We begin our investigation of FTR feasibility by examining today’s transport rotorcraft and the potential for extending their capabilities. We then consider the potential of advanced technologies and the risks and potential benefits associated with new science and technology concepts. An analysis of survivability issues follows, and we conclude by describing our recommendations for how the Army can continue to investigate the risks and benefits associated with this concept.

Figure 2 shows two pictures of the Soviet V-12 experimental rotorcraft that lifted 34 tons in 1969. This craft had two large rotors placed on wings supported by structural members, as seen in the left half of the figure. The V-12 was an experimental aircraft and flew only twice.\(^1\)

The V-12 illustrates an important point about the feasibility of the FTR. It is clearly possible to build a rotorcraft that is significantly larger than current vehicles. Specific to FTR, a helicopter based on current technology could be built and achieve the nominal requirements of 20-ton lift for a 500-kilometer radius. It is merely a matter of building large engines, cargo boxes, transmissions, and blades, all of which could perform at today’s level of operating efficiency. The key questions involve the ultimate costs of such a vehicle, the cost risk, the risk associated with technologies aimed at improved efficiency and cost reduction, and survivability. Equally important are

\(^1\)See Alexander (1975) for a discussion of the V12.
reliability, operating and infrastructure costs, and noise and vibration. Also critical is whether such a vehicle can be made acceptably survivable for the types of missions envisioned for its use.

CURRENT ROTORCRAFT CAPABILITIES

Figure 3 compares the nominal FTR requirements presented in Figure 1 with today’s transport rotorcraft on a payload-radius chart. The payload-radius curves are developed for an all-VTOL mission (vertical takeoff with payload, vertical landing with payload). The curves have been developed for standard Army design conditions of 95°F and hover out of ground effect (HOGE) at 4,000 feet.

The curve shows the nominal FTR requirement at 20 tons and a 500-kilometer radius, and the ability to self-deploy. The figure also shows that today’s large transport rotorcraft have problems meeting FTR requirements. The largest helicopter in the world is the Russian Mi-26. The Mi-26 carries a maximum payload of about 13 tons. The Army’s CH-47F Chinook will be the next most capable (in terms of payload and radius) when it becomes fully operational. The U.S. military’s heaviest lift vehicle today is the Marine Corps CH-53E Sea Stallion. The chart also shows the payload-radius capability of the Marine Corps V-22 tiltrotor. The tiltrotor can lift only 6 tons in these

\[\text{Figure 2—The V-12 Lifted 34 Tons in 1969}\]

\[\text{Photographs courtesy of Ken Duffey.}\]

\[\text{2Current Army aviation infrastructure was not designed to support an FTR-type vehicle. The cost to upgrade facilities needs to be determined and should be the topic of future research once the FTR is better defined.}\]
conditions, but the less severe slope of the radius-payload curve reflects better fuel efficiency in the turboprop mode. In contrast, the steep slope of the Mi-26 indicates poor fuel efficiency.

In addition to the radius-payload requirement, the FTR must have sufficient cargo volume to carry the FCS. Figure 4 illustrates the length and height of the cargo boxes of several relevant vehicles. Although the FCS is not yet designed, there is a preliminary assumption that it should fit within a C-130 cargo box. As shown in Figure 4, the Mi-26 already has a cargo box of equivalent size. The CH-53E has a similar but slightly larger box than the CH-47F, but they are roughly comparable and smaller than the Mi-26 or the C-130. The tradeoff between FCS performance and size has not been completed and may result in a vehicle that can fit in a CH-47F/53E cargo box.

The Mi-26 cargo box demonstrates that it is already possible to lift a cargo box of sufficient volume to carry the C-130 deployable FCS. However, the Mi-26 has neither the range nor the payload capability needed to transport the FCS, nor the fuel efficiency to meet the self-
deployment requirement. We do note that a Mi-26 upgrade program is being offered and may significantly improve these Mi-26 performance capabilities.

**CH-53E UPGRADE**

Figure 5 illustrates potential CH-53E upgrades with demonstrated subsystems. Replacement of the existing engines with larger, more fuel efficient, and lighter (per unit of power) engines, such as those used on the V-22, would dramatically increase the radius-payload capability of the Sea Stallion. However the curve would still lie well below the nominal performance requirement for the FTR.

