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Future Battlefield Rotorcraft Capability

Anno 2035 and Beyond

Joint Air Power Competence Centre

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Comments and queries on this document should be directed to the Air Operations Support Branch, JAPCC, von-Seydlitz-Kaserne, Römerstraße 140, D-47546 Kalkar. Please visit our website www.japcc.org for the latest information on JAPCC, or e-mail us at contact@japcc.org.

Author
Cdr Maurizio Modesto (ITA Navy)

Published and distributed by
The Joint Air Power Competence Centre
von-Seydlitz-Kaserne
Römerstraße 140
47546 Kalkar
Germany

Telephone: +49 (0) 2824 90 2201
Facsimile: +49 (0) 2824 90 2208
E-Mail: contact@japcc.org
Website: www.japcc.org

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FROM:
The Executive Director of the Joint Air Power Competence Centre (JAPCC)

SUBJECT:
JAPCC Publication Release:
Future Battlefield Rotorcraft Capability (FBRC) – Anno 2035 and Beyond

DISTRIBUTION:
All NATO Commands, Nations, Ministries of Defence and Relevant Organizations

I am very pleased to provide you with the JAPCC study 'FBRC – Anno 2035 and Beyond'. This study is based on an independent analysis regarding the necessary requirements of a future military rotorcraft capability in support of NATO rotary wing operations in 2035 and beyond. In line with the JAPCC Director's vision to deliver effective solutions through independent thought and analysis, the findings of this study address the need for a change in NATO with regard to future acquisitions of rotorcraft.

Within the 2030–2035 timeframe, many of NATO's medium-lift helicopters will be due for replacement, and many allies are due to refurbish or retire their current helicopter fleets.

The intent of FBRC is to provide JAPCC primary stakeholders with an independent study driven by operational considerations and drawing on industrial and technological developments.

I invite you and your staff to read through this study. We welcome any comments you may have with regard to this document. Please feel free to contact the JAPCC's Air Operations Support Branch via e-mail at AOS@japcc.org.

Klaus Habersetzer
Lieutenant General, DEU AF
Executive Director, JAPCC

JOINT AIR POWER COMPETENCE CENTRE
Joint Air Power Competence Centre | centre de compétence de la puissance aérienne interarmées
von-Seydlitz-Kaserne | Römerstraße 140 | 47546 Kalkar | Germany/Allemagne | Tel +49 (0) 2824 90 2201 | Fax +49 (0) 2824 90 2208 | www.japcc.org
NCN: +234 or 239 2201 | **E-Mail:** contact@japcc.org

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CHAPTER 1

Introduction

Forecasting the future is a daunting task, however, identified fast-moving trends across the diplomatic, information, military, and economic subjects are rapidly transforming the nature of all aspects of society and human life, including the character of warfare[1]. To be prepared for the future to come, national and military organizations are conducting strategic analysis trying to visualize the Future Operational Environment[2] (FOE).

The North Atlantic Treaty Organization (NATO) has recognized that the future of the Armed Forces will be different from today. During the Wales summit in 2014, it already was stated that NATO Joint Air Power capabilities will require longer-term consideration and analyses of the future role of joint air power. In the 'NATO Strategic Foresight Analysis (SFA) 2017' Alliance leadership tries to visualize the future security environment, characterized by a rapid rate of change, complexity, uncertainty and interconnectedness. The SFA describes the future NATO expects to unfold to 2035 and beyond, in terms of political, social, technological, economic, and environmental trends.[3]

These trends will also have their effect on subareas like rotary wing operations. The importance of rotorcraft in both past and present military operations is widely recognized and they have proven to be an important element in the success of operations. Warfare[4] is expected to become more complex in the future, and the 'Future Battlefield Rotorcraft Capability' (FBRC) will be an indispensable, and most critical capability requirement for conducting air movement or armed combat missions. In analysis, it is expected possible adversaries will adopt new technologies, new doctrines and revised strategic concepts, modernizing their capabilities in the 2017–2035 timeframe[5], making differences among conventional forces smaller. It is also expected that the timeframe 2035–2050 will be marked by significant breakthroughs in technology and convergences regarding capabilities, which will lead to significant changes in the character of warfare[6].

In the 2030–2035 timeframe many of NATO's helicopters will be due for replacement[7] and many allies will refurbish or retire their current helicopter fleets. In fact, the German Ministry of Defense (MOD)[8] is preparing for the creation of a future multirole heavy transport helicopter, as their current CH-53 fleet is expected to reach the end of its service life in the next decade. The United Kingdom MOD is currently assessing their long-term requirements for replacing their medium helicopters from the mid to late 2030s.[9] In this case, a potential result of the UK Army-led combined, Multi-Role Capability Investigation (MRCI)[10], and the Maritime Organic Aviation Capability (MOAC)[11] led by the Navy, is that a single type will replace the current mixed fleet of Merlin, Puma and Wildcat helicopters. Largely all of these helicopter types in use are based on technology and requirements of the 1970s and 80s.

Due to the time needed to develop new types of helicopters, preparing for the new era will be one of the toughest challenges that NATO faces in the next 15–20 years and beyond.

1.1 Aim

1.1.1 This study aims to provide an independent analysis regarding the necessary requirements of a future military rotorcraft capability in support of future NATO rotary wing operations in 2035 and beyond.

1.2 Scope

1.2.1 Aspects of future rotorcraft capabilities are being discussed across a wide community of interest. Within NATO several agencies and Working Groups (WGs), e.g. the Science and Technology Organisation, Applied Vehicle Technology Panel, the NATO Army Armaments Group – Joint Capability Group on Vertical Lift (NAAG/JCGVL), the NATO Standardization Office's helicopter related working groups and panels, and the NATO Helicopter Design and Development Production and Logistics Management Agency[12], are discussing all the aspects regarding future rotorcraft capabilities.

1.2.2 Possibly leading to the development and fielding of next-generation rotorcraft by nations[13], the NAAG/JCGVL established the 'Next Generation Rotorcraft Capability Team of Experts' (NGRC ToE) to inform nations and create support for the development of a draft NATO Staff Requirement (NSR). As part of the NGRC ToE study, the Joint Air Power Competence Centre (JAPCC) executed a sub-study to define the future operational environment. Additionally, synchronizing the NGRC ToE study, the JAPCC published articles in journals[14] on the subject of future rotorcraft. Furthermore, on request of the Italian Air Force Staff, the NATO Special Operations HQ (NSHQ), and the European Personnel Recovery Centre (EPRC), the JAPCC conducted an independent analysis of how future rotorcraft will be properly developed for future NATO operations.

1.2.3 The articles published by the JAPCC should be seen as the first step of an independent contribution to the discussions in shaping the future rotorcraft capabilities. This White Paper is a successive study partially based on the information/aspects derived from those JAPCC articles.

1.2.4 This White Paper will provide the Alliance with a series of deductions on how the FBRC could be shaped in the coming years. The actual acquisition of rotorcraft airframes is ultimately a task of respective Ministries of Defence, in conjunction with the Military Aviation Authorities (MAAs) regarding the airworthiness certification of these airframes. This process is outside the scope of this paper.

1.3 Objective

1.3.1 To understand how the FBRC should be shaped, one needs to understand what kind of aspects can or should affect or influence the FBRC.

1.3.2 Future Operational Environment (FOE)

1.3.2.1 The FOE unfolding to 2035 and beyond will be affected by political, social, technological, economic, and environmental trends. Within these trends, it is expected that environmental and technological changes will have a direct impact on the security environment and therefore on the future battlefield. The political, social (human) and economic trends will also have indirect effects and or consequences on the battlefield and therefore on the developments and requirements of systems of the FRBC.

1.3.3 Operational and Customers Requirements

1.3.3.1 Despite the rapid changes to the security environment within the FOE, future military capabilities have to remain relevant and credible on the future battlefield to accomplish their core tasks. Within the study, an analysis of the FBRC customer's future requirements will be conducted against future threats that will shape the new capability. By understanding the future environment and possible future developments in technology, adequate operational analysis of potential threats, and related future user requirements can be made, resulting in a set of technical and operational requirements which can shape the FBRC to remain relevant and credible on the future battlefield. Capability requirements will be presented in this study in terms of platform characteristics, such as size, cargo capacity, speed etc.

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CHAPTER 2

Future Operational Environmental (FOE)

2.1 General

2.1.1 The global environment has already changed significantly during the past decade and is expected to change more rapidly in the years to come, forcing nations and military organizations to envision the possible FOE. The FOE is considered to be influenced by what the European Environmental Agency describes as five distinct global megatrends[1]: political, economic, social, technological and environmental. Those factors will be affected by the effects of globalization, described in levels of risks and uncertainties as 'Congested, Cluttered, Contested, Connected and Constrained'[2].

2.2 Political and Economic Environment

2.2.1 By a combination of global population growth and increases in productivity, people will demand governments deliver more security. However, distrust, polarization and a growing list of emerging issues could hamper government performance. Increasing instability driven by power transitions and power diffusions from governments to non-state actors worldwide, contributes to growing public discontent. Deteriorating confidence in political and economic institutions, which may contribute to radicalization and terrorist activities, combined with weak and failing states increases the risk of instability around the world, affecting the security environment.

2.2.2 The global economic centre of gravity is shifting from west to east and north to south. Globalization has already and will further open emerging markets and has and will continue to intensify economic integration between nations. However, it is expected this will shift jobs to countries with cheaper labour, increasing social inequality. Increased migration flows of people moving to find employment can have effects such as fractured and conflictual societies, violent extremism, nationalism, isolationism, and protectionism, leading to social unrest, affecting the security environment.

2.3 Physical Environment

2.3.1 Environmental impacts are expected to increase as the world becomes progressively more populated and industrialized and climates continue to change. The increase of the world's population and urbanization affect landscape and the physical environment in which people live. Economic circumstances may result in large-scale population movements within countries and across national borders. Growing populations with longer life expectancy, asymmetric but greater demographic mobility and unregulated urbanization, increasing inequality and endemic poverty can all work to diminish state capacity and resilience.

