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BRIEFING

Assessment of Navy Heavy-Lift Aircraft Options

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Prepared for the United States Navy

RAND NATIONAL DEFENSE RESEARCH INSTITUTE

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SUMMARY

This research was conducted by RAND for N-81, the Navy Staff, in the Pentagon. RAND was asked to conduct a quick assessment of different heavy-lift (HL) aircraft alternatives that could be used by the Navy in the future. The Navy also asked RAND to conduct a survivability assessment of this type of aircraft against different levels of threats. This document provides the results of RAND's analysis and our recommendations.

The study is divided into two sections: a technical aircraft assessment and the aircraft survivability analysis.

BACKGROUND

The Army and Marine Corps have been considering future HL aircraft since the mid-1990s. The Marines will soon start to deploy the V-22 Osprey tilt-rotor aircraft as a replacement for the aging CH-46 light transport helicopter. The Army is currently planning to upgrade some of its CH-47 medium-lift helicopters. Both services also want to examine HL aircraft that could be used for cargo and personnel transport, as well as for participating in air assaults into hostile territory.

The Navy and Marine Corps have used helicopters since the 1940s. The Marines helped pioneer the concept of "vertical envelopment" by using ship-based helicopters to supplement its traditional over-the-shore modes of amphibious assault. As helicopters gradually became larger, with greater cargo capacity both internally and externally, the Marines were able to add heavy weapons (howitzers, heavy antiarmor systems) and light vehicles to their air-assault echelons. The soon-to-be-fielded V-22 Osprey tilt-rotor, faster and with greater range than a helicopter, can carry roughly 24 combat-loaded Marines and light equipment. Should a future HL aircraft of the type considered in this study be deployed, it would permit more troops, heavier weapons, and vehicles of roughly 20 tons or less to be moved ashore by air.

The Navy has recently started its own examination of the issue of HL aircraft. The still-emerging sea-basing concepts offer the sea services, and the entire joint force, the opportunity to conduct operations in proximity to critical locations without having to have access ashore. Recent experience in Afghanistan and Iraq shows that internal political factors can prevent some nations from granting the U.S. military access to facilities in their nations that cause them to limit the kinds of operations that they will permit from their territory. Sea basing offers a supplement or, in some cases, an alternative to operations from bases ashore.

Part of the sea-basing concepts of operations could include the use of HL aircraft. Such aircraft could be used to move supplies, equipment, and personnel from ship to ship, ship to shore, and within lodgments ashore. Additionally, there is the possibility that such aircraft could be used to transport Army and Marine personnel and equipment in air-assault operations.

One of the issues explored in this study is the survivability of this type of large aircraft, particularly in an air-assault or vertical-envelopment mode. Air assaults are, of course, but one use of this type of aircraft, including logistics functions. The Army is also interested in employing an aircraft like this for air-assault purposes. Survivability analyses of the type included in this report, plus examination of the lessons from recent operations, will help inform the Navy, Marine Corps and Army as to the viability of future air-assault operations using large aircraft.

We conducted a technical assessment of seven different aircraft alternatives:

- CH-53X, a much modified version of the current CH-53E that would have increased capability
- two new large, conventional helicopters: single and tandem rotors
- a coaxial HL "flying crane" helicopter design with no tail assembly
- large tip-jet helicopters—an improved, modern version of a design that has been explored since the 1950s; small engines would be mounted in the tips of the rotor blade.
- a Naval Postgraduate School design for a compound Reverse Velocity Rotor (RVR) hybrid helicopter with lift fans; NPS combined several existing systems, such as JSF engines, lift fans, and the fuselage of a C-130 with modified wings in their conceptual design
- a quad tilt-rotor, essentially a much larger, four-engine version of the V-22 tilt-rotor.

TECHNICAL ASSESSMENT

The technical assessment examined the pros and cons and the significant technical challenges associated with each of the seven alternatives listed above. Additionally, this assessment determined a range of possible initial operational capability (IOC) dates, likely research and development (R&D), and unit flyaway costs for each of the alternatives. Table S.1 summarizes the assessment of the seven aircraft.

