CP-594

Mission Re-Planning for Standoff Weapons

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I. SUMMARY

This paper frames a general discussion of current air campaign planning methods at the campaign and mission command echelons, and discusses the operational and technical mission re-planning requirements required for standoff weapons to engage fleeting targets or targets discovered immediately before or during a weapons delivery mission. Some weapon systems already have the technology needed to engage this threat; doctrinal advances and allocation of scarce sensor and weapons resources are the driving factors preventing effective fleeting target engagement.

II. Introduction

While this conference addresses unmanned aircraft, certain medium and long range standoff air-to-surface weapons take on many of the same characteristics such as navigation and target detection. Navigation to a target area or attack point must be planned along with target location and characteristics. A typical mission planning session for stand off weapons will address this information. In the heat of battle, new high priority targets may be discovered, known and planned targets may move, or designated targets may be destroyed before weapon launch or the weapon terminal attack phase. In any of these situations, it is desirable to re-plan or redirect the weapon

In order to understand mission re-planning, we must first understand how the mission was originally planned. A close understanding of both the campaign and mission level operations cycle is necessary before considering how and when mission re-planning can occur. Since mission planning and re-planning take place primarily at the command echelons, they will provide our fundamental operational considerations. From these, we will derive some basic technical requirements for engaging the more difficult target types.

III. Planning

We define planning as happening at two distinct levels of command, each operating with very distinct decision sets and timelines for reaching those decisions. Campaign planning includes the theater level planning of overall objectives, sensor and other theater level asset tasking, developing of unit level tasking, and targeting priorities. Mission level operations are concerned with

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carrying out the actual mission of platform/weapon to target delivery.

In most air campaigns today, there may be several other levels of command hierarchy present, such as the wing, unit, squadron, or base level command. In most cases, these hierarchies are limited to an 'organize-train-equip' role in the modern air war. Only in rare exceptions are they directly involved in target selection. They only provide the resources and infrastructure needed to strike targets. We will consider the flight or force level command hierarchy as being included as part of mission level planning — force packages consisting of one or more platforms directly responsible for carrying out a target strike, supporting a target strike, counter-air over a particular geographic region, or a similar mission.

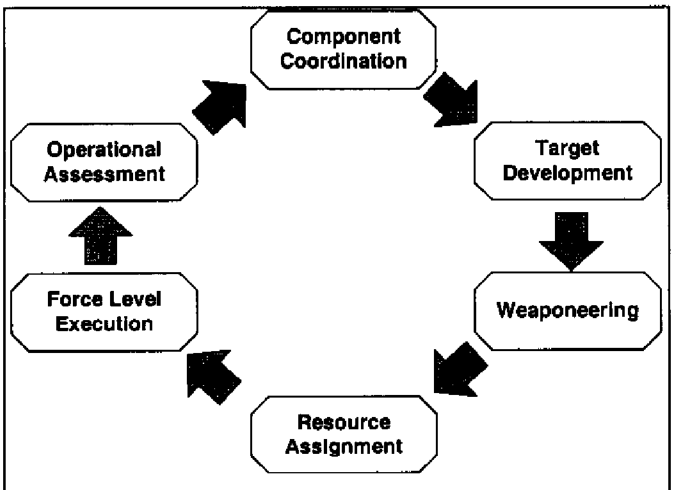

Figure 1 Operations Cycle -- Campaign Level

A. Campaign Level Air Tasking Cycle

The operations cycle at the campaign level generally follows the six steps outlined in figure 1. The purpose of planning at the campaign level is to ensure that joint air operations are carried out both efficiently and effectively. These steps are normally carried out in a centralized location (an Air Operations Center, or similar), with planners, targeteers, intelligence officers, other service, or allied liaisons, and operational experts in the same location as the senior decision-maker. Only the briefest of summaries is given here.[i, ii]

The cycle shown is repetitive and continuous from day to day. In general, there are at least three task orders in planning or review in this cycle at any one time. Today's task order is being carried out, which means that the campaign level personnel are tracking current developments in execution status. They are carrying out the latter two steps of the air tasking cycle. The middle two steps of the air tasking cycle are simultaneously working tomorrow's task order — defining and disseminating mission "solutions" to the problems that were posed in the first two steps which are concerned with more broadly defining the following day's strategic plan and target priorities.

