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Survivability Options for Maneuver and Transport Aircraft

Analytic Support to the Army Science Board

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Summary

Overcoming the Paradox in Operational Maneuver

Historically, when commanders have been able to leverage and exploit operational maneuver, they have enjoyed significant military advantages and outcomes on the battlefield. Despite the growing importance of operational maneuver, it has been difficult to realize its full potential in terms of combined speed and combat capability in the new era of warfighting. On one hand, modern transport aircraft can offer speed in the delivery of forces, but they can generally move only light forces in large quantities. These forces have limited tactical mobility and combat capability once delivered. On the other hand, heavy armor forces that are tactically agile and offer highly effective ground combat capability can generally only be moved relatively slowly. Such forces are typically transported by the surface network system (e.g., roads, rail, and sea). Thus, the ability to provide combined characteristics of speed and combat capability has become a modern-day warfighter’s paradox. If this inherent contradiction could ultimately be resolved, however, it could revolutionize ground operations on a future battlefield.

Over the past several years, the Army has been aggressively exploring and developing a new way to fight, one that involves much lighter armored vehicles equipped with the highest levels of informa-

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1 Refer to Chapter One of this document for a formal definition of operational maneuver.
tion technologies. Part of the utility in developing this new way to fight is to develop a solution to that paradox: air-based operational maneuver.\textsuperscript{2} The combined capability of new, advanced transport aircraft in conjunction with future ground vehicles represents the central theme of a new, transformed military force. Interestingly enough, this capability is seen by some in the defense community as \textit{long overdue}, as it is simply the next logical step in mechanized warfare and an extension of ground operational maneuver as it has been conducted in the past. By others, however, it is seen as a \textit{bridge too far}, given technological and budgetary constraints. Nonetheless, few would argue about the overall warfighting advantage such a force would provide to the combatant commanders and the National Command Authority.

\textbf{Assessing Survivability}

With respect to technological constraints, one major area of ongoing debate is the survivability of large transports. More specifically, given the nature of the changing air defense environment, can large aircraft survive against modern air defense capabilities? Since the end of the Cold War, the air defense environment has in some ways become even more dangerous for aircraft. A proliferation of surface-to-air missiles (SAMs) is under way, in which advanced air defense systems ranging from man-portable air defense systems (MANPADS) to larger multivehicle high-altitude air defense systems are being openly marketed and sold by various countries. In parallel, SAM technology and system capabilities continue to improve as an asymmetric response to U.S. air supremacy.

This research sought to assess the survivability questions facing a large transport aircraft in a plausible future scenario at the small-scale

\footnote{2 Light forces would have the additional benefit of being strategically deployable (in a matter of days) with the appropriate allocation of airlift.}
This study was conducted at the request of the Army Science Board (ASB), and it represents one part of a much broader study that is aimed at developing and shaping a Science and Technology (S&T) and Research and Development (R&D) roadmap to meet future Army aviation needs. Using a conceptual framework developed by the ASB, RAND, through its Joint Warfare Simulation and Analysis (JWSA) group, identified and then conducted a “quick-look” assessment of a range of survivability concepts and technologies. Quantitative, high-resolution models and simulations were used as part of the analytic process. Key research findings are summarized below.

Survivability Technologies Are Becoming Available

Although there is clearly a desire for aircraft to operate outside of enemy airspace (or above it), this may not always be possible. For instances where aircraft may be exposed to air defense systems, there are technologies both near term and farther term that could be integrated into the layered conceptual framework posited by the ASB. Specifically, the ASB envisioned a survivability framework that included three major tiers: preparation of the battlefield, team protection, and individual protection. In keeping with the structure of the ASB framework, the technologies were broken down according to the kind of protection or layer in which they contribute. The technologies were categorized as either near term, where the technology is either already proven or is potentially available within the next few years or so, or farther term, where the technology is seen as somewhat less mature but could be available for implementation within the next decade or so. A summary of these technologies is shown in Table S.1.

