»CRUISER FEEDER AIRSHIP AND INNOVATIVE PROPULSION FOR GREENING THE FUTURE EU TRANSPORT«

Workshop
MAAT - Book of Abstracts

AERO 2013 - Friedrichshafen – Germany
Imprint:
A publication related to the Seventh Framework Programme FP7-EU-Project
“MAAT – Multibody Advanced Airship for Transport”,
Theme [AAT.2001.6.3-1 AAT.2011.6.2-1], GA 285602.
www.eumaat.info

Editorial Office:
LogisticNetwork Consultants GmbH
Breite Straße 7, 30159 Hannover, Germany
www.LNC-Hannover.de
April 2013, printed in Germany

Disclaimer:
MAAT - Multibody Advanced Airship for Transport - is a project within the Seventh Programme
and is co-funded by the European Union (Grant Agreement N° 285602).

The contents of this brochure are the sole responsibility of the MAAT Consortium and can
under no circumstances be regarded as reflecting the position of the European Union.
Introduction

Air transport is a global market with a huge potential for growth. The aviation traffic is predicted to grow dramatically in the next decade particularly in the emerging markets. However, the market of air transportation is overloaded because of several reasons. There is not enough space to build new airports close enough to large cities, the airspace is also overloaded above large air hubs, the fuel consumption and, thus, emission and noise regulation restricts air transport usage. Airship transport solves most of these problems and can offer brilliant solution to get more travelling into the air and by this reduce pressure on the ground transport links.

The MAAT project – Multibody Advanced Airship for Transport - aims to investigate aerial transportation possibility by airship based cruiser-feeder system. MAAT is composed by three modules:

- the cruiser, named PTAH, (acronym of Photovoltaic Transport Aerial High altitude system) is a heavy payload and high quote cruiser which remains airborne on stable routes;

- the feeder, named ATEN (Aerial Transport Elevator Network feeder), is a VTOL system (Vertical Take Off and Landing) which ensure the connection between the cruiser and the ground;

- the vertical airport hub, named AHA (Airport Hub for Airship) is a new concept of low cost vertical airport hub joinable by ATEN, easy to build both in towns and in logistic centres.

The feeder can lift up and down by the control of buoyancy force and displace horizontally to join to cruiser. In particular MAAT aims to define:

- a systemic and organic solution to the transport based on cruiser/feeder air vehicles;
- design an airship based cruiser/feeder system completely fed by photovoltaic energy;
- the best type of propulsion for the cruiser, by considering centralized options designed to supply the problems connected with propellers at high altitudes, where the atmosphere is rarefied and to ensure a simple control during cruiser/feeder engagement operations;
- the optimal feeder and cruiser architecture both for their specific operative conditions and for engagement and linking operations;
- the structure and interconnections necessary for docking operations and safe transferring operations passengers and goods from the feeder to the cruiser and vice-versa;

MAAT is a green system due to the complete absence of emission such as carbon dioxide and is powered by photovoltaic systems. MAAT is the ideal vehicle for connecting urban centres worldwide. The vertical take-off and landing allows stopping at urban contexts, thereby minimizing delivery times. MAAT airport hubs result in a reduced consumption of soil due to air transport free of the necessity of long runways. Also, airport hubs can be located close to town centres and would reduce passengers’ travelling times.
On the 26th April 2013, the MAAT Consortium (Multibody Advanced Airship for Transport) is organizing a workshop entitled “Cruiser/feeder airship and innovative propulsion for greening the future EU transport”. The workshop is taking place in the framework of the General Aviation fair AERO Friedrichshafen.

