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Developing a European Research Strategy in the High Altitude Aircraft and Airship Sector (HAAS)

FINAL ACTIVITY REPORT

(From March 2005 to October 2006)

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Consortium Composition

1 *Creative Technologies Israel (CTI)*
2 *Royal Military Academy, Brussels (RMA)*
3 *Deutsches Zentrum für Luft Raumfahrt e.V (DLR)*
4 *University of York (UoY)*
5 *Israel Aircraft Industries (IAI)*
6 *University of Liège (ULg)*

ABSTRACT

USE-HAAS is an SSA seeking to develop a European Strategic Research Agenda for High Altitude Aircraft and Airships (HAAS). These are platforms in the stratosphere, with considerable potential for delivery of a range of services including communications and remote sensing. This report summarises the background, the activity within the project, and the main Findings. The report should serve to inform those concerned with HAAS, and also the wider community.

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Introduction

This document presents the Summary Findings of a proposed Strategic Research Agenda for Europe in the area of High Altitude Aircraft and Airships ('HAAS') over the next 20+ years. It is the Final Activity Report of an 18-month activity to identify the state-or-the-art, the potential and the needs of this sector. It summarises the background, the vision and the objectives. The work has been undertaken by a consortium from industry and academia, with considerable guidance from other stakeholders including users and regulators. Further details maybe found in the more substantive SRA documentation: Volume 2 which sets out the Research and Development Needs in more detail, and Volume 3 which deals with Missions and Applications.

Background

For a number of years a range of developing commercial and governmental tasks have emerged calling for a new form of aerial platform – one able to operate and offer services from an altitude lower than space-based satellites but at the same time higher than that currently used by commercial aircraft, i.e. from the stratosphere. New requirements and opportunities have arisen especially in the communications, remote sensing and security sectors.

Progress in both stratospheric research and the new aeronautical technologies has been encouraging and indicates that the development and commercial operation of such stratospheric platforms should be both technologically and commercially feasible within the next ten to twenty years. Currently existing platforms either do not totally fulfil the requirements or are not yet available, and the same applies to the applications equipment. There are gaps in a number of technologies and also in the current regulatory environment. Stakeholders also lack a clear vision, with a confused picture led so far, at least in Europe, largely by a number of uncoordinated start-up activities.

It is therefore clear that a strategic agenda is needed, outlining the technology, opportunities, challenges, variety of applications and various future oriented market possibilities. This will act as a stimulus to all those with an interest in the relevant research programmes for stratospheric based platforms and related applications.

There are two fundamental types of platform technology capable of stratospheric flight: unmanned aircraft and unmanned airships. The acronym *HAAS* is taken to mean such high-altitude airships and aircraft, and the term *HAP* (High Altitude Platform) is similarly commonly used. Other platform technologies, such as manned aircraft and tethered aerostats, and lower altitude UAVs (Unmanned Aerial Vehicles) also have a developmental role towards HAAS. HAAS share a number of common features with more conventional UAVs, but they also present unique challenges.

A rapidly growing communications market with its continuous requirement to provide ever-increasing data capacity represents the most overt demand for HAAS projects. Here HAAS can provide services exploiting the best features of both terrestrial and satellite delivery, with a number of advantages which include:

- Replace need for terrestrial infrastructure, with environmental and cost benefit
- Close range and line-of-sight, yielding high grade of service and high capacity
- Flexibility, reconfigurability, and ability for very effective resource yielding very efficient spectrum utilisation.

Additionally, however, enhanced opportunities for earth observation with considerably better quality data than may be achieved from low earth orbit (LEO) satellites, and especially the prospect of long-endurance unmanned stratospheric flights, have also been important drivers in the planning of new market initiatives. Advantages of HAAS include:

- Close range (much better than satellite) yielding high resolution
- Reconfigurability
- Repositioning capability and ability to loiter as required.