For near-term technologies, perhaps most notable are the infrared countermeasures systems, which typically involve the use of an array of passive infrared sensors to detect the launch of a missile (e.g.,

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3 The threat was based on a modernized version of forces seen in Operation Allied Force in Kosovo in 1999.
Table S.1
Near- and Farther-Term Technologies for Improving Survivability of Large Transport Aircraft

<table>
<thead>
<tr>
<th>Layer of Survivability</th>
<th>Near-Term Technologies to Incorporate</th>
<th>Farther-Term Technologies to Develop</th>
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<tbody>
<tr>
<td>Preparation of the battlefield</td>
<td>• Advanced RSTA systems (e.g., foliage penetration radar, small, agile UAVs, or unattended ground sensors) • Prep fires using area weapons (e.g., fuel air explosives)</td>
<td>• Long endurance, autonomous loitering aircraft/missile, with target recognition • Long-haul command, control, and communications • Clearing of landing zones with energy weapons</td>
</tr>
<tr>
<td>Team protection</td>
<td>• Low cost expendable decoys • Small high-speed anti-radiation missile (HARM) • Low-cost autonomous attack submunition (LOCAAS)</td>
<td>• Unmanned Combat Armed Rotorcraft (UCAR) • Directed energy (solid state lasers) for hard kill of airborne SAM</td>
</tr>
<tr>
<td>Individual protection</td>
<td>• Suite of Integrated Infrared Countermeasures (SIIRCM) • Directional Infrared Countermeasures (DIRCM) • Suite of Integrated Radio-Frequency Countermeasures (SIRFC) • Hybrid lightweight armor</td>
<td>• Airborne version of the small low-cost interceptor device (SLID) • Directed energy; Multifunction electro-optics for defense of U.S. aircraft (MEDUSA) • Signature reduction • Intelligence obscurants</td>
</tr>
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</table>

a shoulder-launched MANPADS). After detection, these sensors can be used to orient either a high-energy lamp or laser that can “blind” or damage the sensor of an incoming missile, causing it to lose its “lock” on the aircraft. Two specific systems that are available today are the Directional Infrared Countermeasures (DIRCM) system and the advanced threat infrared countermeasure (ATIRCM) system. These systems have already been shown to provide some protection against different kinds of IR-guided missiles.

An exemplary farther-term technology that shows theoretical promise is the application of unmanned aircraft, specifically the un-
manned combat aerial vehicle (UCAV) and the unmanned combat armed rotorcraft (UCAR). These systems can potentially serve as decoys, where they are intermixed into a transport package, or as “hunters” that rapidly neutralize air defense systems as they expose themselves to engage the flight of the transports. If this technology matures, it is possible that both applications will evolve.

Individual Technologies Show Limitations in a Robust SSC

In this research there was a broad expectation that the survivability challenge could be overcome by the novel application of technologies. However, no single technology assessed in the SSC scenario appeared to provide a complete solution for ensuring survivability of transport aircraft in defended airspace. In this quick-look analysis, both medium- and low-altitude ingress approaches were considered.

For medium-altitude cases, where the transports were flown in without any kind of protection, more than half the transports were lost. That is, on average, of the 30 aircraft in a transport package, 21 were assessed as shot down, with medium-altitude systems providing the majority of attrition.4 When flown at low altitude, the end results are similar: an average of 23 aircraft were shot down, with more participation from MANPADS and guided anti-aircraft artillery (AAA). From this baseline set of cases, a number of excursions were conducted to assess the impact of: joint suppression of enemy air defense (JSEAD) and destruction of enemy air defense (DEAD), local landing zone (LZ) preparation, unmanned aircraft serving as decoys, unmanned aircraft armed with anti-radiation missiles, and a notional active protection system (APS).5

Essentially, the results for the insertion mission show that individual concepts and technologies can result in a notable improvement

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4 In this analysis, there were no high-altitude SAMs, such as the highly capable “double digit” SAMs.

