Coordinating International Research in Hybrid/Electric Flight

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ABSTRACT

Hybrid/electric flight is becoming a prominent research topic for addressing the imminent climatic challenges that increasing air traffic induces. The topic however requires to integrate many different views, such as engineering areas, a wide range of stakeholders and nations, as well as various end-users. In order to efficiently use resources, it is of utmost impoortance that research and development in the field are coordinated closely amongst the different actors. This paper gives an overview on some of such coordination initiatives and categorizes them according to the dimensions of end-users, expertise areas, stakeholders, and nations. Gaps are identified and the NATO research task group on the field is pointed out as a possible nucleus for a more general coordination approach. Any interested actor in the field is welcome to join this initiative or to discuss extended cooperations.

1 INTRODUCTION

Electric and hybrid propulsion for aircraft is becoming a more and more pertinent topic in the aviation industry and research communities. Highly beneficial properties are often assigned to this approach, such as less noise, less emmissions, and innovative services. However, there is no consensus yet as to the actual benefits to be expected. More research is clearly needed in order to thoroughly evaluate the different expectations.

While the technical challenges are not negligeable by themselves, the problem becomes even more complex if aspects such as energy supply chain, market potentials, regulations, and social acceptance are considered. It seems to become clear, that the topic of electric flight is not manageable by a single research or industry entity. Instead, cooperation accross all stakeholders and all nations is necessary to tackle this field. This includes also all kinds of end-users, such as military or civilian. But it also requires cooperation between otherwise widely unrelated business fields, such as electronics and aviation.

This work therefore aims to lay out a few of these cooperations and it will point to even more cooperation being necessary to solve the question of sustainable aviation based on hybrid/electric flight.

Figure 1: Cooperation is key in every respect

2 COORDINATION INITIATIVES...

This section will outline three exemplary coordination initiatives:

1) The future sky energy (FSE) initiative of the association of European research establishments in aeronautics (EREA) is the ad-hoc group formed by the european research community to tackle this field. [1–4]

2) The technical cluster (TC) for novel propulsion architectures (NPA) of the engines industry management group (EIMG) is the body formed by the international engine industry with the same goal.

3) The two NATO initiatives AVT-310 and AVT-323 are NATO's response to integrate military end-users in the discussion. [5]

These initiatives will be categorized according to the following categories (see also Figure 4):

End-users Different end-users can be identified for hybrid/electric flight and all of them will pose different requirements on the envisaged aircraft. While civilian users will mostly ask for efficiency and cost, military users might be more interested in special mission capabilities, which are offered by hybrid/electric propulsion. While adressing the global climatic challenges will require a wide adoption of sustainable energy sources in the civil sector mainly, the military sector might act as an early-adoptor and proof favorable properties of hybrid/electric flight also for the civil sector.

Expertise areas With hybrid/electric propulsion, not only the boundaries between airframe and propulsion will blur. Also, many traditionally unrelated areas of expertise will have to work together seemlessly, in order to develop viable hybrid/electric solutions. This involves aeronautics engineering and electrical engineering, but may also count for synergetic competence areas such as autonomy and software or for systemic competence areas such as sociology and law.

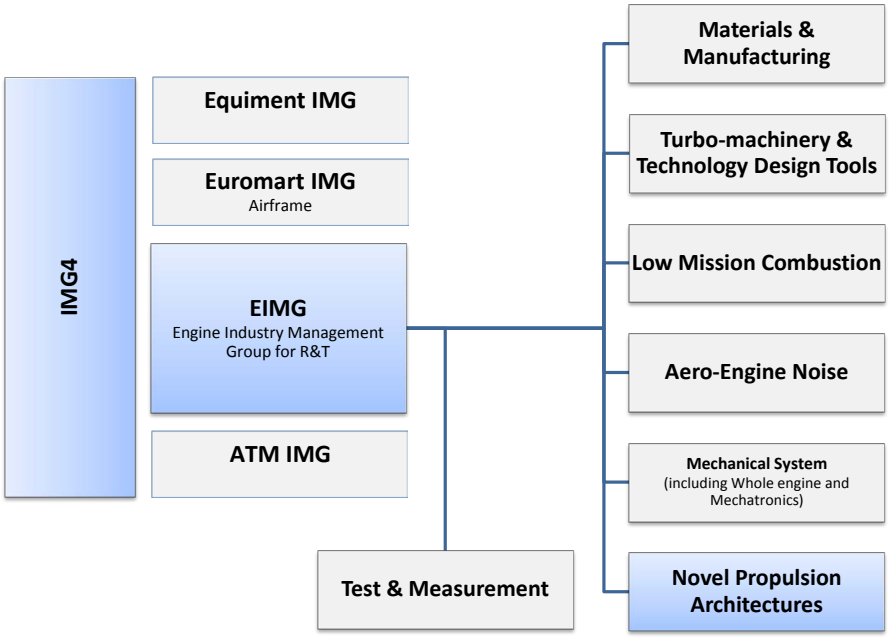

Figure 2: The technology cluster on novel propulsion architectures organizes part of the European industry.