The tasks listed are broad and over-simplified for our use. In reality there is continuous task overlap and information, and personnel are involved in many different phases and sub-tasks.

1. Component Coordination

Initially, the theater commander consults with ground, air, and naval component commanders to review the progress of the warfighting effort, and to provide overall guidance. His component commanders will recommend target sets (and possibly priorities) to meet the theater commander's guidance. The output of the component coordination task is the sortie apportionment, which defines the percentage of available sorties to be used in various air task categories, such counter-air for air superiority, strategic attack, interdiction, or close air support. This apportionment ensures the most effective use of the limited air resources in support of the theater commander's intent and objectives.

2. Target Development

Each component now brings to the limited air resources a list of prospective targets. After extensive coordination among the staffs, a prioritized target list will be produced, along with supporting guidance, rules of engagement, and other information.

3. Weaponeering

Once a prioritized list of targets and objectives (destroy, damage, neutralize, delay) is available, targeteers define the aircraft/platform/weapon combination most likely to produce the desired result. They will consider aim points, fusing, approach direction, angle of attack, target identification, threat areas, probability of destruction, etc.

Other planners are simultaneously constructing force packages to meet the mission requirements, grouping targets similar in location or nature, and defining support aircraft needed to ensure an individual mission's success. For example, surveillance missions, Suppression of Enemy Air Defense (SEAD) strikes, and electronic warfare missions may all need to be flown prior to, or in conjunction with, an air interdiction mission in one or several regions.

Taken together, the weaponeered (and prioritized) target set, target location, enemy defenses, apportionment decision, and overall guidance will determine roughly the schedule and type of missions needed.

At this time the range and likely release points of the weapons will be considered. While the release point of an unguided direct attack or gravity weapon is a major component of the impact point, guided gravity weapons have guidance kits that allow considerable offset from a purely ballistic strike point. Powered weapons and longer range stand-off weapons fly complete flight paths of many miles on their own after launch.

4. Resource Assignment

Armed with an overall plan of attack for tomorrow's operation, the difficult task of assigning many aircraft from many locations (and possibly services and nationalities) to many different targets begins. They also must define call signs, IFF, frequencies, etc. This process takes anywhere from six hours for a small or routine air campaign to twenty four hours for large or contingency-based operations.

Throughout this time period, other planners work airspace control issues — safe ingress and egress aircraft routes — as well as determine span of control issues for air defense and air control. They also finalize tanker and other support aircraft sorties.

The output of this phase is a set of mission lines, defining to a very explicit level of detail the aircraft/platform/weapons to be used to destroy known aim points of specific targets at specific times. This information is passed to the force level for execution with enough time for unit-level preparation before the first targets are to be struck.

5. Force-Level Execution

This includes all the various and sundry tasks involved with carrying out the resource assignments so meticulously made in the previous task. At the campaign level, combat operations personnel are monitoring current developments and making "real time" modifications to previously published orders based on weather or enemy reactions. They also monitor battle damage assessment and in flight reports.

6. Operational Assessment

The operational assessment phase is where the overall results of the on-going air operation is evaluated, including munitions effectiveness, and recommendations. Planners involved in this task must weight likely enemy courses of action in light of successes to date, and make recommendations to both the air component commander and theater commander as to how to best use current air resources in order to further the campaign objectives. Although it is listed as the last task, it is in a very real sense also the first task, providing the inputs necessary to continue component coordination, target priorities, weaponeering and allocation, and future resource assignments.

B. Mission Level Operations

Mission operations, as we have defined them here, have a much longer history than campaign level operations. Individual aircrews have been briefed on the target to be hit along with suggestions on how to conduct the raid since World War I pilots dropped shells on enemy positions. Given the complexities of today's weapons, we have large planning assistance computer programs such and the Air Force Mission Support System (AFMSS).