Figure 5 also shows the impact of new blade technology on the radius-payload curve. This new blade is a combination of technology employed on smaller systems (the Black Hawk) and modest design advances proven in the laboratory. It would be an all-composite design with a new tip, and it would use today’s airfoil technology.

In one sense we can say that with the new engines and blades, we have reached the “knee” in the cost versus performance curve. After replacing the old engines with improved but existing engines and using new composite rotors, there are diminishing returns for the use

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3The authors wish to thank Andy Keith and his colleagues at Sikorsky Aircraft for extensive explanations of CH-53 capabilities and for conducting numerous calculations and tradeoffs in support of our efforts.

4Communication from engineers at Sikorsky Aircraft.
of new technology to improve the performance of a CH-53E. A CH-47F would also need structural modifications to reap the benefits of new engines and rotors/blades. Even with these modifications, the CH-47F would not offer significant performance improvements over a similarly upgraded CH-53E.

We also note that the CH-53E cargo box displayed on Figure 5 could be enlarged to carry the largest FCS vehicle. This might cost as much as a ton of payload capability not reflected in the figure. Hence, the FTR design point is actually further from the CH-53E curves than indicated in the figure.

The performance versus platform cost curve will have a knee between modification of current platforms and the development of a new platform. By using the vendor’s estimates for the possible improvements to a CH-53E we have identified the knee of this curve.
Figure 6—CH-53E Upgrades and Other Missions

Figure 6 displays the same radius-payload curves in Figure 5 and overlays two new missions that might be achieved by an upgraded CH-53E. These missions cannot be conducted with today's transport rotorcraft and may have relevance for the Objective Force.

MilVan containers are the military's units of packing for oceangoing freight. They can contain a maximum of 22.5 tons, though 90 percent of MilVan containers weigh 15 tons or less. Figure 6 shows that an upgraded CH-53E with V-22 engines could haul 90 percent of the MilVan containers over modest distances. It should also be noted that one of the key problems in the deployment of military units is the congestion point created when the containers are unloaded from ships. Upgraded CH-53Es could alleviate this problem by unloading

5 Information provided by Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC).
these containers with an external sling. Since this unloading occurs at sea level, the payload capability is at least 10 percent higher than indicated in Figure 6.

Another mission involves movement of the Light Armored Vehicle (LAV). The Marine LAV I weighs around 14 tons, and the Army’s Stryker interim force combat vehicle (based on the LAV III) will weigh around 18 tons. While the latter is somewhat beyond the radius-payload capability displayed here, we should remember that the curve in Figure 6 is for an all-VTOL flight at a 4,000-foot HOGE and at 95°F, with two landings and takeoffs. Under less stringent conditions, it is possible to consider the use of large transport rotorcraft with today’s subsystems to deploy the Stryker in a limited vertical envelopment scenario.

CHAPTER SUMMARY

Today’s helicopters fall far short of the goals of a 20-ton payload with a 500-kilometer radius. Upgrading existing rotorcraft with modern large engines might allow for fulfillment of the mission if the FCS is only 12–15 tons and a shorter radius is required. We do, however, caution that the FCS might need to be sling-loaded, as even a 12-ton FCS might not fit into the CH-53E cargo box. Of course, one other option is to seek modernization of the Mi-26. We should also mention that modernization of the CH-53E or Mi-26 might also allow fulfillment of other missions such as movement of MilVan containers and possibly movement of the Marine LAVs and Army Strykers.

The RDT&E cost to develop new aircraft has varied from approximately $9 billion for the C-17 to $11 billion each for the RAH-66 and V-22. Complex aircraft such as the F-22 and F-35 are expected to have RDT&E costs in excess of $20 billion. Comparing these costs to the $100 million to modernize the C-130H to the C-130J and the few hundred million dollars needed to modernize a CH-53E or Mi-26, we identify our first “knee in the curve.” The development cost versus FTR performance curve clearly has a knee between modernization and new start.