The workshop is debating topics related to airship advanced research:

- Paving the way for future solar powered airships (Prof. Dumas, University of Modena and Reggio Emilia),
- The MAAT Airship Sustainable Energy System (Prof. Stewart, University of Lincoln),
- Cabins, Cargos, and Transfer systems: Docking in the Stratosphere (Gaviraghi, Design Lab eDL; Prof. Vucinic, Vrije Universiteit Brussel),
- MAAT control system (Prof. Pshikhopov, Southern Federal University),
- Hydrogen in MAAT Project: Safety Measures (Saba, Politecnico di Torino),
- Computer modeling and optimization methods in green air transport development (Ph. D. Ing Voloshin, University of Hertfordshire),
- ACHEON - thrust vectoring green propulsion system (Ph. D. Ing Trancossi, University of Modena e Reggio Emilia),
- CROP - Cycloidal Rotors for propulsion of future air-vehicles (Prof. Páscoa, University of Beira Interior),

The workshop is jointly organized with the MAAT-sister projects, namely CROP - Cycloidal Rotors for propulsion of future air-vehicles (http://cropproject.wordpress.com) and ACHEON - Aerial Coanda High Efficiency Orienting-jet Nozzle (www.acheon.eu). The three projects are research breakthroughs and emerging technologies for radical new concepts in the air transport.

On the next pages, you will find abstracts of the separate lectures and more information about ACHEON and CROP.
Paving the way for future solar powered airships
Prof. Antonio Dumas, University of Modena and Reggio Emilia (Italy)

Several concepts of airships have been presented in the literature. The most different shapes can be identified, from classic Parsifal ball and disc-shaped forms. In all cases the aim has always been thought of as transport. It is then presented with the conceptual path that allowed defining the future of new aircraft ecological systems. The first concept is PSYCHE (Photovoltaic stratospheric Isle for Conversion Hydrogen as Energy-vector). It aims producing hydrogen by photovoltaic solar energy.

Hydrogen is liquefied and transported on the ground by a feeder airship that lift up the necessary water for Hydrolysis and lift down hydrogen and oxygen. This concept has been then modified to produce novel air vehicle concepts more suitable for transport operations. The concept of PSICHE has been evolved in the MAAT (Multibody Advanced Airship for Transport) cruiser feeder airship concept. This project is becoming an effective platform for studies related to future green aeronautics and for ensuring the future European leadership in green aeronautics.

The MAAT Airship Sustainable Energy System
Prof. Paul Stewart, University of Lincoln (U.K.)

Current air transport systems are almost fully dependent on hydrocarbon fuels for operation due to the lack of alternatives with respect to high energy density [1][2][3]. Over the past decade significant advances in both solar energy conversion and energy storage have occurred allowing the potential use of renewable energy systems for air transport. This has been exemplified by the operation of both lighter than air and fixed wing UAVs utilising solar power as the sole energy source [4][5][6]. Associated advances in technology have also been seen in power electronics, electric motors and drives. However there is still the need for significant progress to be made before such technologies can be practically realised in the MAAT concept but clearly the potential does exist in this worthwhile and visionary transport system concept.

With the application of renewable energy as the prime source of power there is no requirement for the traditional take-off and landing phases, in fact, it is better to remain in operation at altitude where the magnitude of available solar energy is three times that available at the surface and is also predictable. This strategy however, necessitates the need for small feeder vehicles capable of VTOL and high altitude docking for passenger and freight transfer.

The day and night operation of the MAAT system has to be considered as one of the prime challenges. The energy harvesting and storage systems will need to take into account the varying day length due to both the latitude and seasonal variations of the day light hours and the limited physical resource of the air vehicle in terms of the exposed surface area.
Consideration of safety is also a key challenge. Solar power is a low-grade energy form that requires concentration prior to transport for use in the MAAT operational and storage systems. Due to the limited resources conventional backup systems will not be feasible. The energetic systems will therefore need to be capable of graceful degradation without unduly impacting availability or generating capacity.

The Energy and Propulsive System design considers the operation of the MAAT system identifying the formidable technical challenges and risks and offering novel technical solutions for the optimal harvesting, concentration, transport and utilisation of energy required that balance energy efficiency, mass, complexity, reliability, safety, maintainability and operability whilst also meeting the environmental requirements[7][8].

