COMMAND AND CONTROL OF FUTURE COMBAT AIR SYSTEMS IN NETWORK ENABLED OPERATIONS

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1. INTRODUCTION

Since the end of the cold war the world changed rapidly with leading to new requirements and ways to ensure protection against today's global security threats. To cope with the new situation the idea of Network Enabled Operations (NEO) was born, ensuring the ability of armed forces to operate in a highly interactive way, and ensuring of being capable to rapidly react to uncertain situations. Therefore NATO members started to transform their armed naval, ground and air forces with focusing on NEO. In this widespread operational environment Future Combat Air Systems (FCAS), containing manned and unmanned air vehicles, will keep an important role. But the required ability to be part of NEO leads to a challenge in development of functional command and control architectures for FCAS, where operational requirements, system capabilities and technical constraints have to be merged up. During the current development at the department of Network Systems at EADS-Military Air Systems, and oriented towards different ETAP Programmes, lots of questions arise while searching for solutions on how to integrate FCAS in NEO. This paper points out the challenges to be faced by developing future FCAS for operating in a NEO environment, it addresses identified problems and describes the ongoing solution process.

2. BACKGROUND

Like actually described in the European Technology Acquisition Programme (ETAP) Global System Study (GSS), the Future Combat Air System (FCAS) has to be capable to operate in a variety of scenarios and missions [1]. Consequently it must have the ability to handle the hostile environment, the opponent's (asymmetric) tactical behaviour and the opponent's intention to prevent actions performed by FCAS. Thereby the FCAS is defined to be a set of manned combat air vehicles, Unmanned Combat Air Vehicles (UCAV), effectors and control stations that are linked together and communicating with their cooperative environment. These entities can be combined in homogeneous or heterogeneous packages of different size and role.

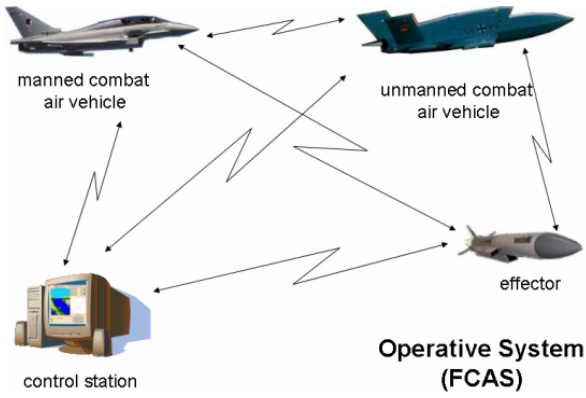

FIG. 1: Inter communication between FCAS members

3. ROLES AND TASKS FOR FCAS

With the end of the cold war and two major powers facing each others on well defined borders, the global situation changed rapidly. Besides the capability of the German armed forces to be prepared to act in global war situation, new scenarios and missions appeared, with the German armed forces are still operating in or intend to operate in. Thereby missions will take place under the scope of scenarios like Peace Keeping (PK), Peace Enforcement (PE) or Counter Asymmetric Threats (CAT). Each of the scenarios requires different capabilities of the FCAS at various operational constraints.

Comparing Close Air Support (CAS) missions performed at peace keeping conditions against CAS missions at limited scale war conditions, there are stricter Rules of Engagement (ROE) and restrictions on collateral damages at peace keeping conditions. Furthermore, the complete engagement has to be performed within stricter time limits at peace keeping conditions. But on the other hand, the threat level itself is quite higher and the missions are more sophisticated at limited scale war conditions. Therefore the different missions' requirements and operational constraints have to be merged up in the functional control architecture.

Due to the nature of military operations each mission plan will be obsolete with the first detection or shot [2]. This has a strong infliction

on the functionality of an UCAV. Due to non predictable situations during operation, an UCAV in conjunction with their operators have to act like a flight crew. They have to contribute the same capability and to take part like manned aircrafts. Moreover they have to cooperate and to coordinate with manned air vehicles and ground/naval forces in the NEO environment in an equal way. The operator and the autonomous capabilities of the UCAV have to ensure, that the UCAV is fully operational in a complex and highly dynamic hostile environment.

