25 Nations for an Aerospace Breakthrough

European Civil Unmanned Air Vehicle Roadmap

Volume 1- Overview

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Executive Summary

There is no doubt today that a huge market is currently emerging from the potential applications and services that will be offered by unmanned aircraft.

Being at the cornerstone of aeronautics, of the global environment monitoring, of the telecommunications and information technology, and of other applications or missions such as surveillance and security, civil Unmanned Air Vehicles (UAV) is a new thematic area that needs to be addressed by the European Research Framework Programs.

A strategic initiative should be prepared by the European Community to provide for the operation, development and production of civil UAVs, in order to be in a position to compete with other UAV initiatives around the world. Civil UAV flight operations that will benefit European society include:

- **Remote Environmental research**
- **Pollution assessment and monitoring**
- **Fire-fighting management**
- **Security e.g. border monitoring, law enforcement**
- **Scientific missions**
- **Agricultural and fisheries applications**
- **Oceanography**
- **Communications relays for wideband applications**

The direct civil UAV benefits are as follows:

- **Direct response to the Strategic Aerospace Review for the 21st century report – ref [1]**
- **Build across Europe a future European Research Area - UAV**
- **Technology development in all 25-member states**
- **Equal opportunities for all 25-member states**
- **Education of students in aeronautics in response to the ACARE report – ref. [2]**
- **Lower risk of a future Europe-U.S. technological gap**

Therefore it is proposed that a pan-European model based on equal opportunity inclusion, from all 25 European countries, by all interested research institutes, universities, industries including small and medium enterprises (SMEs) and potential investors be introduced in order to establish a Research Area as a Centre of Excellence organised by a Coordinating Civil UAV Body with a wide range of technological initiatives.

A pan-European civil UAV program will catalyse further unity within Europe through the synergetic efforts involved in the program. The civil UAV program will provide a cross-

European effort that will also meet the Strategic Aerospace Review for the 21st century (STAR21) requirements for economic growth, security and quality of life.

In addition, it will create a coherent market and policy framework, vital to European aeronautics, as set out in the STAR21.

The major strategic enablers to realise this vision, Certification and Regulatory Support, Cost Reduction and Safety & Reliability Enhancement, should be supported. The relevant research activities will be a very important element of a true European Research Area where researchers, academicians, European regulation authorities and industry including SMEs from across Europe will tackle the challenges, which presently obstruct the path.

Early groundwork, for certification and regulation, has already been laid by the Joint JAA/Eurocontrol UAV Task Force, in which our EU-funded USICO project participated. Initial work on interoperability with the FAA in the U.S. has begun. Further **efforts towards cost reduction and safety and reliability** were carried out in the FP-5 funded **UAVNET**, **CAPECON, USICO** and **HELIPLAT** projects. Additionally, the **IFATS** project, which focuses on pilot-less transport aircraft technologies, is another stepping stone towards civil UAV operations.

This proposal offers a unique opportunity to further unite and integrate Europe's Aeronautics capabilities and develop a research and technological infrastructure to benefit society. A brief outline of a coherent long-term perspective for European UNMANNED AIR VEHICLES - the next generation of aerospace technology is presented in this preliminary document. The full Roadmap will be published in the spring of 2005.

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1 VISION STATEMENT

Within ten years, Europe can be transformed into a major influence in civil Unmanned Air Vehicles (UAVs). Therefore, action should be taken to set up a Research Area as a Centre of Excellence, which will include the establishment of a Coordinating Civil UAV Body. The proposed civil UAV initiatives will:

- **Facilitate civil Unmanned Air Vehicle flight operations to benefit European society through:**
  - **Remote Environmental research**
  - **Pollution assessment and monitoring**
  - **Fire-fighting management**
  - **Security e.g. border monitoring, law enforcement**
  - **Scientific missions**
  - **Agricultural and fisheries applications**
  - **Oceanography**
  - **Communications relays for wideband applications**
- **Ensure that Europe will remain self-sufficient, supplying its own requirements.**
- **Initiate and launch research and development of core technologies enhancing education and key skills**
- **Provide the catalyst to enrich the aerospace infrastructure across the 25 nations of Europe.**
- **Encourage pan-European activity with all interested member states participating in this new field by matching technologies with capabilities**

1.1 STRATEGIC OVERVIEW

Applications and services made possible by unmanned aircraft are generating a vast emerging market.

In order to effectively tap into this market, Europe should create a European Research Area for civil Unmanned Air Vehicles. Civil Unmanned Air Vehicles is a new thematic area that needs to be addressed by the European Research Framework Programs.

It is crucial to Europe to prepare a strategic initiative for civil UAVs, in order to be in a position to compete with other UAV initiatives around the world. The European goals, relevant to civil UAV aeronautics, as set out in the STAR21 report, state that part of Europe's long-term strategic objectives are:

- **The confidence of an aerospace industry vital for meeting Europe's objectives for economic growth, security and quality of life**
- **The establishment of a strong globally competitive industrial base essential for Europe**
- **The assurance that Europe remains at the forefront of key technologies**
- **The guarantee that Europe's aerospace industry maintain a strong competitive position to compete in worldwide markets**
- **The conviction that the essential education and training needs of a long-term skilled workforce is addressed – in order to avoid a skills gap**
- **The allocation of sufficient funds to support long-term civil Unmanned Air Vehicles infrastructure**

UAVs are aircraft, which can fly autonomously, and operate a wide variety of missions, and in emergencies can be controlled by a ground control station – see Figure 1-1 Civil UAV Integration into Civil Airspace. Their size can be as varied as their missions. The smallest UAV, a Micro-UAV, may have the size of a decimetre, and some of the largest ones can fly at very high altitudes and have a wingspan of tens of meters.

The main challenges to the integration of civil UAVs into manned airspace are: safety and reliability followed by cost and regulation.

It is important that Europe set up a pan-European Coordinating Civil UAV Body, which will coordinate research and development, matching technologies to capabilities in all interested research institutes, universities, industries and potential investors, across the 25 European

countries.

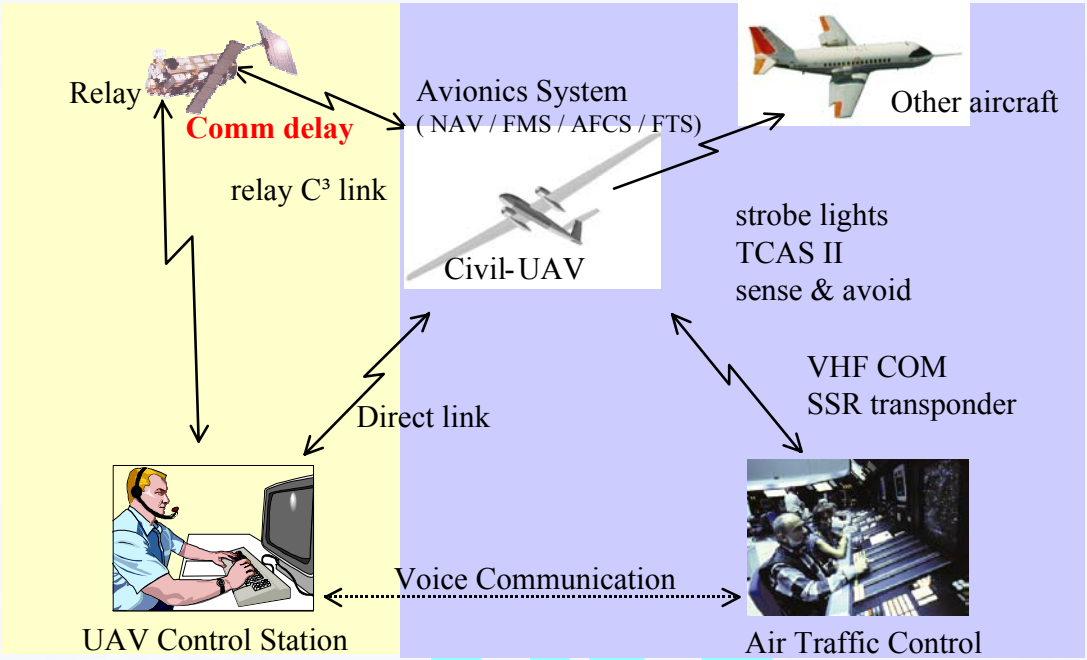

FIGURE 1-1 CIVIL UAV INTEGRATION INTO CIVIL AIRSPACE

European aeronautics research has a major role in ensuring a secure and prosperous Europe. In addition, civil UAV technology will improve the expertise of Europe's personnel, enhancing key skills needed to maintain an advantage in the market place, and avoid a skills gap and a brain drain to other parts of the world.

A European initiative is crucial.

This document presents an overview of the civil Unmanned Air Vehicle Roadmap, to meet the objectives stated above in the field of civil UAVs, complementing other aeronautics initiatives, such as the IFATS project. The roadmap prepares a strategic initiative for research, development, operation and validation of civil UAVs, in order to enable Europe to position itself to compete with other UAV initiatives around the world.