1. Mission Planning

Ranging from receipt of the air tasking order (target, objective, weapons load, and time over target) and scheduling the aircrew to providing a tape or mission cartridge for downloading information to the aircraft mission/stores/weapons management system and the weapon itself, the mission planning process is critical to the successful delivery of the weapon.

This task includes analyzing the target and objective area to confirm proper weapon selection and gathering scene perspectives. Likely enemy defenses and threat within the target delivery zone and the route are defined. The actual weapon delivery parameters (range, altitude, direction and angle of attack, speed, weapon setting, etc.) are chosen, and platform maneuvers to attain those delivery parameters are finalized.

Backing up from the delivery point, platform planners determine a safe and efficient route to position the weapon for delivery and still meet time-on-target demands. These include launch, possibly landing and divert locations, air refueling, and consideration of weather conditions and of airspace deconfliction (safe ingress and egress routes that prevent different aircraft from attempting to occupy the same air space at the same time).

With guided weapons, the release point is more of a release area, somewhat elliptical in nature, from which the weapon may still successfully guide to the target. This area is calculated by the weapon planner/mission planning system based on the range, dynamics, and guidance characteristics of the weapon. This is supported in the mission planning software system by a model (3 Degrees of Freedom (DOF) or 6 DOF) of the weapons characteristics. The planning

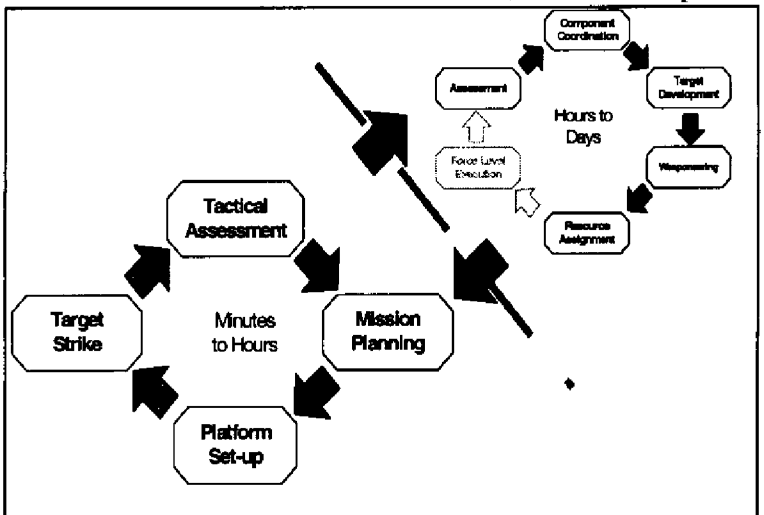

Figure 2 Operations Cycle -- Mission-Campaign Coupling

software can simulate the flight of the weapon and show either the possible impact points from a given release point and conditions or the release area and conditions required to impact a given point with given approach direction and impact angle. Impact velocity which is very important when attacking hardened targets is also calculated.

The entire process is repeated for secondary or tertiary targets, in case the primary target is unreachable or has already been struck.

All of this information (maps, scene perspectives, delivery parameters, etc.) is collectively called a combat mission folder, which aircrews will take with them on the mission. When computer supported mission planning is used, the planning information for each of these targets is prepared and transferred to the aircraft stores management and navigation systems.

On many advanced mission planning computer support systems, planners or aircrews can perform a simulated "fly-by" into and over the target area, with computer visuals, relying on geographic and photographic data allowing construction of a fairly simple, dynamic, polyhedron-based perspective of landmarks and terrain to be encountered on the proposed route.

Our discussion thus far has assumed a ground-based planning cell, with minutes to hours at their disposal to plan a target strike. During divert missions, planners must go through essentially the same process, usually in drastically shortened timeline. Where and how this re-planning should be done, and how long this type of re-planning might take will depend on many different factors, which we will defer until section IV.