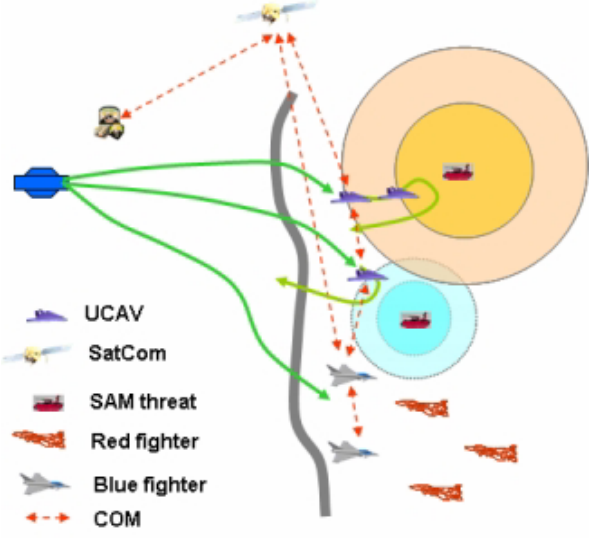

FIG. 2: FCAS mission

Besides the new capabilities required for performing the new FCAS missions, the benefits of the information age 'entered the game'. The idea of Network Enabled Operations (NEO) was born in 1999 [3]. Former mostly separated ground, sea and air forces commanded by hierarchical structures are now being merged, interacting and operating together to use the benefit of information superiority against enemy forces. As proven in first missions, the benefit of networked forces against conventional forces operating in the same scenarios cannot be neglected [4, 5]. It is shown that although less own entities are operating, the missions can be performed more effectively with losing less own forces. One major reason is the raising of the operation's dynamics that could be achieved.
Beyond these benefits, this new joint operations or even joint coalition operations lead to further requirements on FCAS functionality and enlarged the problem space of interoperability to other entities [6].
But beyond of this, there is still the question arising: what is NEO with respect to FCAS?

- Is NEO just a new philosophy - with nothing to be changed in FCAS development?
- Is it just new software or hardware - easily to be implemented?
- Is it the requirement for new sophisticated technologies?
- Or is it in general a big challenge to be overcome?

4. CHALLENGES IN THE DEVELOPMENT OF FCAS

The basis for NEO is the fact that information or knowledge superiority is a key driver for quickly gaining operational superiority against enemy forces. This is the footing for the overall transformation of the armed forces by implementing Network Enabled Capabilities (NEC).
With using the benefits of the information age the capabilities of each FCAS can be enhanced to quickly decide, act and react in every kind of mission. By having more information on demand and therefore a quicker and better understanding of the situation, the own forces are capable to act before the enemy is not even able to analyse the situation.
Additionally the networking of all forces opens the capability for joint operations. The sharing of knowledge and situation awareness across the different forces enables the commanders to operate together in a more direct way. In NEO they can directly communicate to commanders of other forces parts, with getting able to cooperate in a direct way. Thus air, ground and sea forces can operate on the same target area, having the same tasks and goals.
But this implies that the missions will not focus on FCAS only. The planned missions for FCAS have to be aligned with other forces missions [7], something we have only little experience in.

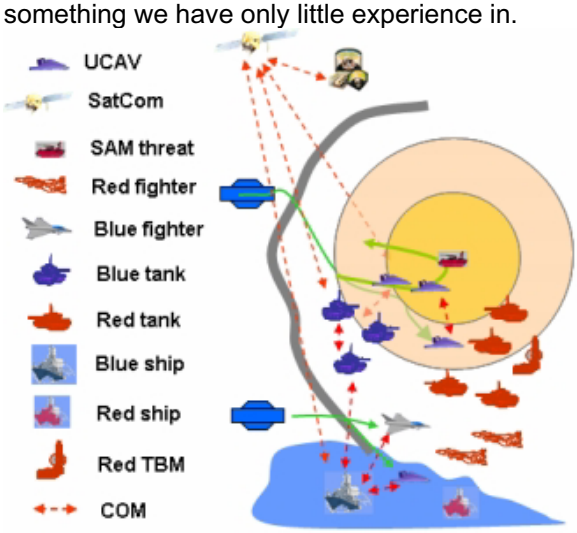

FIG. 3: Joint mission

Furthermore it requires high demands on cooperation and synchronisation of platforms of

different types [8]. Air forces have to be available in time when they where needed by ground forces for close air support. Target information and location have to be transferred in an appropriate way. New threat information has to be disseminated immediately to protect own forces. To sum up, the commanders intentions have to be transmitted in a clear and for others understandable way. One can estimate the challenge that arises to transfer commanders' intentions to UCAV with enabling them to react in a way that others can rely on.
But also with more forces taking part in joint operations, the more sources for information exist. Each sensor, each soldier, each pilot or operator will contribute to the information network.

