In this chapter we consider the policy implications of the preceding analysis and identify strategies for the Army to continue to pursue the concept of vertical envelopment.

Figure 22 depicts the principal finding from the analysis: an FTR capable of carrying a lighter load, for a shorter distance, and around the edges of the battlefield may be more survivable and technically and financially feasible than an FTR aimed at fulfilling the nominal requirements. We also note that the military analysis of the vertical envelopment mission has not been carried out to such detail that these two concepts can be distinguished in terms of their impact on combat effectiveness. *It is too early for the Army to focus in on a single FTR concept. Prospective analyses should remain open to a wide range of options until there are compelling reasons to identify a single concept.*

It is also important to recognize that there is no compelling rationale for either the 20-ton lift or the 500-kilometer all-VTOL radius. The 20-ton number emerged from the Army’s desire to ensure that the FCS could be transported aboard the C-130 and the mistaken assumption that 20 tons was a reasonable planning number for the C-130. The C-130 can only transport 20 tons under the most favorable conditions. It is more realistic to assume the C-130 is capable of carrying between 12 and 18 tons on a routine basis.¹

¹See Cassidy (2001) for a discussion of the lift limitations of the C-130.
After payload, the most significant requirement is radius. The 500-kilometer radius results in significant demands for fuel efficiency and power, implying the need to develop innovative technology to compensate for the associated cost increase.

Is a 500-kilometer radius needed? Figure 23 highlights the entire transportation web for a deployment of the FCS from the home station to the battlefield. The schematic also highlights the circumstances in which a 500-kilometer, all-VTOL, radius would be needed.

Deploying FCS from home station requires ships or large transport aircraft like the C-17. C-17 capacity is a major concern, particularly given other deployment priorities that will limit Army use of the aircraft. In this regard, the Air Force’s proposed C-5 fleet modernization could represent an important priority for the Army.

Once in an overseas staging area, the role of the FTR would depend on the relative location of the staging area, local airfields, and the battle site. It would also depend on the availability of C-130s and perhaps the Advanced Technology Transport, which is a paper design for an advanced aircraft capable of transporting FCS. The ATT is intended to land in farm fields at distances of 750 feet. However, if
the FTR were to depart directly from the staging area or a local airfield, it would not require an initial vertical takeoff or a final vertical landing.

The compelling case for an all-vertical capability is for movement within the battle site. However we have not yet seen scenarios in which 500-kilometer movements are essential. Five hundred kilometers is more typically a distance associated with strategic deployment. This kind of distance capability would be important if we view the FTR as part of the strategic deployment process, moving the FCS from rearward staging bases toward staging bases near the battle site.

There is obviously significant uncertainty as to the actual radius requirements for an FTR engaged in the vertical envelopment mission. As noted above, the actual need will depend on the interplay of various other assets under diverse scenarios. The Army has not yet performed a broad “systems” transportation study, so it is difficult to precisely define FTR needs. Such a study would seem to be a prerequisite for a more-precise definition of FTR requirements.

Figure 24 amplifies the issues of FTR range/radius needs by illustrating the vast overall payload capability of the C-130, the Air Force’s
midrange transport. While the C-17 and C-5 are typically viewed as the Air Force’s heavy lifters, the greater number of C-130s implies that there is actually more C-130 capacity at short range than there is C-17 capacity. There are over 600 C-130 aircraft, and about 300–400 could be made available in a national emergency (roughly 200–300 C-130s are not configured as transports or are older models that would need modifications/extended maintenance to be able to transport a FCS combat vehicle).

Figure 24 suggests that the 500-kilometer range of the FTR might constitute an unnecessarily demanding requirement. There is ample C-130 capacity to bring the FCS to airfields near the battle site. The C-130 cannot provide vertical lift within the battle site, and it is for these shorter distances that the FTR might play a critical role. Reducing the FTR range/radius could have substantial benefits for lowering costs and simplifying technology requirements.

Table 1 highlights many of the variables the Army will need to consider before it can determine whether an FTR is needed and the specific performance parameters that it should fulfill.
Most obvious, but partially forgotten in the FTR policy discussion, has been its central role in FCS transportation and the need to design the FTR for the FCS weight. The programs should therefore be “joined at the hip,” but in fact the FCS is still only poorly defined, and moreover there has been little “crosstalk” between the programs. At this point, the single parameter of weight is the central linkage between the programs. As discussed above, the FTR community has assumed the FCS would weigh 20 tons because of the idealized C-130 capacity. The actual C-130 limitations may be a powerful force to lower the FCS maximum weight, while the need for ballistic protection of the vehicle could increase it. A firm understanding of FCS weight is essential before moving toward consideration of more detailed FTR design options.

There is also the need for additional combat modeling to better understand FTR survivability issues. We only looked at the effects on the FTR of various levels of air defenses. We did not investigate techniques (e.g., swarming) and technologies (e.g., UCAVs and decoys) that may have the potential to reduce or suppress the air defenses to the required levels. Lastly, there is a need to use additional combat modeling to better understand the military utility of FTR and vertical envelopment under significantly more varied scenarios.

Table 2 summarizes our findings from this study. As noted previously, computer battle modeling has shown significant advantages of
the vertical envelopment concept, assuming that the FTR is survivable and can operate freely over the battlefield. However, this modeling is still preliminary and is not detailed enough to support the “nominal” parameters being used to size the FTR. We still do not know if a more limited FTR would provide the same utility and whether operational limitations aimed at improving survivability would erode the FTR’s value. We should also point out that the FTR has not been compared on an equal cost basis with other advanced technologies that might also improve the performance of the Objective Force.

The vertical envelopment concept is sufficiently attractive that the Army may want to continue to consider its feasibility, but it should realize that achievement of the nominal technical parameters is an ambitious and risky goal. To meet this goal in time for the FTR to be deployed with the Objective Force, the Army S&T community has proposed a technology development program that assumes the pace of progress will exceed historical patterns. We find little basis for this optimism.

The study sponsor asked us to find the “knee in the curve” in terms of critical FTR development issues. We found the knee in the curve for FTR cost, technical risk, and survivability. Modifying an existing heavy lift helicopter such as the CH-53E would mean a few hundred million dollars in development cost and result in an “FTR” unit cost
of less than $40 million. The CH-53X would not meet the FTR nominal requirements but might have enough “battlefield utility” to be a relatively inexpensive implementation of the vertical envelopment concept. A new start would cost between $10 billion and $15 billion and FTR unit costs between $100 million and $150 million. The knee in the cost versus performance curve occurs, therefore, between modification of the CH-53E and new start.

Using NASA’s technology readiness levels, we found that helicopters have significantly less developmental risk than tiltrotors and that quad tiltrotor technology is not mature enough at present to warrant its consideration as a potential FTR design. We note that TRLs only evaluate program risk. They do not specify how long it will take to reduce risk to an appropriate level. Until critical subsystems for the quad tiltrotor have been demonstrated, its development risk is beyond the knee of the technology maturity versus performance curve.

The last curve we examined was survivability versus level of enemy air defense assets. Here the knee of the curve occurred between the different generations of currently deployed IR and RF SAMs and AAA. Given that the latest generations of SAMs and AAA are available on the world market, the survivability of an FTR will require that new countermeasures and/or new tactics, techniques, and procedures be developed and validated.

We recommend that the Army S&T community establish more modest goals and the operational community determine if achievement of those goals would allow development of a militarily useful system.

Thus our central conclusion is that there is still a significant unexplored tradeoff space and that it is too early to focus on a point design for FTR or even exclusively on a rotorcraft solution.