And for all applications, HAAS offer the advantage of:

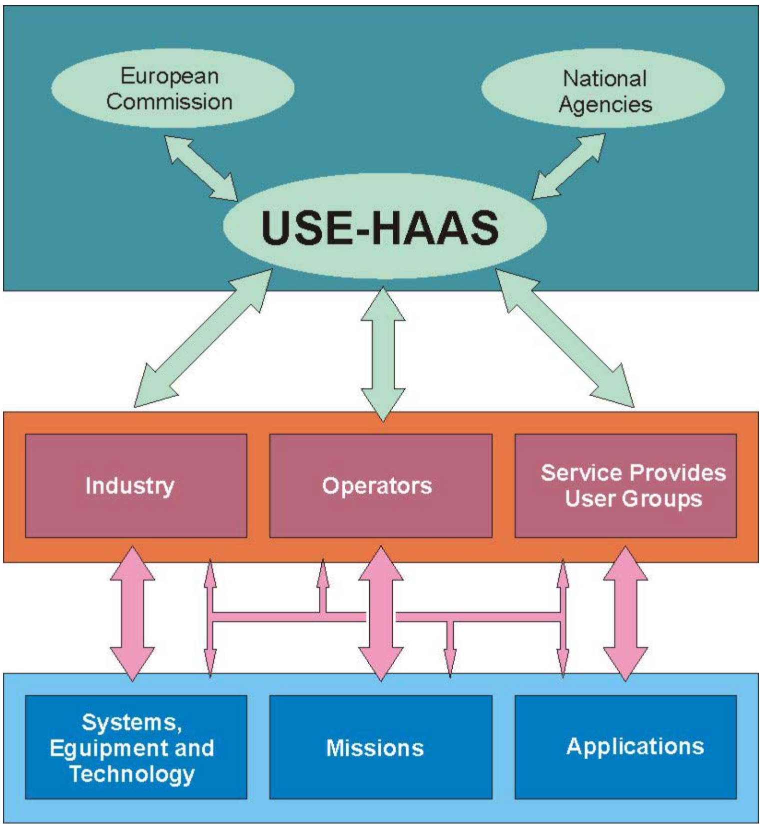
- Rapid deployment
- Potentially low cost.

In 2005 the USE-HAAS project was established, as a Specific Support Action under EC funding, with Arie Lavie of CTI as Chair and Coordinator, to develop a forward strategy, and a Strategic Research Agenda (SRA) or Roadmap for the sector.

The role and operation of USE-HAAS

The objectives of USE-HAAS were: To analyse HAAS state-of-the-art; To analyse HAAS missions, needs and applications; To prepare a HAAS Strategic Research Agenda for Europe. This task was delivered to a team with members representing the aeronautical and applications communities, strengthened by specialists from the airship community and from the aerospace and defence industry. Working Groups were established as follows:- High Altitude Airships (Chair – Bernd Sträter of Zeppelin); High Altitude Aircraft (Chair – Paul Davey of QinetiQ); HAAS Communications (Chair – Patrice Bongibault of EADS); HAAS Security Applications (Chair – Stefan Axberg of FHS); HAAS Remote Sensing (Chair – Bavo Delauré of VITO). The teams met on numerous occasions, and also interacted extensively by e-mail. Additionally, international specialists from all relevant sectors (platform, applications, operations and regulation), from research centres, industry, public bodies and other stakeholders were invited to two workshops, as well as other meetings, in order to clarify international status and needs. The principal Workshops, which took place in Brussels in 2005 and 2006, attracted over 136 participants and a wide range of informed contribution as well as interactive discussion. As well as European stakeholders, there were direct contributions from Japan, Korea and the USA.

The USE-HAAS agenda encompasses all relevant contributors and stakeholders. The need for such an agenda is also driven by a variety of interested communities envisioning applications and business opportunities. Each group, with its specific contributions, expectations and capabilities, is involved in the preparation, and the generic inter-relations are outlined below.



USE-HAAS Generic Inter-relations

A list of Consortium members and of all those who contributed to USE-HAAS is given at the end of this Report.

The broad picture for HAAS

Overview

HAAS offers valuable capability for communications service delivery with a number of specific advantages and benefits. It also offers huge potential for remote sensing with a wide range of end-user applications. These extend readily into a range of security-related applications. The topic of Security has become highly important in recent years as Europe and the world have faced increased threats from international terrorism, organised crime, refugee streams, natural hazards and industrial disasters. These threats have become more diverse and less predictable due to the variety of methods of attack and changes both in the natural environment and technology. Driving factors include terrorist attacks in Spain, UK and USA, intercommunal disturbances in France, environmental hazards in Asia and USA, refugee streams across the Mediterranean, or simply worsening city traffic congestion. Also public events such as the recent Winter Olympic Games in Italy or the football world cup in Germany have sensitised politics and public opinion to the topic of security research. Furthermore, the enlargement process of the European Union will lead to an increased population, increased territory and longer direct borders with less stable regions that need special observation and security.