References:


Cabin, Cargos and Transfer systems: Docking in the Stratosphere
Prof. Dean Vucinic, Vrije Universiteit Brussel (Belgium)
Prof. Pier Marzocca, Giorgio Gaviraghi, Esponential design Lab. S.A. (Uruguay)

In the general framework of the FP7 MAAT project, a novel green air transport architecture is under development. The cruiser/feeder concept is especially focusing on pleasant and spacious cabins, large cargo and efficient transfer system, and necessitates rendezvous and docking operations at the stratospheric altitude, in order to facilitate the mobility and transfer of people and goods. This has been identified as the most challenging and complex design task in MAAT, as it was never attempted before to our knowledge. New advanced technologies, equipment and systems, as well as, the safe docking procedures, represents the central elements, thus – must - be developed, to make possible the envisaged docking and undocking, which are the most critical phases within the MAAT airships flight process.

Feeders will transport the passengers and goods between the Airship Hub Airport (AHA) and the stratospheric Cruiser. While at the stratospheric altitude, passengers will be accompanied by their robocart luggage transport system till they will leave their designated Cruiser accommodations and embark on board of the descending Feeder. Several alternatives docking and joint systems have been considered including external and internal docking and undocking mechanisms. The proposed automated robocart system, eliminates the luggage container transfer and it accompanies passengers from their travel start (1) arrival at the terminal for departure to the end of the travel (2) arrival to their destination terminal, where they pick their luggage, thus ending their MAAT travel.

For the maximum comfort, safety and security of the passengers the MAAT passenger spaces are completely designed as continuous pressurized environment. Such system is also present in the designed AHA terminals, which is expected to allow easy and simple transfer to and from the railway stations and parking areas to the terminal gates. Research activity around the docking/undocking and the all-around transfer of passengers and cargo within the MAAT system are currently pursued, in order to support the development of the two MAAT demonstrator vehicles, whose initial flight operations are planned within the 1 year period.

References:
MAAT control system

Prof. Viacheslav Pshikhopov, Southern Federal University (Russia)

Development of control system of MAAT is a challenging task dealing with a number of issues [1]. One of the main issues for all airships is energy aspect. While common airplanes has a powerful propulsion in order of magnitude higher than power of disturbing wind, situation for airships is very different. Power of propulsion of airships is comparable with power of wind pressure, generating on frontal area of envelope. Similar situation is expected in MAAT [2],[3].

Hence development of novel control strategies for energy efficient flight is required. First of all study of flight environment is performed. Probability maps of winds distributed in altitude and geoposition makes possible creating of energy efficient trajectory. Hereby decreasing of vertical speed in tail winds and increasing it in frontal wind is a good approach to economize energy for a feeder flight. Here a various methods for local search and optimization can be applied: graphs creation with edges estimation, mathematical programming, genetic algorithms, neural networks.

In flight formed trajectory is to be corrected according to the real flight. Similar approach is planned for application for the cruiser in higher altitude. Cruiser have to catch steady-state tail wind streams with small altering of altitude in stratosphere. The second control issue is docking. Whether there is no precedent in the world science and technologies for airships docking in atmosphere, successful control of this process is a breakthrough in modern aeronautics. While highly disturbing environment is one of the aspect, that should be overcomed with powerful propulsion and accurate sensors and local navigation system, issues of sudden change of cruiser parameters when feeder is docking/undocking has to be considered. The third control issue is take-off and landing. Here issues of ground docking and effective positioning of feeder in wind conditions are to be solved.