Stakeholders In order to successfully deploy hybrid/electric aicraft in a wider scope, it will be necessary to join forces with all involved stakeholders, such as academia and industry; but also with politics, operators and the actual people traveling in the aircraft. Only if all these stakeholders agree on hybrid/electric aircraft to be a favorable solution will this technology prevail.

Locations Climate change is a global issue. So, addressing it should be a global issue as well. This is important in two dimensions. On the one hand, there is no time and resource to waste in developing solutions to this challenge and it is time to overcome regional protectionism. On the other hand, all regions and markets on the planet will have to adopt a radical solution to sustainable air traffic in order to effectively solve the climatic issue.

2.1 ...in the European Engines Industry

The engines industry in Europe is organized within the EIMG. Together with similar groups for equipment, airframe and air traffic management (ATM), the EIMG forms a group of four industry management groups (IMG4). So, there is a somewhat extensive network of the European aviation industry.

In order to coordinate technical work within the engines community, the EIMG has dedicated seven TCs. Next to typical technological questions regarding the core engine technologies, one of these TCs is the NPA TC. It is dedicated to redically new approaches to aircraft propulsion. As such, its technical areas include distributed propulsion and hybrid/electric systems.

The cluster is composed of specialists from the EIMG companies. It's objective is mainly to prepare specialised research and innovation activities such as collaborative research projects or coordination and support actions

Figure 3: Future Sky Energy is one of the four long-lead research themes of the European research establishments.

to be submitted to the European research framework programme (H2020). The cluster then ensures coherence between the projects submitted.

In our classification of coordination efforts, the NPA TC is the Civilian Aeronautics Industry in Europe.

2.2 ...in the European Research Establishments in Aeronautics

The future sky initiative by the EREA is somewhat similar to EIMG's NPA TC. It has been set up to guide EREA's member establishments to the next generation of aeronautics. Future sky is meant to address necessary research for aviation beyond the products currently in development, i.e. $N+2$. All major research establishments in Europe are part of this initiative.

Four themes have been envisaged in this effort: safety, quiet air transport, unmanned air transport / mobility, and energy. The goal of FSE is specifically to push for hybrid-electric architectures. In a broader sense, FSE will look at future energy sources for aviation, e.g. also synthetic fuels.

FSE also works through coordinating H2020 proposal coordination. As part of this, a number of smaller and one big proposal have been submitted to the European comission (EC). Obviously, FSE includes industry in its proposals. One prominent partner is the NPA TC described earlier. For the so-called international cooperation (InCo) flagship calls, FSE also reaches out to outer-European countries. Additional objectives are to generically strengthen the network of the EREA members in the field of aviation propulsion and to disseminate the members' research with in the European community. In the long-term, FSE also intends to coordinate EREA-internal research, by initiating collaborative projects, mapping capabilities, and consolidating research infrastructure for hybrid/electric flight.

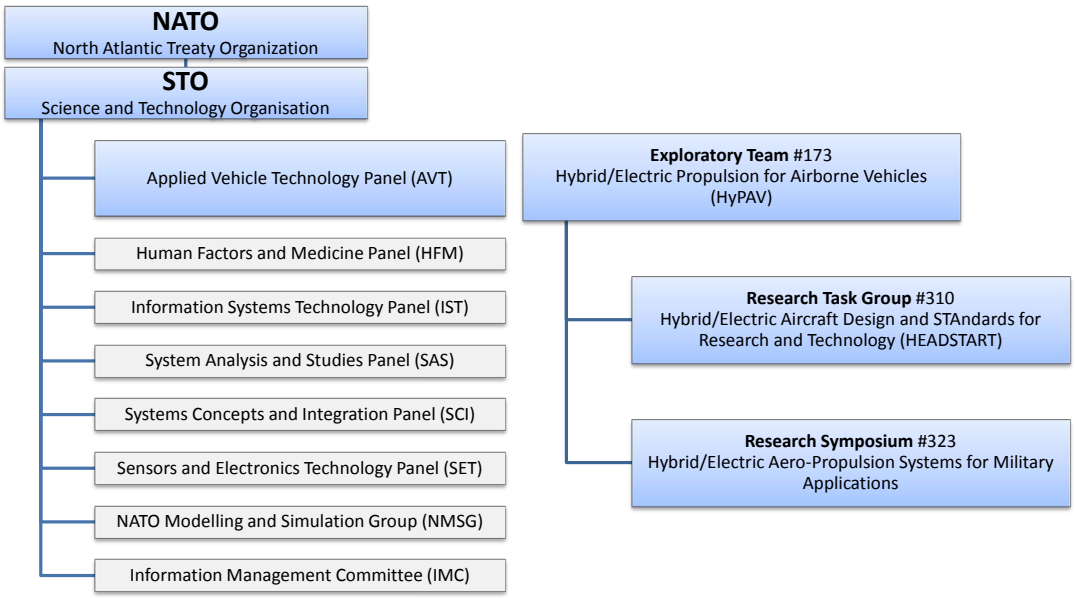

Figure 4: Within NATO's science and technology organisation, three groups work on hybrid/electric propulsion.