2 PRESENT STATE OF CIVIL UNMANNED AIR VEHICLES

It is clear that the increasing demand for civil UAV missions will bring about solutions to the challenges presently facing civil UAVs and eventually lead to their incorporation into the civil airspace.

Across the world, strategic civil UAV roadmaps are pointing to the years 2010-2015 as the years when civil UAVs will become widespread in civil aviation.

The major necessities to fulfil in order to allow widespread civil UAV flights are safety/reliability improvement, cost reduction and regulatory requirements.

By acting now the technological gap will not be widened.

The intensity of the activities in the US will open a "technological capabilities gap" within the next five years, which could produce the situation shown in Figure 2-1. This gap could last decades. The US is investing vast amounts of funds in homeland security and Air Traffic Control integration. Already civil UAVs patrol the U.S.-Mexican border. Furthermore, the FAA has begun to lay down the foundations for the necessary regulations to incorporate unmanned flight into National Airspace (NAS). NASA and industry are working together with a budget of over $140 million under the ACCESS 5 program. **Japan** has fully certified and is operating rotary civil UAV crop sprayers. **Australia** was the first to regulate the civil applications of UAV in 2002, and is very active in plans to patrol its vast ocean shores, with civil UAVs. **South Korea** has also set out a strategic roadmap for their vision of civil UAVs to fulfil their requirements.

Major nations have understood the benefits that can be derived from UAV systems. The **U.S. is planning to invest more than 15 billion dollars in the next seven years** to accelerate the development of UAV systems, platforms, and payloads so that these systems will be capable of performing necessary security missions.

A European coordinated research and development effort in civil UAV technologies is critical.

Europe, in sharp contrast, does not have any strategic initiative for civil UAVs, and up to now **Europe has invested approximately €15 million**, under the FP5 program, in the four projects concerned with civil UAVs. UAVNET, USICO, CAPECON and HELIPLAT. A significant positive step was taken but it will be lost if there is no plan for continuation.

Uncoordinated and scattered research efforts hamper overall EU R&D efficiency.

In practice, there have been several occasions, in Europe, on which the **civil UAV capabilities were demonstrated but they require continued further support**.

In Germany, the USICO project organised a sophisticated simulation of the integration of UAVs into

civil airspace. It was successfully shown, with actual Air traffic controllers from all over Europe playing an active part in the simulation, that by using the concepts developed by the USICO project, it was possible to safely fly a UAV within the airspace of even a very busy airport (e.g. Frankfurt). The simulation was attended by representatives from industry, institutes and regulatory bodies, who were impressed by the possibility of smooth UAV operation. In parallel, Germany supported the WASLA-HALE demonstration programme. On another occasion, Swedish air traffic control participated in a demonstration of a civil UAV (EADS/IAI Eagle) flying from Kiruna in Northern Sweden on a scientific mission, with a long flight over inhabited areas. Belgium has certified B-Hunter UAVs for civil operational flight in most of the country's airspace. In Holland, a civil UAV was flown, monitoring rail tracks near the Amsterdam central train station, demonstrating automobile tracking, crowd control and observing waterways activities. By flying over the Amsterdam metropolitan area, the aircraft flew within airspace controlled by Schipol Airport. In France, the French Ministry of Defence in project USAR is preparing the ground to enable the integration of UAVs into the airspace. Hungary and France have used simulated UAV flights to monitor and aid in fire fighting activities in comparison to existing methods.

FIGURE 2-1 WITHOUT SERIOUS EUROPEAN INVESTMENT

European research Commissioner Philippe Busquin[1] says. "Americans have made better long-term strategic choices."

It is necessary for Europe to formulate a strategic approach to civil UAVs.

Presently Europe lacks a coordinated approach to civil UAVs. **It is therefore, recommended that a common European plan be prepared to meet the challenges posed – see Figure 2-2.** The European Union should invest in civil Unmanned Air Vehicles including the full range of technological activities in order to reap the benefits, throughout the growth stages to maturity, while meeting the long-term goals it has set for itself in STAR21.

[1] Time Europe January 19, 2004 | Vol. 163 No. 3 – "**How To Plug Europe's Brain Drain"**

FIGURE 2-2 WITH SERIOUS EUROPEAN ACTION – TAKING ADVANTAGE OF EUROPEAN RESOURCES AND DEVELOPMENT

3 CONTRIBUTIONS TO EUROPEAN POLICY

The aerospace industry is a key component for the credibility of the European security and defence policy. STAR21, Strategic Aerospace Review for the 21st century, analysed the needs for the European Community based on decisions taken in the Lisbon[2] and the Barcelona[3] European Council, concerning overall R&D and innovation effort on frontier technologies.

It is important that the European Commission remains committed to nurture on-going activities in civil UAV research and development.

A direct outcome of STAR21 is the development of an essential new generation of equipment in crucial areas such as data collection for fisheries protection, border patrols, law enforcement using Unmanned Air Vehicles. In addition, it is essential that EU member states and industry act to maintain Europe's position as a world-class aerospace producer – see Figure 2-2.

Civil UAVs will generate the opportunity to expand and mature the European aerospace industry, particularly for the countries with limited aeronautical industry, such that all interested EU member states can actively participate.

Recently certain applications for civil UAVs have come into focus, due to more pressing issues and the relative ease[4] to implement them, with topics such as:

- Monitoring vital infrastructure sites of national interest (power plants, critical buildings, harbours, power or energy distribution).
- Oil spillage and pollution
- Security surveillance of drug and arms trafficking
- Wide-ranging police and law enforcement missions
- Land and sea border monitoring to minimise Illegal immigration
- Fire management

However, civil UAV applications are not limited to those mentioned above. Further uses of civil UAVs are possible during major catastrophic events without endangering the life of pilots. In addition, these civil UAVs can play an important role for remote environmental research, ocean surveillance, and atmospheric measurements – see Figure 3-4, Figure 3-5, Figure 3-6, and Figure 3-7.

New European approaches to support and strengthen research and development, for civil

[2] In 2000

[3] In 2002

[4] Emergencies and security take a precedence over cost and certification requirements.

UAVs, are urgently needed. The aerospace industry is a key component for the credibility of the European security and defence policy. **One of the key systems mentioned in the STAR21 are *Unmanned Air Vehicle systems*** since **they provide a reliable and cost efficient means** for criminal activity surveillance, border patrols, law and order enforcement, data management for fisheries protection, civil search and rescue and other applications with considerable social importance and market potential.

Experts from the UAVNET-USICO-CAPECON projects representing European Industry, Research Institutes and Academia have prepared the "***25 Nations for an Aerospace Breakthrough*** " document of which this is the Overview of the full Roadmap, as a response to the European requirements formulated in the Lisbon[5] and Barcelona[6] European Council decisions and the STAR21 report concerning new breakthrough technology - the technology of Unmanned Air Vehicles, civil UAVs.

3.1 New European Research Potential Opportunity

To build a future Europe, research programs have to be initiated and funded. During the 5th Framework the Thematic Network UAVNET and the two projects USICO and CAPECON were approved to advance the concept of civil and commercial UAVs. In the FP-6 work programme, no funding was made available for civil UAVs, stemming progress.

European leaders should facilitate a European Research Area for civil UAV systems.

The Civil UAV development activities require the support of European Commission research in order to achieve the proposed Visions. To proceed further, it is essential for Europe to support necessary technological developments, application validations and prepare and institute regulatory changes.

To minimise the risks involved, the European Commission should use the experience gained in the four civil UAV projects, which was used in the preparation of this European Civil Unmanned Air Vehicle Roadmap.

The momentum provided by these projects should not be lost and a Coordinating Civil UAV Body should be established to bring that initiative to fruition.

In order that Europe fully benefits from civil UAVs, it should:

- Invest in civil UAV technologies. **Europe should grasp the opportunity and take the initiative to make Europe competitive on the market of civil UAV systems.**

[5] LISBON 2000 - LISBON European Council Conclusions EU-Summit, Lisbon, Portugal, 2000

[6] BARCELONA 2002 - BARCELONA European Council Conclusions EU-Summit, Barcelona, Spain, 2002

- Maintain the momentum attained through the civil UAV projects carried out in FP5. The work carried out by the UAVNET, CAPECON, USICO and HELIPLAT projects together with the information gained in local projects can be used as a springboard to form the basis of the European civil UAV technological infrastructure.
- Minimise the risks by using the initial work on the civil UAV projects and ensure continuity
- Use the information gained as a lever to promote civil UAVs **- Europe should not permit the knowledge gained so far in the field of civil UAVs to dissolve.**
- Build a civil UAV centre of excellence where efforts are coordinated and resources shared across present (IFATS[7], and SESAME[8]) and future projects
- Formulate the Coordinating Civil UAV Body that will synchronize activities in this field.