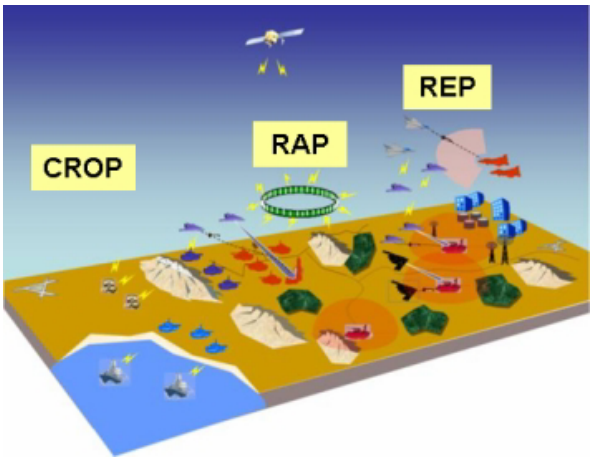

FIG. 4: Information that may be available in a NEO environment

Therefore lots of more information is available to everybody being integral part of the NCO environment. But the amount of available information and the capabilities of a pilot, soldier, operator or an Unmanned Combat Air System (UCAV) to perform appropriate decisions are not in a linear relationship. There is a maximum on information that is useful and can be handled in time. Therefore the information has to be filtered in a proper manner, enabling to make the right decisions at the right time in the right manner. Even with condensed information like in the Common Relevant Operational Picture (CROP), Recognised Air Picture (RAP) or Recognised Environmental Picture (REP) there is a lot of information that may not be required by a FCAS at the moment. For a FCAS there may be no need to know the position of all enemy forces in the target area. But there is the need for information about possible collateral damage, about own forces or threats that threatens the FCAS. This may differ to a ground soldiers' needs, depending on its actual task. But if operating collaboratively together, the information for both has to be corresponding in actuality and content.
One can understand that the implementation of NEC to the armed forces and especially to FCAS from the information point of view is a continuous process that has already started. Thus NEO left the stage of being just a philosophy. It is a continuous ongoing process, leading to new technical developments and requirements, depending on the stage of experience
One may argue that the implementation of NEO from the information point of view is just new software or hardware than. But the capability to share information and knowledge is just one side of the medal. There is the request of having the best available technology to be installed in combat air systems for gaining best mission success. Former only specialists like fighter pilots or forward air controllers were directly involved in the decision making process and had to operate with such systems. Thus there was only one technology gap to cross over, the gap from the industrial 'innovators' to the 'early adopters' [9]. It was to transfer high tech solutions to certified applications that got used in air combat systems.

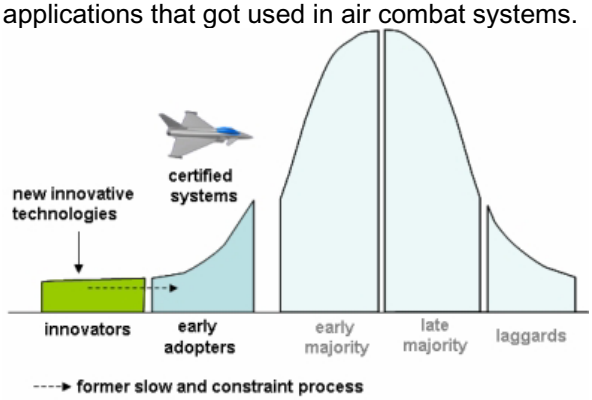

FIG. 5: Former chasm to be crossed

This will change in a highly dynamic NCO environment, as more but less specialized people need to rely on the available technology to share technology and information. Highly specialized and sophisticated solutions won't be accepted by the ordinary soldier as he has no time and willingness to handle them during missions [4]. Thus simple and less expensive solutions were required with higher produced numbers than for FCAS. This leads to the demand for the use of Commercial of the Self (COTS) products to reduce costs [10]. As COTS products are originated and used for the commercial 'early and late majority' markets, there use inflicts a strong influence on the development of FCAS. Not only one chasm has to be crossed to integrate new certified technologies in FCAS. There are two chasms to be crossed in different ways.

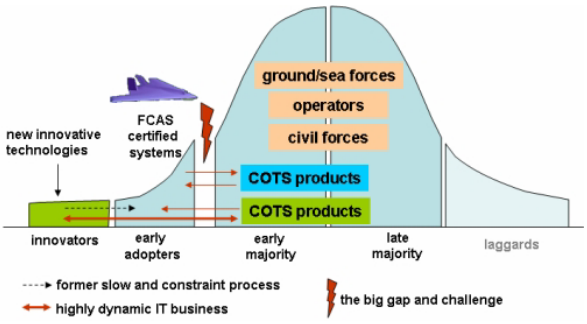

FIG. 6: New chasms to be crossed using COTS products for development

If COTS products are used as basis for the development of applications and technologies for ground forces, they often cannot be directly transferred to FCAS. They have to be merged with new innovative technologies that are developed for FCAS. If for example a tool to synchronize mission tasks for ground forces has to be used to synchronize mission tasks of with UCAV also, the tool has to be merged with innovative autonomous mission management systems. Thus the COTS product has to go two chasms back to be merged with innovative technologies. But for the integration to FCAS, the new technology has to cross the chasm of certification additionally. This will happen several times, when taking FCAS and COTS products different live cycle times or the continuous transformation process into account.