The wide range of possible uses of HAAS technologies described in the Agenda includes security and observation applications as well as environmental control, disaster management, infrastructure control and many others.

The main markets for new HAAS applications or existing applications with improved performance may be summarised:

- Communication services
- Traffic monitoring
- Pipeline and power line control
- Contamination and environmental control
- Regional earth observation
- Natural disaster monitoring
- Agricultural optimisation
- Infrastructure observation
- Border and maritime control
- Military surveillance

European and International activities

Almost all the HAAS projects in Europe have been limited to studies and some modest technology trials, in contrast to more substantial activities in other parts of the world.

Various studies have been supported or financed by EC programmes, such as FP6, including CAPANINA (broadband communications technology), HAPCOS (COST Action 297: ‘High Altitude Platforms for Communications and Other Services’), and several aeronautical studies with the object of investigating safety and operational aspects of UAVs for a variety of applications including stratospheric missions (UAVNET, CAPECON, USICO). Additionally

ESA has contracted a feasibility study, and a few military investigations are also running. Research organisations and industry have not yet focused significantly on HAAS projects although there are several individual modest activities in France, Germany, the UK, Belgium and elsewhere. The defence industry (e.g. EADS, THALES, DASSAULT, IAI) mainly deals with UAVs which primarily operate with short mission duration and at below stratospheric height, although these limitations are constantly being challenged. In the field of airship developments Advanced Technologies Group (ATG), Lindstrand Balloons (both UK) and Zeppelin (Germany) are companies based in Europe that have already made some initial investigations into stratospheric airship platforms. There is a rapidly developing airship project from StratXX in Switzerland involving RUAG Aerospace Technologies, EMPA, ETH and EPFL among others.

Outside Europe research and technological preparatory work for HAAS systems are more established and in some cases well advanced:

The Japanese governmental aerospace exploration agency (JAXA) has, since 1998, invested in research and airship demonstrator programmes expending a budget of approximately €140million. Initial small-scale demonstrator vehicles have flown at stratospheric altitudes.

The Korean governmental aerospace research institute (KARI) began activities in 2000. An unmanned low altitude airship demonstrator vehicle for testing control and data link packages has been built.

In the USA, NASA has been developing high altitude UAVs for many years. A new long-term programme including UAVs and large payload airships was recently announced.

The US DoD has issued a second stage contract to Lockheed-Martin after the successful conclusion of the definition phase for a small-scale airship demonstrator to fly in 2009. The total contract expenditure, including the previous phases, now amounts to approximately $190million.

Several private US companies (Techsphere, Sanswire, AeroVironment) are working on UAV or airship projects mainly for the commercial market.

And in other parts of the world there is a growing interest with some start-up activities in Russia, China, Malaysia, and Taiwan.

HAAS Vision and Objectives

Before examining the structure and content of the Agenda it is appropriate to summarise the overall and high-level objectives of the future vision of HAAS and of this initiative.

The HAAS vision developed through this SRA extends to the year 2020, and is an innovation for Europe that proposes the simultaneous achievement of two Top-Level Objectives:

- Meeting society’s needs
- Creating Leadership for Europe in the HAAS sector.

Society’s need

Society needs to embrace the whole range of benefits which nations, industries and also citizens can expect from the new markets created by HAAS. Benefits manifest themselves as ripples of prosperity moving out from such activity; from the direct and indirect impact of the HAAS sector and its own trading, through the induced economic effect caused by the spending of earnings from different sectors to the reliance effects upon a wide range of HAAS businesses. Whilst contributions naturally vary between regions and nations, cumulatively the sector generates a directly added value to the economy and society's needs in general. These benefits alone would be noteworthy but the HAAS sector can also lubricate the overall economy, providing its citizens with access to a full array of scientific, security and telecom services thereby improving their overall quality of life. With many new businesses yet to be created, the contribution of the HAAS sector to the EC's economy is expected therefore to be significant. A further benefit will result from sustained investment in HAAS R&D over an extended period which may spawn many innovations similar to those already realised in the aeronautical industry.