2.3.2 Urbanization is integrally connected to three pillars of sustainable development: economic development industrialization, social development, and environmental protection.[3] In the current and future urban areas, people live in official and informal settlements (slums). Slums are and will continue to be especially vulnerable to natural disasters and other impacts of a changing climate which create a range of economic, social, physical and legal vulnerabilities for their inhabitants. Few living there will see effective governance. Additionally, megacity slums can generate instances of insecurity like ethnic rivalry, cultural grievance, criminality and religious extremism.

2.3.3 It is expected that urban areas will be home to 65 percent of the world's population by 2040[4], and habitable locations could depend on the availability of resources like water and food. The majority of these congested urban clusters will be situated in the vicinity of the coast in littoral areas[5]. In combination with economic growth, rapid urbanization will increase the demand for natural resources, which may lead to resource scarcity.

2.3.4 Climate change will reduce the availability of basic natural resources, exacerbate existing environmental stresses, and increase the risk of extreme weather events and natural disasters, which can additionally lead to an increased need for humanitarian assistance and relief, disrupting societies. The expected increasing demands for water and food, fertile and arable land, or other resources like natural energy sources, will likely intensify international migration pressures. It may reduce the resilience of society at large, stress eco-systems services, and increase the role in power politics to access, control and distribute natural resources thereby stressing governments' abilities to keep peace and provide for the needs of their populaces.

2.4 Technology Environment

2.4.1 Global growth of the population will continue to accelerate the rate of innovation and technology development. Information technology and the digitization of cyberspace of the world will continue to improve offering great opportunities to individuals, state- and non-state actors. The future will see individuals using an increasing number of network-enabled devices where new technology is connected and intersecting to other new technologies and advances, each optimized for the *'human factors'* related to the primary functions served by each device. However, it will also create vulnerabilities allowing individuals and groups on the growing global networks immediate access to information and knowledge, making data increasingly a strategic resource.

2.4.2 Increasingly affordable technology will permit system replacements to incorporate higher-order capabilities, and off-the-shelf systems will become available. Individuals, state- and non-state actors will have opportunities to exploit available technology innovatively, making capability gaps smaller.

2.4.3 Research and development of materials and structures are expected to result in a range of new materials and advanced material capabilities, combined with developments in software and computer systems generating improved ways of making superior products.

2.5 FBRC Operating Environment

2.5.1 The transition of the world into a multipolar and multi-dimensional one, with a multitude of state actors, the increasing role of non-state actors, and increasing multifaceted threats, create the potential for further instability. Together with the environmental aspects and technological developments, this transition will rapidly change the security environment[6]. In the military sphere, during armed conflict confronted with different threats and risks, new concepts of operations will affect the development of future military capabilities in general and rotorcraft capacity in detail.

2.5.2 Environment

2.5.2.1 Due to the urbanization-related to the growth and migration of populations, it can be expected that megacities, the majority of which will be in littoral environments, will be the main future Area of Operation (AoO), changing the way of conducting operations in urban warfare. However, reacting to natural disasters and the protection of scarce resources, as a result of urbanization and climate change, will focus operations in these areas in addition to long-distance operations that will continue to remain significant.

2.5.3 Technological

2.5.3.1 Current and future technological developments will be required to strengthen, in parallel, an increased effort in counter solutions and an innovative way to accomplish future rotorcraft operations. Furthermore, NATO's technological advantage will be challenged and the Alliance will have to develop


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abilities to counter a wide range of increasing threats posed by the rising capabilities of near-peer or potential peer adversaries.

2.5.3.2 The increasing availability of and advances in information technology, the growing connectivity in networking capacity and digitalization of civil and military data, software and systems could form important targets in future conflicts. The future Cyber domain will permit nearly all elements of nations, organizations, communities to impact the military. Cyber threats and attacks are becoming more common, sophisticated and damaging. Weapons, designed to deceive, degrade, disable or destroy information, networks, sensors, and weapon and communication systems, could be deployed. Development of new materials and software will support the construction of superior military systems and platforms and could allow for enhanced protection, health, stealth, energy efficiency and situational awareness.

2.5.3.3 'Remotely Piloted Aircraft' (RPA) or fully autonomous rotorcraft systems will increasingly be able to team up with manned rotorcraft. By combining the future employment of robotics[7] systems and/or artificial intelligence, could reduce the dangers and risks for crew and may let autonomous rotorcraft to be operated safely and reliably. However, these developments will raise legal and ethical questions and how these developments might be affected by the application of the law of armed conflict needs to be considered.

2.5.4 Future Weapon Threat

2.5.4.1 In the future operating environment the FBRC, due to the nature of their employment operating close to the ground, will increasingly be exposed to the risks and threats of kinetic and lethal weapons, also undergoing technological developments. These weapons can range from small arms and Rocket Propelled Grenades (RPGs), Anti-Air Artillery (AAA) Man-Portable Air Defence Systems (MANPADS) and Surface-to-Air Missiles (SAMs). They might also be exposed to less kinetic, but equally lethal, attacks with Chemical, Biological, Radiological or Nuclear (CBRN)[8] weapons, putting the crews and passengers at serious risk. Additionally, newly developed classes of weapons, e.g. Directed Energy Weapons (DEWs), and High-Power Lasers and microwave emitters, can cause widespread destruction or have widespread effects. Finally, rotorcraft will be forced to operate in a highly contested electromagnetic environment in which FBRC units and platforms could become the targets of electronic warfare[9].

2.5.4.2 The future global security environment through 2035 and beyond, influenced by the rapid changes of the FOE, will be dynamic, of increasing complexity, and ambiguous. The FBRC will be exposed to existing kinetic and lethal technological developments and newly developed weapons systems during the execution of operations. These systems will have the potential to destroy rotorcraft or at least severely degrade their performance to the extent that could lead to mission failure. To remain relevant and credible on the future battlefield, the development of a new vertical lift platform should not be constrained by the physical limitations of existing traditionally designs[10].

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CHAPTER 3

FBRC Land, Sea and Littoral Environments and Challenges

3.1 Introduction

3.1.1 Nations are considering how they should replace their assault, attack and scout aircraft[1] which is giving life to programs and offices to move forward on analysis of alternatives of future rotorcraft[2]. Those studies, other than being the first step to start any future program, will help define the first capabilities requirements for the future rotorcraft that each nation has in mind or is willing to invest in. In this chapter, there will be an analysis of the challenges for operations within the Land, Sea and Littoral environments.

3.2 Land and Urban Challenges

3.2.1 Today's Armies have not yet fully realized that the nature of war means it is susceptible to the constantly changing operational environment.[3] Whereas warfare of the past was typically localized to one battlefield, unaffected for the most part by anything not physically on the battlefield, today's operations are subject to much more complex affecting factors. Modern warfare is increasingly conducted with a new concept that involves small-footprint operations and partnering with allies to provide cost-effective campaigns. Enablers, like information age technology and network-based organizations, have enhanced a combatant's capabilities and power projection capacity.

3.2.2 Increased unmanned operations are expected to contribute to lower human attrition during combat in the future. Over the last 15 years, the attrition rate of NATO soldiers during humanitarian assistance and logistics supply operations was significant due to a rapid rise in the employment of Improvised Explosive Devices (IED).[4]

3.2.3 In an urban environment, the way soldiers fight must be strictly balanced against the risk of potential collateral damage, to protect civilians in a densely congested battlefield. NATO armies have in the past, and will continue in the future, to place a high priority on the lives of innocent civilians and other non-combatants. If Nations want to achieve success on the future urban battlefields on which NATO will inevitably find itself, changes must be made to ensure those protections continue. Throughout history, military forces either sought to avoid or simply did not need to engage in urban combat. Most military doctrine, and the strategic theory it is built upon, encourages land forces to bypass, lay siege to, or – if required – isolate and slowly clear cities from the outside in. Today, different armies of the Alliance have accepted that global population growth and urbanization trends will increasingly force military operations into crowded cities, and military forces must, therefore, be capable of conducting the full range of operations in large, dense urban areas. US Army Chief of Staff General Mark Milley recently remarked that the Army 'has been designed, manned, trained and equipped for the last 241 years to operate primarily in rural areas. But that is about to change. In the future, with very high degrees of confidence, the US Army is probably going to be fighting in urban areas. We need to man, organize, train and equip the force for operations in urban areas, highly congested areas, and that's a different construct. We're not organized like that right now'[5].

3.2.4 Despite the clear recognition that armed forces will increasingly be required to fight in urban areas, no army has committed to train, organize, and equip forces specifically to operate within cities. A 2016 United Nations report estimated 54.5 percent of the world's population lived in urban areas[6]. By 2030, that percentage is projected to increase to 60 percent. In 2016, there were 512 cities with at least one million inhabitants. By 2030, a projected 662 cities will have at least one million residents. And the number of 'megacities' in the world – those with ten million residents or more – is projected to grow from 31 to 41 in the same period.

3.2.5 Armies would be well-served by the establishment of specialized units dedicated to preparing to operate in dense urban environments, particularly megacities. Both lessons learned from recent Alliance campaigns in an urban environment and research and evidence on operating in a megacity can be used to design such a unit today. Starting from scratch, a unit could be built based on the specific requirements we know operations in a megacity would call for. The unit leadership would need extreme flexibility and authority for manning, staffing, and equipping the unit. Environmental conditions will continue to impact transport and support operations in those urban environments.

3.2.6 Operations in heavy, hot, and sometimes high altitude conditions like those experienced in Afghanistan and Iraq have challenged rotorcraft performance. In order to compensate for slow transit times, initiatives are taken in advance to reduce exposure time of attack helicopters in the target area in case of a Troops in Contact (TiC) situation. Speed must also be considered when planning troop transport. The aim is to set a new benchmark for high-speed transport rotorcraft.

3.2.7 A 2012 report by the US Congressional Research Service[7] found 31 percent of the US warplanes currently in service are unmanned, depicting the changing nature of combat. Israeli military planners have stated[8] that any army that wishes to continue to function as an army in the future will need to rebuild itself and to adapt its manpower, its chain of command and its combat strategy to a situation in which operations are executed by swarms of unmanned devices. It is estimated that future unmanned systems will be capable of performing the majority of the classic military tasks[9]. We will need human fighters in this era too, but they will serve within very specialized frameworks and will be trained to execute specific tasks that have been determined to be better suited for humans to execute, mainly for moral and ethical reasons.