5. Solution Process

To cross those chasm problems we started to catch up the whole complexity of the problem space. The new types of scenarios, missions and the requirements for NEO have a big impact on the development of FCAS. For the future systems to handle the highly dynamic missions in a cooperative way with other forces, they have to have enough capabilities that are represented by functionality available. These capabilities merged together in functional control architecture have to address everything that generates requirements on the development of FCAS. Therefore four major columns have to be addressed relying on the missions to be performed:

- the operational requirements, giving information about constraints on and how to perform the mission
- the system requirements, giving the constraints of a FCAS platforms and the system capabilities (functionalities)
- the technical requirements, giving information about the capabilities of sub-systems like payload or communication devices
- chasm constraints to be crossed

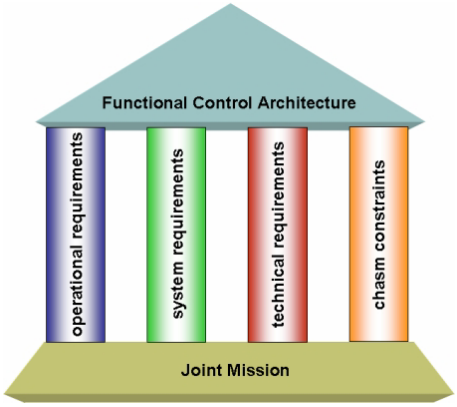

FIG. 7: Columns for development of a functional control architecture

All the requirements and constraints have to be merged together in a functional control architecture that enables the FCAS to perform its mission in a best possible way.
Due to our work on the definition of functional control architectures we identified that it is mandatory to reduce the complexity wherever possible. Otherwise the complexity will start to overwhelm and will slow down the development process. In the worst case a continuous and iterative process for the development to follow the transformation and learning process will become impossible. We identified that it is troublesome to mix up mission related and platform related functionalities as especially mission related functionality will change continuously. If there are no clear boundaries defined, the requirement of upgrading mission related functionality may create a cascade effect for an upgrading requirement to other functionality.

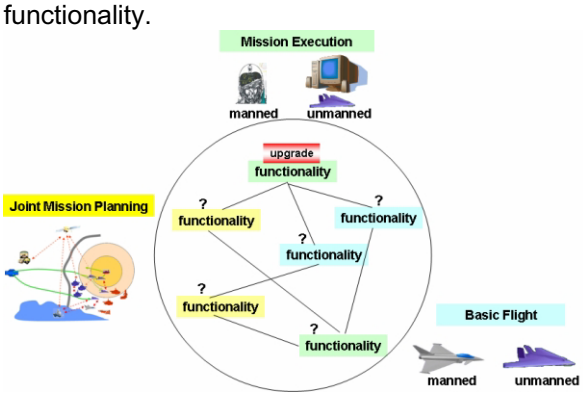

FIG. 8: Functional control architecture with complex defined boundaries

To reduce the complexity we identified that clear boundaries between the different missions related, platform related and even mission-planning related functionalities have to be drawn. The interactions between the boundaries have to

be limited as much as possible. The granularity of the modules representing the functionality has to be as high as possible.

FIG. 9: Functional control architecture with well defined boundaries

For the development of the functionality, one has to think about in advance what the danger of crossing a chasm is, if he wants to use COTS products or sophisticated high tech solutions for development. Otherwise an insufficient crossing of the chasms will limit the capabilities to certify the FCAS functionality. In the worst case complete functionality has to be redesigned if the chasm could not be crossed.

But this awareness will not address the development of FCAS only. For the development of solutions for ground/or sea forces, there are limited constraints by using COTS products. Those solutions can be easily updated, as there are no certification constraints. These even if the COTS products themselves improve continuously due to following the commercial market.

But if those solutions cannot be transferred to FCAS and the interoperability to air forces gets lost. The NEO capabilities will be reduced and will separate the forces again. To solve this problem space is one of our greatest challenges in developing Future Combat Air Vehicles that have to operate in Network Enabled Operations. And although the gaps seem to be endless, we start to find bridges and developing solutions.

6. CONCLUSION

The application to NEO means a continuous transformation process. As nobody knows where the transformation will end and what solutions are the appropriate ones. A 100% solution from the scratch will be impossible therefore. Moreover it requires a continuous upgrading of current functional architectures that are defined for the development of FCAS in NEO. This calls for a continuous learning process across all chasms, indicating to be a big challenge.

The industry has to learn in close cooperation with the customer how to develop this solutions for joint forces, how to implement this solutions and how to gain maximum benefit out of the solutions. Both have to learn to understand the others "world of problems". A long way to go, but we are on a promising way.

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