IMAV 2017

9th INTERNATIONAL MICRO AIR VEHICLES
CONFERENCE AND FLIGHT COMPETITION
SEPTEMBER 18-21, 2017

- Conference and Competition Book –

Organizers

ISAE SUPAERO · MAV Research Center · ENAC · ONERA The French Aerospace Lab

Partners

Toulouse European City of Science – Label ESOF 2018 · Préfecture de la Haute-Garonne · Cugnaux · Airborne Concept SAS · Aerospace Valley

Sponsors

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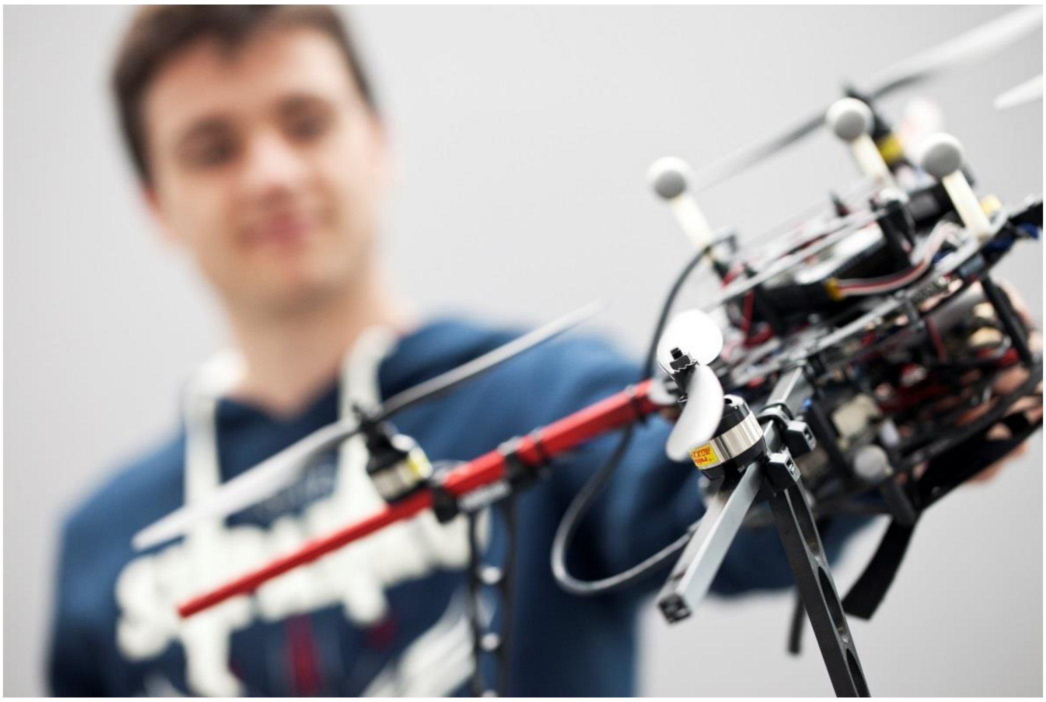

On behalf of the Scientific Committee, it is my pleasure to extend a warm welcome to everyone attending the 2017 edition of our International Micro Air Vehicle Conference & Flight Competition. This event was possible thanks to the joint efforts of ISAE-SUPAERO, ENAC and ONERA, members of the MAV Research Center. I would like to thank Henry de Plinval (ONERA), Conference Chairman who prepared a fantastic array of high-quality speakers and Gautier Hattenberger (ENAC), Competition Chairman and Flight Director, who selected the world's best MAV teams.

Prof. Jean-Marc Moschetta, ISAE-SUPAERO, IMAV 2017 General Chair

Scientific Committee

CAMPOY, Pascual (UPM, Madrid, Spain)

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SEROKHVOSTOV, Sergey (MIPT, Moscow, Russia)

WATKINS, Simon (RMIT University, Melbourne, Australia)

	AM	PM
Mon,18	09:00 Conference 12:30	14:00 Conference 17:30 group photo 18:30 Cocktail City Hall
Tue,19	09:00 Conference / Outdoor Practice Session 12:30	14:00 Conference / Indoor Practice Session 17:30
Wed,20	09:00 OUTDOOR COMPETITION	OUTDOOR COMPETITION *Treasure hunt challenge *Drone Parade Trophy *Tech demos 18:30 IMAV2017 Banquet
Thu,21	09:00 INDOOR COMPETITION	INDOOR COMPETITION *Record Breaking Session *Tech demos 17:00 Award Ceremony / IMAV2018 announcement

Please note that the conference (Sept. 18 & Sept. 19) and the indoor competition (Sept. 21) will take place at ISAE-SUPAERO.

Only the Practice outdoor flight session (Sept. 19 morning) and the Outdoor flight competition (Sept. 20) will take place at Francazal airport.

Monday September 18th 2017	
0845	**Welcome address – Amphi 2** **Olivier Lesbre**, *Director of ISAE-SUPAERO* **Opening address** **Jean-Marc Moschetta**, *ISAE-SUPAERO, IMAV 2017 chair*
0915	**Keynote Lecture 1 – Amphi 2** **How to get complex things working as soon as possible** Eric Johnson, *Georgia Tech*, Atlanta, GA, USA
0950	**Keynote Lecture 2 – Amphi 2** **Development of a Tail-Sitter Hybrid Unmanned Aerial Vehicle** Ben Chen, *National University of Singapore*, Singapore
1025	**Coffee break – Room Clément Ader**

Monday morning September 18th 2017	Parallel session SA1 – Amphi 2 **Aerodynamics and flow control** Chaired by : Thierry Jardin, *ISAE-SUPAERO*, Toulouse, France	Parallel Session SB1 – Amphi 1 **Control designs and analysis for MAVs** Chaired by : Eric Johnson, *Georgia Tech*, GA, USA
1100	**MAV17-PARSA1a** **Qualitative Investigation of the Dynamics of a Leading Edge Control Surfaces for Micro Air Vehicle Applications** A Panta, Petersen P, Marino M, Watkins S and Mohamed A, *RMIT University*, Melbourne Australia	**MAV17-PARSB1a** **A numerical approach for attitude control of a quadrotor** Huu-Phuc Nguyen, Jérôme De Miras, Ali Charara and Stephane Bonnet, *Université de Technologie de Compiègne*, CNRS, Heudiasyc, Compiègne, France

1130	**MAV17-PARSA1b** **Aerodynamic design of a martian micro air vehicle** T. Desert, J.M. Moschetta, and H. Bezard *ONERA & ISAE-SUPAERO*, Toulouse, France	**MAV17-PARSB1b** **Application of a switching control strategy to extract energy from turbulence by a UAV** F. Pasquali, Y. Brière, and N. Gavrilovic *ISAE-SUPAERO*, Toulouse, France
1200	**MAV17-PARSA1c** **Study of ducted fans interference for copter type multirotor UAV/RPAS** K. Stremousov and M. Arkhipov *MIPT*, Zhukovsky, Russia	**MAV17-PARSB1c** **Prioritized Control Allocation for Quadrotors Subject to Saturation** E.J.J. Smeur, D.C. Hoppener, C. De Wagter *TU Delft*, The Neterlands
1220	**Lunch - Restaurant**	
1330	**Keynote Lecture 3 – Amphi 2** **Using small UAV for atmospheric turbulence measurements** Jens Bange, *University of Tübingen*, Germany EBERHARD KARLS UNIVERSITÄT TÜBINGEN	
Monday afternoon September 18th 2017	**Parallel Session SA2 – Amphi 2** **Aeroacoustics Investigations** Chaired by : D Moormann, *Aachen University*, Germany	**Parallel Session SB2 – Amphi 1** **Drones Control and Navigation Strategies** Chaired by : Y. Brière, *ISAE-SUPAERO*, Toulouse, France
1405	**MAV17-PARSA2a** **Aeroacoustics investigation on nano coaxial rotor** Zhen Liu, Chen Bu, Xiangxu Kong, and Dong Yang *Jiaotong University*, Xi'an, China	**MAV17-PARSB2a** **Cooperative Aerial Payload Transportation Using Two Quadrotors** A. Rajaeizadeh, A. Naghash, and A. Mohamadifard *Amirkabir University of Technology*, Tehran, Iran
1435	**MAV17-PARSA2b** **Reducing the noise of Micro-Air Vehicles in hover** R. Serre, V. Chapin, J.M. Moschetta and H. Fournier *ISAE-SUPAERO*, Toulouse, France	**MAV17-PARSB2b** **Robust Attitude Control for Quadrotors with External Disturbances** H. Nemati, A. Naghash, S. Mozafari, and A. Jamei *Amirkabir University of Technology*, Tehran, Iran
1505	**MAV17-PARSA2c** **Application of Lattice Boltzmann Method to some challenges related to Micro Air Vehicles** N. Gourdain, T. Jardin, R. Serre, S. Prothin and J.-M. Moschetta ISAE-SUPAERO, Toulouse, France	