3.3 Sea and Littoral Challenges

3.3.1 Cities and megacities will hold 65 percent of the world's population by 2040[10]. The majority of these congested urban clusters will be situated in the vicinity of the coast in littoral areas[11]. NATO's ability to command the seas in areas where future conflicts may take place drives us to reconsider Allied naval force organizational structures and size and to focus more on the capabilities required in the complex operating environment of the littoral or coastlines of the earth. Therefore, NATO's understanding of specific naval warfare doctrine and policies may be changed in consideration of the future conditions. NATO should structure a fundamentally different naval force to respond to strategic demands[12], and that new force must be flexible enough and powerful enough to satisfy enduring security requirements.

3.3.2 In the littoral, the employment of airlift to provide tactical mobility and logistic support for the littoral landing task force is essential. In fact, the movement of high priority cargo and troops within the immediate area of operations, air-to-air refuelling and personnel and cargo recovery are some of the most critical missions in support of any assault operation. Potential adversaries are forcing the services to move their support platforms (ships) further away from the FLOT. New requirements on the future of rotorcraft performances, survivability and sustainability, may arise from these battlefield conditions.

3.3.3 In the near future certain non-state actors such as DAESH/ISIS, Al-Qaeda, Boko Haram and similar groups may operate in a littoral environment. This is the primary reason why NATO maritime forces have executed the NATO Article V Operation ACTIVE ENDEAVOUR in the Mediterranean Sea[13], with the purpose of building and maintaining a Recognized Maritime Picture (RMP) in the area, and to make it harder for terrorist-driven illegal trade to take place. The same necessity applies to piracy taking place in the Strait of Malacca and near the Horn of Africa where the ties to the economic foundation of Al-Qaeda and other terrorist-related organizations can be hard to neglect.

3.3.4 The littoral battlespace is characterized by interdependent joint operations conducted in a conjoined land and maritime area[14]. To achieve littoral area superiority, troops are required to manoeuvre freely in time and space. The evolution of expeditionary capabilities was once considered the sole purview of powers like France, the UK and the USA, but now other forces are turning their attention to developing this kind of capability. The trend is most pronounced in the Asia-Pacific region, but European nations like Spain and Italy continue to invest in advanced expeditionary capabilities[15] with a broader eye on events in Africa. Large, modern and multirole Landing Helicopter Dock (LHD) ships are the benchmark platform for effective, rapidly deployable expeditionary forces.

3.3.5 Future rotorcraft support to littoral operations is a concern for all armed forces with a littoral capability and most of them are looking into programs for the next generation of rotorcraft, taking into account that littoral operations start from a ship and generally end on a ship.[16]

3.3.6 Rotorcraft that operate in support of littoral operations are transported in the AOA with warships,

and they operate, at least in the starting moments of operation, to/from a ship flight deck. To operate from a warship, a rotorcraft must meet different requirements from land rotorcraft. Those specific requirements can, if not met, be a showstopper for maritime rotorcraft operations. Developers of FBRC which will be used in support of littoral operations should keep this concept in mind from the starting point of the platform design. The FBRC design should also include from the very early stages the indications related to compliance with helicopter operations from ships other than aircraft carriers (HOSTAC) requirements or the suggestions for ship's modifications and updates for safe operations in the required sea states.

3.3.7 One major constraint when operating on board a warship is the space available on the flight deck and in the hangar that is considerably less than what we can find in military airports or land facilities. Furthermore, a flight deck is an unstable moving surface affected by weather and sea conditions. In this context FBRC dedicated ship-based littoral operations will have to maintain a minimum footprint to reduce the space needed for removal in flight deck and hangar, this will require sophisticated automatic blade and tail folding systems.

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CHAPTER 4

FBRC Main Missions

4.1 General

4.1.1 The unique capabilities that rotorcraft integrate and their significant contribution to the asymmetric environment were recognized during the recent campaigns in Iraq and Afghanistan.[1] However, it is becoming gradually evident to Commanders that the shortfalls within the international helicopter community negatively affect the overall mission. Similarly, Alliance States' Gross Domestic Product (GDP) reductions have had a negative impact on rotorcraft resources availability and operability. The latter could be mitigated by NATO's Smart Defence Initiative in which all Nations contribute to the resourcing of future military operations in the multinational environment.

4.1.2 The rotorcraft operations in the latest campaigns reveal that every platform must integrate multiple capabilities for every mission. Traditional platform requirements have often been disregarded to achieve mission success on the modern battlefield. Most of the FBRC operations will take place in the commitment phase[2] of an operation where the more static Forward Operating Bases (FOBs) are linked to temporary Forward Operating Locations (FOLs), out of which tactical operations will be planned and launched by rather small units. Depending on the conditions of the Air Operations Area (AOA) these FOBs could be sea as well as land-based. In the future, both FOBs and FOLs will be manned with fewer personnel and less equipment than is currently the case, as is described by the British House of Commons Defence Committee in its Future Army 2020 plan.[3] The NATO *Research and Technology Organization (RTO)* confirms that this trend will endure into the considered timeframe (2035 and beyond). In its Joint Operations 2030 final report[4] the

RTO states: *'In the future, military operations will increasingly be the domain of small units and teams … that must generally execute autonomous, independent missions for considerable periods of time.'*

4.1.3 In all operations it is important to consider effectiveness and in this respect, three types of transport rotorcraft that would be required in the future. They will be referred to as light, medium and heavy and be required to support attack, transport, MEDEVAC and SOF missions.

4.2 Attack, Air Assault and Troop Transport

4.2.1 Following the completion of the *'International Security Assistance Force (ISAF)'* mission at the end of 2014, a new, follow-on, NATO-led mission called *'Resolute Support'*[5] was launched on 1 January 2015 to provide further training, advice and assistance for the Afghan security forces and institutions. During this operation helicopters were employed in sustained operations to accomplish Combat Support (CS) and Combat Service Support (CSS) missions. CS refers to rotorcraft units that are focused on providing operational support for combat entities. CSS is executed by rotorcraft units which primarily provide logistical support for supply, maintenance, transportation, health support and other services required by the soldiers of combat elements to continue their missions. CS missions for helicopters are intended to support specifically trained units such as *SOF Air operations, Joint Personnel Recovery (JPR) and Quick Reaction Force (QRF)*. Specific tactical transport rotorcraft will be needed to support the missions above. In fact, rotorcraft's unique ability to hover and land arguably everywhere, and move virtually unhindered by natural or artificial obstacles across the battlespace have made those machines an indispensable asset for war-fighters at all levels.

4.2.2 Rotorcraft will play an integral part in all kinds of operations for modern militaries in the future so nations will likely develop airframes in different weight/size classes which can be adapted to different roles through the installation of mission-specific equipment. These operations will generate a series of sub-missions for the FBRC. It all starts with the insertion of a tailored *Task Force (TF)* into the *Engagement Area (EA)* by transport rotorcraft while combat rotorcraft provide augmented situational awareness and precision Fire Support (FSp). After the insertion, and in addition to the standby missions mentioned, assets will need to be ready to execute *Reconnaissance and Surveillance (R&S)*, FSp as well as punctual or emergency resupply missions for the duration of the engagement. Operations often end with an escorted extraction of the *TF* from the *EA* back to the *FOL* or *FOB* for reconditioning. Furthermore, there is an ongoing requirement to be combat ready while escorting and transporting packages in support of superior SA and FSp.

4.2.3 Future combat rotorcraft will primarily fly missions in fire support, usually in coordination with fixed-wing unmanned and manned aircraft. The second role will be the *'sensor-and-shooter'* for which rotorcraft, such as attack helicopters, have been specially developed to provide augmented Situational Awareness and Precision Fire Support to ground forces in the pursuit of their objectives, whenever and wherever required. Despite their very effective and efficient support to operations in the land environment, it is fair to say that rotorcraft share this role with manned combat aircraft and *RPAs*, each with their inherent advantages and disadvantages. Although in the past, certain rotorcraft have been exclusively designed to execute *R&S* missions, evidence suggests that these variants will no longer be found on the battlefields of the future and that their missions will be performed by combat helicopters teaming up with RPA as is already the case in the United States Army[6].

4.3 Logistic Resupply and Transport

4.3.1 Transport rotorcraft are employed for transporting personnel and cargo in support of operations. The benefit of rotorcraft employment for these operations is that personnel and cargo can reach any surface, even non-prepared, for landing. Cargo is carried either internally, or externally by slung cargo equipment in

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which the load is suspended from an attachment point underneath the aircraft, while troops are primarily loaded and unloaded while the helicopter is on the ground. However, when the helicopter landing manoeuvres are limited due to terrain, personnel may also be picked up and dropped off using specialized devices, such as rescue hoists or special rope lines (fast rope and rappelling device), while the aircraft hovers overhead.

4.3.2 The most necessary and frequent mission during operations is a routine logistic resupply, and within that kind of mission, all types of consumables will need to be transported. In particular, when it becomes virtually impossible for effective and efficient resupply by utilizing ground convoys, due to the nature of the terrain, road infrastructure or threat, these missions could become very resource-consuming for the FBRC[7].

4.4 MEDEVAC

4.4.1 Some specific and specialized missions require crews and dedicated rotorcraft to remain on standby 24/7, with a very high alert status and short notice-to-move requirement. One of the most visible and important of these is medical evacuation. Current military operations have shown that on-call medical support is a fundamental requirement for an expeditionary military force. This operational necessity has been emphasized in theatres such as Afghanistan, where war has completely depleted local medical facilities, rendering host nation medical support less than adequate according to Western standards, or even non-existent. In accordance with NATO Standardization Agreement (STANAG) 3204[8], forward Medical Evacuation (MEDEVAC) is *'the phase of evacuation which provides airlift for patients between points within the battlefield, from the battlefield, as far forward as the* *point of wounding, to the initial point of treatment and to subsequent points of treatment within the combat zone'.* This means highly skilled medical crews rely on rotorcraft for rapid ingress directly to the wounded, regardless of their proximity to enemy positions. But, not all services can deploy these kinds of highly skilled medical personnel and, often, the medic, doctor or nurse on board has only basic trauma skills, which are not enough to treat the severe injuries that Improvised Explosive Devices (IED)/Small Arms Fire (SAF) victims suffer. For those reasons, MEDEVAC stand-by missions will remain in the future priority missions, albeit at a considerable cost regarding platform and crew allocation.