It should be noted that this table focuses on the technical and cost aspects of the seven aircraft that we examined. The operational advantages and disadvantages of the alternatives are not included here but are instead addressed in the main body of the document. For example, although the quad tilt-rotor appears to be high risk and expensive on this table, some of its operational attributes, such as higher speed and altitude capabilities than helicopters, could be seen by some as worth the cost and development risk.

It should be noted that we did not conduct an assessment of the range of the various aircraft alternatives. It was assumed that, with the notable exception of the CH-53X, all the variants would be able to self-deploy 2,100 nmi without cargo. That range would allow the aircraft to reach intermediate staging bases in any cross-Pacific or Atlantic deployment.

SURVIVABILITY

The second major portion of the study was an assessment of survivability of this class of large cargo-type aircraft. RAND has performed similar analyses of aircraft survivability for Air Force and Army sponsors. Several important factors influence the survivability requirements of this type of aircraft:

- Is the aircraft primarily a cargo lifter, intended for use in relatively "safe" areas, or is it intended to be an air-assault aircraft, designed to go into a contested battlespace?
- What are the natures of the low, medium, and high-altitude threats?
- What countermeasures are available?
- How deep must the aircraft go into enemy airspace?
- What are the threats in the LZ?

Our survivability assessment included use of some existing analysis that was performed for the Army, as well as new analysis conducted specifically for this study. RAND's Radar Jamming Aircraft Simulation (RJARS) model was used for the simulation of 12 HL helicopters (red bars in Figure S.1) or tilt-rotors (blue bars in Figure S.1) making an approach from the sea into a LZ roughly 50 km inland. Different levels of enemy

Table S.1
RAND Technical Assessment of HL Alternatives

VTOL	Technology Readiness Level	Risk Areas[a]	Technical Risk[b]	Operational Risk[c]	Development Cost ($B)	URF Cost ($M)	IOC
CH-53X	7	Rotor Transmission Scalability	8	7	2–2.5	45	2010–2015
Tandem	6	Rotor Engines	7	7	5–9	80–140	2013–2016
New helicopter design	6	Transmission Scalability	7	6	5–9	90–150	2013–2016
Coaxial	5	Transmission Rotor	5	6	6–11	80–140	2015–2018
Tip jet	4	Engines	5	5	6–12	80–140	2017–2020
NPS RVR hybrid	4	Transmission Scalability Rotor	4	4	9–15	120–180	2018–2022
Quad tiltrotor	4	Rotor Transmission	5	3	9–15	140–210	2019–2025

[a]In general, these include the transmission, rotor, engine, efficiency, and scalability.

[b]1 = high; 10 = low.

[c]1 = high; 10 = low.

defenses were examined. These included (1) a totally safe medium altitude (above 15,000 ft) approach compared to (2) an "ambush" of the aircraft while still at medium altitude and headed to the landing zone (LZ). In the latter case, one three-launcher battery of either SA-6 or SA-15 was allowed to engage the aircraft. Once the LZ was reached and the aircraft had descended to low altitude, two different levels of LZ defenses were examined. The first included only infantry-type weapons (heavy machine guns and rocket-propelled grenades [RPGs]), while the more-difficult LZ case added three SA-16 man-portable air-defense (MANPAD) systems and three 30-mm antiaircraft guns in the vicinity of the LZ.

The results of the model runs are shown in Figure S.1. These results included the effects of various countermeasures, such as directed energy systems (DIRCMs), to reduce the effectiveness of infrared-guided MANPADs, as well as various levels of jamming and suppression of enemy radar-guided surface-to-air missiles (the SA-6 and 15s).