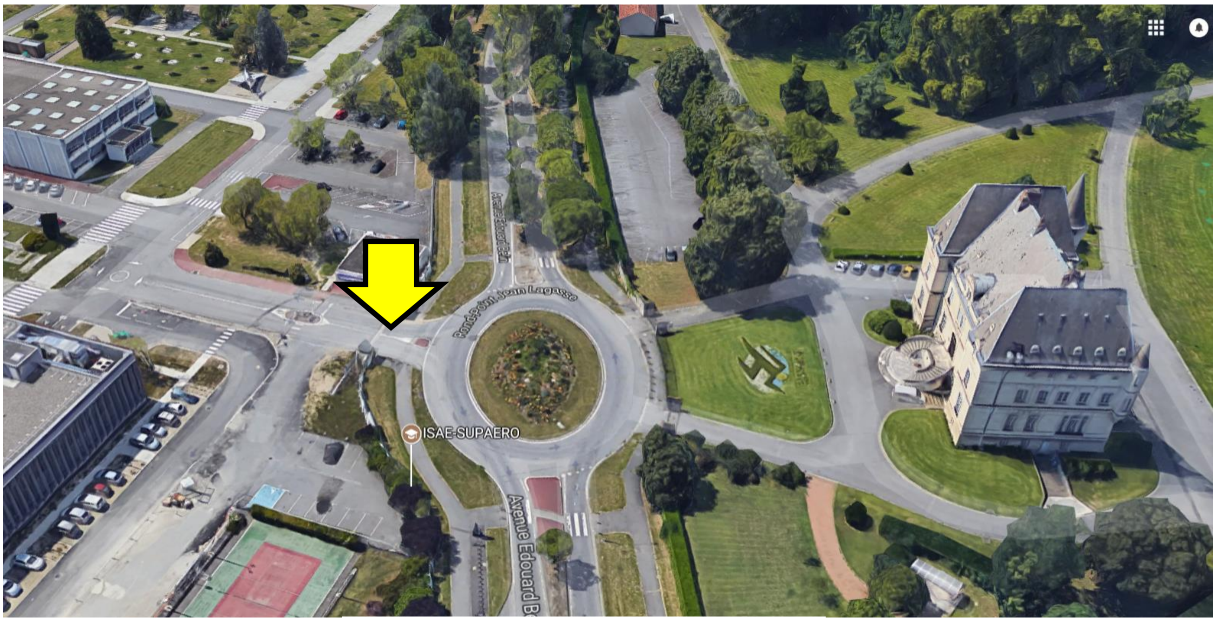
1525	**Coffee break – Room Clément Ader**	
Monday afternoon September 18th 2017	**Parallel Session TA1 – Amphi 2** **Control Designs and Analysis** Chaired by : H de Plinval, *ONERA*, Toulouse, Ffrance	**Parallel Session TB1 – Amphi 1** **Navigation Strategies and the Use of Vision** Chaired by : Y Watanabe, *ONERA*, Toulouse, France
1600	**MAV17-PARTA1a** **Robustness Analysis of a Controlled Quadrotor MAV Carrying a Cable-suspended Load** N. Santos, E. Laroche, R. Kieferzand S. Durand *ICube*, Illkirch, France	**MAV17-PARTB1a** **Human-Robot Cooperation in Surface Inspection Aerial Missions** Martin Molina, Pedro Frau, Dario Maravall, José Luis Sanchez-Lopez, Hriday Bayle, P. Campoy *Technical University of Madrid*, Spain
1620	**MAV17-PARTA1b** **Landing and Take-off on/from Sloped and Non-planar Surfaces with more than 50 Degrees of Inclination** M. Tognon and A. Franchi *LAAS-CNRS*, Toulouse, France	**MAV17-PARTB1b** **An Intelligent Unmanned Aircraft System for Wilderness Search and Rescue** Huai Yu, Jinwang Wang, Kaimin Fu, Wen Yang *Wuhan University*, China
1640	**MAV17-PARTA1c** **Flight Simulation of a MAKO UAV for Use in Data-Driven Fault Diagnosis** Elgiz Baskaya, Murat Bronz, and Daniel Delahaye *ENAC*, Toulouse, France	**MAV17-PARTB1c** **A honeybee's navigational toolkit on Board a Bio-inspired Micro Flying Robot** Erik Vanhoutte, Franck Ruffier and Julien Serres *ISM*, CNRS, Marseille, France
1700	**MAV17-PARTA1d** **Incremental Nonlinear Dynamic Inversion and Multihole Pressure Probes for Disturbance Rejection Control of Fixed-wing Micro Air Vehicles** Elisabeth S. van der Sman, Ewoud J. J. Smeur, B. Remes, C. De Wagter, and Qiping Chu *TU Delft*, The Netherlands	**MAV17-PARTB1d** **Towards a MOMDP model for UAV safe path planning in urban environment** Jean-Alexis Delamer, Yoko Watanabe, Caroline P. Carvalho Chanel *ONERA & ISAE-SUPAERO*, Toulouse, France
1725	**Group photograph – Main court**	
1745	**Downtown buses depart from Main Court**	
1830	**Welcome reception** City Hall "Salle des Illustres", Place du Capitole, Toulouse	

Tuesday September 19th 2017		
Tuesday morning September 19th 2017	**Parallel session SA3 – Amphi 2** **Novel Designs for MAVs** Chaired by : B Chen, *National University of Singapore*, Singapore	**Parallel session SB3 – Amphi 1** **Wind Measurements using MAVs** Chaired by : Christophe De Wagter, *TU Delft*, The Netherlands
0845	**MAV17-PARSA3a** **Investigation on Natural Frequency and Fuselage Effect for Small UAVs Lateral Motion** M. El-Salamony, S. Serokhvostov *MIPT*, Zhukovsky, Russia	**MAV17-PARSB3a** **Using MAVs for Atmospheric Wind Measurements: Opportunities and Challenges** S. Watkins, M. Abdulghani, S. Prudden, M. Marino, R. Clothier, A. Fisher and A. Panta *RMIT*, Melbourne, Australia
0915	**MAV17-PARSA3b** **Team MAVion entry in the IMAV'17 outdoor challenge -- A tail-sitting trajectory-tracking μUAV** Leandro R. Lustosa, J. M. O. Barth, J.-P. Condomines, F. Defay and J.-M. Moschetta *ISAE-SUPAERO & ENAC*, Toulouse, France	**MAV17-PARSB3b** **Bio-inspired Wind Field Estimation-Part 1: AoA Measurements Through Surface Pressure Distribution** Nikola Gavrilovic, M. Bronz, J.-M. Moschetta, E. Benard and P. Pastor *ISAE-SUPAERO & ENAC*, Toulouse, France
0945	**MAV17-PARSA3c** **Simulation and Control of a Tandem Tiltwing RPAS Without Experimental Data** Y. Beyer *TU Braunschweig*, Germany	**MAV17-PARSB3c** **Developing a stable UAS for Operation in Turbulent Urban Environment** A. Mohamed, P. Poksawat, S. Watkins, R. Gigacz *RMIT*, Melbourne, Australia
1005	**Coffee break – Room Clément Ader**	
1040	**Keynote Lecture 4 – Amphi 2** **Drones in Archaeology. State-of-the-art and Future Perspectives.** Stefano Campana, *University of Siena*, Italy	

1115	**Keynote Lecture 5 – Amphi 2** **Flying Robot Companions for Future Smart Cities** Mirko Kovac, *Imperial College*, London, UK Imperial College London	
1140	**Keynote Lecture 6 – Amphi 2** **Towards better MAVs and what we can learn from birds and bees** Simon Watkins, *RMIT*, Melbourne, Australia RMIT UNIVERSITY	
1215	**Lunch - Restaurant**	
Tuesday afternoon September 19th 2017	**Parallel session TA2 – Amphi 2** **Multiple Vehicles Cooperation** Chaired by : S Lacroix, *LAAS-CNRS*, Toulouse, France	**Parallel session TB2 – Amphi 1** **Novel Design Methodologies for MAVs** Chaired by : M Bronz, *ENAC*, Toulouse, France
1345	**MAV17-PARTA2a** **Collision Avoidance of multiple MAVs using a multiple Outputs to Input Saturation Technique** C. Chauffaut, L. Burlion, F. Defay, H. de Plinval *ISAE-SUPAERO & ONERA*, Toulouse, France	**MAV17-PARTB2a** **Optimization of Energy Consumption for Quadrotor UAV** F. Yacef, N. Rizoug, O. Bouhali, and M. Hamerlain *ESTACA*, Laval, France & *Jijel University*, Algeria
1405	**MAV17-PARTA2b** **A Hybrid Approach for 3D Formation Control in a Swarm of UAVs using ROS** Rafael G. Braga, R. C. da Silva, A. C. B. Ramos, F. Mora-Camino *Federal University of Itajub´a*, Brasil & *ENAC*, Toulouse, France	**MAV17-PARTB2b** **Development and Design Methodology of an Anti-Vibration System on Micro-UAVs** Zhenming Li, Mingjie Lao, Swee King Phang, Mohamed Redhwan, Abdul Hamid, Kok Zuea Tang, and Feng Lin *National University of Singapore*, Singapore
1425	**MAV17-PARTA2c** **Formation flight of fixed-wing aircraft by employing guidance vector fields** Hector Garcia de Marina and G. Hattenberger *ENAC*, Toulouse, France	**MAV17-PARTB2c** **Quick aerodynamic design of micro air vehicles** V. Vyshinsky, A. Kislovskiy *MIPT*, Zhukovsky, Russia
1445	**MAV17-PARTA2d** **EDURA: an Evolvable Demonstrator for Upset Recovery Approaches with a 3D-printed Launcher** Torbjørn Cunis and Murat Bronz *ENAC*, Toulouse, France	**MAV17-PARTB2d** **Copter Size Minimization for IMAV-2017 Competition in Record Breaking Session** S.Serokhvostov, and B.Makaev *MIPT*, Zhukovsky, Russia

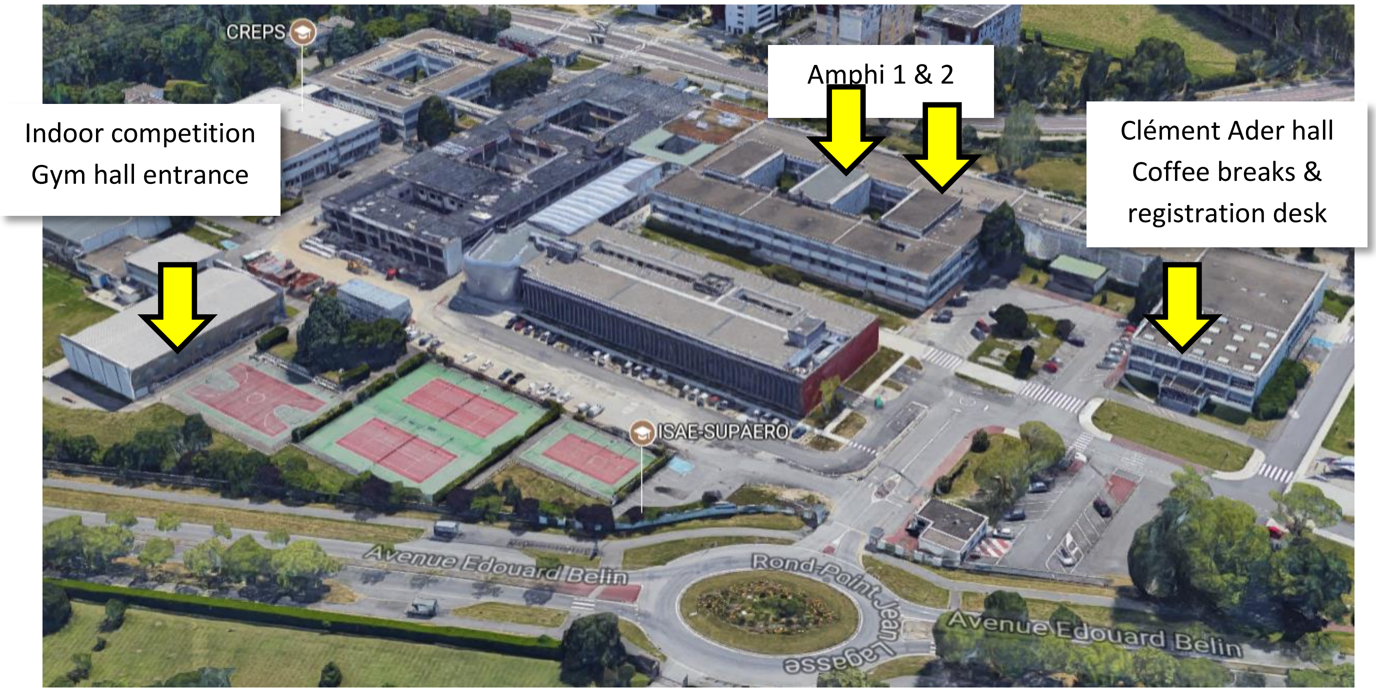
1505	Coffee break – Room Clément Ader	
Tuesday afternoon September 19th 2017	Parallel session SA4 – Amphi 2 **Specific MAVs designs : flapping and Folding Wings, and bio-inspired Designs** Chaired by : M. Kovak, *Imperial College*, UK	Parallel Session SB4 – Amphi 1 **Image Processing Developments** Chaired by : P Campoy, *Technical University of Madrid*, Spain
1540	**MAV17-PARSA4a** **Bond Graph based design tool for a passive rotation flapping wing** Le Anh Doan, Christophe Delebarre, Sebastien Grondel, Eric Cattan *University of Valenciennes & Centrale Lille*, France	**MAV17-PARSB4a** **Development of Vision Based Navigation for Micro Aerial Vehicles in Harsh Environment** Hailong Qin, Yingcai Bi, F. Lin and Ben M. Chen *National University of Singapore*, Singapore
1610	**MAV17-PARSA4b** **Quad-thopter: Tailless Flapping Wing Robot with 4 Pairs of Wings.** Christophe De Wagter, Matej Karasekyand and Guido de Croon *TU Delft*, The Netherlands	**MAV17-PARSB4b** **Efficient Global Indoor Localization for Micro Aerial Vehicles** V. Strobel, R. Meertens, and G.C.H.E. de Croon *TU Delft*, The Netherlands
1640	**MAV17-PARSA4c** **Analysis of Folding Wing Rolling Moment** T. Pantuphag, S. Catteeyothai, N. Krajangsawasdi, and C. Thipyopas *Kasetsart University*, Bangkok, Thailand	**MAV17-PARSB4c** **Reconstruction of Complex Structures with Online Profiling and Adaptive Viewpoint Sampling** Abdullah Abduldayem, Dongming Gany, Lakmal Seneviratnez, Tarek Taha *Khalifa University*, Abu Dhabi, United Arab Emirates
1710		**MAV17-PARSB4d** **An Automated Rapid Mapping Solution Based on ORBSLAM and Agisoft Photoscan API** Markus Bobbe, Alexander Kern, Yogesh Khedar, Simon Batzdorfer and Ulf Bestmann *TU Braunschweig*, Germany
1800	Downtown buses depart from Main Court	