2. Platform Set-up

From the time the tasking for a particular mission is received from the campaign headquarters, the support crews for the platform/weapon combination have been busy as well, preparing and loading the weapon system for its designated mission.

The mission planning computer support systems mentioned earlier also support a data transfer device from the computer workstation to the platform/weapon. It will load the planner's decisions onto a read/writeable media that can be carried to the platform and will automatically initialize the aircraft and weapon with way point information, weapons parameters, and the like.

3. Target Strike

The target strike is the instantiation of the entire mission planning effort, both at the campaign and mission operations level.

This task, the culmination of many man-hours of thought and effort, usually is accomplished on the order of seconds.

4. Tactical Assessment

Both the last and the first step of any mission — a tactical assessment of the target area is both an input into the mission planning task and an output, to be fed back into the force-level execution task at the campaign level.

IV. Mission Re-planning

A. General Considerations

We set the stage for our operational consideration of re-planning activities by considering two fundamental questions — what causes mission re-planning, and what impacts the re-planning process?[iii]

B. Mission Re-Planning Causes

The causes of the need to re-plan or re-direct a mission are discovered at various points in the timeline and command level where the re-planning takes place. Not surprisingly, there is a close correlation between the two. While there are many reasons for re-planning, several stand out:

Availability of friendly resources. An increase in capability or availability of bases, aircraft, or weapons means in turn an increase in available sorties and the possibility of attacking new or multiple targets that could not safely be attacked at that time with the lesser capability.

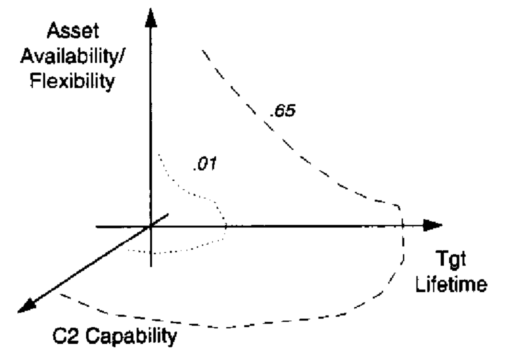

Figure 3 Probability of sortie success based on mission-re-planning considerations. What might iso-probable surfaces look like?

New target priorities. New target priorities will be primarily determined based on operational successes or setbacks to date. SEAD missions may take priority over interdiction, if initial intelligence underestimated enemy threats. Unexpected successes also open up the possibility of attacks that even though highly important were thought too dangerous to attack until later.

New priorities will results in different apportionment, as the theater commander shifts his emphasis, and under current operations would take a day or more to fully implement. Re-planning based on new target priorities is currently the purview of the campaign planning staff.

Urgent Close Air Support (CAS) (or other high priority) targets. Every air campaign allocates some portion of its strike forces to close air support, where the exact time or need of the air mission may not be known. These forces are normally allocated to support a particular geographic region. Since aircraft are normally on the ground or possibly even air alert status, mission planning (or re-planning) is done dynamically. In some cases, the general location and type of strike desired is usually known, and the target timeline is relatively long, even for mobile targets. These missions will have been previously allocated for and planned by the campaign planners. In other cases, the location and type of strike required may not be known *a priori*. This is the case of the fleeting target, which we will discuss in much more detail below.

Mission parameter changes. Weather, enemy defensive changes, or lack of accurate target intelligence, etc. characterize the normal divert mission of aircraft. Nearly all missions plan a secondary target site, in case the first is already destroyed or unreachable. Relatively few divert missions are solely targets of opportunity — those that are usually fall into:

Critical emerging threats. Individual targets may emerge during combat that fundamentally impact or even threaten the theater commander's battle plan, like the imminent deployment of weapons of mass destruction. Substantial mission re-planning might be required depending on the target set and its defenses. Again, although the timeline required is shorter than new priorities, it would remain the prerogative of the campaign planner to find the resources needed to attack this target. This scenario is not likely to happen very often. There are few individual targets, that would not have been recognized, of such danger that an entire day's or campaign's operation would be in jeopardy unless they were struck. These would require a significant resource commitment within a very short timeframe.