4.4.2 Operations during Desert Storm demonstrated that the old concept of forward deploying large medical facilities which could provide definitive surgery on all patients and hold them until they were 'stable' was no longer viable. It became evident that the movement of more 'stabilized' or 'unstable' patients would become the norm, and most of the nations have now implemented systems to ensure the provision of more highly-trained medical aircrews and more 'intensive care unit' – like equipment in both fixed and rotary wing ambulances. For these reasons, all Nations within NATO are starting to look into programs of unmanned vertical lift platforms designed for MEDEVAC.

4.4.3 The US Army continues to evaluate capabilities associated with the Future Vertical Lift (FVL)[9] program – which is still a developing program. This study presents two significant outcomes associated with the future aeromedical evacuation platform capabilities and one finding associated with medical doctrine and the planning for future brigade operations. These three results are based on simplifying assumptions and constraints for a scenario where a future brigade is operating in an area 300 x 300 km, and zero-risk aircraft ground speed[10] required for the FVL platform is 350 nautical miles per hour. The zero risk speed is defined as that speed required to transport the patient from point of injury to an adequate medical facility within 60 minutes. Given these same parameters and constraints, for the future brigade projecting power in a circle of radius 150 km, the zero-risk ground speed required for the FVL platform would be 260 knots. Because the locations of casualties in future brigade-size stability and support operations cannot be accurately forecasted, collocating aeromedical evacuation assets and surgical elements within 60-minutes is the best option to address the problem within the so-called 'golden hour' rule that has saved the lives of seriously wounded troops in recent NATO operations.[11]

4.4.4 Different studies assessed the potential applications of UAS for assisting combat troops on the battlefield[12], and particularly for facilitating a quick and relatively safe medical evacuation. An unmanned rotorcraft that could land safely in a remote landing zone to pick up an injured soldier could be a vast improvement, but if that the same airframe needs to accommodate equipment and a surgeon who can operate on a wounded soldier, that is a more complicated matter. Given the nature of these missions, it is reasonable to believe that they will be executed by manned rotorcraft, escorted by unmanned ones.

4.5 SOF

4.5.1 Special operations are those specially designated, organized, trained, and equipped forces using operational tactics, techniques, and modes of employment that are not standard to conventional forces to achieve operational to strategic effects and with levels of physical and political risk normally not associated with conventional operations[13]. NATO SOF operations, often referred to simply as 'SOF', are inherently joint and will usually require support, close coordination, and shared interoperability among other SOF and the conventional components of a joint force.

4.5.2 SOF Rotary Wing aircrew generally use conventional rotorcraft in ways unexpected by the opponent to achieve operational and strategic results. Some nations have fielded very specialized, purpose-built aircraft, while other nations have been able to achieve very good results with some after-market modifications to aircraft already in use by their conventional fleets.

4.5.3 Recent NATO operations revealed that two main missions could be assigned to SOF rotorcraft; Direct Action (DA) consisting of infiltration and exfiltration of SOF personnel and equipment and actions over an objective area; and Special Reconnaissance (SR).[14] Those kinds of operations frequently involve extended ranges and difficult flying conditions (e.g. low illumination levels, harsh environments, and high threat levels). The movement, pre-positioning, and resupply of these troops and their caches are often conducted discreetly or covertly which is critical to overall success. For future operations, due to threats from evolving enemy capabilities, it is improbable that 12 or more soldiers with their specialized equipment could take off on a rotorcraft and be repositioned to a location in direct contact with the enemy based on the unfolding situation on the battlefield.

4.5.4 Future RW special operations aircrews will be affected by the same environmental conditions as conventional air operations. Being able to operate beyond the enemy's capabilities will be a critical factor in reducing risk and increasing success. One of the worst limitations of today's SOF rotorcraft is the performance in extreme environmental conditions. In fact high atmosphere temperature and high-density altitude affect rotorcraft allowable payload, range and ability to hover or land at higher altitudes.

4.5.5 For many years rotorcraft in support of SOF aviation have been developed rapidly and inexpensively using the technology and airframes already in use for other armed forces. In fact, SOF aviation today continues the use of non-dedicated rotorcraft designs modified for their own specific mission purposes. This will likely continue in the future as it will not be economically feasible to design FBRC systems only for SOF aviation due to their small fleet requirements.

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CHAPTER 5

FBRC Capability Requirements

5.1 Introduction

5.1.1 Alliance armed forces[1] currently employ almost ten thousand rotorcraft from numerous manufacturers. As mentioned before, in many countries replacement or modernization programs are ongoing or planned in the short- and medium-term. However, little effort to harmonize capabilities has been done by Allies or their industry partners. The improvement of NATO's future rotary wing capabilities cannot be based solely on the acquisition or upgrade of a single helicopter model. Considering recent operational experience, rapid advancement of technology and expected threat environment, NATO should formulate a concept of operations for vertical lift. This concept should provide a coherent and comprehensive strategy for a widely harmonized and accepted development project. Through at least 2030, it is expected that a combination of highly advanced new generation aircraft will operate concurrently with 'legacy' equipment.

5.1.2 As a result of the ongoing resource constraints on the FRBC development project, the most important prerequisite is the 'materiel'. The different versions and rotorcraft mission types, including those required for ground support operations, will shape the FBRC. Not every nation within the Alliance will be able or willing to acquire and operate the complete array of rotorcraft. Nations might decide to replace only their current inventory with a similar FBRC version or acquire another variant to complement or upgrade legacy equipment. Nations must be aware of the considerable impact on interoperability since major differences in performance must be expected. For these reasons, it could be necessary to establish a matrix of the required common capabilities following the guidelines of the NATO STANAG 4555 by defining the applicable MEP (Mission Equipment Package) that could be used by legacy aircraft. It should be clear to Force Commanders that they will require balanced, deployable fleets able to execute the wide array of missions in the most effective and efficient way. Being NATO's catalyst for the transformation of capabilities, Allied Command for Transformation (ACT) has a leading role to play in this process that is about to commence and will continue for the following 5 to 15 years.

5.1.3 In defining the FBRC, the physical environment will contribute significantly to shaping the requirements. The current requirements for 'Hot & High' will endure. Specific attention will have to be paid to the particular dangers the future physical operating environment will pose to crews and rotorcraft. Consequentially, fully automated take-offs, approaches and landings should be made possible to mitigate the very detrimental effects of 'brownout' and, albeit to a lesser degree, 'whiteout', conditions, which are described as the most dangerous manoeuvre a rotorcraft pilot can perform. Poor performance in these conditions during these sequences of flight can and have resulted in injury or death and of course loss or damage to aircraft. This phenomena, a costly problem for NATO forces during recent operations, can be mitigated with increased training but could also be resolved with the acquisition of modern technologies.

5.1.4 To facilitate operations in the very complex four-dimensional battlespace as described in Chapter 2 of this study, every rotorcraft will need to be equipped with sensors and devices to prevent collisions with natural as well as man-made objects including others operating in the congested airspace of the future.

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Future rotorcraft will need to implement the concepts of agile communications, resiliency and adaptability of integrated networks, and adopt the utilization of multiple sensor platforms including man-machine teaming to overcome shortfalls in battle management command and control, leveraging increased contributions from space assets and utilizing cyber-based capabilities as well as airmen that can operate them.

5.1.5 The future aviators' and Commanders' demands will dictate that the FBRC concept must be fulfilled by new platforms which should adopt the latest technological innovations, have increased performance and be more operable, maintainable and reliable than existing designs. The requirement aims to be the foundation for replacing the current fleet with advanced capability by shaping the development of vertical lift aircraft for the next 25 to 40 years.

5.1.6 The key drivers for the FBRC should include the following Key Performance Parameters (KPP):

- high operational flexibility and availability;
- high useful loads and performances;
- high safety and security standards;
- modularity and crew support;
- low Life Cycle Costs (LCC).

5.2 Performance

5.2.1 The FBRC will require increased performance in cruise speed and maximum range and payload. Increasing performance in high temperature and high altitude operating conditions must also be considered. Increased speed and range are critical factors for the full spectrum of military operations. An important operational advantage of increased flight performance is the extended time on station at a given range.

5.2.2 Pay Load

5.2.2.1 Most military helicopters are armoured to some extent. However, all equipment configuration is weight-limited due to the lifting capability of the rotorcraft. Limitations of installed equipment result in restrictions to the allowable payload. An aspect to keep in consideration is the total weight of the units, teams and individual soldiers that need to be transported by the helicopter. NATO combat patrol units operating in Afghanistan and Iraq over the past decade carried personal equipment loads of approximately 58 kg[2] – more than 25 kg over the maximum 'approach march load' recommended by the US Army Field Manual.[3] This 58 kg load included batteries, ammunition, gear requirement interface, body armour, boots, weapons and water[4]. Various studies are underway by the US military to optimize the 'approach march load', which could increase despite technological advances.

5.2.2.2 Technology will support the soldier's abilities in the form of powered exoskeletons which will alleviate the load-bearing burden and allow them to carry even more weight. Consequently, the total weight of the individual soldier to be transported will increase dramatically. The NATO Army Armament Group assessed[5] that as a guide for future rotorcraft capability development, an average weight of 150 kg per soldier should be taken into consideration[6]. Also, extra capacity will be required to supply support equipment, such as larger portable weapon systems or remotely controlled air and ground vehicles, to name just a few. All of this might well add up to a total weight of 200 kg per person to be transported on board. Additionally, it is to be expected that even larger pieces of equipment or cargo might need to be transported externally, especially by the *'medium'* and *'heavy'* rotorcraft. This will come at a considerable cost concerning aircraft performance.

5.2.2.3 The light manned transport rotorcraft should be able to lift at least six fully equipped soldiers or 1,200 kg of cargo at the full operational range. The medium manned transport rotorcraft should be able to lift at least 16 fully equipped soldiers or 3,000 kg of internal cargo at the full operational range and also be able to lift 4,500 kg of total cargo, externally, at reduced operational range. The heavy manned transport rotorcraft should be able to lift at least 48 fully equipped soldiers or 9,000 kg of cargo at the full operational range and lift 12,000 kg of total cargo, externally, at a reduced operational range. This approach should support standard modular capabilities to allow the use/reuse of applicable Mission Equipment Package (MEP).