- Conferences and the indoor competition (Sept. 21) will take place at: ISAE-SUPAERO, 10 Avenue Edouard Belin 31400 Toulouse, **Monday Sept. 18 & Tuesday Sept. 19**

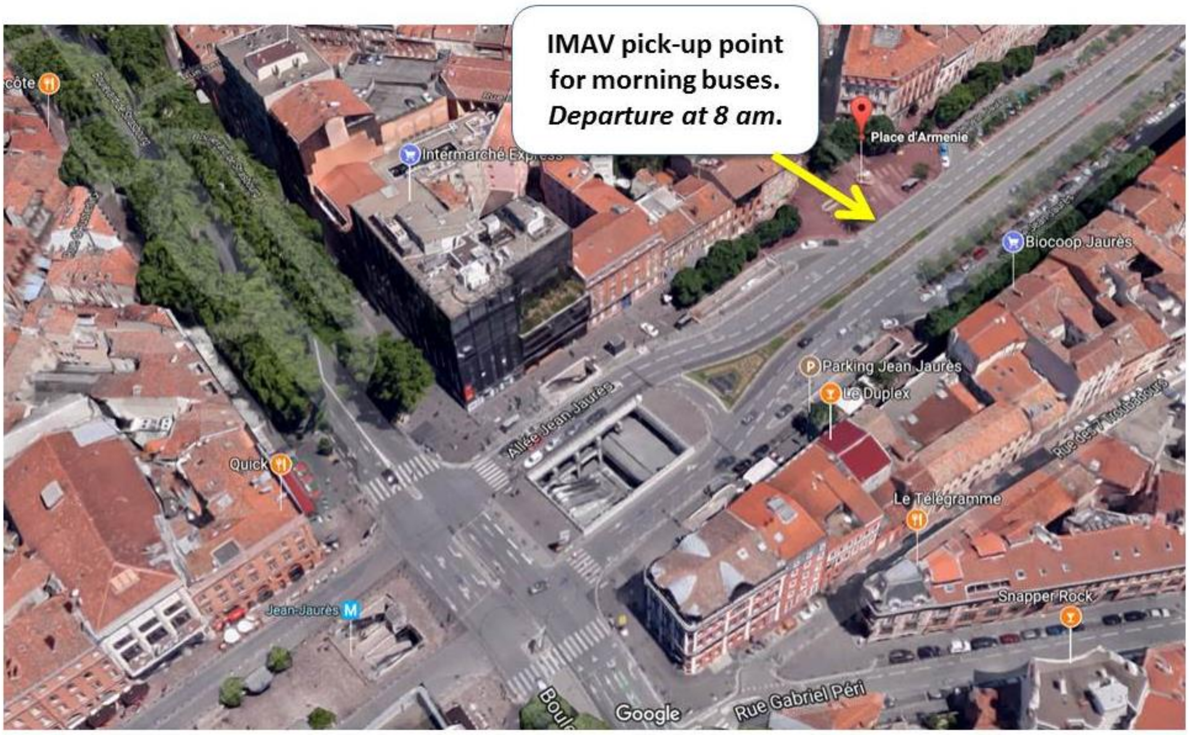


ISAE-SUPAERO, main entrance

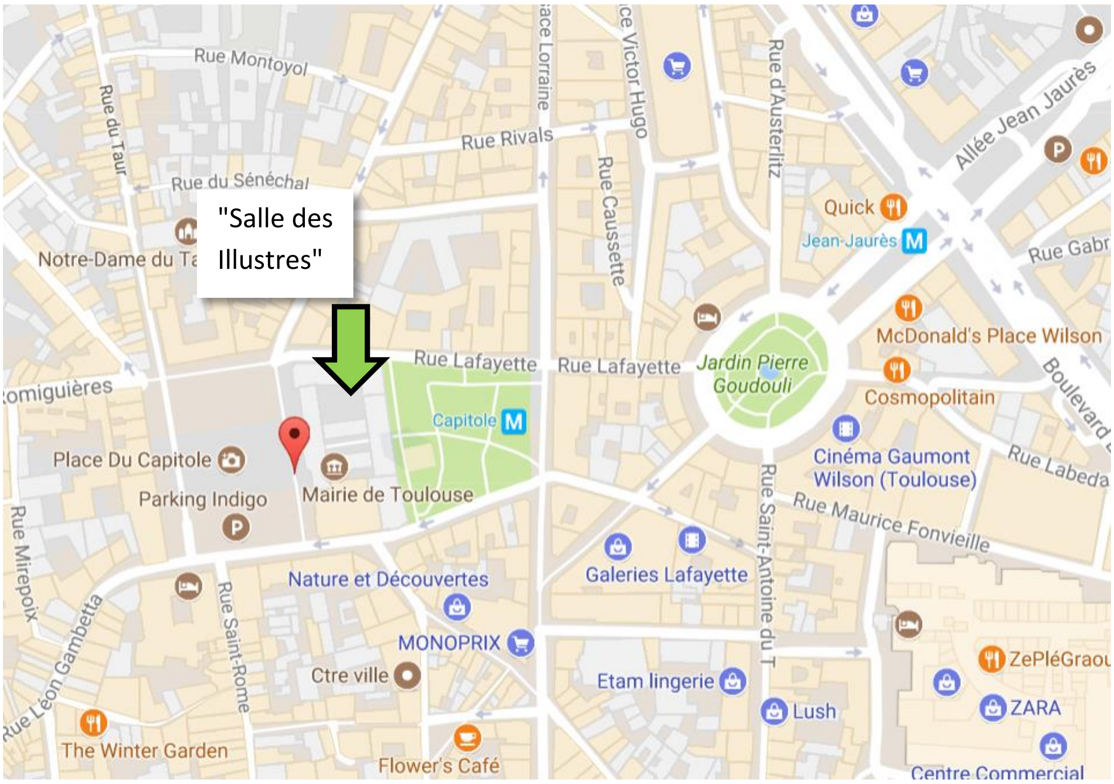
- ISAE-SUPAERO campus map

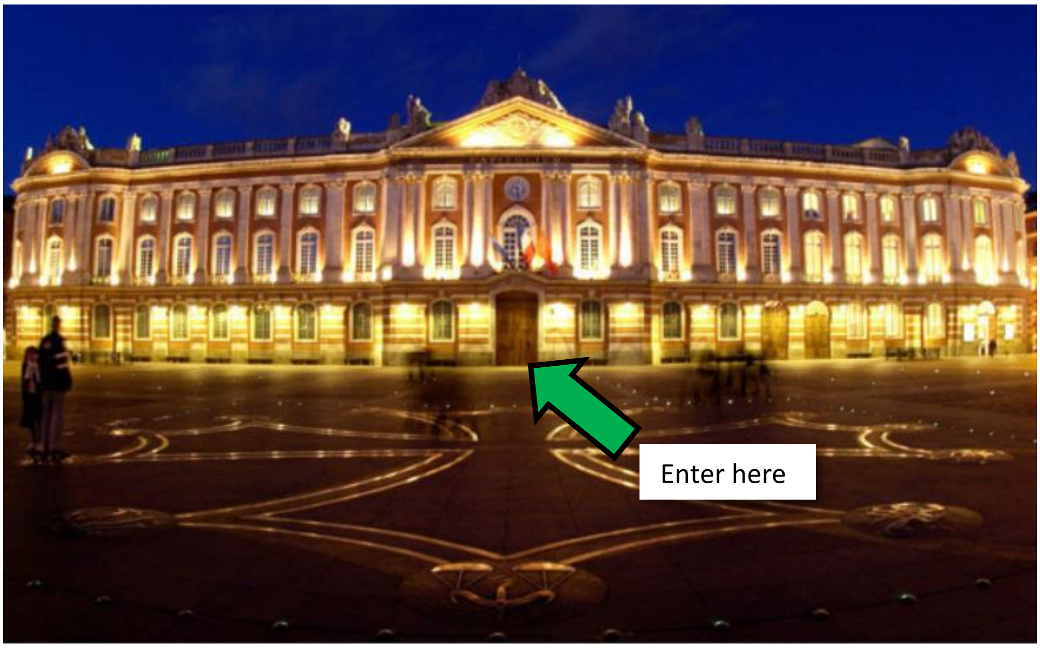


- Daily shuttle bus departure point



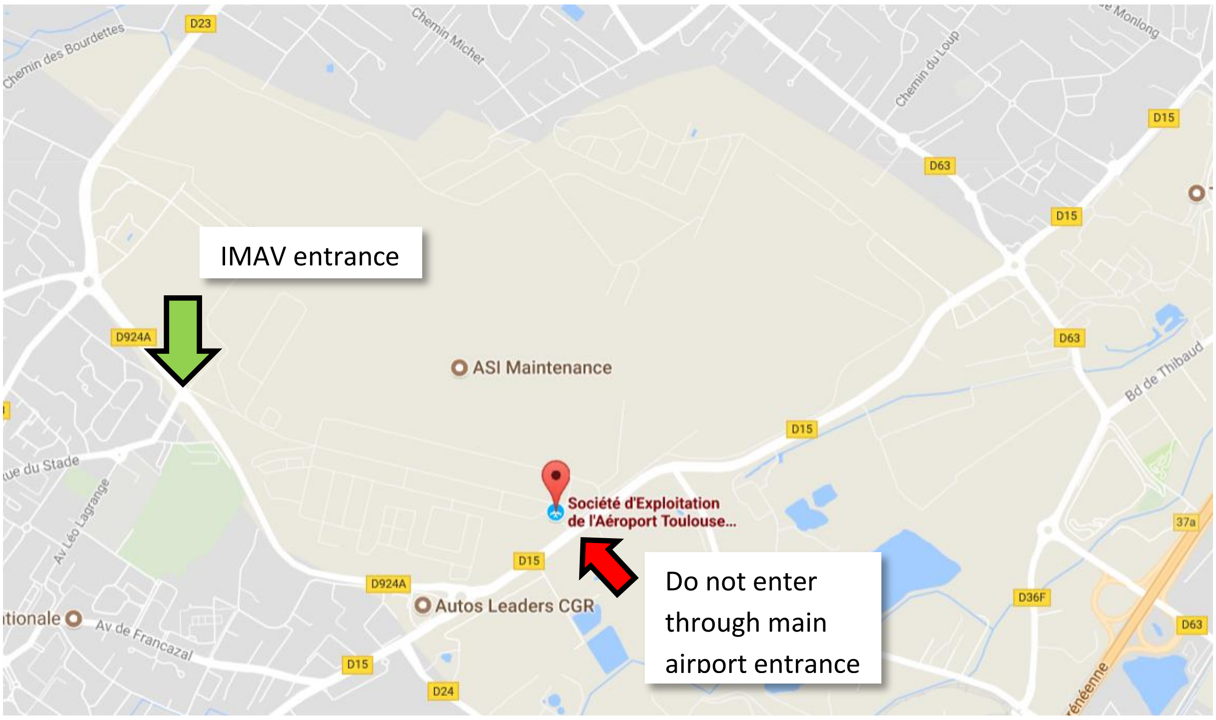
- Welcome reception at the “Salle des Illustres”, Toulouse city hall, “Place du Capitole”, **Monday Sept. 18 at 6.30pm.**

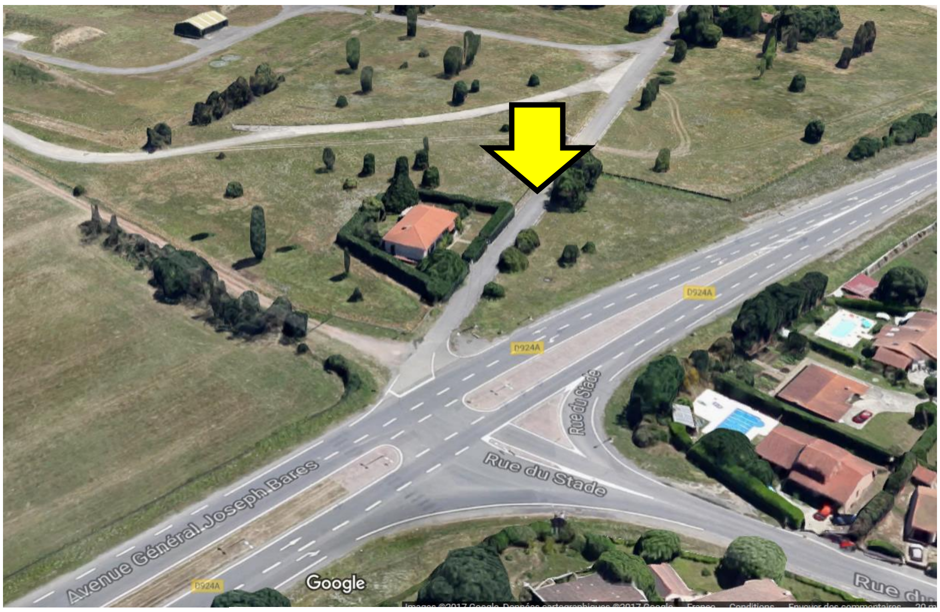




IMAV welcome reception – “Salle des Illustres”, place du Capitole

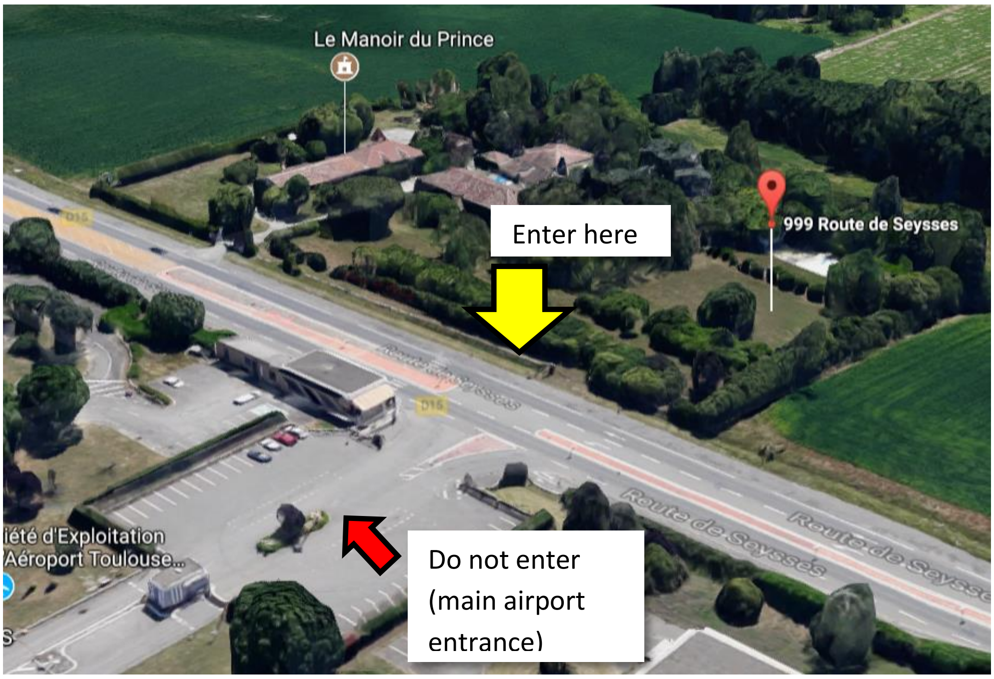
- Outdoor competitions will take place at Aéroport Toulouse Francazal, Avenue du General Barès, 31270 Cugnaux. Directly in front of "Rue du stade", **Wednesday Sept. 20 at 8.30am.**





Francazal airport, Western gate
(special IMAV entrance)

- Banquet hall at "Manoir du Prince" 999 Routes de Seysses 31120 Portet-sur-Garonne (opposite the main Francazal airport entrance), **Wednesday Sept. 20 at 6.30pm.**



Prof. Eric N. Johnson

Georgia Institute of Technology

Title : **How to get complex things working as soon as possible**

Time : 0915 (Monday Sept. 18)
Place : Amphi 2

Abstract : Developing highly automated aerial systems to perform complex missions inherently includes a significant number of challenges. Designs must be made, algorithms chosen/developed, hardware procured, software written, and everything brought together and tested safely; all within time and budget. For Unmanned Aerial Systems (UAS) specifically, there is also great emphasis on incorporation of new technology that adds new capabilities. As any competitor in IMAV knows, getting this all to work is not easy. This presentation will offer some easy-to-remember and actually use guidance on performing these types of complex system design and integration activities. This includes how to prioritize development and testing activities as well as some specific methods that can enable things to happen more quickly and with greater confidence. This presentation will utilize case studies from several autonomous air vehicle challenges and related projects.

Webpage : http://www.uavrf.gatech.edu/

Prof. Ben M. Chen

NUS National University of Singapore

Title : **Development of a Tail-Sitter Hybrid Unmanned Aerial Vehicle**

Time : 0950 (Monday Sept. 18)
Place : Amphi 2

