanding of AMPS logic would allow for real-time modifications within cértain constraints. The AMPS could be programmed to accept operator changes that fall within predefined system or procedural limits.

Decentralize Control and Execution

As one can see in the AMPS model, there are real possibilities for applying autonomous or semiautonomous, decentralized control and execution--frequently at the operator level. Even under the stringent constraints of nuclear warfare, there are significant opportunities for AMPS application, such as in a dispersed command center or a strategic bomber. Given the preservation of legal, centralized authority over the execution of certain weapon systems (e.g., presidential purview of tile release of nuclear weapons), decentralized control and execution, where allowable, are needed for adaptive mission planning. As long as the weapon system operator's decision to redirect his mission-- based on an adaptive planning input--can be coordinated and deconflicted* with the arrival of other friendly forces, decentralized control and execution build greater timeliness and flexibility into force employment tactics and procedures. If given this much responsibility, the operator must have a user-friendly, partially autonomous AMPS. Routine AMPS mission changes could be programmed for autonomous operation; mission-critical changes could be executed only on operator command (semiautonomous).

*This term refers to the proper timing of weapons arrival on target to prevent these weapons from destroying each other.

A High-Leverage AMPS Application: The Strategic Bomber

The SAC bomber is a good candidate for an onboard AMPS. Despite having a "man-in-the-loop," this most flexible leg of our strategic Triad currently flies highly structured missions that are preprogrammed for each aircraft's offensive avionics system (OAS). Once the bomber is airborne, we lack the flexibility we need to change the mission. Should a mission proceed according to plan, the OAS would contribute significant accuracy to weapons employment; but we all know that no mission ever goes exactly according to plan. Accuracy without flexibility fails to account for the unexpected and could diminish the employment contribution of any force. The battlefield faced by the bomber force is dynamic; enemy defenses and enemy targets will relocate and new directions from higher headquarters must be processed. Almost anything could happen. A viable on-board AMPS, if combined with evolutionary improvements to aircraft sensors and command, control, and communications (C^3) systems, would improve the weapon system's capability to deal with these eventualities.

The concept of operations for an AMPS-assisted bomber shifts much of the responsibility for mission success from outside to inside the aircraft. The AMPS situation-assessment module would receive and process new information from aircraft sensors and external sources (overhead sensors, higher headquarters, or other aircraft), correlate this new data with other significant events, and, when necessary, inform the crew. If warranted, the AMPS mission-planning module would calculate a mission change and display it to the crew. The AMPS system-employment module would execute a critical mission change on crew command or a noncritical mission change by implied consent. Following execution, the AMPS would update affected data bases and report selected actions to external agencies such as higher headquarters or other bombers.

The viability of a bomber AMPS would depend on the careful application of the two principles discussed earlier: (1) an expert system, designed within the constraints of nuclear surety, and (2) decentralized control and execution. The first principle requires a "knowledge engineer" to work with the experts (strategic planners and crew members) to develop the rules that the AMPS can manipulate. "The knowledge base in an expert system stores more than just facts; it also contains heuristic knowledge which replicates the expertise an expert develops in a specific domain."[3] It is this heuristic knowledge that would allow the AMPS to make highly educated guesses to solve in-flight mission-planning problems. Given that the knowledge engineer and the experts designed a credible, nuclear-certifiable AMPS, senior civilian and military authorities would likely approve the application of the second principle (decentralized control and execution).

The fully mature bomber AMPS would provide a battle management system that could respond adaptively to real-time changes in guidance, direction, threat, or aircraft status. It would be able to process, correlate, prioritize, and display mission-significant events to the crew. Some of the events requiring mission replanning would be unexpected threats, new directions from higher headquarters, and aircraft system status alarms. The AMPS, applying heuristic algorithms, would automatically calculate route updates for terrain masking, fuel conservation, aircraft and weapon employment tactics, and dynamic deconfliction. It would execute a new course of action on crew command (autonomously or by implied consent, for predefined noncritical actions). The primary objective of the bomber AMPS would be to optimize both the expected damage against the executed target system and the probability of aircraft arrival at the poststrike base.

Further, the system would have growth capability. The AMPS rule tables could be revised and refined as new sensors, communications systems, and computer technologies evolve. When the crew members disagree on the specific actions and sequence and timing of actions taken in response to a new mission event, they could be authorized, within certain approved limits, to reprogram their AMPS to accommodate different flying techniques. The bomber's inherent adaptability in conflict, coupled with its enhanced capability to avoid or destroy threats during the mission, would mean more weapons on target before the aircraft reached its poststrike base. In short, the onboard replanning capability of the AMPS would represent an important force multiplier in that the manned bomber would adapt better to the "fog of war," and hence would realize the full warfighting potential of the "man-in-the-loop."

Applying the Concept

Obviously, there is much to be done before AMPS becomes a reality. First, we must agree, in concept, that AMPS really could make a difference in executing US military strategies, and then decide on how, when, and where an AMPS could be applied to gain the greatest military return on an investment. The Strategic Air Command seeks to capitalize where it can on the benefits of adaptive planning. Accordingly, several SAC adaptive planning initiatives are under way. For example, the second edition of the *SAC Adaptive Planning System Master Plan*, approved by CINCSAC, provides a roadmap for improving adaptive planning systems and procedures throughout the command until the year 2000. Many AMPS programs, including prototypes for inflight replanning of the B-1B and the advanced technology bomber, are under development. The Pilot's Associate Program and other initiatives highlighted in Project Forecast II are also evaluating the feasibility of deploying expert systems on board an aircraft. But support for AMPS must also exist at the "grass-roots" level--at the combat unit where plans are executed and the need for adaptive planning is best determined. Both planners and operators must justify their AMPS need to the appropriate authorities. Perhaps every Department of Defense (DOD) organization responsible for developing weapon systems should determine an appropriate level of adaptive planning for each new weapon system and what sort of AMPS already exists or should exist to support that level.

Summary

Adaptive planning is important because it improves our prospects for defeating a numerically superior adversary under unpredictable conditions. Projecting the "experts" into the basic battle unit, in the form of a knowledge-based adaptive mission-planning system, gives the battle unit an important edge: it can quickly compute and execute on command high-leverage mission-planning solutions to highly complex battlefield problems. Some quality control may be sacrificed to achieve speed, but a timely plan is much better than a perfect plan that is too late to carry out the mission. The strategic bomber is one of the many military weapon systems that could benefit from an AMPS. DOD organizations responsible for establishing requirements and developing technology for weapon systems should consider the need to provide adaptive planning support for those systems.

"Systems that can function 'intelligently' as consultants or advisors will become commonplace in the next decade."[4] We must not ignore the tremendou potential that knowledge-based, expert systems offer. By cloning expert knowledge into a weapon system AMPS, that weapon system can adapt more rapidly and effectively to unexpected events. Weapon systems using the leverage provided by adaptive mission planning have greater potential for prevailing in combat.

Notes

1. National level directives on weapons employment, such as National Security Decision Directive (NSDD)-13, NSDD-178, and Nuclear Weapons Employment Policy (NUWEP)-84 make it clear that adaptability in our forces and $C^3$1, and thus in our planning, are prerequisite to effective war waging.

2. Edward Fiegenbaum, "Knowledge Engineering for the 1980s," Computer Science Department, Stanford University, 1982, 1.

3. Col Pat O. Clifton, *Artificial Intelligence: A User Friendly Introduction* (Maxwell AFB, Ala.: Air University Press, 1985), 19.

4. Ibid., 55.

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