C. Mission Re-Planning Considerations

There are two primary considerations for mission re-planning feasibility: asset availability/flexibility and target lifetime. Both of these are influenced by the command and control capability that can be brought to bear.

Asset availability/flexibility. This factor primarily combines the number and type of platform/weapon available, the flexibility of that asset to engage different types of targets, and the range (time) needed to engage a given target. Obviously, if a theater has a high number of resources available to it, if the current platform/weapon combination is easily engaged against multiple target types, or the range from a current target to a new one is small, then both the mission and campaign level commanders have considerable latitude in mission re-planning (all other things being equal).

Target lifetime. This is the time that a target's location and defenses can be reliably tracked by the current information resources brought to bear. A tank column in motion with mobile air defense units is representative of a short target lifetime. A power plant with fixed defensive units has a longer lifetime and the time that it is to be neutralized is dependent on its function rather than its availability as a target.

Influencing these considerations are the command and control capability of both sensor to platform/weapon, and within the battle space.[iv] How accurate and timely is the targeting information to the platform crew /weapon? Can highly mobile or fleeting targets be tracked outside their "move-launch-move-hide" window? How much time will be needed for mission re-planning activities, including possible mission rehearsal? How long will mission coordination, including possible air-refueling, SEAD, electronic combat (plus airspace control over all of these) take? Note these questions concern both operational and technology considerations.

A combination of these two critical considerations could lead to a given probability of sortie success. Since command and control capability is not completely independent of target lifetime or asset flexibility, the orthogonal relationship in figure 3 is notional. Nonetheless, a "go/no-go" decision should be made based on the probability of mission success. Where and how this decision should be made, and some technical considerations that will enable the decision-making, is postponed to section VI and VII.

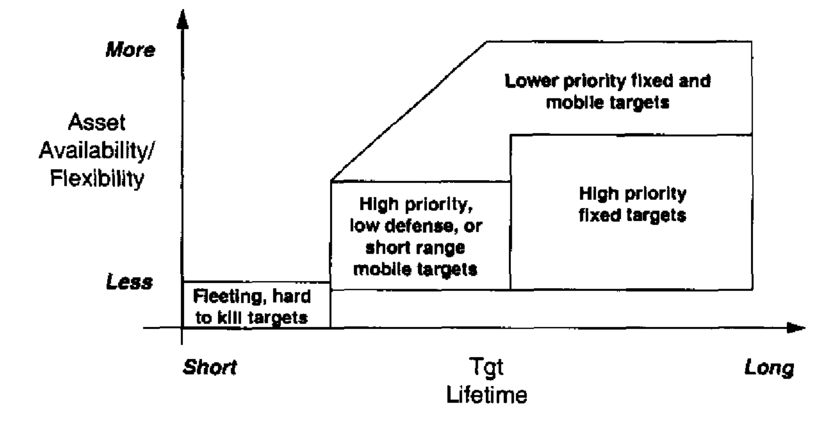

Figure 4 Target Categories

V. Target Types

With the following background in hand, four different types of targets are clear, with different re-planning needs for each of them (see figure 4).

We will deal with the first three in relatively cursory fashion. The driver for new operational and technical considerations lies in the fourth category.

Lower priority targets have varying target lifetimes, but are usually well within today's operational and technical capabilities. Because of their priority, they can be considered later in today's or the next day's planning process. Missions against targets of this nature are routinely re-planned at the campaign level operations (the Air

Operations Center), or as divert missions for close air support.

High priority fixed targets have somewhat less asset flexibility and availability associated with them, because they must be neutralized quickly. Because air assets are either involved in planning for or dedicated to other operations, the mission re-planner will have less flexibility for dealing with them. Mission re-planning will initiate at campaign level, with close coordination with mission level crews once resources are identified. As with the above, no significant operational or technical changes are needed.