Abstract : In this talk, we aim to present the development of a hybrid unmanned aircraft, which has both vertical take-off and landing (VTOL) and cruising fight capabilities. The platform is in tail-sitter structure. It combines the advantages of a fixed-wing plane and a rotor helicopter effectively. It allows to transit from vertical take-off to hovering, before flying in cruise mode for efficient long duration fight. The drone can transit back to the VTOL mode for landing. The transition between the VTOL and fixed-wing modes are highly nonlinear and challenging. Our design has been successfully verified by actual fight experiments.

Webpage : http://uav.ece.nus.edu.sg/

Prof. Dr. Jens Bange

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

Title : **Using small UAV for atmospheric turbulence measurements**

Time : 1330 (Monday Sept. 18)
Place : Amphi 2

Abstract : Unmanned small research aeroplanes (UAV) are a very suited instrument for the investigation of atmospheric turbulence, its structure and the turbulent transport of energy, momentum, gases and particles. The presentation will discuss in situ measurement approaches and compare the pros and cons of manned research aircraft and small UAV. Due to the requirement of turbulent wind measurements, the presentation is focused on fixed-wing aircraft. As an example for a small research UAV, the system MASC (Multi-purpose Airborne Sensor Carrier) and its scientific equipment will be explained, with emphasise on the turbulent wind vector measurement. Finally, results obtained from small research UAV in wind-energy research will be shown, with focus on the spatial wind field in complex terrain – possibly the most challenging applications for such research UAV.

Webpage : http://www.geo.uni-tuebingen.de/umphy

Prof. Stefano Campana

Title : **Drones in Archaeology. State-of-the-art and Future Perspectives**

Time : 1040 (Tuesday Sept. 19)
Place : Amphi 2

Abstract : In addition to traditional platforms for low-level remote sensing (balloons, kites, etc.) new and more complex automated systems [unmanned aerial vehicles (UAVs) or drones] have become available in the last decade. The success and market expansion of these platforms has been a driving force in the development of active and passive sensors specifically designed for UAVs. In the last few years archaeologists have started testing both platforms and sensors, particularly for the following applications: three-dimensional (3D) documentation of archaeological excavations; 3D survey of monuments and historic buildings; survey of archaeological sites and landscapes; exploratory aerial survey; and the archaeological survey of woodland areas. The scale of these applications has ranged from site-based to landscapes-based (approximately up to about 10 km^2 in extent). The role of such platforms in the archaeological survey of excavations and landscapes, and in diagnostics more generally, is of great interest and is inexorably growing.