The HAAS sector contribution to European GDP may be significant. The wide variety of services from HAAS should exhibit very rapid growth as new markets and opportunities develop. This will include both European and export-led potential. We therefore expect that the HAAS sector will create many more new jobs within Europe by 2020, both directly and indirectly. The prizes for Europe in achieving the goals set for this sector are enormous. Every country in the EU will benefit and every citizen will be able to trace some tangible security strand of advantage.

Global competitiveness for Europe

The second objective seeks *internationally competitive* HAAS solutions. The commercial benefits, which are part of the society's needs, can only be achieved if this objective is fulfilled. A further objective, based upon competitive products and services, could assure economic leadership in this field. Such leadership would, however, need strong coordination and common effort from all involved parties, i.e. governments, researchers, regulation authorities and industries. Having achieved such a status Europe would become a competitive system supplier and that would also then open the door to opportunities for experts and supply industries to participate in HAAS programmes outside of Europe.

Challenge Areas

In supporting these objectives four specific challenge areas were identified. These are defined as the key issues to be successfully tackled in progressing towards the Top Level Objectives – identified constituent goals that contribute to the required achievements.

Quality and affordability are challenge factors for the delivery of worthwhile HAAS services to customers. They are vital for sustained international competitive success and should have the aims of:

- Providing available user- and mission-optimised platforms with very high technical reliability
- Creating new services
- Reducing HAAS service charges in comparison with alternative service providers
- Increasing customers' choice
- Transforming equivalent terrestrial and satellite services
- Creating a competitive supply chain able to reduce time-to-market.

The environment is the challenge factor of meeting continually rising demand for HAAS services while demonstrating sensitivity to society's needs by reducing the environmental impact of operating, maintaining, manufacturing and disposing of HAAS platforms and their associated systems. This challenge presents goals:

- To use pollutant free propulsion systems
- To make substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of high altitude platforms and related products.

Safety and Security represent the challenges of sustaining the confidence of both the end-user and society as a whole that stratospheric unmanned operation will remain extremely safe and will reduce the incidents of accidents to an acceptable minimum. This is achieved by:

- Creating the rules for safe co-operation of unmanned and manned flights in controlled airspace
- Using multi-redundant systems for autonomous flights
- Reducing human errors in fabrication and operation and their consequences.
- The introduction of self-protection and self-destruction systems for avoiding accidents.

HAAS system efficiency must be substantially increased in comparison with HAAS demonstrators to date in order to achieve the economic needs of Europe's end-users. This topic includes reliability and endurance. Improvements can be met by international competitiveness coupled with sound engineering and business development.

HAAS SRA: Research and Development Needs

- The work of the USE-HAAS consortium has resulted in detailed findings which are published: *STRATEGIC RESEARCH AGENDA Volume 2. HAAS Research and Development Needs*. This expands on the vision and the strategic research agenda for HAAS.
- The applications and missions are dealt with in more detail in a separate document: *STRATEGIC RESEARCH AGENDA Volume 3. HAAS Missions and Applications*. This is created as a separate self-standing document because of the variety of possible applications and the variety of end-users.
- The overall SRA is summarised also in Volume 1: *STRATEGIC RESEARCH AGENDA Volume 1. HAAS SRA Summary.*

Synopsis of HAAS Research and Development Needs (Volume 2, Section 2)

A comprehensive survey has been undertaken of the state-of-the art in HAAS technology and projects; the worldwide market, the research and industrial situation in Europe and in other parts of the world.

HAAS market potential, and level of potential economic activity, is very large, although hard to quantify in a market which remains to be developed. Analogy may be made with growth figures given for UAV activities where annual growth potential of up to 50% leading ultimately to the order of €1billion economic activity per annum is suggested, with consequences of creating new services and new working places. While these figures, and the timeframe, must be largely speculative for HAAS at present, these are impressive figures which should trigger strong interest and concerted action by all involved parties.