Those requirements foresee the need for NATO to look beyond a single type of technology or a single platform. Regarding FBRC NATO minimum capability requirements for SOF, as reported by the NATO SOF headquarters, should aim for the transport of 16 troops fully loaded, up to a total of 2,400 kg of payload with a minimum of 2 flight hours. Based on future requirements it is possible to foresee that a single FBRC in support of littoral operations will need to be able to carry three platoons of an average of twelve troops each (36), fully loaded from a distance of a least 240 miles both ways at an average speed of 250 knots.

5.2.3 Speed and Range

5.2.3.1 Ever since the appearance of helicopters over the battlefield in significant numbers following the end of Second World War, helicopter performance has been limited by fundamental laws of physics regarding the speeds at which they can cruise. Apart from a few experimental models, the maximum speed margins have seen no significant improvement for decades. A phenomenon known as dissymmetry of lift has limited the efforts to increase helicopter maximum speeds for many years. Basically, as a 'helicopter moves through the air, the relative airflow through the main rotor disk is different on the advancing side than on the retreating side'.[7] This results in more lift on the side of the advancing blade and less lift on the side of the retreating blade. If left unaddressed, the dissymmetry of lift results in a pitch attitude of the aircraft that could end in uncontrollable flight. Systems that vary the pitch of individual blades during the rotation cycle compensate for the dissymmetry of lift but maximum speed is limited due to a possibility of lost lift as a retreating blade attempts to compensate for slower relative wind, approaching a high angle of attack. If uncorrected, this would cause a retreating blade to stall thus resulting in loss of lift on the retreating side and a roll in the same direction. Dissymmetry of lift has been the real Achilles heel of helicopter design.[8]

5.2.3.2 In addition, in Afghanistan and to a lesser extent Iraq, bases were very isolated and operations were often dependent on the availability of MEDEVAC helicopters and the distances they could cover to deliver critically injured service members to appropriate care within the Golden Hour.[9] The importance of the MEDEVAC mission in any future operation, has prompted US Army medical planners to perform a capability analysis.[10] Their findings are based on zero-risk planning assumptions as described in Chapter 4 resulting in a speed requirement of 260 Knots. Although the advantages of higher speeds are obvious with regard to logistical footprint expansion and fewer required assets for one specific theatre, it is not the sole important factor in comparison with other technical or operational requirements. While a helicopter cruising speed of 400 knots appears to be achievable, the aim is to validate the best trade-off between speed, cost, sustainability and mission performance.

5.2.3.3 A similar line of thought can be followed for range, especially when considering the potential future requirements for Littoral, Special Forces and Personnel Recovery missions. Although technology would more than likely be able to provide solutions to cater for a specific requirement, planners and manufacturers alike must remain vigilant not to accept these solutions without considering other and perhaps more important requirements such as manoeuvrability, survivability and sustainability in theatre. Those three requirements will be fundamental in the complex confined areas of operations.

5.2.3.4 It is fundamental for any amphibious command to be able to launch a helicopter assault from over the horizon because it provides a better element of surprise and protection to the assaulting fleet by reducing the exposure of the amphibious sea vessels and troops. The amphibious assault has been a valuable military tool to many countries for hundreds of years.

5.3 Survivability

5.3.1 Increased survivability is generally considered as one of the highest priorities to the military operator especially for those who often fly slow assets low and close to threats. As threats continue to evolve, it is essential that the level of platform survivability at least keeps pace with those developments. Increasing survivability has become a very high priority for the military operator who has faced, in recent years, rapidly evolving complex threats. In the 2030–2035 timeframe rotorcraft will be required to undertake missions in complex threat environments which are likely to be multispectral. For the future rotorcraft, it will be vitally important to analyse aspects like durability and damage tolerance, fatigue and fracture mechanics, advanced metallic and composite structures, and structural design criteria. At the same time, emphasis should be placed on the development of new structural design concepts for minimizing occupant post-crash injuries and fatalities, systems integration analyses, crash criteria and computational methods for design validation. In this context the FBRC design approach should consider the detailed assessment of the following focal points:

- information sharing to include obstructions, human-made obstacles and real-time updates to threat data;
- distributed aperture systems for spherical protection;
- multi-sensor real-time fusion for Device Visual Element (DVE) heads-up flight operations;
- kinetic, passive and active sensors integrations;
- counter rotorcraft mines/Counter Improvised Explosive Devices (IEDs) systems.

5.3.2 In relation to survivability, particular attention should be focused on aspects such as design, analysis, and structure technologies that reduce aircraft vulnerability. For that reason topics for FBRC should include threat and structural response modelling, advanced structural concepts for ballistic tolerance, integrating ballistic passive/reactive protection into a primary structure, and design criteria and concepts for optimizing fully ballistic protection.

5.3.3 Noise

5.3.3.1 Helicopter rotors currently rely on passive designs, such as the blade shape, to optimize their efficiency with respect to noise effects. In contrast, an aeroplane's wing has evolved to include flaps, slats and some aircraft can even modify the shape of the aircraft by 'sweeping' their wings closer to the body in flight. FBRC must develop designs able to reduce noise through all the phases of the flight. Reducing noise will reduce the advance warning of an approaching rotorcraft giving the enemy less time to target it thereby increasing survivability.

5.3.4 Low Observability

5.3.4.1 In addition to being difficult to detect via sound, the future rotorcraft platform must be as close to invisible as possible. Power and propulsion systems should be designed accordingly so that emissions in the acoustic and infrared (IR) spectrum are reduced. The airframe's outer skin should be coated with an appropriate material to create a very small Radar Cross Section (RCS). Even though rotor blades may not provide low RCS, stealth airframe design may be adopted. Specific attention should be given to the techniques to alter the aircraft IR signature providing the capabilities to modify the entire fuselage's apparent temperature in the direction where the IR radiation is emitted resulting in a camouflage of the FBRC.

5.3.5 Self-Protection System

5.3.5.1 In future, rotorcraft kinetic capability may be a significant factor in its survivability. Even if a robust design achieves high speeds, speed alone may not eliminate all threats. In this context FBRC will need to integrate the following:

- kinetic, passive and active sensors;
- Counter Unmanned Aerial System (UAS);
- counter helicopter mines/IED systems on landing operations.

5.3.5.2 For future rotorcraft a fully adaptable, automated and integrated Electromagnetic Operations Self Protection System (EOSPS) is required. FBRC pilots should have a low workload EOSPS against all electromagnetic spectrum threats. As a result, EOSPS should be capable of protecting the rotorcraft laser directed missiles (laser counter-measures), which means a laser shift system may be integrated into the airframe. IR countermeasures should be integrated as well, and expendables such as chaff and flares should be employed in support of electromagnetic survivability. Besides, EOSPS, the system must integrate the latest techniques and jamming methods in regards to electromagnetic spectrum threats. Even more, EOSPS is required to be adaptable and easily programmable to respond to every new electromagnetic spectrum threat. It should also react automatically to electromagnetic threat and counter by pre-programmed jamming techniques. However, EOSPS requires real-time feedback to identify if the electromagnetic threat is countered effectively by jamming and if any further adaptation may be required. It is evident that future rotorcraft EOSPS must integrate features of electronic attack, support and protection. However, rotorcraft may still be required to carry external electromagnetic operations pods to fulfil any assigned mission.

5.3.5.3 FBRC airframe and hardware may integrate robust protection against high power jammers and portable electromagnetic pulse devices. Electromagnetic weapons are being developed, and they may be used for many military purposes in the future battlefield such as for suppressing an enemy Integrated Air Defence System (IADS). However, EMP explosions may not be fully controllable, and mission-critical rotorcraft avionics may be vulnerable and suspended by a friendly EMP weapon.

5.3.6 Cyber Protection

5.3.6.1 The evolution of cyberwarfare indicates that modern networked air vehicles may be susceptible to cyber-attack. Therefore, cyber protection and countermeasures should be integrated into the FBRC design. Cyber protection features may be integrated into the EOSPS, or it might be one of the integral systems of an air vehicle. Even the design of rotorcraft hardware may require dedicated designs to counter cyber-attacks. Anti-virus or anti-malware software may be required to be integrated into the rotorcraft fire and mission control computer software. This approach implies the update of the existing common criteria of Target of Evaluation (TOE) that should integrate the cyber-qualified TOE for the onboard operation systems and firmware.

5.3.7 Unmanned Air Vehicles Self Protection System (UCAVSPS)

5.3.7.1 The unmanned technology evolution may represent that future rotorcraft may be vulnerable to enemy Unmanned Combat Air Vehicle (UCAV) attack in certain phases of its mission. It is apparent that UCAV technology may let very low observable UAS like swarm formations employ weapons against rotorcraft. Even DEW such as lasers may be employed against a rotorcraft. Biomimetic technology also involves robotic UAS the size of a medium to large bird, and they could carry either high Electromagnetic Pulse (EMP) weapons or conventional munitions, which could be lethally employed against rotorcraft. As a consequence, a system of UCAV detection towards protection should be integrated into the future rotorcraft. It might employ a set of sensors to detect and target enemy low-observable low-speed UAS for denying any imminent drone attack.

5.3.8 Sea-Based Operations

5.3.8.1 Strengthened areas on the FBRC fuselage in support of littoral operations will need to withstand lashing onto the deck or into the hangar. Landing gear will have to be built to be highly resistant to the hard impact connected with a touchdown on a rocking flight deck, and the airframe should be equipped with an emergency floatation device to increase buoyancy in case of ditching. Moreover, shipborne FBRC will need to be equipped with some type of a rotor brake to mitigate dangerous situations deriving from rotor blades flapping in gusty winds over the flight deck. Also, to be able to operate from a warship, FBRC will require intensive testing during high electromagnetic conditions to safeguard against ship interference with ammunition and the triggering of launchers and cartridge activated devices. These devices can include engine compartments, fire extinguishers and emergency cable cutters for the rescue hoist if installed. Specific requirements for deck operations encompassing rotary wings, tilt rotors and compound solutions and their limitations shall be provided as part of the critical maritime design compliances.