References:


Hydrogen in MAAT Project: Safety Measures

Fabio Saba, University of Torino (Italy)

The widespread use of hydrogen in the MAAT Project demands stringent research on hydrogen safety. The safe design and operation of transportation plant and piping require that provisions be made for releases under specified operational and emergency conditions. Assessments of the consequences associated with accidental releases of flammable substances are also needed as the basis of safety reports and risk assessments. Hydrogen is known to have very low density and wide flammability limit. These unique characteristics imply that hydrogen could disperse extremely fast at an accidental release and combust easily at the presence of an ignition source. A sound understanding of dispersion, stratification and diffusion of accidental hydrogen releases is, therefore, of practical importance and use to better understand the possibility of ignition, combustion and explosion of such releases within the context of hydrogen safety in the MAAT Project. Towards this end, three research activities have been undertaken:

- analytical and numerical simulation of hydrogen permeation from on board tanks;
- analytical and numerical simulation of hydrogen dispersion in enclosures;
- hydrogen dispersion experiments with several release rates within enclosures under different ventilation regimes.

Two independent approaches have been adopted in the simulation of hydrogen permeation and dispersion processes:

- analytical calculation performed using simple formula based on Thermodynamic Method;
- numerical simulations performed according to the Computational Fluid Dynamic Method using general purpose codes (Fluent Code, FDS Code) and home-made codes.

Analytical relations used in preliminary simulations of the hydrogen dispersion in enclosures have been originally derived, according to the Thermodynamic Method, by the GRF-Dener C of Politecnico di Torino for predicting smoke filling of compartments during fire events. A facility to perform hydrogen dispersion experiments in real scale is currently under project.

References:

[1.] E. Cafaro (Editor), Physical and Mathematical modeling of fires in enclosures, Eurotherm Seminar, Turin 2002
[2.] E. Cafaro, Progettazione termofluidodinamica del sistema galleria, Politeko, Torino 2003
Computer modelling and optimisation methods in green air transport development  
Vitaly Voloshin, University of Hertfordshire (U.K.)

There is not much room left to improve significantly the efficiency of existing air transport modes. Airplanes are much optimised, but still require tons of fuel for even a short flight. This is because the airplanes need energy to keep them in the air as well as to overcome drag to go forward. So, the focus of highly efficient air transport has switched to lighter than air vehicles, specifically, to airships. They do not require any significant energy to keep them in the air as they use the buoyancy forces produced by the large volume of light gas. Moreover, there is no minimum limit for the velocity, so, they need much smaller ground surface for take-offs and landings.

But airships have several disadvantages like high drag due to sheer size of the balloon with buoyant gas. Moreover, conventional airships have low resistance to side winds. And the internal combustion engines currently used for propulsion are not an effective way of using fuel. Ideal scenario is to use alternative energy source (solar power, for instance) with electrical motors used for propulsion. But it adds more unresolved problems. So, all in all, the airship should be developed taking into consideration aerodynamic, propulsion, structure, energy and control systems, economic viability and many other parameters. But improving one parameter usually causes worsening of others. So, the compromise should be achieved.

Modern level of science and technology offers a wide range of methods and tools in order to get as close as possible to achieving the golden ratio for the airship. These tools include FEA and CFD (including some unconventional techniques) analysis for aerodynamics and structures, mathematical modelling for sensitivity analysis, Multi-Objective and Multi-Disciplinary optimisation techniques, etc. This talk will cover methods and tools used by MAAT project partners for achieving the compromise and developing new highly efficient green air transportation system based on airships.
ACHEON thrust vectoring green propulsion system
Michele Trancossi, University of Modena and Reggio Emilia (Italy)

The consciousness of the technological maturity reached today by transport industry including aeronautics is leading to a general absence of innovation and implies the need of breakthrough innovations which could give new impetus to the development of new models for the future. ACHEON is a new project funded by FP7 Transport (Level 0) and aimed at developing breakthrough emerging propulsion technology for green air transport. It is an example of project starting from academic basic research which aims to produce an impact in terms of effective industrial innovation.