An overview has been produced of potential applications with the main segments of communication, security and civil control and monitoring tasks and of the associated end-users. Key HAAS players worldwide are identified and projects described.

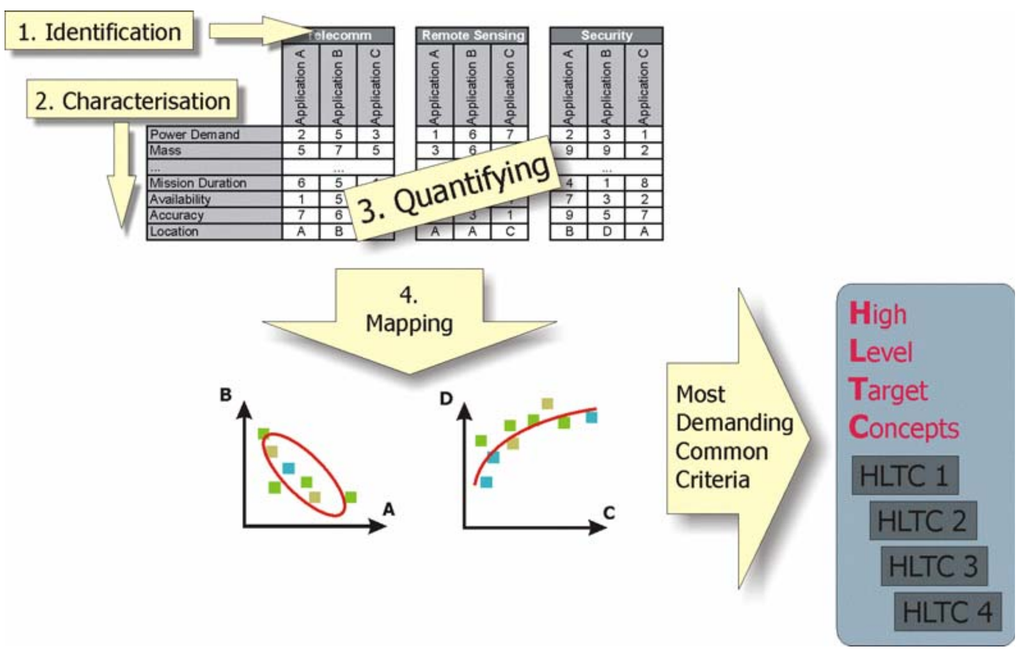
Technical and economic challenges are highlighted: most specifically the need to achieve investment; safety and security; regulatory hurdles; and market competitiveness.

HAP Vision and High Level Target Concepts – HLTCs (Volume 2, Section 3)

Different users have different needs for their specific applications. As broad as the range of applications is, equally varied are the operational characteristics and technology needs. Therefore it is necessary to establish a systematic approach and to focus on the common aspects without losing the broad perspective of high altitude platforms.

The HLTCs were defined as the results of a more detailed investigation made with the aim of translating user requirements emerging from the different applications into technical requirements for the HAAS system.

This was done in several steps as shown in the Figure below. Firstly, different representative applications from the various sectors (communication, remote sensing science and security) have to be identified and described by their needs, potential and challenges. This activity defines list of characteristics. Typical examples are the payload power demand, mass, mission duration, required availability, and on-time availability.



The development of the HLTCs

These characteristics open the door to a more general description of the different applications and quantify their specific needs. After weighing the characteristics a quantified group of the most demanding common criteria can be produced that directly lead to consistent, integrated HLTCs. The HLTCs were then found to provide a very powerful tool for organising the SRA activities and technology developments. In order to achieve the targets in the different concepts, a variety of technology improvements are necessary simultaneously. Therefore these help to organise the technology development, to prioritise them and to develop detailed planning for the HAAS SRA, ultimately providing a technological road-map to future activities. Among the High Level Target Concepts (HLTCs) are:-

- Very Long Endurance, Very High Altitude missions
- Large payload airships
- Multi mission flexibility
- Inherent safety.

Section 3 of the report also looks beyond the horizon of the HLTCs and is a useful extension of the concept into the more distant future.