5.4 Mission and Flight Management Systems

5.4.1 To keep up with technology today and in the future the FBRC must have advance mission and flight management systems incorporating an open architecture structure. These systems must make use of advanced avionics, active control systems and tactical data links. These concepts working together will increase flexibility, adaptability and connectivity.

5.4.2 The advanced avionics must present, to the pilots, information in an easy to manage format to increase mission effectiveness and decrease workload. Active control system must provide for automated takeoff and landings as well as autopilot control. Tactical data links must be able to connect to legacy systems as well as future systems for a seamless exchange of information enhancing mission effectiveness.

5.5 Maintenance Management

5.5.1 Today, NATO nations are required to invest a lot of resources on helicopter fleets to keep them aloft and ready to produce flight hours as required. As a result, the military is working overtime to find a less burdensome way forward for what it calls vertical lift aircraft. Future rotorcraft, as any new aircraft, will have increased life cycle costs starting from the design and the development phase and throughout the operational phase including training for flight crews and technicians.

5.6 Human Factors

5.6.1 The FBRC should strive to eliminate human factor issues inherent with current rotorcraft. These new systems should reduce noise and vibration, provide for clear communication within as well as outside the rotorcraft, and provide for reduced pilot workload reducing fatigue and increase safety.

5.6.2 In Addition FBRC should be equipped with multifunction displays providing intuitive information exchange directly with the pilots' helmets. By projecting information the pilot will not need to hunt for data. This coupled with increased automation will decrease human factors challenges. Current rotorcraft


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present many issues for the crew, chief among them is an extremely demanding workload for pilots. Current systems lack sufficient flight automation, fly-by-wire systems, proper environmental control systems and compatibility with night vision goggles. The lack of these items coupled with the noise and vibration inherent with the rotorcraft exacerbate fatigue issues with the crew.

5.6.3 The physical environment within the rotorcraft itself, limits communication amongst crew members as well as with the operational command. The lack of clear communication ability, to include satellite communications, can lead to misunderstandings and increase the risk of mishaps.

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CHAPTER 6

Ways Forward

6.1 Introduction

6.1.1 The ways forward are multiple but tend to centre around technological advances whether that be in materials, concept design, avionics or maintenance practices. Close partnership with industry and countries seeking replacement or modernization programs must increase efforts to harmonize required capabilities. FBRC will need to focus on avionics, link capacity, full autopilot, and integrated multimode radar for a map of the earth and low-level flight operations in clouds or extremely poor visibility conditions. In addition to digital maps, greater situational awareness, mission planning and management capability will furnish aircrews with the accuracy that those operations require.

6.1.2 Due to the effectiveness of sea-based rotorcraft in support of littoral operations as have been extensively demonstrated during contingency operations in Grenada, Panama, Somalia, Haiti[1] and lately in the 2011 Libyan crisis[2], future benefits could be derived from economies of scale in rotorcraft platforms. These platforms could be manned or unmanned, able to operate over land and are also capable of being relocated and launched from a warship in power projection ashore within littoral operations. Those future rotorcraft platforms could be of interest to a wider audience. The Armies, Air Forces and Navies of smaller NATO Allies and partners could especially mitigate the increased costs of a single platform using the advantages derived from common logistics, maintenance and training programs.

6.2 Human Factors

6.2.1 Human beings are a unique 'machine'. Even in a group of people who have been selected and trained

under the same standards towards a specific mission or task, every human of this group will not be identical with respect to performance and attitude. Properly analysing and addressing human factors will directly affect FBRC effectiveness and safety by optimizing workload. Increased capability and accident prevention are inevitable if human factors are taken into account seriously when designing FBRC. At the same time, the aim will be to reduce and prevent accidents and increase human performance.

6.2.2 With better consideration of human factors, the workload will be optimized and more capability will be available for the mission with the objective of increasing flight safety. Pilots for their part will become more tightly coupled to their new rotorcraft via a growing number of man-machine interfaces, known in human factors circles as 'modalities'. Included are interactions with increasingly complex automated systems, larger displays complete with touchscreen capability, voice-recognition systems and visual systems that will soon be capable of 'seeing' the real world through practically any weather. The next frontier is the connectivity of everything. The connected aircraft will also require better man-machine relations to help pilots make optimal and safe decisions. The key to reducing the workload will be engineering simpler interfaces, an improvement that could also be helpful in upgrading legacy cockpits.

6.2.3 Monitoring real-time stress and fatigue to which the flight crew is subjected during flight could be another step forward for FBRC. The current modern or updated rotorcraft design, characterized by the presence of Multi-Function Display (MFD), requires a considerable effort of interpretation by the crews even if they conform to requirements by NATO standards (MIL-STD-2525). In the field of FBRC and, more generally, human-machine interface, there is ample room for improvement. This is the driving factor for companies to invest in the realization of a prototype that measures and reduces pilot stress at the controls. A prototype defined as the Infrared Stress Monitoring System (ISMS)[3] can evaluate the cognitive load and the stress level of the crew members during flight through objective psychophysiological indices. To collect this information, infrared technologies were interfaced with the human body. Similar components that also use voice analysis and a 'digital shirt' for the collection of biometric data could be the backbone of human factors analysis for the FBRC.

6.3 Technological Advancements

6.3.1 Materials and Design

6.3.1.1 As rotorcraft designs and mission requirements change, cargo load thresholds related to the currently used 'light, medium and heavy classification' as well as the current NATO agreed capability codes would need revision. Within the context of the development of an entirely new capability, this is to be expected. Modern helicopters, in general, are being classified as smart, safe and more efficient or reliable with respect to those in the past. Rotorcraft categories based on aircraft weight, operational footprint, and cargo capacity are no longer to be considered as the primary driving factor. Instead, the FBRC should be categorized based on analysis of things like survivability in particular environments or acoustic signature.

6.3.1.2 One of the most important factors for the design of the FBRC is to develop an improved turbine engine or to generate an airframe that can compensate for the extra weight, so that mission performance is not degraded. Some increased performance may be possible by improved rotor design, but the major payoff will come from reducing the basic empty weight by employing advanced structural methods and composite material or modular equipment solutions that can help tailor the payload to the mission. Rotorcraft will benefit from material and structural technologies being developed for the fixed-wing industry, but a large part of rotorcraft weight and the cost is due to components particular to rotorcraft, such as rotors and transmissions[4]. Applied research specifically for rotorcraft components will be required to achieve an empty weight reduction that could be estimated in approximately 25–30 percent from current levels.

6.3.1.3 For future rotorcraft single rotor design might be obsolete in the future battlefield, and a variety of technologies might be mixed by the manufacturers to produce the most appropriate platform configuration. Likely future designs may integrate coaxial rotors, compounded with pusher props, fans, propellers or advanced tilt-rotor, whichever will deliver optimal configuration for future missions. FBRC with an additional propulsion device or distributed propulsion could be the solution to increase speed, range and payload. The maximum power produced could be allocated across multiple rotors, each providing a portion of the rotorcraft lift. This could contribute to excellent, or at least better, hot and high performance allowing, at the same time, high payload reducing the number of flight hours needed to accomplish a task. Improvements in performance can be achieved through advances in all propulsion-related technologies and new compound configurations.

6.3.1.4 Improved rotor design will increase performance, in hot and high altitude environments, as well as the agility of the FBRC. This may also carry the added benefits of reduced fuel consumption, vibration levels and noise. Tilt-rotor, compound rotorcraft and variable speed rotor systems could be solutions to achieve these performance increases. In addition, reducing download of the rotor wash on the wing and fuselage has a major impact on the speed and vertical take-off payload of rotorcraft. This is particularly true for tilt-rotor, for which download is estimated to range from near zero in ground effect to as much as 12 percent of take-off gross weight out of ground effect.

6.3.1.5 For the long-term, strategic plans should consider the development of advanced pressurized tilt-rotors for specialized heavy lift with the objective of generating operational flexibility. In addition, tilt-rotor technology could also be one of the solutions to fulfil light and medium lift capabilities for MEDEVAC, SOF and JPR missions. The pressurized cabin will allow them to overcome the traditional rotorcraft inability to fly over high mountains or above poor weather conditions while decreasing the traditionally very loud external noise signature of previous rotorcraft platforms.

6.3.1.6 Use of electric assistance for engines equipping the FBRC could be one of the possible solutions to increase performance. In the near future, it could be possible to pause one of the two engines in cruising phase, generating fuel savings of around 15 percent. It is also possible to envisage an auxiliary electric motor that would provide additional power during acceleration and in emergency conditions. With those systems, margins of safety will be increased with less weight (engine size and power are optimized to a bare minimum) and fuel consumption. The first turbines equipped with this technology could be on the market by 2025.

6.3.1.7 Researchers from NASA and others organizations discovered how the rotor blades could change their shape like fixed-wing aircraft to incorporate the same characteristics and capabilities in a helicopter blade of the future. NASA and the Defence Advanced Research Projects Agency, also known as DARPA, the US Army, and the Boeing Company have spent the past decade experimenting with smart material actuated rotor, technology, or SMART, which includes piezoelectric materials. SMART rotor technology holds the promise of substantially improving the performance of the rotor and allowing it to fly much farther using the same amount of fuel, while also enabling much quieter operations.

6.3.1.8 The ultimate test of SMART rotor noise and vibration reduction capability would be flight tests on a real rotorcraft, where the effects of noise effects of noise in various atmospheric conditions and above or near different types of terrain could be evaluated as well. Leonardo Helicopters has started an advanced program on vibration and noise reductions with the use of active rotor systems to contribute to the external noise reduction. These early steps have shown that those kinds of power transmission and designs have significant noise and vibration abatement in the area ahead of the flight path in forward flight, although the noise production for landing and take-off and speeds up to 130 knots remains the same as standard rotorcraft.

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6.3.1.9 The recent activities performed under the CLEAN SKY Green Rotorcraft programme should be considered for external noise reduction and to guide the design of future rotorcraft solutions. To overcome this obstacle, prototypes are in development which increase thrust by replacing the traditional tail rotor with a 'pushing' propeller. Versatile platforms will be required to conduct a variety of missions such as assault, protection and security, attack, maritime interdiction, medical evacuation, humanitarian assistance and disaster relief, tactical resupply, direct action for SOF, noncombat evacuation operations, search and rescue and personnel recovery.