Webpage : https://www.dssbc.unisi.it/en

Dr. Mirko Kovac

Imperial College London

Title : **Flying Robot Companions for Future Smart Cities**

Time : 1115 (Tuesday Sept. 19)
Place : Amphi 2

Abstract : The rise of robotics offers a unique opportunity to re-imagine the design and function of urban environments. Future smart cities will behave like complex ecosystems in which humans, nature and robots exist in symbiosis, performing various tasks that are laborious, dangerous or expensive to do by manual means. In these future cities, swarms of friendly flying robots could interact autonomously with humans to serve society for e.g. construction and repair of buildings, urban logistics and environmental monitoring. Some of the most exciting prospects for these future robotics systems draw their inspiration from energy-efficient, adaptive strategies seen in living organisms that can thrive in complex, changing environments.

In this talk, Dr. Mirko Kovac will show the newest bio-inspired flying robots that have been developed at the Imperial College Aerial Robotics Laboratory illustrating how the study of natural systems can enable next-generation aerial robots to enhance operations and human wellbeing in future cities.

Webpage : http://www.imperial.ac.uk/aerialrobotics

Prof. Simon Watkins

RMIT UNIVERSITY

Title : **Towards better MAVs and what we can learn from birds and bees**

Time : 1140 (Tuesday Sept. 19)
Place : Amphi 2

Abstract : The typical flight environment of nature's fliers and micro air vehicles is turbulent as depicted above. It is characterised by relatively high levels of turbulence inherent in the lower levels of the atmospheric boundary layer. This highly energetic environment can result in large dynamic inputs which reduce only slightly as wingspans reduce, whereas the inertial resistance to inputs decreases rapidly with wingspan. As some of the main uses of MAVs will take them close to and possibly into, buildings this raises new challenges which have not been addresses by traditional aeronautical research. These include endurance, noise (it's reduction and human response to noise type), rapid control movements with limited actuator power and highly accurate autonomous tracking in the presence of strong wind gradients. An overview of recent work at RMIT on addressing these challenges will be given with a focus on advances in reducing the deleterious movement associated with turbulence (or "gusts").

Webpage : http://ruasrt.com

Dr. Greg Roberts

Title : **Field notes from above: Deploying drones for atmospheric science**

Time : 1900
Place : Banquet hall

Biography : Dr. Greg Roberts is an atmospheric scientist at the Centre National de Recherches Météorologiques (CNRM) in Toulouse, France with a joint-appointment at Scripps Institution of Oceanography in La Jolla, USA. His recent research has focused aerosol-cloud interactions and the on the development of a miniaturized, autonomous observing systems for deployment in unmanned aerial systems (UAS), balloons and light aircraft. Roberts has extensive experience with UAS operations and is coordinating several UAS projects at CNRM to study clouds, aerosol fluxes, turbulence and fog using multi-dimensional observation approaches. Roberts is a member of ISARRA (International Society for Atmospheric Research using Remotely Piloted Aircraft) and the GIS-Micro-Drone working group (Toulouse). In addition, Roberts has co-patented a cloud chamber that is now an international standard for understanding aerosol-cloud interactions.

Title : **Qualitative Investigation of the Dynamics of a Leading Edge Control Surfaces for MAV Applications**

Authors : **A Panta, Petersen P, Marino M, Watkins S, Fisher A and Mohamed A**

Institute : RMIT University, Melbourne, Australia

Time : 1100
Place : Amphi 2

Abstract : Conventional control surfaces mounted on wing trailing edges actuated with commercially available servos have not been able to achieve sufficient control authority and rapidity to keep small MAVs flying straight and level in turbulent flow. Non-conventional leading edge control surfaces are investigated as an alternative actuation solution with the potential to enhance control authority and rapidity. In this study, flow visualization of leading edge control surface revealed that higher deflection rates delayed flow separation and this is expected to enhance control forces. Higher actuation rates produced dominant leading edge vortices and hence a transient lift enhancement over the airfoil. Lift spikes from high rate actuations could be exploited to compensate for the high frequency perturbations from gusts.

Title : **A numerical approach for attitude control of a quadrotor**

Authors : **Huu-Phuc Nguyen, Jérôme De Miras, Ali Charara and Stéphane Bonnet**

Institute : Université de Technologie de Compiègne, CNRS, Heudiasyc, Compiègne, France

Time : 1100
Place : Amphi 1

Abstract : This paper deals with a numerical approach to control aggressive maneuvers of a multi-rotor aerial vehicle. The proposed controller uses an approximate tabulated one-step time discretization of the state-space model to find out the outputs of controller. It objective is to minimize the distance between the plant output and a linear well chosen closed loop system used as reference, leading the system to adopt its dynamical behavior. The prediction horizon is only one step time that ensures the execution time is completely bounded. The results from simulation for quadrotor show the performance and robustness of the proposed controller.

Title : **Aerodynamic Design of a Martian Micro Air Vehicle**

Authors : **T. Désert, J.M. Moschetta, and H. Bézard**

Institute : ONERA & ISAE-SUPAERO, Toulouse, France

Time : 1130
Place : Amphi 2

Abstract : The present study aims at developing a reliable propulsion system for a rotary wing micro air vehicle (MAV) associated to rovers in order to enhance Martian exploration rate. The main challenge encountered for MAV design is Martian atmosphere's density and speed of sound that are significantly lower than on Earth. Leading to compressible ultra low Reynolds number (2, 000 < Re_{dom} < 10, 000) flows met at blades tip that are unusual and unknown in the biosphere. Consequently, evaluations of numerical tools have been carried out recreating a depressurized experiment. 2D and 3D steady and unsteady Navier-Stokes computations are compared to XFoil for flow behavior apprehension and solver assessment. Based on XFoil's performances evaluations, camber line and thickness distribution have been optimized for 2D incompressible and compressible flows. Optimal shape for a steady solver is a highly cambered airfoil shifting the boundary layer separation downstream. 2D unsteady Navier-Stokes computations show that airfoils delaying heavy unsteadiness generation are producing higher lift and lower drag in 2D than the picked airfoils enhancing vortex production, such as dragonfly airfoils. The impact of airfoil shape on 3D flows is evaluated with a first of its kind experimental campaign in collaboration with CNES. The experimental facility is a ONERA's 18m3 tank recreating Martian atmosphere in terms on kinematic viscosity and composition. The tank size allows to reduce wall effects and provide – as compared to previous studies - a more accurate evaluation of rotor performances.

Title : **Application of a Switching Control Strategy to Extract Energy from Turbulence by a Fixed-wing UAV**

Authors : **F. Pasquali, Y. Brière, and N. Gavrilovic**

Institute : ISAE-SUPAERO, Toulouse, France

Time : 1130
Place : Amphi 1

Abstract : The objective of this paper is to design a control law to allow a small fixed-wing Unmanned Aerial Vehicle to extract energy from atmospheric turbulence. From literature data the properties of atmospheric gusts at low altitude are discussed and a single point measurement is proved to be representative of the wind field. The longitudinal flight dynamics of the aircraft is analyzed and the phugoid mode is found to be the main driver of the energy extraction process. A switching controller that places the poles of the phugoid mode depending on the instantaneous variation of energy of the aircraft is designed. Statistical simulations show an increase of energy of the aircraft when this strategy is applied.

Title : **Study of ducted fans interference for copter type multirotor UAV/RPAS**

Authors : **Stremousov K., Arkhipov M.**

Institute : MIPT, Zhukovsky, Russia

Time : 1200
Place : Amphi 2

Abstract : The interference of 17 inch ducted fans with a height of 10% of propellers diameter was studied in hovering regime for the case as it was installed on a quad-rotor copter-type UAV/RPAS. Numerical simulations were provided by solving RANS equations with SST turbulence model using actuator disc with radial distribution of pressure difference according to numerical and experimental investigation of 17 propeller in hovering regime. The straight modeling of the ducted fan with propeller rotation was conducted to obtain higher quality resulting flowfield around the ducted fan. During the 3D numerical simulation of the interference of four ducted fans the improvements of duct geometry were provided in the term of the power consumption with a constant thrust. The wind stability of the quad-rotor copter with four ducted fans was studied by modeling the side wind of different velocities.

Title : **Prioritized Control Allocation for Quadrotors Subject to Saturation**

Authors : **E.J.J. Smeur, D.C. Höppener, C. De Wagter**

Institute : TU Delft, The Netherlands

Time : 1200
Place : Amphi 1

Abstract : This paper deals with the problem of actuator saturation for INDI (Incremental Nonlinear Dynamic Inversion) controlled flying vehicles. The primary problem that arises from actuator saturation for quadrotors, is that of arbitrary control objective realization. We have integrated the weighted least squares control allocation algorithm into INDI, which allows for prioritization between roll, pitch, yaw and thrust. We propose that for a quadrotor, the highest priority should go to pitch and roll, then thrust, and then yaw. Through an experiment, we show that through this method, and the appropriate prioritization, errors in roll and pitch are greatly reduced when applying large yaw moments. Ultimately, this leads to increased stability and robustness.

Title : **Aeroacoustics Investigation on Nano Coaxial Rotor in Hover**

Authors : **Zhen Liu, Chen Bu, Xiangxu Kong, and Dong Yang**

Institute : Jiaotong University, Xi'an, China

Time : 1405
Place : Amphi 2

Abstract : Aeroacoustics of nano rotor has an impact on the stability and reliability of nano air vehicle. The interference between rotors on aeroacoustics was investigated for nano coaxial counter-rotating rotor. The aerodynamic model of upper rotor of nano rotor was firstly established with sliding mesh technique and multi-blocks method. The unsteady flow field of upper rotor was then studied with LES method and the pressure, the velocity and the vorticity distribution were analyzed. On the basis of the analysis of flow field, the FW-H method was used to study the aeroacoustics of upper rotor. The total sound pressure level and the frequency noise spectrum of the upper rotor were monitored. In order to verify the results of simulation, the test bench for measuring the aeronautics of upper rotor was established. The variation of sound pressure level was measured. The results between the simulation and experiment were compared. It was found that the sound pressure level of monitor point which is near the vortex is high. In the frequency noise spectrum, there is an integer in multiple of the rotation frequency and fundamental frequency, and the peak value decreases with the increase of frequency. The experimental aeroacoustics results match well with that of the computational results so that the computational method is validated. The aeroacoustics of nano coaxial rotor was then studied numerically. When comparing with upper rotor, it was found that the SPL of nano coaxial rotor increased. Flow field analysis showed that the shedding vortices of upper rotor interact the lower rotor resulting the blade-vortex interaction. It is evident that the aeroacoustics was enhanced by the interference of upper rotor and lower rotor.

