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Methodologies for Analyzing Remotely Piloted Aircraft in Future Roles and Missions

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The U.S. Air Force’s remotely piloted aircraft (RPAs), such as RQ-4 Global Hawk, MQ-1 Predator, and MQ-9 Reaper, have made significant contributions to current operations in Southwest Asia. Although these aircraft primarily provide intelligence, surveillance, and reconnaissance (ISR) to joint warfighters, armed variants are also able to provide rapid precision strike against time-sensitive targets. The planned increase in RPA inventories over the next several years reflects a growing awareness of the value of these aircraft. In addition, new sensor technologies, such as wide-area airborne surveillance (WAAS), will further augment RPAs’ potential contribution to future warfighting.

Given these developments, the time is ripe for the Air Force to consider additional roles for future RPAs, whether to help address capability gaps that are currently unfulfilled or to replace or complement manned systems in current missions. Thoughtful study is needed to identify promising mission areas, to consider potential platform alternatives, and to analyze how different options could contribute to specific missions and to overall campaigns in cost-effective ways.

This documented briefing discusses a suite of tools and models developed by RAND Project AIR FORCE (PAF) researchers to help the Air Force think through these issues. Figure S.1 depicts the overall methodology for evaluating operational effectiveness. When analyzing alternative force structures, the first step is to identify capability gaps. Sources may include the Air Force Capabilities Review and Risk Assessment and the Multi-Service Force Deployment scenarios. The next step is to develop appropriate mission vignettes that represent a range of ways in which platforms could help fill capability gaps. Next, the trade-offs between different candidate RPAs and other systems (such as manned platforms, satellites, or ground-based systems) should be explored within a series of mission vignettes. The vignettes are selected to represent a range of potential future RPA roles under a range of conditions. Finally, the analysis results in an effectiveness matrix, which describes the conditions under which different platforms and configurations are effective. The operational effectiveness of a system can be defined as the degree to which it improves the warfighter’s level of success in a given set of missions or enlarges the range of conditions under which the warfighter is likely to be successful in those missions. Operational effectiveness cannot be computed from the technical specifications of systems alone but can be observed only in terms of outcomes in an operational context that includes all the other capabilities in the theater, including space and threat systems. Because many or all of the systems being compared do not yet exist, placing the system in an operational context requires constructive simulation. Simulation further allows examination of a
breadth of situations within a relatively short time frame. The effectiveness matrix provides insights into the operational suitability of a given system at the mission level. In order to understand the overall force structure needed, analysis at the campaign level must occur. The result provides understanding of a candidate system’s performance based on campaign-level measures of effectiveness (MOEs).

Additional entry points exist for leveraging PAF’s analytic methodology. For example, alternative candidate RPAs or advanced technologies may be proposed for evaluation. In this instance, the evaluation would flow from the “Define candidate RPA systems” step to the capability-gap step in order to identify which gaps the system or technology might address. Another possibility would be evaluating force structure alternatives (based on budget constraints) in which the study objective is to assess proposed force structures and the analysis would flow to identifying the capability gaps that could arise for each. Last, analysis could start with the mission vignette step, in which the Air Force wants an assessment of the impact of a new threat capability, for example.

The models and tools used in this methodology are depicted in Figure S.2. Their purpose is to analyze the operational effectiveness and cost-effectiveness of RPAs and other candidate systems (including space systems and ground-based assets). Systems must be evaluated at the mission level first for operational effectiveness and then at the campaign level to determine overall Force Structure Effectiveness (FSE). The suite includes tools to analyze specific aspects of platforms, sensor performance against various targets, weapon effects, environmental factors, platform survivability, weapon employment, computational processing of data, and exploitation of sensor products. The individual tools contribute to the mission-level analysis

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1. Constructive simulation is typically a time- or event-stepped abstraction of force-on-force operations, often employing digital terrain for analysis.

2. The reader is referred to textbooks for sensor details, such as *Introduction to Radar Systems* by Merrill Skolnik and *Introduction to Sensor Systems* by Shahen Hovanessian.
performed with PAF’s Systems and CONOPS [concept of operations] Operational Effectiveness Model (SCOPEM). SCOPEM is structured to build a rich vignette, including terrain effects, multiple assets operating together, varied behaviors for platforms, and other features that simulate complex operational environments. The modeling occurs in simple modules of code, which provide insight into the factors that drive mission-level outcomes. MOE examples derived from SCOPEM modules include detection of a target for a sensor, line-of-sight (LOS) obscuration from terrain, and probability of kill from weapon employment. This level of detail is essential to building an effectiveness matrix, which not only identifies effective platforms and CONOPS but also defines the range of conditions under which platforms either succeed or fail at a given mission.

It is not enough to evaluate a platform’s mission effectiveness to pursue a given candidate platform; one must also understand force structure implications of employing a particular RPA. To do so, we explore RPA employment at the campaign level. For example, we would like to know, for a given distribution of targets over an area of responsibility (AOR), what the effectiveness level is as a function of fleet size. A campaign scenario should include mission-level insights, as well as broader considerations, such as basing locations of RPAs and the demand frequency of mission occurrence (i.e., ground truth on target distributions in time and space). PAF has developed the FSE model to perform this campaign analysis. The campaign look afforded by FSE results in a required force size under varying effectiveness levels. The previously mentioned individual tools and the mission-level outcomes from SCOPEM inform the campaign model, FSE. Last, when the force structure evaluation is coupled with cost analysis, a cost-effectiveness examination of the candidate systems is created.
Taken together, this suite of models and tools can help the Air Force explore the most cost-effective ways to take advantage of the unique capabilities of RPAs in the future. PAF is now using SCOPEM to study a set of roles and missions for next-generation RPAs.