In our classification of coordination efforts, FSE is the Civilian Aeronautics Research in Europe.

2.3 ...in the NATO Science & Technology Organization

The north Atlantic treaty organization (NATO) interfaces with civilian science and technology development through its sience & technology organisation (STO). It promotes and conducts co-operative scientific research and exchange of technical information among NATO and partner nations.

The NATO STO involves over 3000 scientists and is organized in panels. One such panel is the applied vehicle technology (AVT) panel. It involves a broad range of activities not only related to aerial vehicles, but also to ground and maritime vehicles. Panels start activities by establishing so-called exploratory teams (ETs), which gather interested personell for a year and then proposes more extensive actions as follow-up activities.

The subject of hybrid/electric flight was picked up in the AVT-ET-173 on "Hybrid/Electric Propulsion for Airborne Vehicles" it involved 29 representatives from 15 organizations in 10 nations. The most important goal was to forecast developments for 2018 and beyond as detailed in table 1. Basically, ET-173 figured that small, all-electric aircraft would be available "immediately"; medium-sized hybrid aircraft woud be developed next; and large passenger aircraft would take a long run to be introduced into the market. While this is an honest assessment of the current state of research, more ambitious research goals will be required in order to fulfil civil climate goals.

A central conclusion from the ET-173 was that hybrid/electric flight is generally treated by civilian representatives and that military end-users are not closely involved in the discussions. Also, it was recognized that a common language and a common strategy would foster the development in the field of hybrid/electric aviation.

Table 1: Forecasted achievements in hybrid/electric propulsion for airborne vehicles

perspective	(in years)	forecasted achievements
short term	2018-2025	all-electric drones and general aviation (2-6 PAX) as well as first UAM demonstrations
medium term	2026-2038	hybrid-electric aircraft (10-20 PAX) and first demonstrations of annexed technologies, such as BLI
long term	after 2038	hybrid-electric propulsion demos with larger payload

In order to address the terminology and strategy issue, a the research task group (RTG) 310 was proposed and kicked off in October 2018. So far, representatives from 10 nations will declare common taxonometric conventions, figures of merit, and interfaces. RTG-310 will also develop and porpose a roadmap leading to a flying demonstrator for NATO purposes. Topics covered in this effort will be propulsors, energy storage and distribution, electrical machines and power electronics, and synergistic annexed technologies. The latter addresses aircraft configuration questions, such as boundary layer ingestion (BLI) or distributed electric propulsion (DEP). The results are expected to also have an impact on the development of hybrid/electric ground and maritime vehicles.

In order to involve more military end-users in the discussion aof hybrid/electric aircraft, the AVT research symposium (RSY) 323 on “Hybrid/Electric Aero-Propulsion Systems for Military Applications” was initiated and takes place in Trondheim, Norway on 07-09 Octobre 2019. The objective is to convene an international array of scientists, engineers, rule-makers, and end-users, both from the military and from the civilian side. The symposiums especially aims for providing a discussion, synchronization and networking forum between (mostly) civilian researchers and military end-users, in order to develop a common set of requirements and applications.

In our classification of coordination efforts, AVT covers the Civilian & Military Aeronautics Research & Industry in NATO nations.

3 CONCLUSIONS

In the previous section, we have presented a number of coordination efforts. Table 2 summarizes these. It can be seen that particular interest groups, such as industry or research establishments can easily recourse to existing regional (e.g. European) networks, such as EREA or EIMG in order to address the modern topic of hybrid/electric flight. These two groups also start to cross-coordinate activities and to involve non-European partners in their activities. The NATO AVT expands the original scope of coordination in three of our categories: it involves different types of end-users, different types of stakeholders, and a broader range of nations.

Such broad coordination efforts will be required, in order to solve the issue of sustainable aviation with hybrid/electric aircraft. These efforts will need to also include societal and political stakeholders. They will need to integrate broader expertise areas, such as electronics and autonomy. And finally, coordination efforts need to world-wide actors, e.g. the rapidly growing aviation markets in Asia.

Table 2: Summary of presented coordination efforts

	end-users	expertise areas	stakeholders	locations
NPA TC	civilian	aeronautics	industry	Europe
FSE	civilian	aeronautics	research	Europe
NATO AVT	civilian & military	aeronautics	research & industry	NATO nations

The NATO AVT efforts will not be the final solution, because of NATO's specific focus on military application and because of NATO's restrictions on participating nations. But they can be first nucleus to develop a world-wide coordination effort from it.

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