The civil UAV field will permit Europe to broaden its knowledge-based economy. It will stem the current brain drain to other non-European countries. In addition, it will use the initial work carried out by the civil UAV projects together with current work on an autonomous air transport aircraft – IFATS together with the SESAME project, to build a solid foundation of civil UAV expertise.

This will be consistent with the commitment made in Barcelona, where the specific aim is to close the innovation and technological gap between Europe and its competitors.

Europe should launch the civil UAV initiative to garner and reap the long-term benefits that civil UAVs will offer.

The capability for European excellence and technological development in civil UAVs is clear, as it possesses the potential to realise new civil UAV technologies through additional research and development (R&D). Europe possesses the experience and technological knowledge in civil aviation to cover all aspects of civil UAV research. Europe has capable manpower, a leading airframe and engine industry, aerospace avionics and advanced electronic system design and certification skills and advanced aeronautical research facilities.

The potential that the aeronautical industry will realise by the network of academic institutions, small and medium enterprises, research institutes and large industry groups working together across Europe, is phenomenal.

[7] Automatic air transport

[8] Single European Sky (SES) program

Only a pan-European cooperation involving and integrating the 25 nations, from industry to research, including national regulatory and legal bodies and guided by an overall integrated plan, will realise the union of technological potential Europe possess – see Figure 3-1.

This overall integrated plan for pan-European cooperation will be based on the European Civil UAV Roadmap to be issued by mid 2005.

The civil UAV focus provides European aeronautics with a unique opportunity to move into the future.

By investing in civil UAVs Europe will provide:

- A driver of innovation
- A technologies generator
- An economic growth engine - due to high technologies involved
- Pan-European unity - civil UAVs are *scalable*, since they vary in size according to application, from micro-UAVs to HALE UAVs. Scalability offered by civil UAV technologies will allow academia, research institutes, universities, higher education, industries (SMEs and others), certification and regulatory bodies, various users, and others to participate in this field

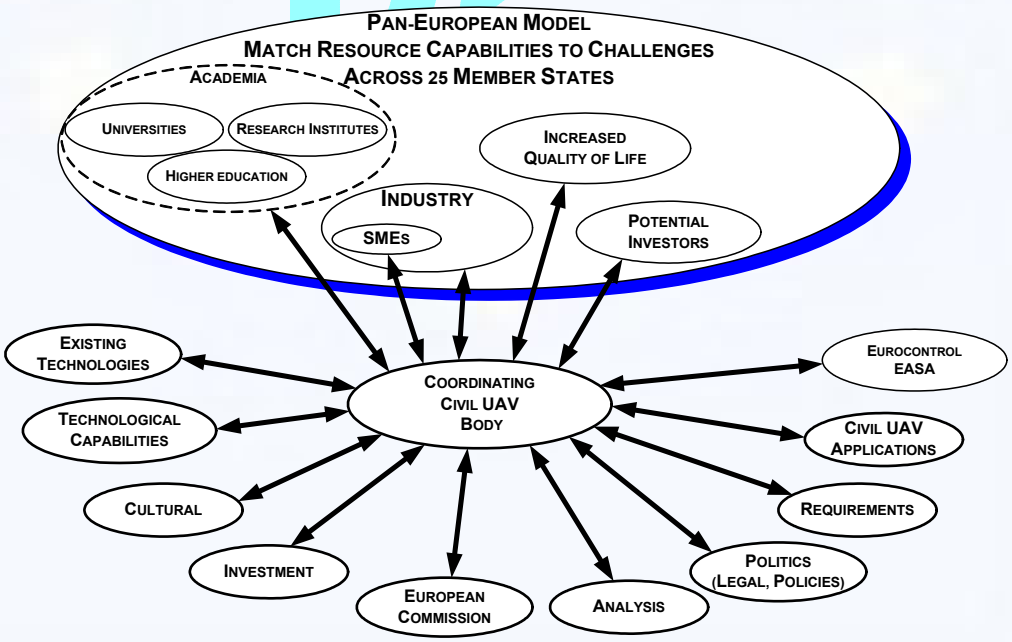

FIGURE 3-1 FOCAL POINT FOR PAN-EUROPE'S CIVIL UNMANNED AIR VEHICLE INITIATIVES

3.2 Economic Growth Generators

Civil UAVs will generate the opportunity to expand and develop the European aerospace industry such that all interested EU member states can actively participate.

Safeguarding and enhancing a strong EU skills base is a key factor in maintaining global competitiveness and retaining investment in Europe.

Civil UAV technology is an important driver of technological innovation.

High technology based industries and sustainable technologies are associated with economic growth. Civil UAVs are high technology subjects.

A strong European aerospace infrastructure is vital to maintaining a broad-based and prosperous economy, where key technologies essential for Europe's future are researched and developed. By investing in civil UAVs, Europe will be able to achieve the relevant level of global competitiveness it set out in the STAR21 initiative.

Aerospace depends on an extended supply chain, including many SMEs located all over Europe. This complex industrial structure makes **aerospace a leading contributor to wealth and employment across Europe**.

In the air transport industry, entry for newcomers is very difficult; it is the game of the big "players", as extremely high capital investments are required. In sharp contrast, and contrary to the transport aircraft precedent, this does not have to be so in the UAV industry. A civil UAV requires relatively low capital investment, where investment is a function of size.

This "low entry barrier", will contribute to a united Europe and will act as a catalyst promoting closer ties in turn encouraging economic growth – either directly or indirectly. The European economy will be able to grow with this new potential theme.

There are numerous applications where the use of civil UAVs is highly preferable over manned flight, where manned flight is too dangerous, expensive or monotonous. Whereas many civil applications could also be performed with **military UAVs**, **high cost, low reliability** and civil air traffic control prohibit the acceptance of UAVs in these roles. A good example is the fire fighting studies, which took place in Hungary and southern France aimed specifically at replacing manned flights. In addition, in a demonstration flight in Idaho (U.S.), a small-unmanned air vehicle (UAV) carrying a video camera proved that it could help firefighters track the movement of forest fires – the thick smoke would have been too dangerous for manned flight. More recently, it has been reported that UAVs were used in search and rescue missions after the Tsunami – tidal waves in Asia.

The civil UAV offers law enforcement bodies a versatile tool to carry out numerous monitoring tasks providing information not readily seen from the ground. These tasks are monotonous and fall in the

category of: **d**angerous, **d**irty and **d**ull (commonly known as D^3 tasks).

Especially dangerous-to-humans, tasks such as volcanic activity, nuclear plant, flight in smoke, poisonous gas monitoring can be performed with civil UAVs, which reduce the risk inherent in similar manned flights – see Figure 3-5.

Critical strategic installations can be continuously monitored using civil UAV technologies. Civil UAVs can fly for long hours along pipelines, inspecting and transmitting video and other information of the pipelines' condition and status. In addition, prolonged uninterrupted infrastructure surveillance of: harbours, power plants, critical buildings and power or energy distribution systems will be made possible through civil UAV use.

Civil UAVs can fly for longer hours than manned flight and eliminate the danger associated with D^3 type flights.

Homeland security will be boosted through: border surveillance, terrorist activities' surveillance, drug trafficking surveillance and humanitarian relief surveillance.

Civil UAVs will be able to carry out maritime traffic surveillance, to identify pollution causing activities, such as tankers dumping oil residues into the sea or other environmentally related actions – see Figure 3-2. This will benefit the quality of life on the beaches and holiday resorts.

Geographic air photography and mineral exploitation will be simplified by using civil UAVs. Air photography can be used to aid in more efficient crop spraying activities, which should also be carried out by a civil UAV as in Japan. Cloud seeding to maximise rainfall is another application that civil UAVs are capable of carrying out. Similarly, agriculture will gain with information on crop yields. Civil UAV services could give the fisheries industry exact shoal locations improving knowledge on "where the fish are".

FIGURE 3-2 MONITORING OIL SPILLAGE

Scientific environmental monitoring using appropriate payloads will allow the civil UAV to provide:

spectral and hyper-spectral imaging, oceanographic data collection, magnetic, radiological, gravimetric mapping and surveying. In addition, earth resources detection and monitoring will be routine. Air, water and soil pollution will be monitored more efficiently. Social and economic benefits using these civil UAVs are obvious.

Investing in innovation today will give Europe tomorrow's technological lead.

Iceberg and sea-ice may be mapped making this information available to shipping companies, in near real-time, 24 hours, 7 days a week using civil UAVs with high bandwidth data communication channels.

Adverse weather monitoring and up to date weather forecasting, can be made immediately available.

Pan-European communications services will be enhanced by high altitude civil UAVs acting as relay stations for broadband Internet, phone and television services. This will be more cost effective than present satellite relays. Satellites have their technology frozen years ahead of launch due to launch costs and reliability-related technological aspects; civil UAVs do not have that problem and so can be used with up-to-date technologies.