Technology Strategic Research Agenda *(Volume 2, Section 4)*

The technological challenges and the research needs are described in detail in this section. The necessary research work is tabled using the HLTCs, technological domains and time of availability as structure elements. These charts – the technological road map – are arranged in a manner similar to the road map of the aeronautical research agenda ACARE

Before addressing the research and technological needs, the challenges of a stratospheric operation should be described briefly:-

Although the stratosphere extends from approximately 10 to 50 km altitude stratospheric aerial platforms will be operated at an altitude of 20 to 25 km. Within this layer there is the lowest wind profile, which will positively influence the platform layout (e.g. lowest thrust requirement for geostationary missions). The most important parameter at this altitude is the air density which is about 1/15th the density at sea level. The requirement to create sufficient lift leads to large wing areas for UAVs or to large volumes for airships – in general to large and complex systems with limited payload. Another essential technical issue is the allocation of sufficient power for mission flights and for operating the payload for extended periods without the need for refuelling. Extremely lightweight construction of platforms, equipment and payload and new remote controlled propulsion and power generating systems (e.g. solar energy, fuel cell) are consequences. Additionally the operating environment is more complex than at lower altitudes. Radiation and wide temperature variations between day and night are challenging parameters for both platform and payload design as well as for their operation. In many domains current aeronautical or space techniques can be used, nevertheless there is a need for further improvement, adaptation and research for specific solutions in all related areas otherwise the requisite commercial goals and the international competitiveness cannot be achieved. The necessary research items are summarised in the roadmap.

There are many technological challenges identified. By way of example, just three of these may be outlined here:-

- Energy storage and propulsion for all types of HAAS. Essentially the need to maintain station-keeping at night when there is no prime power from solar cells means that batteries or fuel cells are required. This is a major area for development.

- Management of thermodynamic behaviour of airships, with large gas volumes in the stratospheric environment.

- Autonomous control for safe air traffic management.

The technology roadmap is intended for use by the aeronautical HAAS stakeholders as a tool for planning the implementation of the associated research programmes. The HTLCs collectively address all the challenge areas and their related goals.

Other enablers *(Volume 2, Section 5)*

A broad-based effort and consistent approach at all levels are key prerequisites for the successful development of high altitude systems, their applications and technological developments. To support the research intention and enable it to function efficiently, a number of other actions will be needed by European institutions including their governments and local and educational authorities.

The institutional and public implications considering business and cost issues and also policy, process, and legal issues have been addressed. Very important are the implications for institutional enablers such as regulatory authorities for platform certification and commercial communication frequency allocations. Commercial success directly depends upon practical solutions for certification and operation, involving the minimum of bureaucracy, and the regulatory hurdles may prove very substantial.

One of the most challenging processes will be the integration of unmanned vehicles into current air traffic management systems; this will apply not only when they are above current airspace height, but also during ascent and descent phases. International rules need to be established in the short term in order to provide involved partners with confidence and an operational framework for new products and their operation.

Besides the necessary contribution of the institutional enablers, strong co-operation with research institutes at all levels is required. Indeed, the initial creation of an efficient research infrastructure will be just as important as any possible co-operation with other HAAS activities outside Europe. Europe has clearly an under-capacity in this field and ultimately also in the field of propulsion and energy generation at high altitude. Creation of a network of research centres to make more efficient use of limited resources is mandatory. Strong collaboration of these centres with industrial research is also required.

As research moves into development, commercialisation, and production, it will be necessary to strengthen industrial collaboration and establish effective supply chains.

HAAS SRA: Missions and Applications

High altitude applications and missions have been considered in some detail, and reported as a separate document because of the variety of possible applications and the plurality of end-users. Not all such users may be directly concerned with the overall payload and system challenges.

Market Analysis *(Volume 3, Section 1)*

Data collection from sensor-equipped aerial platforms operating at different altitudes has been a growing market for a number of years. In the past, access to satellite technology and military aircraft deployed at very high altitude was limited or not economically feasible for a variety of potential applications. Platforms for acquiring data from stratospheric altitude were normally stratospheric balloons with very limited performance. New high-flying platform concepts (HAAS), operating at stratospheric altitude, can fulfill a number of these requirements. In order to attract governmental, civil and commercial customers, HAAS platforms will need to demonstrate clear in-service cost and/or performance benefits to end-users in their fields of application. They are partly in competition with air- and space-borne approaches. Moreover, every potential application has some low-tech solution (e.g. foot patrol, watch tower, ground sensors etc). In many applications HAAS platforms will be able to provide additional and extended capabilities over and above current or alternative methods. Although the approaches can be competitive with each other, there are many applications where the complementarities of the platforms can yield a superior and cost effective solution. The major markets and applications are described in detail.