Title : **Cooperative Aerial Payload Transportation Using Two Quadrotors**

Authors : **A. Rajaeizadeh, A. Naghash, and A. Mohamadifard**

Institute : Amirkabir University of Technology, Tehran, Iran

Time : 1405
Place : Amphi 1

Abstract : In this paper, we consider the problem of controlling multiple quadrotors fastened to a payload and cooperatively transport it in 3 dimensions. We model the quadrotors as a group rigidly attached to a payload. Then we develop the equations of motion of this rigid system. We propose a rigid-body formation system controller based on LQR method as well as a Paparazzi-based guidance scheme for the payload mission trajectory. Also a PD controller is developed and its results are compared with the main controller's results. A simulation study with two quadrotors cooperatively stabilizing, and transporting a payload along two different desired three-dimensional trajectories is presented.

Title : **Reducing the noise of Micro–Air Vehicles in hover**

Authors : **R. Serré, V. Chapin, J.M. Moschetta and H. Fournier**

Institute : ISAE-SUPAERO, Toulouse, France

Time : 1435
Place : Amphi 2

Abstract : Micro–Air Vehicles (MAV) are becoming common devices in a wide range of operations while the optimization of their propulsion system is rarely addressed. On the one hand, an aerodynamic optimization would have a straightforward effect on the endurance. On the other hand, an aeroacoustic optimization might increase discretion in military operating conditions, reduce
noise pollution in civilian, urban environment and allow sound recordings in dual applications. This contribution aims at presenting a complete methodology for the design of silent and still efficient rotors for MAV, from aerodynamic prediction to aeroacoustic optimization and experimental validation. This approach is suitable for engineering purposes. The aerodynamic and acoustic modeling are described and the optimization procedure is presented. A step–by–step optimization is achieved and measured on an experimental bench suitable for non–anechoic environment. A discussion on the results is proposed. Key parameters on the blade geometry for the reduction of rotor noise are provided at the end of the paper.

Title : **Robust Attitude Control for Quadrotors with External Disturbances**

Authors : **H. Nemati, A. Naghash, S. Mozafari, and A. Jamei**

Institute : Amirkabir University of Technology, Tehran, Iran

Time : 1435
Place : Amphi 1

Abstract : This study investigates a design procedure for a robust nonlinear control algorithm based on sliding mode control (SMC) to stabilize the attitude of a 3-DOF quadrotor UAV subject to external disturbances. Since traditional sliding mode controllers are sensitive against external disturbances in the reaching phase, a new algorithm is proposed to enhance the robust performance of an SMC strategy. Dynamic equations are obtained using Newton-Euler formalism and the quadrotor's centre of mass is assumed not to be coincident at the origin of body frame. The robust stability and the robust tracking property are achieved using the Lyapunov's direct method. Experimental results are given to highlight the effectiveness of the designed control strategy.

Title : **Application of Lattice Boltzmann Method to some challenges related to Micro Air Vehicles**

Authors : **Nicolas Gourdain, Thierry Jardin, Ronan Serre, Sébastien Prothin and Jean-Marc Moschetta**

Institute : ISAE-SUPAERO, Toulouse, France

Time : 1505
Place : Amphi 2

Abstract : Micro Air Vehicles (MAVs) recently appeared as a relevant solution for missions of observation and surveillance. MAVs with enhanced endurance and ability to operate in constrained environments would considerably decrease surveillance costs while preserving operators safety in many civilian and military applications. To go beyond the current state of the art for MAV propulsion, there is still a need to improve our aptitude to deal with complex flow physics, including aerodynamics, aero-acoustics or fluid/structure interactions. Instead of directly solving the Navier-Stokes equations, the Lattice-Boltzmann Method (LBM) is based on a statistical equation for the kinetics of gas molecules. Thus, the primitive variables of the LBM represent the statistical particle probability distribution function, to which the usual macroscopic variables pressure and velocity relate as velocity moments, or observables in the sense of statistical mechanics. The particle distribution is a continuous quantity: in contrary to popular believe, the LBM is a continuum method, and not a discrete particle approach. Indeed, the method offers an Eulerian view of the flow and is mesh-based. To illustrate the advantages and drawbacks of LBM, two applications have been selected in line with Micro-Air Vehicles: a rotor operating in-ground effect and a rotor optimized for noise reduction.

Title : **Controller Tuning Strategy for Quadrotor MAV Carrying a Cable-suspended Load**

Authors : **Nestor A. Santos Ortiz, Edouard Larochey, Renaud Kieferz and Sylvain Durand**

Institute : ICube, Illkirch, France

Time : 1600
Place : Amphi 2

Abstract : This paper presents a controller tuning strategy for a quadrotor MAV carrying a cable-suspended load. In our study, no measurement nor estimation of the load's position is used in the control strategy and only the quadrotor attitude and position are controlled. The tuning of the controllers has been done in order to satisfy mixed H_∞ requirements and a pole-location requirement. The resolution is made with an available tool based on non-smooth optimization. The proposed methodology, allowing to find a good trade-off between fast displacements of the MAV and well damped oscillations of the load, is validated in simulation. Keywords : PID control, quadrotor, suspended load perturbations, fixed-structure controller tuning.

Title : **Human-Robot Cooperation in Surface Inspection Aerial Missions**

Authors : **Martin Molina, Pedro Frau, Dario Maravall**
Jose Luis Sanchez-Lopez, Hriday Bavle, Pascual Campoy

Institute : Technical University of Madrid, Spain

Time : 1600
Place : Amphi 1

Abstract : The goal of the work presented in this paper is to facilitate the cooperation between human operators and aerial robots to perform surface inspection missions. Our approach is based on a model of human collaborative control with a mixed initiative interaction. In the paper, we present our human-robot cooperation model based on the combination of a supervisory mode and an assistance mode with a set of interaction patterns. We developed a software system implementing this interaction model and carried out several

real flight experiments that proved that this approach can be used in aerial robotics for surface inspection missions (e.g., in vision based indoor missions). Compared to a conventional tele-operated inspection system, the solution presented in this paper gives more autonomy to the aerial systems, reducing the cognitive load of the operator during the mission development.

Title : **Landing and Take-off on/from Sloped and Non-planar Surfaces with more than 50 Degrees of Inclination**

Authors : **M. Tognon and A. Franchi**

Institute : LAAS-CNRS, Toulouse, France

Time : 1620
Place : Amphi 2

Abstract : This technical paper summarizes the recent experimental results concerning the challenging problem of landing and take-off on/from a sloped
surface with an aerial vehicle exploiting the force provided by an anchored taut tether. A special regard is given to the practical aspects concerning the experimental part. In this manuscript we show extreme landing and take-off maneuvers on slopes with at least 50 inclination and non flat surfaces, such as, e.g., on industrial pipes.

Title : **An Intelligent Unmanned Aircraft System for Wilderness Search and Rescue**

Authors : **Huai Yu, Shijie Lin, Jinwang Wang, Kaimin Fu, Wen Yang**

Institute : Wuhan University, China

Time : 1620
Place : Amphi 1

Abstract : In this paper, we presented a wilderness search and rescue (WiSAR) system based on DJI M100 Unmanned Aerial Vehicle (UAV) and a ground station to search and rescue the survivors in wild. We combined infrared and optical target detection to increase the detection speed and accuracy and used multiple sensors to make this system can autonomous avoiding obstructions and landing on mobile platform. For further increase the Average Precision of SSD, we build a field people dataset UAV-PP and use ResNet-101 as the base net. The actual flying test have been conducted in multiple situations to verify the feasibility of our WiSAR system. Our WiSAR system laying a solid foundation for building a more intelligent search and rescue system based on UAV.

Title : **Flight Simulation of a MAKO UAV for Use in Data-Driven Fault Diagnosis**

Authors : **Elgiz Baskaya, Murat Bronz, and Daniel Delahaye**

Institute : ENAC, Toulouse, France

Time : 1640
Place : Amphi 2

Abstract : Last decade witnessed the rapid increase in number of drones of various purposes. This pushes the regulators to rush for safe integration strategies in a way to properly share the utilization of airspace. Accommodating faults and failures is one of the key issues since they constitute the bigger chunk in the occurrence reports available. The hardware limitations for these small vehicles point the utilization of analytical redundancy rather than the usual practice of hardware redundancy in the conventional flights. In the course of this study, fault detection and diagnosis for aircraft is reviewed. Then a nonlinear model for MAKO aircraft is simulated to generate faulty and nominal flight data. This platform enables to generate data for various flight conditions and design machine learning implementations for fault detection and diagnosis.

Title : **A honeybee's navigational toolkit on Board a Bio-inspired Micro Flying Robot**

Authors : **Erik Vanhoutte, Franck Ruffier and Julien Serres**

Institute : ISM, CNRS, Marseille, France

Time : 1640
Place : Amphi 1

Abstract : In this paper, a 395-gram micro flying robot equipped with an insect-inspired visual system is presented. The robot's visual system was designed to make it avoid both ground and lateral obstacles, using optic flow-based regulation principles. The quadrotor is an open-hardware X4-MaG drone with an active gimbal system based on a pair of serial servo motors, which stabilizes 8 retinas dedicated to optic flow measurements in the 25 °/s to 1000 °/s range, each of which comprises 12 auto-adaptive pixels working in a 7-decade lighting range. The X4-MaG drone is tested in front of a slanted wall, its quasipanoramic bio-inspired eye on board is able to estimate the angle of incidence in the 0° to 50° range with an error of less than 2.5° when flying. These experimental results are a first step towards a fully autonomous micro quadrotor requiring no magnetometers, which will be able in the near future to "sense and avoid" obstacles in GPS-denied environments.

Title : **Incremental Nonlinear Dynamic Inversion and Multihole Pressure Probes for Disturbance Rejection Control of Fixed-wing Micro Air Vehicles**

Authors : **Elisabeth S. van der Sman, Ewoud J. J. Smeur, Bart Remes, Christophe De Wagter, and Qiping Chu**

Institute : TU Delft, The Netherlands

Time : 1700
Place : Amphi 2

Abstract : Maintaining stable flight during high turbulence intensities is challenging for fixed-wing micro air vehicles (MAV). Two methods are proposed to improve the disturbance rejection performance of the MAV: incremental nonlinear dynamic inversion (INDI) control and phase advanced pitch probes. INDI uses the angular acceleration measurements to counteract disturbances. Multihole pressure probes measure the incoming flow angle and velocity ahead of the wing in order to react to gusts before an inertial response has occurred. The performance of INDI is compared to a traditional proportional integral derivative (PID) controller with and without the multihole pressure probes. The attitude controllers are tested by performing autonomous wind tunnel flights and stability augmented outdoor flights. This paper shows that INDI improves the disturbance rejection performance of fixed-wing MAVs compared to traditional proportional integral derivative controllers.