FIGURE 3-3 SATELLITE TECHNOLOGY IS FROZEN YEARS AHEAD

Pan-European society will benefit greatly by these technological advances. The civil UAV development, production and operation will involve almost every field of engineering from civil engineering (ground communications, infrastructures, airports), chemical engineering in the nanotechnology field, through sophisticated communications, electronics, avionics and systems engineering, mechanics, and aeronautics to certification.

Civil UAV systems and their technologies can become a powerful driver of innovation. Particularly

for the smaller civil UAVs, SMEs and start-ups are expected to play a major role. The civil UAV field is diverse enough to extend the opportunity to interested industries and universities from all member states, by contributing to the technological development of this budding field as well as to influence the final shape of civil UAV aviation.

The civil UAV is an opportunity for the European Aeronautics Industry, presenting it with a fantastic growth engine and the opportunity to develop specific expertise. This expertise will allow Europe to establish its place in this new field. The benefits for research, development, and production in the aeronautical industry will allow participating nations to further enhance the European economic machine and increase its knowledge-based infrastructure.

Each participating state will not only contribute to the whole, but also will personally advance and benefit its own technological infrastructure. Furthermore, by creating a Europe-wide (research area) unmanned vehicles, interested parties (investors, research centres, designers, manufacturers, service providers), will interact thus further strengthening Europe and its civil UAV program.

New economic opportunities will be made possible using the civil UAV technologies through:

- Symbiosis - applications together with technologies will generate wealth
- Migration of technologies - from one application field to another will be commonplace – “dual use technologies” – and will enhance the economy
- A healthy knowledge-based economy will be enhanced

In addition to purchase possibilities, service industries will arise. Service industries, such as civil UAV leasing operations, “pay per use” or fractional ownership, which will come into play when small users with little capital require services provided by these civil UAVs. This in itself will create a business of leasing operators, rather similar to the automotive and small aircraft industries. These opportunities are in themselves generators of new start-up businesses.

Training centres will appear to address the knowledge gap in civil UAV operating service industries. Likewise institutes of higher education, research institutes and universities will all contribute to this new service oriented field.

These service industries will in turn generate new ideas and will provide new business opportunities with their associated economic benefits, driving the overall economy even further.

Civil UAV industries will contribute to the development of second and third tier industries, rather like the air transport industry. Service and light industries will be created providing different expertise,

from software and electronic system companies to operator type companies.

All these objectives can only be met if the European economic, industrial and research structure are prepared of responding to the challenges that lie ahead.

Research on technologies related to civil UAVs and in addition validation of the capability of civil UAVs to perform missions as well as development of procedures for ATC integration and certification can therefore have a key strategic role in ensuring a secure and prosperous Europe.

The civil UAV field will permit Europe to broaden its knowledge-based economy.

3.3 Social Benefits and Quality if Life

Benefits to the European citizen are direct and indirect. European society will be safer due to the utilization of civil UAVs for homeland security, law enforcement and disaster applications and a better place to live due to improved quality of life when UAVs will be operational.

Europe should not permit a "skills gap" to develop

In addition, it will attract more students with the required skills for aeronautics. This will occur at a time when according to ACARE [2] - a shortage of well-educated people has been observed, partly due to the reduced attractiveness of the aerospace business.

European civil UAVs can directly contribute to GMES (Global Monitoring for Environment and Security) and IST (Information Society Technologies) activities within the European Union as generic air platforms.

Europe should invest, since it cannot afford a brain drain.

The dynamic knowledge-based economy will be enhanced by civil UAV development and exploitation. Information will permeate throughout society adding economic co-operation and development through knowledge sharing schemes. Civil UAVs' contribution to society's well-being and quality of life is clear – see Figure 3-4, Figure 3-5, Figure 3-6, and Figure 3-7. European society as a whole will gain immensely through the introduction of civil UAVs into Europe.

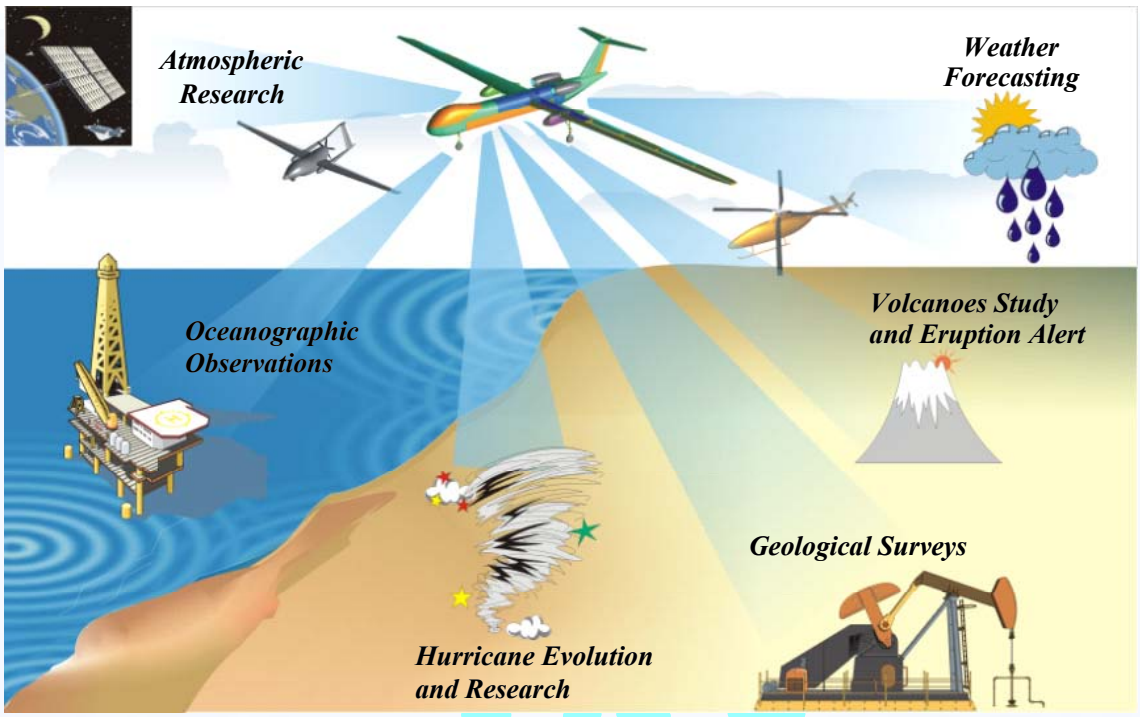

FIGURE 3-4 CIVIL UAV ENVIRONMENTAL APPLICATIONS

Improving the quality of life and establishing higher living standards in Europe are key issues of European policy. Civil UAVs will perform their missions better because of their **unique qualities**. In complementing or even replacing satellites, the accuracy of monitoring, surveillance and data collection will be enhanced because of the considerably closer distance to the objective. Using a UAV for cell-phone transmission will eliminate the much-feared ground-based antennas with their urban radiation – see Figure 3-7. Infrastructure monitoring will be performed with more accurate electronic instruments offering much higher resolution and at a faster pace than humans.

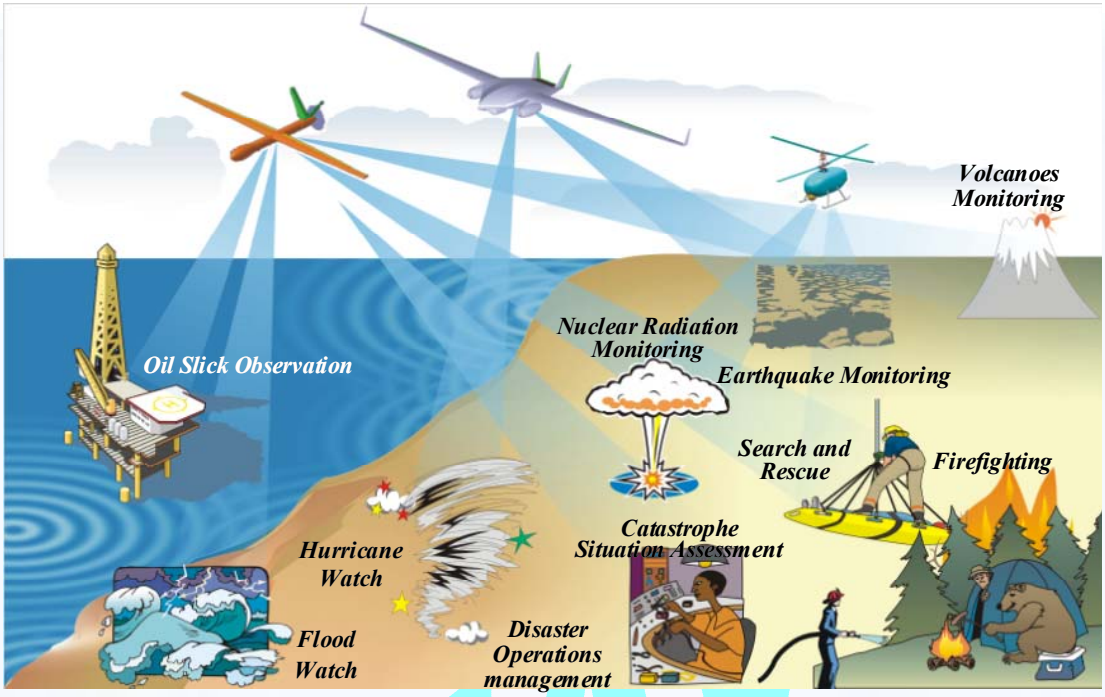

FIGURE 3-5 CIVIL UAV EMERGENCY APPLICATIONS

A wide range of techniques, approaches and technologies are used in the UAV systems, from aerodynamics, data links, electro-optic technology, synthetic environment, computers, software development and logistics, to name but a few. The available resources for the European civil UAV program will be found or developed across the 25 nations, at universities, research institutes or industry.