ACHEON project explores the feasibility of a novel propulsive system for aircraft which is expected overcome the main limitations of traditional systems related to commonly known jet deflection system. The main advantage related to ACHEON is to produce the trust vectoring only by fluid-dynamic effect without any part in movement. The ACHEON thrust system involves three different physical effects:

• High speed jet mixing effects;
• Coanda effect of adhesion of a high speed jet to a convex surface;
• Coanda effect control by Electrostatic fields.

In this short talk a general model of the system will be presented involving an integral equation model analyzing the control strategies for the system and demonstrating its feasibility.
CROP - Cycloidal Rotor Optimized for Propulsion
Prof. José Páscoa, Portugal, Universidade da Beira Interior (Portugal)

The CROP project introduces an innovative propulsion system for aircraft based on the cycloidal rotor concept, using an integrated approach that includes the electric drive train, airframe integration and an environmental friendly energy source. The CROP system is supported on a multi-physics approach: 1. The high thrust is obtained by unsteady-based cycloidal rotor operation; 2. The development of low-weight electric power drives for the system; 3. Airframe re-design to accomplish optimum integration of the cycloidal propulsor; 4. Environmentally friendly energy source based on hydrogen and photovoltaic cells.

The strengths of the CROP concept are: - High thrust levels by using unsteady airflows; - Low weight by using an integrated design approach between airframe and cycloidal propulsor.

The results of this project are: a) improvement in aerodynamic efficiency of the cycloidal rotor for application in large vehicles; b) integration of low-weight electric drives into the cycloidal propulsion system; c) analysis of the more promising configurations for airframe/cycloidal propulsion integration; d) assessment and optimization of energy necessities for the novel propulsion system.

The possibilities opened by the development of an air vehicle that is capable to attain high subsonic velocities and also capable of VTOL without the need to make a radical reconfiguration of its geometry are enormous: 1) more convenient commercial transportation; 2) rapid disaster/rescue response; 3) flexible multi-mission military defence vehicles; 4) green friendly vehicles able to be powered by renewable or photovoltaic electricity.

References:
The Future of Air Transport – European Vision

*Thomas Möller, LogisticNetwork Consultants GmbH (Germany)*

The Air Transport System (ATS), which includes the aeronautics manufacturing industry, airports, airlines and air navigation service providers, is an important economic player all over Europe. Not only does it ensure that people and goods move around but it also generates wealth and jobs. As such, it is at the heart of the EUROPE 2020 strategy and its flagship initiatives including: innovation union, an industrial policy for the globalization era and resource efficient Europe. However, future air traffic growth is difficult to predict, but a number of signs are already apparent - airport congestion and capacity limitations, volatility of oil prices, concerns for the global climate, environmental legislation, etc. - which raise questions about the idea of continuous growth.

For the global increased competition, Europe must address three key challenges: increase the level of technology investment, enhance its competitiveness in world air transport markets and accelerate the pace of policy integration. In this context, technological leadership, the root of Europe’s current success, will continue to be the major competitive differentiator. Building on the vision for 2020, and the ensuing ACARE initiative, the lecture in this workshop lays out also a short view of the vision for European Aviation to 2050. Today and even more so tomorrow, a safe and efficient Air Transport System, led by innovative technology, will be a vital vector for our economy, our society and the cohesion of Europe and the world.
Publications MAAT Consortium


UBI: Review Article „A critical review of propulsion concepts for modern airships“, Galina Ilieva, José C. Páscoa, António Dumas and Michele Trancossi, Central European Journal of Engineering –CEJE, Volume 2, Number 2, Springer, DE, 02/06/2012, pp. 189-200, DOI: 10.2478/s13531-011-0070-1, URL: http://www.springerlink.com/content/6613m00302825w46/


URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6260129&tag=1


URL: http://ijass.org/PublishedPaper/topic_abstract.asp?idx=156

URL: http://papers.sae.org/2011-01-2786/

URL: http://papers.sae.org/2011-01-2784/


UNIMORE: Review Article „A critical review of propulsion concepts for modern airships“, Galina Ilieva, José C. Páscoa, Antonio Dumas and Michele Trancossi, Central European Journal of Engineering –CEJE, Volume 2, Number 2, Springer, DE, 02/06/2012, pp. 189-200, DOI: 10.2478/s13531-011-0070-1, URL: http://www.springerlink.com/content/6613m00302825w46/


ACHEON is a new project funded by FP7 Transport (Level 0) and aimed at developing breakthrough emerging propulsion technology for green air transport. It is an example of project starting from academic basic research which aims to produce an impact in terms of effective industrial innovation. ACHEON project explores the feasibility of a novel propulsive system for aircraft which is expected overcome the main limitations of traditional systems related to commonly known jet deflection system. 

The main advantage related to ACHEON is to produce the trust vectoring only by fluid-dynamic effect without any part in movement. In particular the project aims to define:

- the system, its control methodology and equations identifying the geometric and physical parameters, their possible limits and the fields of applications;
- system design methods applicable to different sizes and architectures;
- to explore the feasibility in the following fields:
  - traditional aerial vehicles architectures;
  - innovative aerial vehicle designs such as distributed propulsion;
  - innovative aircraft optimized for thrust vectoring

The ACHEON thrust system involves three different physical effects:

- High speed jet mixing effects
- Coanda effect of adhesion of a high speed jet to a convex surface
- Coanda effect control by Electrostatic fields.

ACHEON is run by a multidisciplinary consortium made of 6 organisations:

- Università di Modena e Reggio Emilia
- Universidade da Beira Interior
- Vrije Universiteit Brussel
- University of Lincoln
- Nimbus SRL
- Reggio Emilia Innovazione

CROP Project (Cycloidal Rotor Optimized for Propulsion)

clusterdem.ubi.pt

Air transport is the main activity which has transformed our society in the last 100 years by “shrinking the planet”, with large economic and social benefits through the world. Free movement of passengers and goods is one of the fundamental freedoms of the EU. However, Europe transport policy continues to suffer from an imbalance in the utilization of the different modes of transport, and of the absence of efficient European coordination platforms.

It is nowadays of paramount importance to devise new breakthrough concepts, that can introduce disruptive advancements, resulting on novel air vehicle designs with improved performances and reduced environmental and energetic impacts. The CROP project introduces a novel propulsion concept that intents to conduct to the design of a radically different new propulsion system for aerial vehicles. This can be a key element for a future break-through innovation in air transport, by implementing an environmentally friendly propulsion system with a reduction in associated costs. This project will also introduce a new concept based on plasma actuators, PECyT (“Plasma Enhanced Cycloydal Thruster”), that is being developed at University of Beira Interior.

Project Consortium

The CROP project is coordinated by the Cluster-DEM research group, belonging to the Electromechanical Engineering, Department and Centre for Aerospace science and Technology from the University of Beira Interior. The remaining consortium is composed by a multidisciplinary group of European universities and companies.

- Universidade da Beira Interior, Portugal
- Università di Modena e Reggio Emilia, Italy
- IAT21 - innovative aeronautics technologies GmbH, Austria
- University of Sheffi eld, United Kingdom
- Grob Aircraft AG, Germany
- Politecnico di Milano, Italy
Project Partners of MAAT

University of Modena and Regio Emilia (UniMoRe)  Italy

Universidade da Beira Interior (UBI)  Portugal

LogisticNetwork Consultants GmbH (LNC)  Germany

The University of Hertfordshire (UH)  U.K.

Southern federal University (SFEDU)  Russia

Engys Ltd. (ENGYS)  U.K.

University of Lincoln (UoL)  U.K.

University if Bologna (UniBo)  Italy

Esponential design Lab. S.A. (eDL)  Uruguay

Aero Sekr S.p.A. (ASKR)  Italy

Vrije Universiteit Brussel (VUB)  Belgium

University of Torino (Polito)  Italy