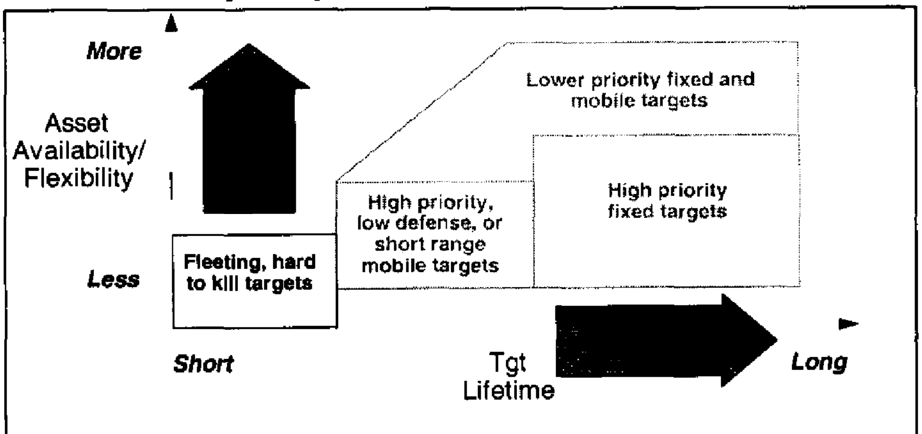

Figure 5 Considerations for killing fleeting target sets -- two degrees of freedom are possible

Air To Surface Weapons
- Unpowered
  - Unguided
  - Guided
    - Inertial Only
    - GPS Aided
    - Man-in-the-loop
    - Autonomous Seeker
    - Cued
- Powered
  - Guided
    - Inertial Only
    - GPS Aided
    - Man-In-The-Loop
    - Autonomous Seeker
    - Cued

Figure 6, Families of weapons

High priority mobile targets that can move easily, but must stop and set up to be dangerous, represent the class that has the best improvement-priority product. Technology can improve the probability of hitting these targets before they can hide or be lost in a cluttered environment. The location of such a target must be communicated through the observing source, various command information channels, to the flight control for the designated strike aircraft and to that aircraft itself. In the case of a "smart" weapon the target parameters must also be communicated to the weapon's guidance and control system.

VI. Weapon Characteristics

Today's "smart" weapons are a far cry from the "dumb bombs" from years past. The weapons of the past acted like chunks of iron and simply fell toward the target. Today weapons take on characteristics more like piloted aircraft. The weapons fall into families that have varying degrees of aircraft-like characteristics. The first delineation is direct attack or stand off. In direct attack, the pilot of the delivery aircraft maintains visual contact with the target through launch. In stand off attack, the pilot launches the weapon and then can turn to avoid the immediate target area.

A. Air-to-Surface Weapon families

When considering the different classes of weapons, it is common to consider first the separation of those that are powered and those that simply fall or glide toward the target. It makes more sense first to divide weapons into categories based on whether they are guided or not and then on the type of guidance. Whether they are powered or not does affect range, but a similarly guided unpowered weapon can perform much like a powered cousin in short ranges. Next, if the weapon is guided, we consider those that have seekers and those that have some other method for finding the target.

Without a terminal seeker, a weapon must rely on some knowledge of its location. We will assume that a data link or some other man-in-the-loop guidance scheme is not feasible without a terminal seeker, so the weapon must determine its location internally. Two common methods exist.

The first is inertial guidance based on position, angle, and rate information transferred from the launch aircraft to the weapon prior to release. For inertial guidance to work, the weapon must also know the inertial space location of the target. The target location in the coordinate system agreed to by the launch aircraft and the weapon is one of the primary parameters loaded from the mission planning system.

Inertial guidance has great benefits when first considered. It is relatively simple, costs have been falling, and it does nothing to alert the enemy of its presence. Unfortunately inertial instruments drift. The longer that a weapon flies from a known location, the less precise its estimate of its location is. This translates to a larger miss distance of the weapon impact. This produces two problems. With relatively small weapons and hardened targets an unacceptable miss distance can cause the strike to be ineffective. The second problem is that of collateral damage. High value targets are often placed adjacent to civilian or religious facilities. Accidentally hitting such a location in the era of CNN can cause loss of will on allied sides, as well as strengthening the resolve of the enemy.