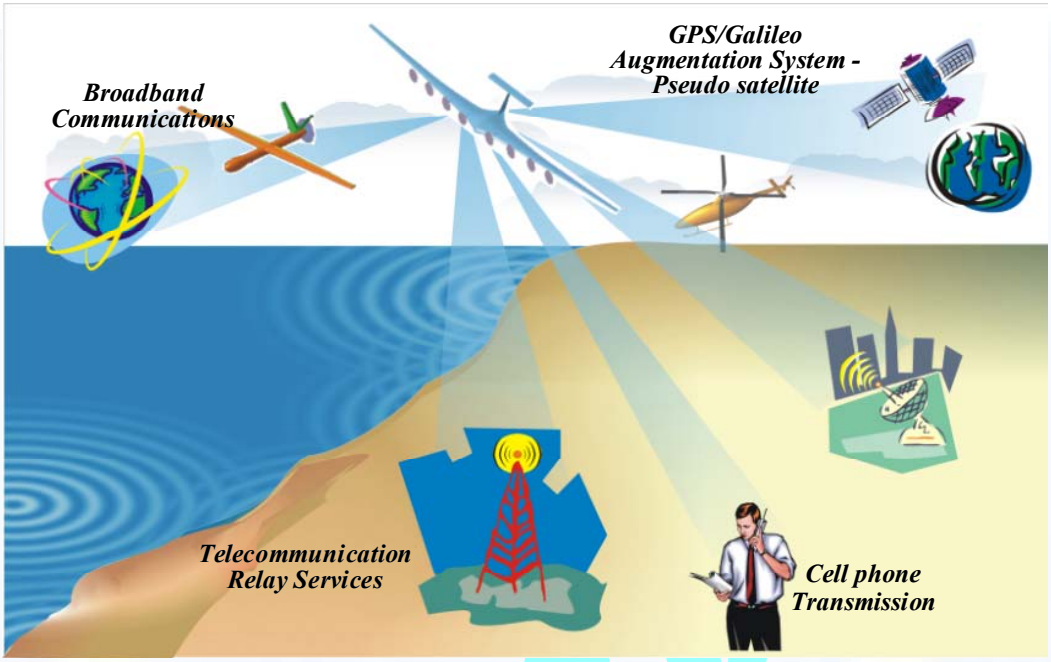

FIGURE 3-6 CIVIL UAV COMMUNICATIONS APPLICATIONS

Given the variety of UAVs foreseen to be required to fulfil the various applications flown with: High Altitude Long Endurance (HALE), Medium Altitude Long Endurance (MALE), Rotary, Mini, and Micro UAVs, the necessary technological developments needed to assure that their operation will be safe and cost effective, there will be tremendous research opportunities for research institutes, universities and industry in all of the 25 European countries interested in being involved. The quantity of necessary research will advance the personnel knowledge levels as well as facility sophistication of all the involved organizations. There will be a blooming of research throughout Europe.

Europe can create an innovative and adaptable workforce with civil UAV technologies.

The diverse spectrum of the engineering fields needed in civil UAV aviation permits synergy between the interested EU member states participating in civil UAV projects.

All the specialities involved are very progressive, as they are on the cutting edge of technology.

The specialities involved in UAVs in general and civil UAVs in particular are typical domains of activities where multi-national research initiatives can be proposed, thus increasing the level of education to the benefit of European nations and their universities.

Universities will be the direct beneficiaries of the increased requirements made by UAV research. They will have to produce more aeronautical students with better knowledge and skill levels. They will be able to involve their student and faculties in real projects, which will add both excitement to

their educational process as well as a measure of reality to their experience within the universities.

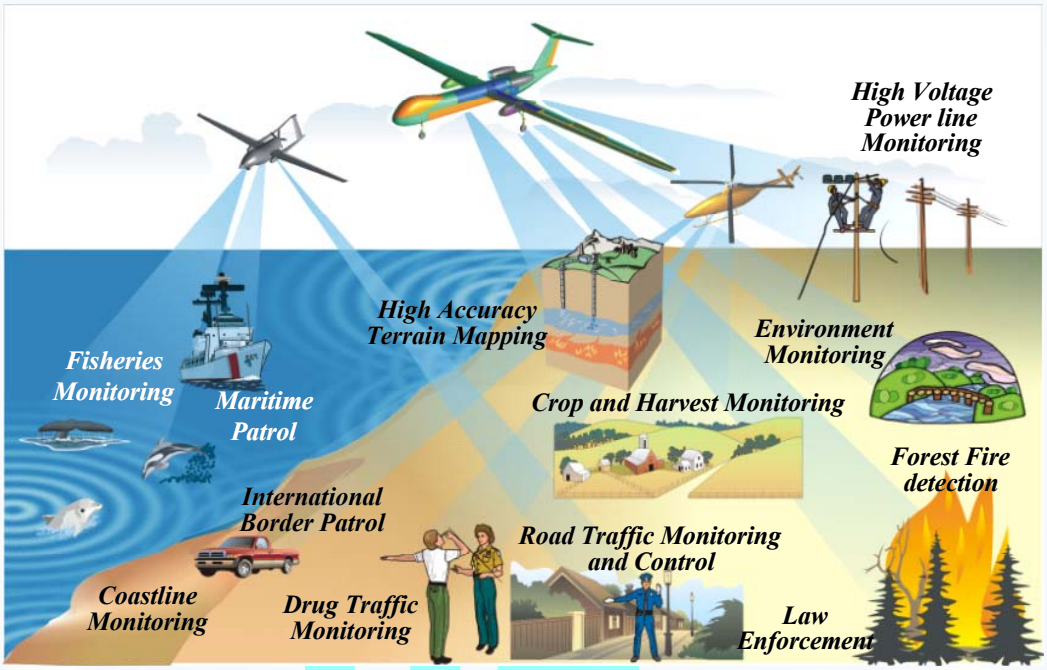

FIGURE 3-7 CIVIL UAV MONITORING OPERATIONS

UAVs will serve missions, which are vital to national security and law enforcement, in addition to offering capabilities for humanitarian missions, infrastructure protection and search and rescue. These missions, amongst others, are consistent with the European Security and Defence Policy [3].

Unless Europe maintains and develops these capabilities further, there is a real risk that Europe's ability to act will be determined by non-European countries that will soon be leading in this field.

Key issues of European policy are improving the quality of life and establishing higher living standards in Europe. Numerous applications to use civil UAVs exist. These applications are preferable to manned flight, especially if manned flight is too dangerous, expensive or monotonous. Better quality of life will be enjoyed through protection of the citizen with more efficient law enforcement, safer cell-phone communications, more accurate weather forecasting, better forest fire management, agricultural and fisheries support, better border surveillance and more.

Aeronautics is an area accustomed to looking far into the future with a new generation of aeronautical systems taking a decade or more from conception to realisation. Similarly, a long-term policy framework is essential if aeronautics is to provide the capabilities, which are required to match the main European goals – *competitiveness* and *security*.

3.4 Dual Use Technologies

Among the advances in safety and reliability are classic examples of dual use technologies that may be used in other fields. Technology developments from civil UAVs will available to be transferred to manned aircraft systems and vice versa – see Figure 3-8. This constant dual migration path will be paved between other combinations of unrelated technologies such as between civil UAVs and automobiles and between civil UAVs and household appliances.

For example, civil UAV electrical systems may be taken from the automotive industry and likewise technologies such as autonomous flight, developed for civil UAVs may migrate towards the automotive industry. The modern anti-skid brake system in today's automobile has its origin in aircraft technology, as does the automobile body. Similarly, early vintage aircraft engines have their origins in the automobile industry. Migration across industries is a natural spin-off for technological applications.