Title : **Towards a MOMDP model for UAV safe path planning in urban environment**

Authors : **Jean-Alexis Delamer, Yoko Watanabey**

Institute : ONERA & ISAE-SUPAERO, Toulouse, France

Time : 1700
Place : Amphi 1

Abstract : This paper tackles a problem of UAV safe path planning in an urban environment in which UAV is at risks of GPS signal occlusion and obstacle collision. The key idea is to perform the UAV path planning along with its navigation and guidance mode planning, where each of these modes uses different sensors whose availability and performance are environment-dependent. A partial knowledge on the environment is supposed to be available in the form of probability maps of obstacles and sensor availabilities. This paper proposes a planner model based on Mixed Observability Markov Decision Process (MOMDP). It allows the planner to propagate such probability map information to the future path for choosing the best action. This paper provides a MOMDP model for the planner with an approximation of the belief states by Mixture of Gaussians.

Title : **Investigation on Natural Frequency and Fuselage Effect for Small UAVs Lateral Motion**

Authors : **M. El-Salamony, S. Serokhvostov**

Institute : MIPT, Zhukovsky, Russia

Time : 0845
Place : Amphi 2

Abstract : An accurate mathematical model is necessary for controlling an aircraft. Although the geometrical scale of Unmanned Aerial Vehicles (UAVs) is very small compared to the large aircrafts, they are usually designed by means of the procedure intended for large ones, and stability calculations similarly follow the same formulas. This fact can severely affect the basic assumptions of the formulas and hence it may not be suitable for UAVs. This research validates the dutch roll natural frequency of lateral motion calculated by comparing the usual methods of estimation for the manned aircraft found in references of Roskam and Ostoslavsky, and the numerical Vortex Lattice Method (VLM) program XFLR5 with experimental values of real flight. Also a study is carried out to examine the effect of fuselage on the dutch roll natural frequency to examine the possibility of neglecting it through the calculations. It is found that approximate methods for Roskam procedure is in accordance with the exact solution, and the same for Ostoslavsky. Estimation methods of Roskam (exact), Ostoslavsky and XFLR5 give good results in agreement with the experiment, while the approximate methods of Roskam underestimate the frequency. The contribution of the regular fuselage is found to be very small and it can safely be neglected.

Title : **Using MAVs for Atmospheric Wind Measurements: Opportunities and Challenges**

Authors : **Simon Watkins, Mohamed Abdulghani, Sam Prudden, Mathew Marino, Reece Clothier, Alex Fisher and Ashim Panta**

Institute : RMIT, Melbourne, Australia

Time : 0845
Place : Amphi 1

Abstract : MAVs are increasingly being used as flying sensors due to their ability to be positioned in hard to access locations for relatively low risk and cost. The use of fixed wing and multi-rotor MAVs as flying anemometers were investigated by instrumenting one of each with multi-hole pressure probes (simplified versions of the TFI Cobra probes) and obtaining data on windy days. A batch of probe heads were produced by stereolithography (STL) rapid prototyping and it was found that a universal calibration could be used for one batch unless extreme levels of accuracy are required. The craft, on-board sensors and the signal processing techniques are described. The limited endurance of multirotors was found to be a significant limitation when trying to obtain the relatively long samples of data (required for good descriptions of atmospheric turbulence). As wind data are usually required at several spatial locations (e.g. vertically displaced replicating the function of several anemometers on a mast) it is necessary to have several craft flying concurrently. Another challenging aspect was holding a steady position for the multi rotor craft. Automated position holding is part of on-going work and we plan to investigate using the technique of stabilising the craft by upstream flow measurements (proven on the fixed wing MAV) for multi-rotors.

Title : **Team MAVion entry in the IMAV'17 outdoor challenge – A tail-sitting trajectory-tracking µUAV**

Authors : **Leandro R. Lustosa, Jacson M. O. Barth, Jean-Philippe Condomines, François Defay, Jean-Marc Moschetta**

Institute : ISAE-SUPAERO & ENAC, Toulouse, France

Time : 0915
Place : Amphi 2

Abstract : This paper outlines current research conducted on tilt-body micro air vehicles at ISAE, and how we exploit recent advances to provide a tail-sitting flying-wing entry for the IMAV'17 outdoor challenge capable of performing automatic vertical take-off, landing, and trajectory-tracking.

Title : **Bio-inspired Wind Field Estimation-Part 1: AoA Measurements Through Surface Pressure Distribution**

Authors : **Nikola Gavrilović, Murat Bronz, Jean-Marc Moschetta, Emmanuel Bénard and Philippe Pastor**

Institute : ISAE-SUPAERO & ENAC, Toulouse, France

Time : 0915
Place : Amphi 1

Abstract : One of the major challenges of Mini-UAV flight is unsteady interaction with turbulent environment while flying in lower levels of atmospheric boundary layer. Following inspiration from nature we expose a new system for angle of attack estimation based on pressure measurements on the wing. Such an equipment can be used for real-time estimation of the angle of attack during flight or even further building of wind velocity vector with additional equipment. Those information can find purpose in control and stabilization of the aircraft due to inequalities seen by the wing or even for various soaring strategies that rely on active control for energy extraction.
In that purpose flying wing UAV has been used with totally four span-wise locations for local angle of attack estimation. In-flight angle of attack estimation of differential pressure measurements have been compared with magnetic sensor with wind vane. Difference in local angle of attack at four span-wise locations has confirmed spatial variation of turbulence. Moreover, theoretical energy dissipation of wind fluctuations described by Kaimal spectrum has shown acceptable match with measured ones.

Title : **Simulation and Control of a Tandem Tiltwing RPAS Without Experimental Data**

Authors : **Y. Beyer**

Institute : TU Braunschweig, Germany

Time : 0945
Place : Amphi 2

Abstract : The tandem tiltwing is one of many aircraft configurations providing vertical takeoff and landing (VTOL). This configuration is expected to be especially suitable for missions requiring VTOL capability combined with high range and space for payload. In this article, an overview of the simulation process of a tandem tiltwing remotely piloted aircraft system (RPAS) without experimental data and its control is given. Contrary to custom, the flight dynamic model, especially the whole aerodynamics model, consists of theoretical equations and interpolations depending on estimated parameters. Compared to complex wind tunnel tests, this approach is less expensive. In order to stabilize the unstable flight characteristics of the tandem tiltwing, a linearquadratic regulator (LQR) is designed. As the change of operating point of this VTOL aircraft is significant, the LQR has to be gain scheduled. For that, multiple trim points during the transition are ascertained making a controlled transition possible. However, due to the lack of test data, the probability of failure caused by an inaccurate flight controller relying on the flight dynamic model is increased. Hence, a robustness analysis of the closed-loop system is conducted, where the probability of stability of the closedloop real RPAS is estimated by a Monte Carlo method. For this purpose, all uncertain model parameters are changed based on the normal distribution
by defining their standard deviation.

Title : **Developing a Stable Small UAS for Operation in Turbulent Urban Environments**

Authors : **R. Gigacz, A. Mohamed, P. Poksawat, S. Watkins and A. Panta**

Institute : RMIT, Melbourne, Australia

Time : 0945
Place : Amphi 1

Abstract : The stability of Small Unmanned Air Systems (SUASs) can be challenged by turbulence during low-altitude flight in cluttered urban environments. This paper explores the benefits of a tandem wing aircraft configuration with the implementation of a pressure based phase-advanced turbulence sensory system on a SUAS for gust mitigation. The objective was to utilize passive and active methods to minimise gust-induced perturbations. Experimentation in repeatable turbulence within a wind tunnel's test section was conducted. The experiments focus on the roll axis, which is isolated through a specially designed roll-axis rig. The results shows improvement over conventional aircraft. This work is part of a larger research project aimed at enabling safe, stable and steady SUAS flight in urban environments.

Title : **Collision Avoidance of multiple MAVs using a multiple Outputs to Input Saturation Technique**

Authors : **C. Chauffaut, L. Burlion, F. Defay and H. de Plinval**

Institute : ISAE-SUPAERO & ONERA, Toulouse, France

Time : 1345
Place : Amphi 2

Abstract : This paper proposes a novel collision avoidance scheme for MAVs. This scheme is based on the use of a recent technique which is based on the transformation of state constraints into time-varying control input saturations. Here, this technique is extended so as to ensure collision avoidance of a formation of up to three MAVs. Experimental results involving three A.R drones show the efficiency of the approach.

Title : **Optimization of Energy Consumption for Quadrotor UAV**

Authors : **F. Yacef, N. Rizoug, O. Bouhali, and M. Hamerlain**

Institute : ESTACA, Laval, France & Jijel University, Algeria

Time : 1345
Place : Amphi 1

Abstract : In this paper we deals with the limitation of flight endurance for quadrotor unmanned aerial vehicles. Quadrotor UAVs are multi-rotors flying machines; thus, a large proportion of their energy is consumed by rotors in order to maintain the vehicle in the air. In this concept, we introduced an energetic model composed of quadrotor movement dynamic, motors dynamic and battery dynamic; then, the proposed model was validated through simulation to show possibility of saving energy. An optimal control problem is formulated and solved in order to compute minimum energy. In this problem, we seeks to find control inputs and vehicle trajectory between initial and final configurations that minimize the consumed energy during a specific mission. Simulation experiment is made for a quadrotor to highlight the proposed optimization method.

Title : **A Combined Approach for 3D Formation Control in a Multi-UAV System using ROS**

Authors : **Rafael G. Braga, Roberto C. da Silva, Alexandre C. B. Ramos and Felix Mora-Camino**

Institute : Federal University of Itajub´a, Brasil & ENAC, Toulouse, France

Time : 1405
Place : Amphi 2

Abstract : Formation control in multi-UAV systems can be obtained through different strategies, each one with its own advantages and disadvantages. In order to minimize the weaknesses of each technique, this paper proposes a combined approach to drive a group of three quadrotor UAVs in a time varying formation, using a virtual structure, a leader-follower strategy and two behavioral rules. To each UAV is assigned a position in a formation that is represented by a virtual structure. The UAVs then have to compute their desired positions in order to achieve the formation. This is done using one of two possible methods, one based on a leader-follower approach and another based on waypoints received from a ground station. Two behavioral rules are then used to move the UAVs towards their goal while avoiding collisions with each other. The algorithm was implemented in C++ using the ROS platform and was tested in simulations using the Pixhawk SITL simulator. Results show that the UAVs are able to move in formation and also to change the formation without colliding with each other.

Title : **Development and Design Methodology of an Anti-Vibration System on Micro-UAVs**

Authors : **Zhenming Li, Mingjie Lao, Swee King Phang, Mohamed Redhwan Abdul Hamid, Kok Zuea Tang, and Feng Lin**

Institute : National University of Singapore, Singapore

Time : 1405
Place : Amphi 1

Abstract : As the potential applications of unmanned aerial vehicles (UAVs) are growing, more sensors are installed on-board. Mechanical vibration of the UAV, which greatly hinders the accuracy of its on-board sensors, becomes an increasingly important issue. In this manuscript, an anti-vibration framework on micro-UAVs is proposed. The vibration sources of the UAV will be investigated and identified. Then, several selections of hardware dampers are tested along with a digital low-pass filter on actual UAV. With the results from different case studies, a criteria of damper selection for micro-UAV is built to serve as a guideline for further practice.