Second, a method that would reset the inertial error before it becomes unacceptable, would keep miss distances within the required values. The Global Positioning System (GPS) performs this function well. A receiver on the weapon constantly updates the inertial system's estimate of position. Since the inertial system can maintain position accurately for short periods of time, the weapon can continue to guide during GPS signal dropout.

Those weapons that have terminal seekers fly out to the target vicinity using inertial guidance and then attempt to remove aim point error by allowing a terminal seeker to provide final guidance commands to hit the target. Weapons with terminal seekers may be totally autonomous, or guided by some external cueing device or via a data link from a person that has information from the trajectory of the weapon.

Autonomous seekers perform some form of target recognition or image analysis to detect, identify, and guide to the target. The mission planning information necessary for this type of seeker is quite complex and involves building models of the target and being able to recognize the target in different weather, at different approach angles, with a portion of the target destroyed, and with smoke. Re-planning of this type weapon is the most difficult technically.

Man-in-the-loop (MIL) seekers, have some form of data link to allow an operator to view information such as a television or infrared video stream from the weapon's seeker. The operator must simply fly the weapon to the point on the target previously designated. Mission planning for this type of weapon consists of inertial information to provide flight path and information such as photographs that will assist the operator in recognizing the target.

Cued weapons have a seeker that responds to targeting information such as a coded laser spot on the aim point. This is a variation of the MIL seeker but in the conventional MIL system, the weapon operator is located in the launch aircraft or another aircraft in the flight. In a cued system the person controlling the terminal approach of the weapon (target designator) may be anywhere within visual range of the target. Mission planning for cued systems involves providing targeting information to the designator as well as ensuring the proper inertial flight of the weapon to a point where cued guidance is possible.

B. Route

The route from takeoff to weapon impact for a stand off weapon is divided into distinct and separate activities. The carrier aircraft transports the weapon to a launch point within the weapon's range of the target. This launch point does not have to be exactly precise; therefore, a region or launch "basket" is defined. The target location, weapon's range, and the flight dynamics of the weapon define the size and position of the launch basket. A truly stand off weapon will navigate in an aircraft fashion using way points and route segments to avoid threats and obstructions to a terminal transition point or terminal basket. Each of these route segments must be flown to avoid most if not all of the danger from ground based anti-aircraft weapons. The terminal basket, in the vicinity of the target, is much smaller and the exact location of the weapon is much more critical than the weapon launch basket. During the terminal phase, the weapon can perform high G maneuvers to approach the target at the exact aim point and at an effective impact angle. It is the purpose of mission planning to build routes that will minimize this danger.

VII. Re-planning Requirements

Since re-planning before weapon take off can be worked as a modification of the normal planning process, we will only discuss in-route re-planning. Each type of weapon presents a different problem and opportunity in re-planning. A direct attack weapon with no guidance capability is planned and re-planned just as the carrier aircraft, because there are no other methods for affecting the performance of the weapon other than through ejection/launch conditions.

In order to re-target an inertial guided weapons in route, the new target's coordinates in inertial space must be communicated to the navigation and guidance systems both on the launch aircraft and the weapon. This requires some data path from the analysis center, surveillance aircraft, or other source with precise knowledge of the precise location of the target and aim point. The position information must be transmitted to the launch aircraft, assuming that the target location system is not on the launch aircraft, processed, and then communicated to the weapon. This also requires that the aircraft can transmit location data to the weapon. Therefore, an inertially guided weapon that is programmed on the ground and then carried on an older aircraft without a weapons bus cannot be re-targeted (re-planned) in route.

Re-targeting of a GPS-aided, inertially guided weapon has essentially the same requirements to transmit target position information from the planner to the weapon.