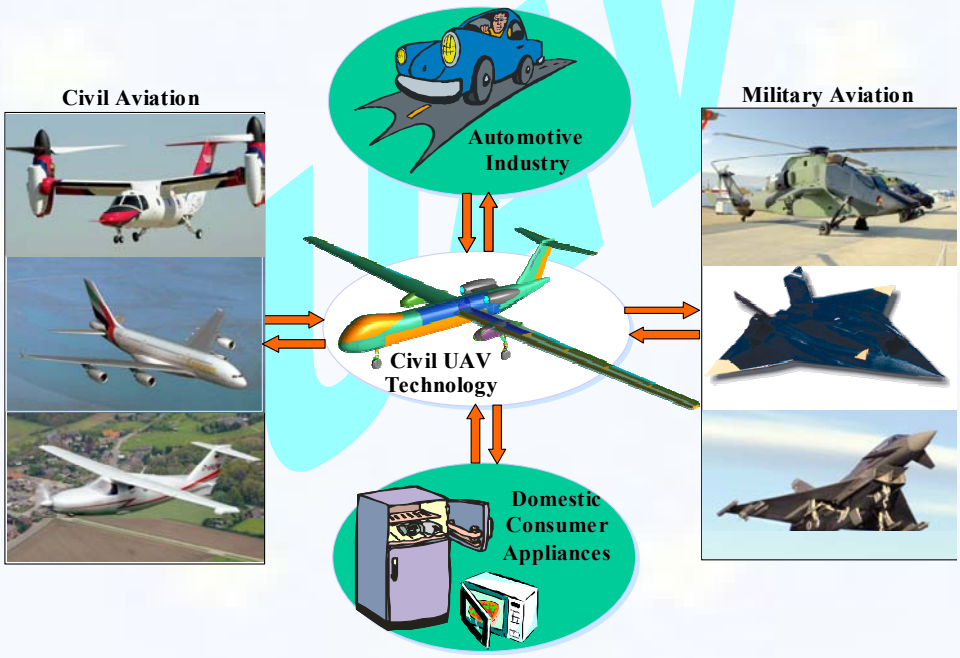

Figure 3-8 Dual Use Technologies

4 ENABLING STRATEGIES

Civil UAVs make extreme demands on its products, requiring simultaneously safety and reliability, low weight, good economics, minimal environmental impact, enhanced power and high efficiency. **Civil UAV technology is one of the keys to Europe's long-term viability, enhancing Europe's future competitiveness.** The technologies developed for civil UAV aerospace products will provide spin-offs in many different sectors including technological migration.

European leaders should build a European Research Area with the first step being to make Civil UAV research a priority in FP-7. It is absolutely essential to invest in civil UAV systems development that will be used for civil applications in Europe permitting European-made civil UAVs tailored to European requirements for the benefit of Europe's potential users and at a reasonable cost– see Figure 4-1.

FIGURE 4-1 ENABLING STRATEGIES

4.1 SAFETY AND RELIABILITY

Civil UAVs have to be designed from the beginning as very safe and reliable systems because the authorities and the public must be comfortable with its operation, and in order to achieve the safety challenges (see Figure 4-2) posed by this new flight mode in controlled airspace, it is important that Europe facilitate developments in this direction, by investing in the technologies relevant to safety

and reliability. Even though, some of these technologies are currently under development for manned aircraft, they need to be miniaturised for use on civil UAVs.

A coordinating Civil UAV body will allow smooth and effective management of the numerous subjects to be dealt with.

It is necessary to develop Sense and Avoid (SAA) technologies, which when combined with the on-board flight management systems, will ensure a safe distance from other aircraft. In addition, development of Air Traffic Detection Sensor Systems (ATDS) technologies, which will be capable of sensing aircraft beyond visual range, and will work in conjunction with the SAA system to provide a comprehensive and timely solution to aircraft evasion in flight, should be carried out. Integration of the Traffic Alert and Collision Avoidance System (TCAS) equipped airliners with civil UAVs has to be studied and developed. The new Automatic Dependent Surveillance – Broadcast (ADS-B) system that periodically reports the aircraft (manned and unmanned) position and flight vector, should also be investigated for inclusion into the safety systems of civil UAVs. In addition, automatic takeoff and landing capabilities should be developed to allow safer civil UAV operations.

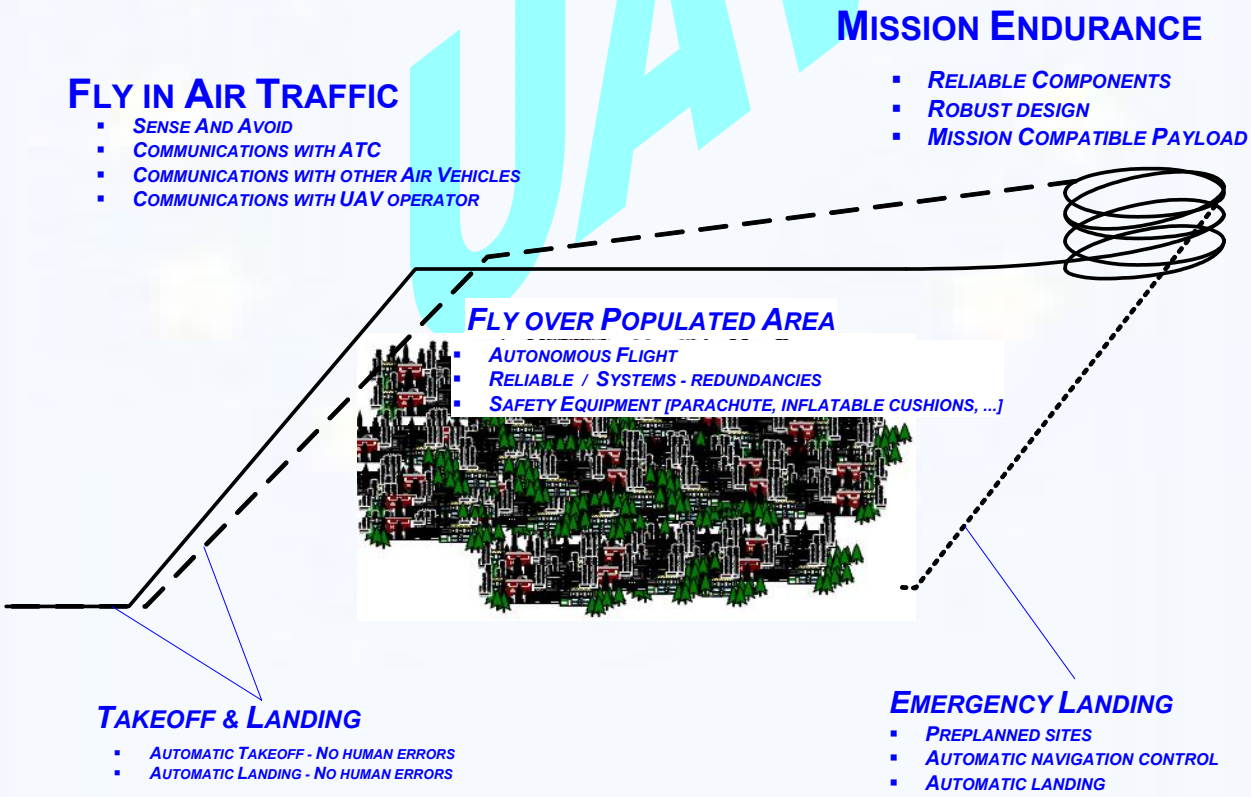

FIGURE 4-2 SAFETY & RELIABILITY CHALLENGES

Accurate positioning of civil UAVs that will be attained using 4D navigation and technologies similar to the U.S. Wide Area Augmentation System (WAAS) system, have to be investigated and incorporated into modern flight safety systems. Whereas, the U.S. will be using the GPS system to allow WAAS operation, **Europe should look into utilising the Galileo navigation system in a similar fashion**.

Vehicle reliability will be enhanced through research into robust, laminar aerodynamic configurations that will further reduce the losses of air vehicles in adverse conditions improving the overall system reliability as well as cost.

"Fail-safe" avionics with on-board self-diagnostics, which will continuously monitor system performance, will be developed and used, together with smart sensors and novel controls, to allow efficient fault tolerance and error recovery. In addition, new control laws, that use this information, will have to be studied and formulated in order to cause an optimum evasion trajectory to further guarantee safe flight.

4.2 Cost Reduction

Cost, which is a major issue in promoting the utilisation of UAV systems for civil and commercial applications, will be lowered by relying on existing technologies wherever possible, thus diminishing the risks involved. Increased UAV system reliability, discussed in the previous section, will manifest itself by requiring fewer air-vehicles, by improving dispatch reliability, enhancing system availability thus lowering the overall cost of ownership – see Figure 4-3. Adaptation of military systems to carry out civil tasks will most likely not be able to offer an affordable solution to the civil market, although it is likely that in the initial stage, some adapted military systems will pave the way for further civil UAV development.

Advanced configurations will be studied to improve aerodynamic robustness, to improve the lift/drag ratio, to adapt to the new flight regime, thus making the civil UAV ever more efficient.