The telecommunications market as economically the most important market may be segmented into a short term (e.g. event servicing/disaster relief), a medium term (e.g. mobile and broadband communications for fixed users in developing countries) and a long term (e.g. mobile and broadband communications for both high-speed mobile and fixed users) markets. For market success a suitable business model for commercial services is essential.

Events over the past few years drive a need for increased protection against terrorism including bio-terrorism and incidents with biological, chemical and other substances. There is also need of research for enhancing crisis management including evacuation, search & rescue operations, active agents control and remediation. There is a special security need for a focus on research into the use of imaging sensors and telecommunications including the multi-dimensional problem of response time, endurance and altitude.

There is no doubt that the overall HAAS concept has great economic market potential. The promise of better performance over currently available systems in the field of valid data collection from a variety of very precise sensors will also be of great use for governmental civil control and monitoring tasks as well as for earth observation for scientific, purposes.

Application field examples *(Volume 3, Section 2)*

Besides the market analysis, various examples of three application fields (Telecommunications, Security, Civil Control and monitoring) are described in detail.

Payload and platform requirements *(Volume 3, Section 3)*

In order to create a market-oriented and successful HAAS system, the necessary payload and platform requirements have to be defined. Electrical power needs, electro-magnetic-compatibility (EMC) and weight/volume limitations all have to be considered when designing a competitive and high performance system.

HAAS Missions and Applications Roadmap *(Volume 3, Section 4)*

The main technological challenges for the payload for the applications outlined above and their appropriate missions have been explored, and are summarised. Some of the technologies are common in the aeronautical industries, but further developments are necessary for their implementation in unmanned vehicles such as airplanes or airships, for example special lightweight design, for operation in high altitude.

The technology road map has been designed in tabular format. It maps the numerous technologies proposed under each HLTC against the broad disciplines areas.

Structure Flow Diagram

This illustrates the processes of which the envisaged SRA is a part.

Summary Findings and Recommendations

The following are the key findings and recommendations of the USE-HAAS work.

1. **The HAAS sector offers considerable potential** to support a range of valuable applications and services. These are numerous, within the key sectors of Communications, Remote Sensing, and Security, and will meet society's needs, contribute to European Objectives and offer economic benefits. HAAS will open up new opportunities as well as significantly enhancing existing services.

2. **HAAS platforms are already available** for limited short-term missions. As a matter of priority, commercially viable missions and applications should be actively supported to generate confidence in the HAAS concept, thereby leveraging investment to tackle the medium- and long-term challenges in the HAAS aeronautical sector.

3. **A phased implementation approach** is proposed for HAAS. Over a period of time this will extend the capabilities from currently available short-duration solutions to advanced long endurance missions. This will also engender wider public and commercial acceptance of this emerging technology.

4. **Key high level targets include:-** Very Long Endurance, Very High Altitude missions; Large payload airships. **High altitude long endurance** craft represent the ultimate goal: this is demanding, and will take several years to accomplish. Demonstrator programmes are essential, especially to encourage external investment. Among many technology challenges, principal issues include propulsion and energy storage. Research should also extend to applications, business models, and reliability factors.

5. **Multi mission flexibility** is also a target for HAAS platforms, which should be developed with the potential to serve a range of missions, perhaps using modular configurations which can be adapted for different payloads and which will develop economies of scale.

6. **Safety and Security** are paramount targets for HAAS. Airworthiness certification of HAAS vehicles is critical, and may present considerable challenges for commercial operation.

7. **Regulatory and policy** matters are highly significant and a potential impediment. In particular, air traffic management, airworthiness certification, and radio spectrum allocations for HAAS represent major issues. These need coordinated and proactive European approaches over a long timeframe to be implemented without delay, and should be integrated with efforts underway worldwide and with appropriate bodies such as EASA.