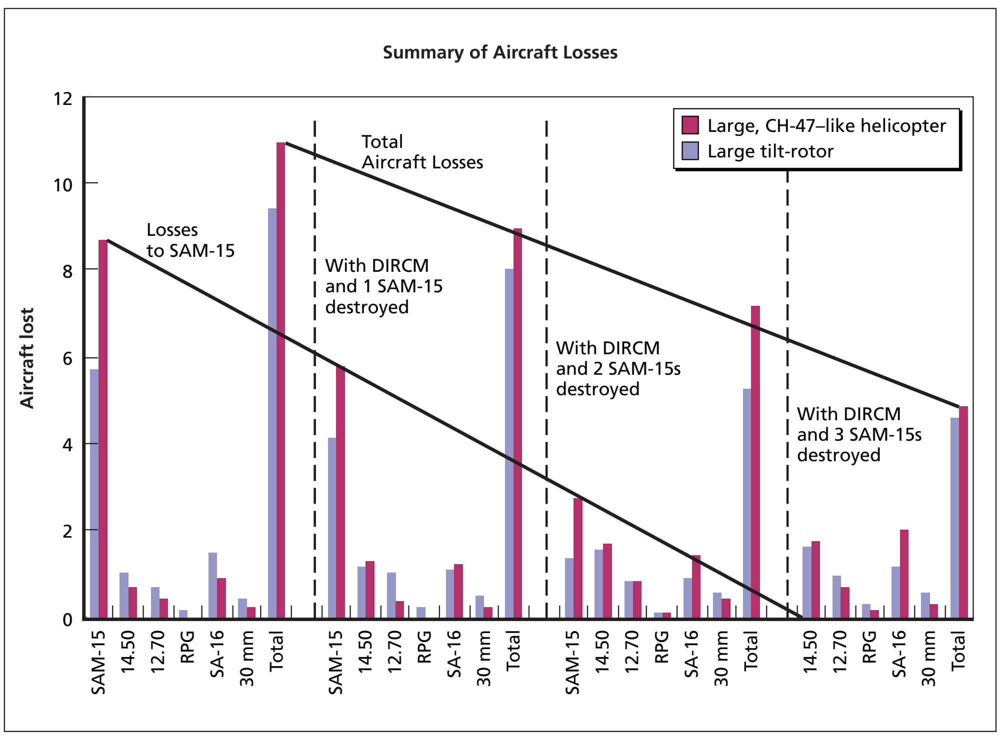

Figure S.1—Summary of Aircraft Losses

In addition to the computer simulation results shown above, we looked for lessons from recent operations, such as Kosovo in 1999, Afghanistan in 2002, and Iraq in 2003. The overall assessment indicates the following:

- Survivability of this class of large aircraft will be very challenging in all but low-threat air-defense environments.
- Recent operations indicate a significant level of hesitancy on the part of senior commanders to employ rotary-wing aircraft, even in relatively low threat situations.

These insights indicated that, while air assaults could be one of the missions of this type of aircraft, it is likely that logistics uses in relatively safe areas will be a far more common. It is probable that commanders will be reluctant to risk large cargo aircraft of the type we examined in air-assault operations unless there is a very low-threat environment or the LZs are clearly in areas that are well away from enemy forces.

CONCLUSIONS AND RECOMMENDATIONS

Our study also offered conclusions and recommendations for the Navy. Based on what we learned from the research, the RAND study team developed the following major HL aircraft options for the Navy (and Marine Corps):

- **Option 1: Buy CH-53X, little or no R&D for new HL aircraft.** In this option the CH-53X would become the Navy (and the USMC's) new HL aircraft. the Department of the Navy (DoN) would encourage the Army to follow a similar course of action, stressing that this option would permit a joint aircraft to be developed with a relatively near-term IOC (2010-2013). A small amount of investment would be made in long-term research and development related to other vertical takeoff and landing (VTOL) HL aircraft technologies and alternatives, but this would be done with the understanding that such an aircraft (possibly as an eventual CH-53X follow-on or supplement to that aircraft) would be delivered post-2030.
- **Option 2: Buy CH-53X, some R&D for new HL aircraft.** In this option, DoN would still purchase the CH-53X as its main HL aircraft. The Navy would still attempt to get the Army to also adopt this alternative. The advantages of this course of action are similar to those of the previous option, although it is possible that a smaller number of 53Xs would be purchased in this case because a higher level of R&D would be required for an eventual higher-performance HL aircraft. A much-