Reduced weight means reduced costs, or as a corollary, will permit longer endurance flights or heavier payloads. Weight reduction can be achieved through blended airframe-propulsion layouts, leading to pioneering aerodynamics and energy systems. This can also be achieved through the increased use of advanced composite materials, multi-purpose adaptive structures, "techno-structures" (advances in nanotechnologies, structural morphing, integrated and blended miniature sensors).

Present conventional propulsion systems will have to studied and modified to increase their efficiency. Improvements will be carried out in technologies for UAV propulsion (conventional two-stroke, four-stroke and rotary internal combustion engines -with or without turbo charging, electric motors and turbojet engines) and fuel systems (heavy and conventional fuels).

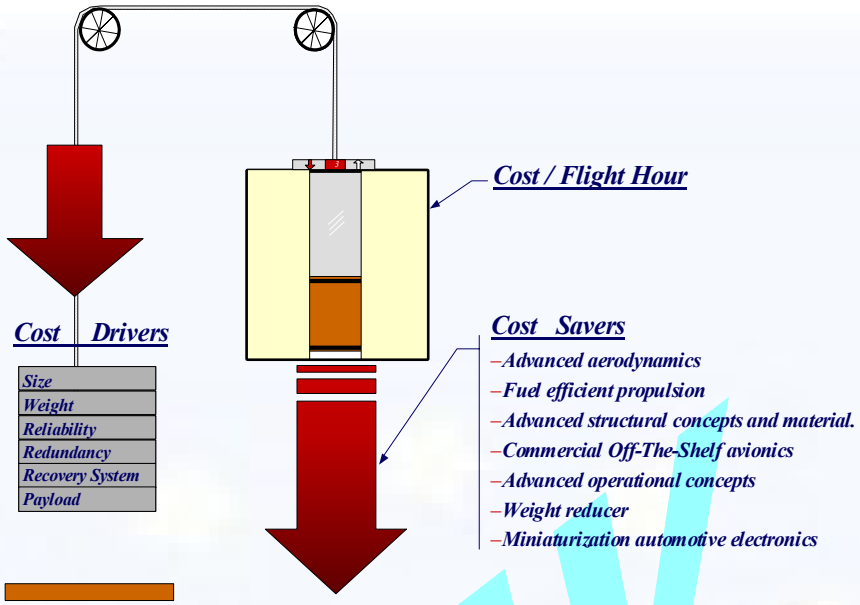

FIGURE 4-3 COST REDUCTION DIAGRAM

To ensure competitiveness, it is essential for European policy on civil UAVs to be focused.

New technologies that will increase propulsion efficiency and indirectly will lower weight, due to lower fuel requirements, will lower direct operating cost. Additionally new propulsion technologies promise to lower pollution emissions, increase the thrust-to-weight ratio while lowering the specific fuel consumption. New technological breakthroughs can be made in electrochemical energy storage e.g. fuel cells. Fuel cell technologies and rechargeable energy cells will be researched for their applicability to civil UAV use. In addition, solar cell technology will be advanced with progress permitting efficient **H**igh **A**ltitude **L**ong **E**ndurance flights (HALE).

An advanced UAV avionics suite will provide vehicle flight management capabilities with high reliability and redundancy coupled with low weight and low cost. This will be made possible by present and future technologies, using components like System on Chip (SOC) and Micro-Electro Mechanical Systems (MEMS).

Novel technology providing advanced miniaturised sensors coupled with sensor fusion will provide the data to precisely position the civil UAV in airspace minimising the errors involved and hence providing enhanced safety, whilst lowering the overall weight.

Communications, both control and data, will exploit next generation secure communications using available and future bandwidths developed to allow command and data signals traffic. These secure channels will allow the uninterrupted flow of required data to the civil UAV customer, lowering the cost.

Miniaturisation and standardisation of payload interfaces and further payload development will create modular payload systems, “Plug & Play” payloads, which will incorporate flexibility and cost-effectiveness economising the installation of payloads, increasing overall UAV system agility and lowering operation cost.

Novel control surfaces, coupled with advanced electronic actuators, will allow effective cost reduction through smaller and lighter components.

Control equipment costs will also be lower since they have to comply with less stringent certification requirements than an airborne cockpit, given that there is no immediate life-threatening situation.

The operational concept will be straightforward simplifying the actions to be taken by the civil UAV operator. In turn, the required operational skills of the operator will be reduced so that a wider scope of candidates will be available, lowering costs. Furthermore, civil UAV personnel training costs are anticipated to be lower than those associated with manned aircraft.

Advances in technologies may migrate in both directions between civil UAVs and manned aircraft, automobiles and domestic appliances. This will have a cost reduction effect, since the technologies do not have to be researched and development will be mostly in adapting the technology.

4.3 Certification & Regulation

Integration of UAVs into the air space including coordination between UAVs and manned aircraft are major issues to be resolved so as to enable civil UAV flight in civil airspace – see Figure 2-1. It is worth mentioning that the United States in 2003 launched the ACCESS 5 initiative, with the goal to have UAVs flying alongside manned aircraft within the next five years.

Civil UAVs must be part of the Single European Sky legislation.

Facilitating technologies will have to be acquired through design or adaptation to allow 100% autonomous flight in all of Europe’s airspace. These technologies will have to include: voice communications, various transponders and sense and avoid systems (see section 4.1 Safety and Reliability). Demonstration flights will have to incorporate these systems to prove seamless interface with ATM and ease of operation in a Single European Sky.

In Europe, the preliminary proposals on certification and regulations for civil UAV operation were laid out in a report produced by the Joint JAA/Eurocontrol Task Force in which our USICO project participated, but further progress has been slow. In addition, EASA will be heavily involved in the certification process of civil UAVs into controlled airspace.

5 STRATEGIC INITIATIVE AND BENEFITS

In order to enable safe civil UAV flight throughout, Europe should take a strategic decision to establish a Coordinating Civil UAV Body involving a sold foundation of political and financial support.

Europe should actualise the proposed civil Unmanned Air Vehicles Roadmap. A detailed work programme shall be presented in the full document to be published in the spring of 2005.

As the Framework 5 projects (UAVNET, USICO, CAPECON, HELIPLAT) prepared the groundwork, it is recommended that this consortium lead the initial stages of the Coordinating Civil UAV Body's work. Studies were conducted within these Framework 5 projects but have to be continued and amplified in order to reap the benefits. Subsequently, it is intended that this Coordinating Body will be expanded to include other leading organisations, which are active in the European UAV scene such as Dassault, Saab, Qinetic, Meteor and others.

The Coordinating Civil UAV Body will create a focal point for Europe's civil UAV research activity. In addition, it will provide the catalyst to unite the European civil UAV effort – see Figure 5-1. and will play a part in coordinating research activities throughout Europe – see Figure 5-2.

European investments in civil UAV research and development will be a direct response to ACARE's educational goals in aeronautics. UAVs are an exciting subject that covers a wide range of disciplines, both technological and social.

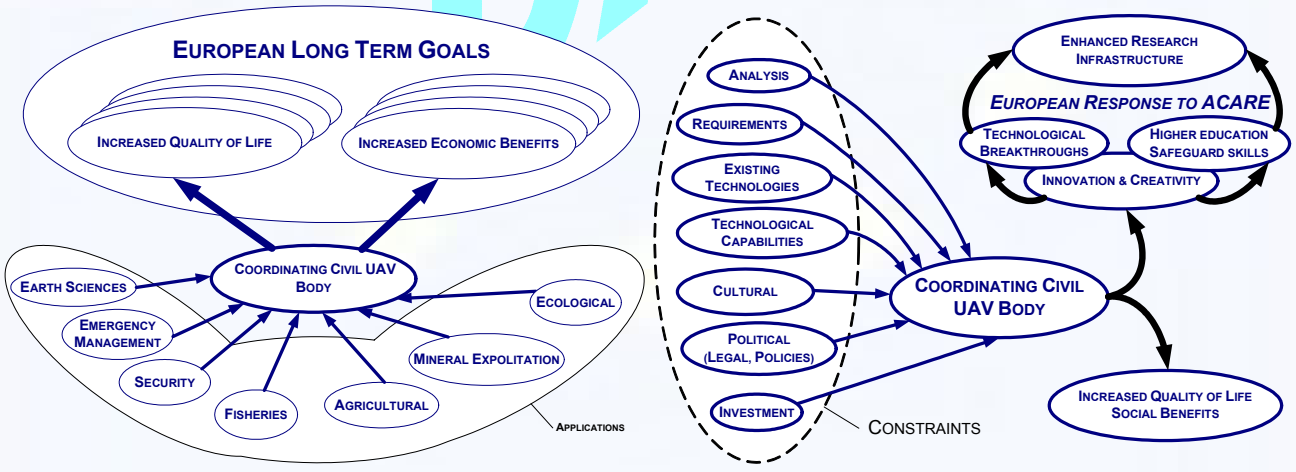

FIGURE 5-1 THE ROLE OF THE COORDINATING CIVIL UAV BODY IN STRATEGIC COORDINATION

The wide range of systems and different UAVs will create a burst of energy throughout European industry and in particular in those countries where the aeronautical and related industries have not enjoyed the challenges of high-tech aerospace products till now. SMEs and major European

industries will find their niche in a beehive of activity providing the products required to improve the European Quality of Life.