6.3.2 Active Control Systems

6.3.2.1 The majority of the current military helicopters in service do not integrate Fly by Wire (FBW) flight or Fly by Light (FBL) control systems, an innovation which has only been adopted in certain military rotorcrafts, as well as in most of the commercial aviation platforms for decades. This is one of the areas of improvement for future rotorcraft. Active flight control systems replace mechanical systems with software controlled systems that feed flight control information from the inceptor to actuators via a FBW or FBL control system. The apparent benefits includes items such as flight envelope protection from human errors, higher maintenance fault tolerance by the built-in system redundancy, lower weight, and higher system reliability. Additionally these systems will contribute to airframe structural integrity by smoother application of flight controls reducing stresses and increasing safety.

6.3.2.2 FBW/FBL solutions when integrated into the FBRC, are expected to increase platform agility and reduce pilot workload. At the same time, technology development in the field of smart actuators are going to simplify air system architectures, reduce weight and increase reliability and safety. Different studies have shown that a significant reduction in vibration is obtained when using active control to reduce airframe structural stress and failures induced by main and tail rotors. Those applications will bring multiple benefits like reduction in weight by eliminating heavy passive vibration absorbers and improved performance due to an expansion of the flight envelope, and a reduction of maintenance costs due to less fatigue with better comfort in the fuselage. Embedding a real-time crew stress monitoring systems such as the ISMS, the onboard Flight Control System (FCS) could reduce pilot's efforts in a critical situation and provide more simplified flight modes to increase the safety of flight in a specific mission.

6.3.3 Advanced Avionic

6.3.3.1 The FBRC will require new standards, tools and techniques to realize new avionic architectures as well as provide for constant upgrade and maintenance of the aircraft over its service lifecycle. The integration of modern and more technological software on FBRC will increase performance but system complexity will also increase, and the safety certification process may also be challenged. In fact, airworthiness, safety, and even cybersecurity certification procedures may not be completely accomplished, if current methods and approaches are applied. Reduction of cost and mitigation of component obsolescence through a building block approach for the avionics and mission systems will increase mission capability, operational flexibility, safety and security. Specific elements for bases of certification derived from Civil European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA) and Military Airworthiness Authorities (MAWA) should be identified as part of the basic type design.

6.3.3.2 The performance of FBRC may be driven by the complexity of the hardware and software interfaces. Based upon current trends, software is projected to account heavily on the total development cost. The ability to rapidly integrate new functionality into the architecture will provide a tactical advantage through the incorporation of new technology, power management, operational flexibility and implementation of engineering solutions to meet the emerging mission needs. The new generation of platforms will require new standards, tools and techniques to exploit the potential of these architectures and to allow rapid modification in light of an evolving operational landscape and be able to dialogue with fifth-generation aircraft.

6.3.4 Tactical Data Link (TDL)

6.3.4.1 Networked aircraft can easily share data and situational awareness within a robust and high-speed data system such as Link 16 or similar systems developed in the future. This interconnectivity is one of the greatest survivability pieces we could possibly have on a rotorcraft. There is probably no better way to reduce the threat in the modern battlefield than to increase threat awareness by having everyone linked as a node in a network sharing information in real-time. That kind of digital interoperability would probably be NATO's greatest advantage over potential opponents. Some potential competitors make good tactical hardware for jets and rotary wing aircraft but they will probably not be able to network them and share information real-time on the battlefield. Having the potential to do so will be the winning point for NATO.

6.3.4.2 TDL provides necessary communications channels between forces to support interoperability. The adoption of rigorous, proven standards ensures that tactical information is imparted securely and reliably to all force elements and is, therefore, a critical enabler to Battlespace Management (BM) and Shared Situational Awareness (SSA) in operations. The most common TDL for National, NATO and Coalition forces is the Multifunctional Information Distribution System (MIDS) Link 16, which has been at the forefront of recent NATO and coalition operations including Bosnia, Iraq, Libya and Afghanistan. The requirements of modern Command and Control, Situational Awareness, Real-Time Into and Out of Cockpit, and Network-Centric Warfare systems all demand the secure transmission of tactical data in as near real-time as possible. Especially in Joint or Combined Operations, the continuous and automatic update of secure voice and data between networks is fundamental to efficient deployment and mission success regarding standards and interface with fifth-generation aeroplanes. Platforms equipped with sensors could also serve as a remotely operated control centre for operations and as air defence platforms for a deployed convoy of ships. FBRC TDL through satellite communications is considered a fundamental requirement to operate in a future operational scenario. In this context, future data link, such as the Multifunction Advanced Data Link (MADL) already in use for the F-35 and installed in the FBRC in conjunction with SATCOM Wide Band Data Link (WBDL), will be able to provide Command and Control and sensor data transfer in mission-critical applications by providing radar, acoustic, video and network interfaces. Future systems similar to the actual ROVER/VORTEX technology should be considered standard equipment for the FBRC especially if in support of Land, SOF and Maritime operations.

6.3.5 Manned/Unmanned Platforms

6.3.5.1 One of the future concepts is to develop unmanned vertical lift platforms for cargo delivery and manned ones for more sensitive or technically complex missions such as long-range troop transport that is considered the **most** important mission in support of amphibious operations.[5] Industry has shown the most interest in developing new rotorcraft that could be flown as either manned or unmanned platforms. This interchangeable possibility could be based on the mission or on the possible threat. This concept is based on the Leonardo Helicopter Division Rotary Unmanned Air Vehicle (RUAV) which is a light single-engine rotorcraft designed for both Optionally Piloted Helicopter (OPH) and unmanned operations. The RUAV is capable of performing a number of roles, including intelligence, surveillance and reconnaissance and cargo re-supply, in both Land and Naval variants. The FBRC should be able to integrate with UAS solutions ranging from remotely piloted such as the Black Hornet Personal Reconnaissance System to the Airborne Ground Surveillance (AGS) by integrating NATO STANAG 4586/AEP 84 interoperable solutions with LOI-5 (Level of Interoperability) architectures, supporting Manned-Unmanned Teaming (MUM-T) capabilities.

6.3.5.2 Other programs authorized by industry and the military include OCEAN2020, which is considered one of the leading programs in support of maritime and littoral operations, and it is the first example of a cross-European military research program. The OCEAN2020 team comprises 42 partners from 15 countries, including Israel Aerospace Industries (IAI), and is on the leading edge of integrating unmanned

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platforms that will be integrated with naval Command and Control centres allowing data exchange via satellite during surveillance and interdiction missions in support of maritime and littoral operations. In future littoral and maritime operations there could be an emergence of swarm technology. The United States Navy has conducted technology demonstrations recently of swarming drones as part of the Low-Cost UAV Swarming Technology (LOCUST) program. The LOCUST program includes a tube-based launcher that can send UAS into the air in rapid succession. The unmanned vehicles then share information among themselves on a wireless network to coordinate their behaviour in defensive or offensive missions.

6.3.5.3 In a futuristic vision, they will be networked with fixed-wing and FBRC platforms. In this context Manned-Unmanned Teaming (MUM-T) operations are developing that could combine the strengths of each platform to increase situational awareness, allowing the armed forces to conduct operations that include combat support and Intelligence, Surveillance, and Reconnaissance missions. Through the use of sophisticated data links, manned aircraft can take advantage of UAS ISR payloads to enhance decision-making and mission effectiveness. This technology could be a force multiplier by enabling pilots in rotary and fixed-wing aircraft the ability to integrate with Unmanned Aircraft Systems (UAS) on the battlefield.

6.3.5.4 Operating in a littoral environment is more demanding and complicated than the land environment due to the environment where those operations take place. Unmanned take-off and landing from a ship is now one of the greatest challenges for NATO navies.[6] It is a fact that future rotorcraft will certainly operate unmanned and future operations will provide human beings to be transported unmanned back and forth from a ship as well as on land. However, it will take some time before the military will trust unmanned vehicles to transport human beings and for the foreseeable future there will be a mix of manned and unmanned platforms.

6.3.5.5 Militaries are looking into the hypothetical Amazon-style[7] delivery Unmanned Aerial System (UAS) to resupply troops in the FLOT (Forward Line of Own Troops).

6.3.5.6 The vision is for more of available workforce to be employed as warfighters rather than in combat support or combat service support roles. This isn't to say that machines should take over soldiering but essentially: humans should do what humans do best, and allow machines to do what they do best. There are many valid reasons why autonomous resupply, via ground, air or sea vehicles, is worth the investment for employment in the modern battlespace. Whether it is to improve the efficient use of manpower and resources, minimize the logistic footprint or reduce vulnerability to enemy attack, resupply by autonomous distribution is likely to be a contributing factor to the war-fighter winning in the future battlespace.

6.4 Maintenance and Sustainability

6.4.1 The future will be more focused on replacing rather than repairing, and this aspect could be the driving factor for increasing costs even if any effort is going to be made in reducing unit maintenance. The zero maintenance program desired by all organizations dealing with aviation and for rotorcraft, where most of the components are rotating ones, is a virtual dream.

6.4.2 The improvements in the durability of transmission parts will hopefully reduce the logistical support demands. New monitoring methods and diagnostic tools interconnected with ground stations will allow a smooth transition to zero maintenance. Future technological capabilities able to execute a full analysis to detect fatigue and damage precursors could be the right way to reduce maintenance and proceed on condition checks based on scheduled time and flight hours. Systems like the Health Usage Monitoring Systems (HUMS) will be the focal point for FBRC. It will enable management of the fleet using interconnected ground stations designed to collect data and resolve technical issues which may potentially drive down operational costs. The HUMS incorporate the most advanced technology in data analysis by using diagnostic models like Advanced Anomaly Detection (AAD) and Advanced Vibration Data Mining (AVDM) to improve diagnostic capability and reduce analyst workload.

6.5 Military/Civilian Rotorcraft

6.5.1 Military rotorcraft have always been instrumental to successful support of civilian missions like humanitarian assistance, disaster relief operations and law enforcement and there is no reason to believe that this will change in the next 20 years.[8] Considering these roles, very small and often very technical or specialized capabilities, such as medical or engineering units, will be deployed and supported in a great range by logistics teams.