more-robust R&D effort for another, farther-future HL aircraft is central to this option. This would allow a robust examination of the other aircraft alternatives presented in this study. The cost of this R&D effort could, hopefully, be shared with the Army, with the prospect of an operational aircraft by 2025.

- **Option 3: Maintain current CH-53 capability, invest heavily in R&D for new HL aircraft.** This option would determine and implement the lowest-cost approach to maintain current CH-53 capabilities and invest heavily in a new HL aircraft. In this option, the Navy would move decisively in the direction of a higher-performance HL aircraft. To determine the lowest overall cost, the Navy would conduct a detailed cost analysis of the trade-offs between buying a new CH-53 and the total cost of keeping the current CH-53 fleet in service until a new HL aircraft could be purchased beginning in 2020 or earlier.

These options were heavily influenced by several key points that came out in the technical assessment of the alternatives and the survivability analysis. First, our assessment indicates that air assaults will be an occasional, not normal, use of this type of large aircraft. Therefore, an aircraft optimized (high-altitude and high-speed capability) for air assaults may not be needed. Second, the technical assessment indicated that all the options are expensive and had R&D times of many years. Indeed, some of the alternatives we examined would probably not have IOC dates prior to 2020. This is significant, particularly if the Marines need an HL aircraft to support the 2015 Marine Expeditionary Brigade and its associated Maritime Prepositioned Force (Future) (MPF[F]) ships. It should be noted that these are all expensive aircraft; even after IOC, it will take a number of years to accumulate an operationally significant number of these aircraft. In that regard, the more expensive the aircraft, the longer it will take to build an operationally useful number.

Next, we note that, for all the alternatives other than CH-53X, shipboard compatibility with existing and planned amphibious ships will be a challenge. These are big aircraft, so large that most of them are far too large to fit on the elevators of the current amphibious ships or on their hangar decks. When combined with the fact that only roughly two landing spots could be used on current amphibious ships (as opposed to roughly nine spots for CH-53–class aircraft), it means that, for practical purposes, the non–CH-53 alternatives will not be able to conduct sustained operations aboard ships of the current amphibious force. The single exception to this is the large tandem design. If the tandem rotor size is held the same as the current CH-53 size, it will offer improved shipboard compatibility on legacy ships (five operating spots instead of two) over the other HL options. In fact, the non–CH-53 alternatives (except for the tandem) would probably be able to operate on a regular basis only from large MPF(F) ships. When one considers the fact that Expeditionary Strike Groups (based around “grey hull” amphibious ships) will be constantly deployed, 365 days a year, year after year, but MPF(F) squadrons will deploy from their bases only occasionally, the implications of buying a large aircraft that is not compatible with the amphibious force are obvious.

We also considered the joint implications of the aircraft alternatives. The Army has been examining a large HL aircraft to transport future equipment since the mid-1990s. The most likely Army use for such an aircraft is to transport the Future Combat System (FCS) fighting vehicles that the Army hopes to start deploying around 2012. The exact weight of the FCS is still undetermined and could range from 16 to well over 20 tons. If a HL aircraft is to become a joint program, serious negotiations will have to be conducted to reach a compromise on the aircraft’s key characteristics. For example, because the Army does not normally consider shipboard compatibility issues when it procures aircraft, it will not be as concerned about the size and rotor-wash parameters that are critical issues for shipboard operations. The Army could insist on “more airplane” than the Navy and Marines need, can afford, or can reasonably use aboard ship. That said, our three alternatives all tried to address how the Army might respond.

The body of the report provides the details on the points that have been highlighted in this summary.