The Coordinating Civil UAV Body, will encourage competitive innovation and excellence will be promoted. The Coordinating Civil UAV Body will persuade all interested parties to take part in civil UAV technological activities by initiating research and development in the related fields.

Advanced technological capabilities will be achieved through this competitive environment, ensuring Europe's technological infrastructure becomes resilient.

A system activity like the one offered in the European civil UAV program is well adapted to European collaboration. This synthesis will increase the European quality of life as a result of stronger inter-European work, triggering new industrial and academic relationships.

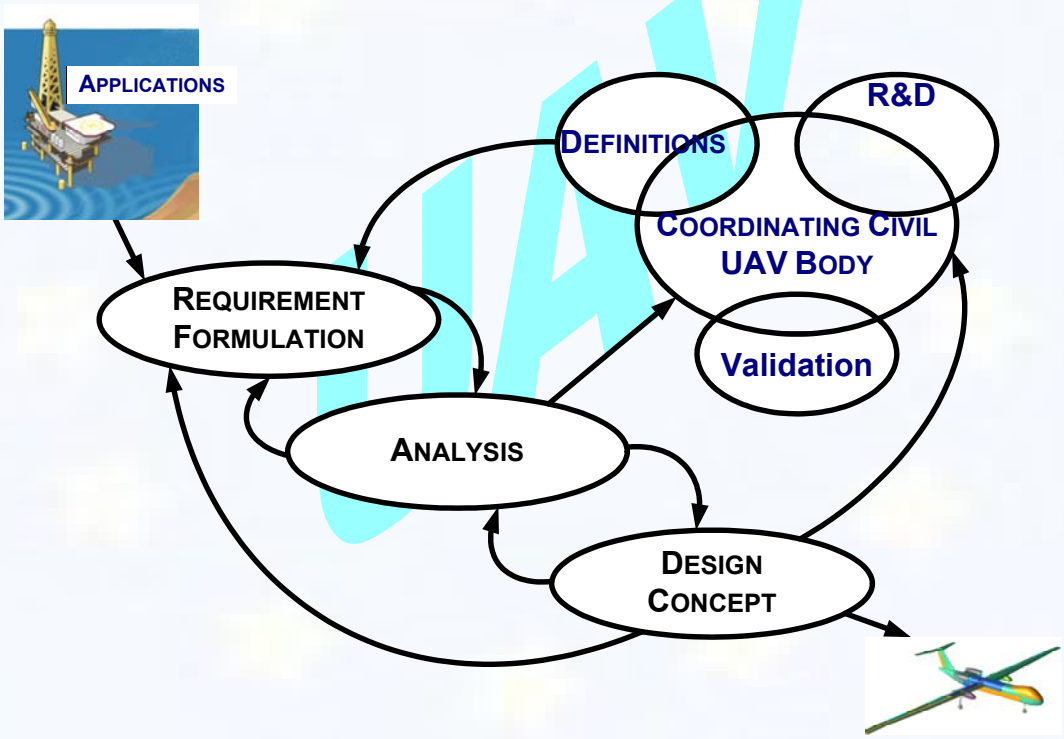

FIGURE 5-2 THE ROLE OF THE COORDINATING CIVIL UAV BODY IN RESEARCH

6 WORK PROGRAM

A civil UAV coordinating body will be created from the major participants to manage and monitor the European Civil Unmanned Air Vehicle Roadmap. Updates of the roadmap will be a function of requirements, technologies and technological developments.

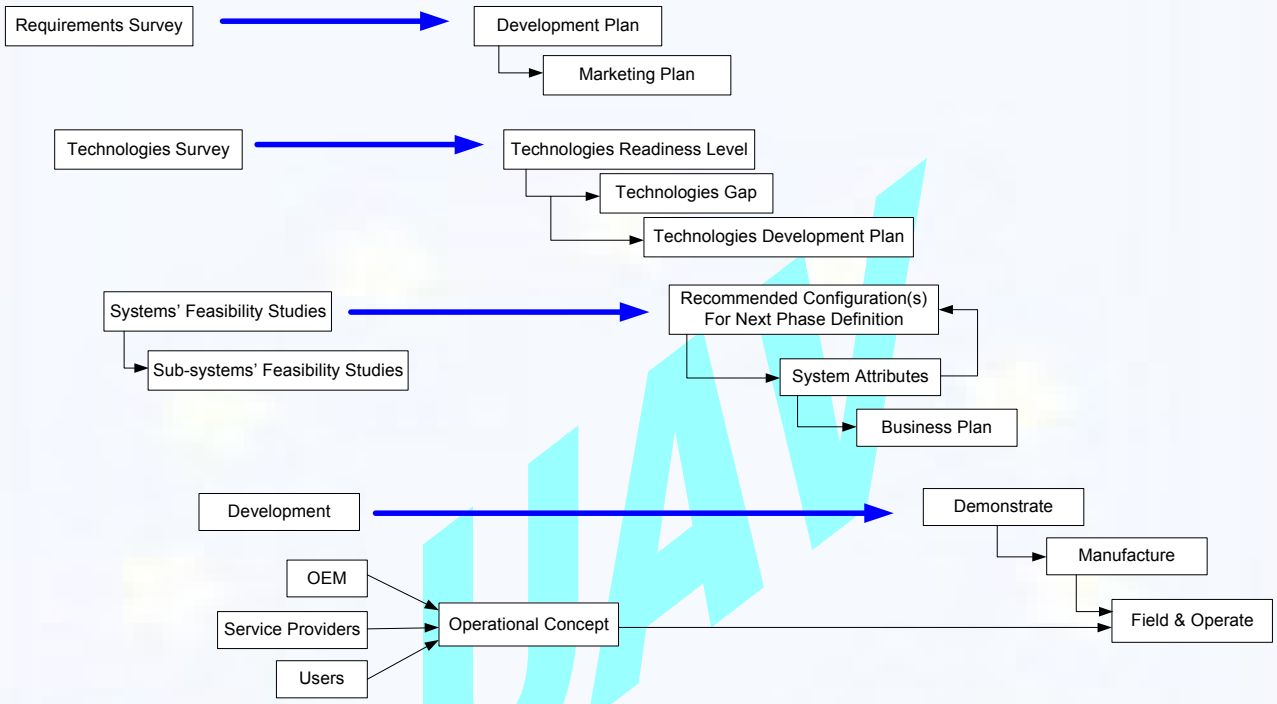

FIGURE 6-1 ROADMAP ACTIVITIES CONCEPT

Prior to selecting the available and requisite technologies, a list of requirements and objectives will be compiled and matched to available technologies, to clearly define the necessary parameters and metrics. The combination of these two tasks will provide indications of present gaps in available technologies and will help to set out the initial phases of research and development. Requirements to be defined include:

- Technological requirements assessment
- Autonomous operational requirements
- Communication link – including security requirements
- Cruising speed requirements
- Emergency situations response requirements
- Failure recovery procedures
- Launch and recovery sites characteristics requirements
- Operating crew competency and training requirements
- Payload size and weight requirements
- Payload standardisation and interfacing
- Positional accuracy requirements
- Range requirements
- Safety requirements - including sense and avoid capabilities' requirements
- Secure operational requirements
- Sensors requirements
- Service altitude requirements
- Other requirements to be defined

The overall roadmap concept of activities is illustrated in Figure 6-1, where the topics to be included and tackled are partially listed above.

A detailed work programme shall be presented in the full document.

7 REFERENCES

1. STAR21 - Strategic Aerospace Review for the 21st Century European Advisory Group on Aerospace European Commission, Enterprise Directorate-General, Brussels, Belgium, July 2002
2. Strategic Research Agenda - Advisory Council for Aeronautics Research (ACARE)
3. COLOGNE 1999 - COLOGNE European Council Conclusion EU-Summit, Cologne, Germany, 1999
4. LISBON 2000 - LISBON European Council Conclusions EU-Summit, Lisbon, Portugal, 2000
5. BARCELONA 2002 - BARCELONA European Council Conclusions EU-Summit, Barcelona, Spain, 2002
6. Access Five Project Overview - 3 November 2004; Dennis Crosby [www.amtech-usa.org/a5/news/110304_ATCA_a5.pdf]
7. UAV Task Force Final Report - The Joint JAA/EuroControl Initiative on UAVs [http://www.jaa.nl/news/UAV Task Force Core Report.pdf]