6.5.2 Future concept of operations for the role of 'dual-use helicopters'[9] should take into consideration how scientific/technological knowledge and innovation are breaking down the traditional barriers between the civilian, military and security sectors. The actors in both the supply and demand sides of the defence market have sought in past years to adapt themselves to the new reality brought about by the changes in the processes by which scientific/technological knowledge is generated. The changes that have taken place through technological innovation have made the civil, security and defence sectors more interconnected, especially from an industrial point of view.

6.5.3 In the case of rotorcraft, it is intended that particular aircraft that are already in the design phase should meet certain standards and be structured for use by civilian, military or public security personnel with few modifications or additions. The role of dual-use helicopters in the security and defence field study was jointly commissioned by the parliaments of Italy, France and the United Kingdom to analyse the possible future use of dual-use helicopters in military operations[10]. Those Nations reviewed positive and negative aspects and they considered every related constraint. Also, the study depicted that national budget restrictions and constraints in defence spending of these countries contributed to more efficient solutions for the required renewal of the fleet. This is often associated with a quantitative reductions in the numbers of rotary assets being procured and thus a reduction in overall capacity and the medium-long term capability programme of machine fleet management.

6.5.4 Dual-use helicopters are not simply civilian helicopters used for military missions, they are platforms that comply with certain airworthiness standards, which are applied in the early phases of design and their airframe structure is designed and ready to adapt and integrate any civilian, military or security/law enforcement requirement without significant modifications. To certify the dual-use rotorcraft airworthiness for specialized missions is crucial not only for the Armed Forces missions but for any other mission requirement as well. In fact, the existence of a cooperation between engineers during the design and test phases to incorporate both military and civilian requirements could provide sufficient engineering solutions and overcome barriers during rotorcraft development.

6.5.5 In the absence of any external threat, the safety of the machine itself in its routine activities, operating by civilian standards is increasingly comparable to those of the military. Within the European Community, work is being done to secure agreement on the definition of hybrid certifications. The term 'safety' implies active or passive protection from intentional threats, i.e. enemy fire, from land or the air. Thus, it is necessary to distinguish between the use of the helicopter in permissive, semi-permissive and non-permissive environments.

6.5.6 For logistical and tactical helicopter transport missions, which do not expose the rotorcraft and their crews to the enemy weapons range, the use of dual helicopters is more effective and efficient, because the dual-use or commercial rotorcraft can have lighter airframes, allowing for increased payload, speed and/or range. Indeed, the absence of combat conditions contributes to fewer requirements, such as those relating to armament systems, which require a greater optimization and adjustment of the dual-use platform, for military purposes. Once certain requirements, such as load capacity and resistance to atmospheric and environmental conditions (such as temperature, altitude, the presence of dust and salt water), are factored into the design, a level of effectiveness satisfactory for dedicated military machines can be achieved by dual-use rotorcraft.

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CHAPTER 7

Conclusion and Recommendations

7.1 The Joint Air Power Competence Centre is thoroughly committed to fostering the development of an overarching future rotorcraft concept and pursuing translation from strategic analysis and technological developments into operational concepts and capability requirements for 2035 and beyond.

7.2 The prominence and reputation of rotorcraft for future operations within NATO has already been identified. In future operations an unacceptable shortage of rotorcraft capacity must be avoided. The FBRC could be manned, remotely controlled, or autonomous. Additionally, the FBRC could be robust and durable, available in relatively few numbers, or available in large numbers as 'disposable' assets. Therefore, anticipating the threat environment in combination with the rapid evolution of technology, NATO must formulate a concept for the future employment of rotorcraft capacities. This research acknowledges that in the 2030–2035 timeframe many of NATO's helicopters will be due for replacement and, in fact, retirement dates for in-service rotorcraft have already been disclosed by several NATO nations. Due to financial restrictions, some Nations will be forced to invest resources in extending the phase-out plan of the rotorcraft in service rather than investing in future programs.

7.3 An analysis of the FOE based on the political, economic, physical and technological environment was conducted to emphasize the implications that this aspect could bring to shaping the FBRC. To design a reliable FBRC, the entire spectrum of warfare needs to be taken into consideration. It is the assessment of this study that a fully autonomous defensive suite

should be part of the FBRC to guarantee full self-protection with a redundancy mode. Assessed future threats and varied environmental and climate conditions will be the driving factors in shaping the FBRC. In this context 'Hot & High' will always be an evolving requirement. Considering the most likely operating areas of the future, the FBRC will need to capable of delivering heavy loads in hot conditions. The capability to operate at high-pressure altitudes will most likely be a double requirement both for the flying route and the terminal area of operation. Automated take-off, approach and landing capabilities will need to be implemented.

7.4 NATO is challenged with predicting the future, as such it must anticipate operational requirements incorporating flexibility into its solutions. In this perspective, technological solutions will be the dogma of FBRC. There is a growing need to use platforms and systems for more than one purpose and in more than one environment. FBRC will need to be modular, adaptable and able to accomplish different missions in different situations. Cyber threats and attacks are everyday operations and the Alliance is adjusting to this evolving complex threat environment and those needs will influence the FBRC. At the same time, FBRC will need to implement the concept of using rapid and secure communications and integrated networks with multiple sensor platforms.

7.5 FBRC core missions will still consist of the Combat Support and the Combat Service Support mission sets. The CSS will be more dependent on an unmanned flight while there will always be a debate about how and what is to be conducted in unmanned CS missions. Logistics resupply missions will still be in high demand within the battlespace. Autonomous logistic UAS can be seen as the future delivery method to the front line troops and there are overwhelming reasons why autonomous air resupply is worth employing in the modern battlespace. As they are today, MEDEVAC missions will be a fundamental requirement for an expeditionary military force, and applications of unmanned aerial systems in assisting combat troops on the battlefield is the future reality. Future MEDEVAC missions are going to be conducted with highly-trained medical aircrews carried to the wounded area with an unmanned rotorcraft.

7.6 The armed forces' organizational structure of the future will be different from today. Urban warfare is the next battlefield frontier, and all the services will have to reconsider their current command structure. In the coming years, large conventional armed forces will have transformed to small, highly mobile and agile units, in which SOF operations will be conducted to a greater extent. Unmanned rotorcraft will join future operations in a more fruitful contribution and platforms equipped with sensors will be managed by a remote control centre. In this context, unmanned FBRC aerial systems will be used for assisting combat troops on the battlefield.

7.7 User requirements of the FBRC in Land, SOF and Littoral operations discussed herein emphasize that each service, Command, battalion, SOF Team and platoons will have different requirements based on the future environment in which they will be asked to operate. As such, the mission sets may be different based on whether they operate as a single service force or in a joint or combined operation. Each service will have different requirements and the phrase 'one solution fits all' would be very unrealistic for the FBRC. In this regard, the statement recently affirmed by the director of the FVL program that 'a single aircraft design can't replace the Army's entire helicopter fleet'[1] is considered appropriate. In fact, it could appear evident that based on the current technology demonstrators of the US FVL program and similar concepts elaborated from European industry, may lead the discussion to the direction of two possible concepts. The first concept oriented to support one modular platform for medium-range transport, attack and scout roles based on agility and speed. The second concept based on tiltrotor technology for Utility, JPR, SOF and MEDEVAC missions based on possible extended range, high-speed and pressurized flight capabilities. Future armies will require FBRC with more manoeuvrability and increased range and speed to reduce the need for forward refuelling points. An increase of payload, in some cases, could also be necessary.

7.8 It is believed that future SOF Air operations involved in team transport will be supported by manned air operations in most cases and unmanned vertical lift platforms will be entering the operations for cargo resupply and surveillance. Platforms equipped with sensors could operate as a remotely operated control centre for all operations and even more for platforms of air defence. Future littoral operations will be supported by manned air operations in most cases.

7.9 Knowledge and innovation are breaking down the traditional barriers between the civilian, military and security sectors. In a military perspective, there are positive and negative aspects to consider as industry and military work in concert to develop the FBRC if industry will start to design future rotorcraft, taking into consideration military, civilian or law enforcement requirements at the same time to develop future platforms. For sure one of the aspects will be that those kinds of platforms could benefit from more safety, effectiveness and efficiency when employed by Armed forces.

7.10 The financial resources necessary for the development of the FBRC are going to be significant since it will be necessary to develop new platforms and not just upgrade the older ones. Some of the major requirements and developments have been highlighted in this study offering food for thought for NATO organizations and Allied Nations. NATO should provide a requirements-based foundation and ideas to be able to design FBRC with an advanced capability, which can be adapted to conduct operations for the next 25 to 40 years.

1. One Size Won't Fit All for Army's Future Helicopter Fleet, Military.com

Maurizio Modesto
Commander (ITA N), NATO OF-4
Air Operations Support Branch
Joint Personnel Recovery, Littoral and Special Operations Subject Matter Expert

ANNEX

About the Author

Commander (ITA N) Maurizio Modesto

joined the Italian Navy in 1988 and completed flight training for both Fix Wings (T-34 & T44) and Rotary Wings (TH 57 A & B) with the US Navy in 1992. In his career, he has flown 5,000 hours mostly in support of Amphibious and Special Operation Force (SOF) operations. He has been an instructor pilot in the SH-3D and EH-101 and has participated in major operations including Somalia 2 and 3, Kosovo and Afghanistan. From 2000–2002 he was an exchange pilot with the Spanish Navy for the SIAF (Spanish Italian Amphibious Force) flying on the AB-212 and the SH-3H in support of Amphibious Operations. From 2010–2011 he was the Italian Navy EH-101 helicopter squadron Commander in Herat (Afghanistan). From 2011–2014 he served as a staff officer at the Italian Naval Air Fleet Command in Rome. Until August 2018, he was stationed at the Joint Air Power Compentence Centre in Kalkar, Germany, as the Subject Matter Expert for Joint Rotary Wing and also in Personnel Recovery, Littoral and SOF operations. Commander Modesto was recently posted to the Italian Navy Fleet Air Arm in Rome.

Notes

Joint Air Power Competence Centre

von-Seydlitz-Kaserne
Römerstraße 140 | 47546 Kalkar (Germany) | www.japcc.org