5 In the analysis, assumptions were made on the success of the operation. For example, the JSEAD aspect of research was conducted parametrically, which assumed removal of SA-15s and partial removal (5 percent) of 2S6 and MANPADS.
in survivability, ranging from ~20 to ~70 percent. The use of low-altitude ingress with an unmanned platform serving as escorts and hunters, armed with a high-speed anti-radiation missile (HARM), was the most effective of the individual cases examined. In this case, we assumed the enemy would engage the formation as aircraft presented themselves, typically shooting at unmanned escorts before the transports. While this resulted in losses of escorts, the air defense systems were essentially suppressed. Despite the relative effectiveness of different survivability technologies, such improvements in survivability still translated to relatively large (and possibly unacceptable) losses of transport aircraft, ranging from 16 to 8 for a single insertion involving 30 aircraft.

**A Layered Approach Can Further Improve Survivability**

Greater effectiveness of the survivability technologies occurred when they were used together. Specifically, a layered, system-of-systems survivability approach provided a more effective means to achieve survivability for transports in this scenario. Using the ASB guidance, survivability starts with intelligence preparation of the battlefield, involves integration of manned and unmanned (MUM) operations through team protection techniques, and ends with platform-centric self-protection technologies.

With a combination of unmanned escorts, JSEAD/DEAD focused at elimination of the SA-15 threat, and landing zone preparation, significant improvement to survivability occurs. For the low-altitude cases, survivability improves to roughly 85 percent for low-altitude ingress (3 aircraft down). Results are not quite as favorable for the medium-altitude ingress cases, with improvement to survivability at 79 percent (5 aircraft down).

From here, the application of advanced technologies, including armed unmanned escorts along with a notional active protection system, brought about even greater improvement to the survivability of the manned aircraft platforms (at the expense of the unmanned escorts). For the low-altitude ingress case, the survivability improved to 97 percent, resulting in approximately one aircraft lost on average. Results were not as favorable for the medium-altitude case, where on
average approximately two aircraft were lost. Interestingly enough, the active protection system technology, which by itself offered little improvement to survivability of the platforms, brought about improvement when used in conjunction with other capabilities. In some ways, this last layer of defense provided a means to overcome the remaining air defense units or “leakers” that were not otherwise manageable within such a dense air defense environment.

**Observations**

In some ways, this research involved a highly analytic and “clean” representation of the performance of the interactions of air defense and aircraft. For example, in this research it was assumed that all enemy systems are not only operational and online, but also alert and ready to fire. With clever deception methods, it is possible that this state of readiness could be degraded. The impact of poor weather, obscurants, or other countermeasures would also reduce the effectiveness of the air defense systems. Thus, by one argument, the cases examined in this quick-look analysis tended to represent a worst case in “risk.”

On the other hand, a critical assumption here is that the JSEAD/DEAD mission, which is assumed to attrit the most capable air defense system postulated in this SSC (the SA-15), is effective. If this assumption proves to be unachievable, much of the corresponding cumulative survivability gain is lost. Additionally, a clever foe could potentially find ways to neutralize many of the technologies examined here.

Overall, this research suggests that operating in defended airspace even within the context of a SSC, albeit a sophisticated one, is a daunting proposition. Even the “best case” assessed included the loss of an aircraft. While a layered concept and associated technologies can provide dramatic improvement over flying transports alone, the application of such an aggressive deployment approach must be done judiciously. Here, operational benefits must be heavily weighed against potential risk. An analysis of transports being delivered to the
“seam” or “edge” of the defended airspace as opposed to overflight resulted in all 30 transports surviving. With this kind of deployment, the survivability concepts and technologies serve more as a useful hedge against a wide range of battlefield uncertainties, including being able to effectively find the “seam” of the defended airspace.