Weapons with an operator in the guidance loop must be given the approximate position where terminal (MIL) guidance is to begin so that when the seeker is turned on, the target is in the weapons field of view. The operator who guides the weapon during the terminal phase to target impact must be given information (pictures, maps, and/or diagrams) to find, recognize, and positively identify the target and to select and track the aim point.

Re-targeting for an autonomously guided weapon represents the greatest challenge. The initial targeting involved building models of the target, determining feature vectors, analyzing the effect of approach angle on the appearance of target, and many other operations. To retarget an autonomous weapon, all of these steps are necessary along with the necessity to transmit target recognition information to the weapon. This requires significantly greater bandwidth of data communication between the planner and the weapon.

The re-targeting of cued weapons is similar to that of the man-in-the-loop weapons. Position of the release point from the aircraft or the point where the weapon goes into terminal mode must be transmitted to the aircraft and weapon. Also, the exact target information and aim point has to be transmitted to the operator of the illuminator or cueing device.

A. Information flow/technical requirements:

Each of the above methods that require transmission of targeting data to the aircraft or weapon introduce required analysis of bandwidth of targeting information, communications capability and bandwidth to the weapon, ability to adapt to changing requirements, range of possible communications, etc.[v] The result of this analysis for each weapon will create individual specifications for the communications scheme.

B. Operational requirements:

The operational requirements may represent a more difficult decision than the technical. This analysis must determine: Who should decide when and how to re-plan and attack? What information does the shooter/decision-maker need? What information does he definitely not need? These and other questions must be addressed in concert with the technical requirements.

VIII. Implications for Unmanned Tactical Aircraft (UTA)

UTAs can contribute to the solution space – they can help either axis to increase our effectiveness. They can increase the target visibility lifetime axis by loitering in areas of prospective target availability to be on station to observe a target that becomes visible. Also they can increase the weapon availability axis by carrying weapons or designators so that once a target is detected, they can participate in its neutralization.

Information transfer of targeting information is similar for UTAs to that for weapons. The UTA will, however, generally also provide intelligence information from their operational area to the various command centers.

IX. Philosophical Considerations

The idea of a pilot or flight leader redirecting a weapon strike generally goes against the current 'centralized planning, decentralized execution' much prized by today's planners. This is in reaction to past campaigns where much of the massing, surprise, flexibility, and economy of force that air power brings to a campaign was lost when that air power was parceled piecemeal out to ground forces.

The operational considerations listed above, in particular with delegation of 'clear to shoot' authority, and relaxation of rules of engagement (ROE), will be a long time coming. In fact, the technology will almost certainly have to be present and the operators thoroughly comfortable with it before any movement downward in clearance to release. Ironically, that same technology that brings a flow of information into the shooter, and that should bring greater freedom to him, may also be feared by him. The same communications suite that carries vital targeting information to him could just as easily transmit data back to the command center and mean that a flag officer could read his HUD and direct him when and how to engage a target.

X. Conclusion

Technical solutions exist to the problem of redirecting weapons to new targets if those new targets can be located and the information communicated to the attacking aircraft. Each of the types of guided weapons discussed has a mechanism for target position/recognition information to be stored and used. For redirection to be accomplished, some form of communications channel must be established from the target selecting person to the aircraft, weapon, and, if applicable, the designator. With some weapon systems, the necessary communications channels only need minor modifications, with others new equipment and significant changes are necessary to the aircraft and weapon. These channels can be established with today's technology, but fundamental changes are necessary to the planning doctrine.

XI. References

[i] Joint Publication 3-56.1, "*Command and Control for Joint Air Operations*", 11 November 1994

[ii] United States Air Force Air and Ground Operations School (AGOS) Computer Based Training Course, "*Joint Air Operations Center Operations*", December 1996

[iii] P. Sergent 3 Feb 97 working level memo to AGARD/MSP WG-03 members

[iv] Advanced Battlespace Information Study (ABIS) Task Force Report, Vol. I - VII, September 1996

[v] United States Air Force Scientific Advisory Board (USAF SAB), New World Vistas, December 1996