8. **HAAS is inherently environmentally sound** in terms of operation and also efficacy of applications. Most platforms require only solar energy, and have minimal environmental impact. HAAS applications can yield a considerable range of benefits through enhanced remote sensing and environmental monitoring. Wireless services can also provide highly efficient utilisation of the radio spectrum. These are strong features and positive selling points for HAAS and their services.

9. **Considerable achievements have been made** in some research areas, most notably as regards communications applications. Major integrated programmes in Japan and the US have shown substantive results. However, progress to date has been patchy especially in

Europe. R&D tends to be fragmented, and the sector has not yet succeeded in convincing commercial investors or service providers. More generally, there is some skepticism and uncertainty of expectation, partly as a result of unrealistic promises and uncoordinated start-up activities. HAAS needs to demonstrate cohesiveness and maturity, with worldwide collaborations encouraged to ensure best practice is brought to the sector.

10. **R&D funding** is currently under-resourced to see this new technology through to commercial and operational sustainability, and is unlikely to meet the strategic priorities unless substantially increased. Current and near-term progress is limited by shortage of proven reliable and long-endurance platforms, and there remain considerable technological challenges in terms of both platforms and applications.

11. **Research needs to be more integrated**, bringing together aeronautical and applications interests and to achieve critical mass. Europe is not realising its potential, and is in danger of falling behind other parts of the world in relation to HAAS R&D. Future EU funding strategies need to adopt a more coherent approach, to encourage appropriate groupings to promote this sector, in particularly bringing together aeronautical and applications interests. Mechanisms need to be established to ensure continuity and cohesiveness of European research in HAAS, monitoring and supporting the sector over the long term, and ensuring international competitiveness by European industry.

12. **Multi-disciplinary skills** are called for, supported by sound engineering and operational experience. These should build upon existing strengths and expertise across Europe, and in particular need to be harnessed from within the aerospace sector, including airship industries and UAV developers.

13. **Participation and support for HAAS is required** from a wider range of communities and stakeholders. In particular from the aeronautical community in terms of acceptance and coexistence, from the existing UAV community in terms of an evolutionary development path, and from all potential users, which will also help overcome the 'Not Invented Here' syndrome. This in turn will engender greater public and commercial acceptance of this technology.

Next Steps

In order to establish successful HAAS projects with their related industries, the proposed next steps are:-

- Acceptance of the HAAS technologies and programmes into the EC Framework Programme, as activities supportable by all member states.
- Establishing the requisite regulatory frameworks for remotely piloted high-altitude flight, in collaboration with other interested sectors. Also securing the necessary communications frequency allocations to support the new services.
- Facilitating links between the member states and their collaboration on matters of aeronautical and applications research within the framework of this agenda. Approaching member states in order to review their own industries' ability and desire to contribute to the new technologies and the new markets.
- Within the USE-HAAS activity the proposal was made for a mechanism to oversee development and implementation of this research agenda following the current USE-

HAAS project. HAAS needs an official and well-supported forum for monitoring and dissemination of the fast moving market requirements and technological progress.

Dissemination

It is vital that the work of USE-HAAS receives the widest possible dissemination. There are five routes for dissemination:-

- The USE-HAAS web-site. www.usehaas.org. This contains the principal output reports and documents, and also copies of presentation material from the Workshops and other meetings (where disclosure is permitted). It is planned that the web-site will be maintained and supported for at least the next three years.

- Links with other bodies. The web-site will be linked from and to other HAAS-related bodies, for example COST297 ('HAPCOS' – www hapcos.org).

- Workshops and meetings already taken place. These have included a wide range of international participants.

- Promotion at future conferences etc. Members of the USE-HAAS consortium remain active in the field, and are taking every opportunity to present the results from USE-HAAS at appropriate international conferences and at meetings of other relevant bodies.

- Documents submitted to the Commission in the course of the USE-HAAS project. Most of these will be in the public domain.

The authors of this Report, or any Consortium members, will be pleased to engage with interested parties.

In Conclusion

High Altitude Aircraft and Airships offer considerable opportunity for the future. USE-HAAS has identified the key issues, and put forward a Strategic Research Agenda for this important and developing field.

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