Title : **Distributed circular formation flight of fixed-wing aircraft with Paparazzi autopilot**

Authors : **Hector Garcia de Marina Gautier Hattenberger**

Institute : ENAC, Toulouse, France

Time : 1425
Place : Amphi 2

Abstract : In this paper we introduce the usage of guidance vector fields for the coordination and formation flight of fixed-wing aircraft. In particular, we describe in detail the technological implementation of the formation flight control for a fully distributed execution of the algorithm by employing the open-source project Paparazzi. In this context, distributed means that each aircraft executes the algorithm on board, each aircraft only needs information about its neighbors, and the implementation is straightforwardly scalable to an arbitrary number of vehicles, i.e., the needed resources such as memory or computational power not necessarily scale with the number of total aircraft. The coordination is based on commanding the aircraft to track circumferences with different radii but sharing the same center. Consequently, the vehicles will travel different distances but with the same speeds in order to control their relative angles in the circumference, i.e., their orbital velocities. We show the effectiveness of the proposed design with actual formation flights during the drone parade in IMAV2017.

Title : **Quick Aerodynamic Design of Micro Air Vehicles**

Authors : **V. Vyshinsky, A. Kislovskiy**

Institute : MIPT, Zhukovsky, Russia

Time : 1425
Place : Amphi 1

Abstract : The quick aerodynamic characteristics estimation method for preliminary design phase is presented in the paper. Simplified mathematical model of aircraft layout, robust and fast direct CFD code as well as artificial neural network (ANN) technique form the basis of the method. For illustration of its possibilities the proposed method was applied to micro air vehicles (MAV) design. Developed mathematical representation approximates MAV layout with 100-dimension parameter vector. The ranges of mathematical representation parameters (aspect ratio, dihedral angle and area of the wing, airfoil relative thickness, airfoil geometry etc.) were determined during existing MAV market review. The layout generator creates a number of layouts, runs CFD computations on different flight regimes. Then the information about flight regime is appended to input vector of the main algorithm. Calculated aerodynamic characteristics forms the output. Outlying layouts are filter out using geometric and aerodynamic criteria. The resulting set of vectors forms training and test sets for machine learning algorithms. For aerodynamic force and momentum coefficients calculations, the separate ANNs were created.

Title : **EDURA: an Evolvable Demonstrator for Upset Recovery Approaches with a 3D-printed Launcher**

Authors : **Torbjørn Cunis and Murat Bronz**

Institute : ENAC, Toulouse, France

Time : 1445
Place : Amphi 2

Abstract : As in-flight loss of control has remained a severe threat to aviation, aeronautical research designed several approaches for upset recovery, few of which has been demonstrated in flight tests. The on-going success of micro air vehicles, however, rises the possibility of cheap and flexible flight demonstrations. In this paper, we present the concept of and first steps towards an aerial experimental platform for upset recovery: EDURA. EDURA is part of the CONVEX project to investigate, develop, and demonstrate non-linear upset recovery control laws in a fixed-wing MAV.

Title : **Copter Size Minimization for the IMAV-2017 Competition in Record Breaking Session**

Authors : **S. Serokhvostov, and B. Makaev**

Institute : MIPT, Zhukovsky, Russia

Time : 1445
Place : Amphi 1

Abstract : Optimization of aircraft design for the IMAV-2017 competition in Record Breaking session is investigated. Analytical research is conducted to understand the ways of optimization. A set of experimental designs was made and investigated to check the analytical results and to test technical solutions.

Title : **Bond Graph based design tool for a passive rotation flapping wing**

Authors : **Le Anh Doan, Christophe Delebarre, Sebastien Grondel, Eric Cattan**

Institute : University of Valenciennes & Centrale Lille, France

Time : 1540
Place : Amphi 2

Abstract : Micro air vehicles (MAVs) are become more popular over larger unmanned aerial vehicles (UAVs) as they are easily portable, more discreet and less dangerous in case of a crash. Among common types of MAVs, the flapping wing configuration shows incredible potential flying skills such as hovering, flying backward and recovering after shock. However, designer faced many difficulties due to the micro-size of the MAVs. In this work, we propose a numerical model based on Bond Graph for our flapping MAV which allows to analyse the wing kinematic and thus predict the total lift force. This Bond Graph model employs the quasi-steady aerodynamic theory and the Lagrange dynamic equation as the main principles. A proper wing kinematic allowing to enhance the total lift force could be derived from this model based on non-linear optimization of the system's sensitivity parameters such as spring stiffness, working frequency and input voltage... A prototype is fabricated and characterized. Comparing the experiment and the simulation, the model is able to predict wing movement and mean lift force, and therefore could be used as a design tool. A take-off demonstration is provided to confirm our results.

Title : **Development of Vision Based Navigation for Micro Aerial Vehicles in Harsh Environment**

Authors : **Hailong Qin, Yingcai Bi, F. Lin and Ben M. Chen**

Institute : National University of Singapore, Singapore

Time : 1540
Place : Amphi 1

Abstract : Safe navigation and planning capabilities are of great importance to Micro Aerial Vehicles (MAVs) applications in different environments. MAVs are allowed to quickly access to the open sky or open area where far away from ground obstacles based on the onboard Global Positioning System (GPS) data. Except for these areas, MAVs become more demanding for missions in complex harsh environment, such as autonomous exploration, inspection and rescue tasks in disaster areas due to their maneuverability and low cost. To complete these missions, visual navigation for MAVs has been extensively studied because of the abundant 3D information and lightweight property. In this article, a complete navigation system with a multi-heterogeneous sensor setup for visual sensing in harsh environment is proposed. Measurements of multiple RGBD visual sensors are utilized for localization in unknown harsh environment. After this, the measurement from visual sensors is fused with MAV onboard Inertial Measurement Unit (IMU) information through a preintegration approach to achieve autonomously takeoff, navigate and landing in unknown harsh environment. Extensive experiments have been conducted in both indoor and outdoor environments to evaluate the performance of the proposed system. Moreover, a preliminary fast navigation in challenge long corridor environment is also conducted to verify the robustness of the system.

Title : **Quad-thopter: Tailless Flapping Wing Robot with 4 Pairs of Wings**

Authors : **Christophe De Wagter and Matěj Karáseky and Guido de Croon**

Institute : TU Delft, The Netherlands

Time : 1610
Place : Amphi 2

Abstract : We present a novel design of a tailless flapping wing Micro Air Vehicle (MAV), which uses four independently driven pairs of flapping wings in order to fly and perform agile maneuvers. The wing pairs are arranged such that differential thrust generates the desired roll and pitch moments, similar to a quadrotor. Moreover, two pairs of wings are tilted clockwise and two pairs of wings anti-clockwise. This allows the MAV to generate a yaw moment. We have constructed the design and performed multiple flight tests
with it, both indoors and outdoors. These tests have shown the vehicle to be capable of agile maneuvers, and able to cope with wind gusts. The main advantage is that the proposed design is relatively simple to produce, and yet has the capabilities expected of tailless flapping wing MAVs.

Title : **Efficient Global Indoor Localization for Micro Aerial Vehicles**

Authors : **V. Strobel, R. Meertens, and G.C.H.E. de Croon**

Institute : TU Delft, The Netherlands

Time : 1610
Place : Amphi 1

Abstract : Indoor localization for autonomous micro aerial vehicles (MAVs) requires specific localization techniques, since GPS is usually not available. We present an onboard computer vision approach that estimates 2D positions of an MAV in real-time. The global localization system does not suffer from error accumulation over time and uses a k-Nearest Neighbors (k-NN) algorithm combined with a particle filter to predict positions based on textons—small image patches. The performance of the approach can be predicted by an evaluation technique that compares environments and identifies critical areas within them. In flight tests, the algorithm had a localization accuracy of approx. 0.6m in a 5m×5m area at a runtime of 32 ms on board of an MAV. Its computational effort is scalable to different platforms, trading off speed and accuracy.

Title : **Analysis of Folding Wing Rolling Moment**

Authors : **C. Thipyopas, N. Krajangsawasdi, T. Pantuphag, and S. Catteeyothai**

Institute : Kasetsart University, Bangkok, Thailand

Time : 1640
Place : Amphi 2

Abstract : Mini and micro aircraft are required to be a multi functioning; which can both maneuver in forward flight and hover for takeoff configuration. This leads to the development of the folding wing aircraft. The folding wing cannot apply any control surface to create a rolling movement because it must move all the time. The benefit of folding is an idea for rolling moment generation. This is an asymmetrical lift that generates form folding unequal area between left and right wing. Therefore, this research focuses on finding a relationship between rolling moment generated by the asymmetrical force and the area ratio of two wings by using CFD simulation to predict them. Firstly, the design of the wing is simulated in cruise condition at various angles of attack to determine the trim angle and the significant aircraft characteristics. Then the trim angle was set at the condition for computing the rolling moment for 3 levels of wing folding. The three levels are not too different in overall wing area, but the area of the two sides are imbalanced so that can generate different rolling moment. The result of the simulation shows that the asymmetry of the wings can generate a rolling moment and it increases dramatically when the area ratio rises.

Title : **3D Reconstruction of Complex Structures with Online Profiling and Adaptive Viewpoint Sampling**

Authors : **Abdullah Abduldayem, Dongming Gan, Lakmal Seneviratne, Tarek Taha**

Institute : Khalifa University, Abu Dhabi, United Arab Emirates

Time : 1640
Place : Amphi 1

Abstract : A modified Next Best View (NBV) approach is presented to improve the 3D reconstruction of complex symmetric structures. Two new stages are introduced to the NBV approach; A profiling stage quickly scans the structure of interest and builds a rough model called the "profile". The profile is relatively sparse but captures the major geometric features of the structure. A symmetry detection stage then determines major lines of symmetry in the profile and labels points of interest. If a point exists in known space but its mirror image lies in unknown space, the mirrored point becomes a point of interest. The reconstruction is performed by a sensor mounted on an Unmanned Aerial Vehicle by using a utility function that incorporates the detected symmetry points. We compare the proposed method with the classical information gain utility function in terms of coverage completeness, total iterations, and travel distance.

Title : **An Automated Rapid Mapping Solution Based on ORB SLAM 2 and Agisoft Photoscan API**

Authors : **Markus Bobbe, Alexander Kern, Yogesh Khedar, Simon Batzdorfer and Ulf Bestmann**

Institute : TU Braunschweig, Germany

Time : 1710
Place : Amphi 1

Abstract : This paper describes a system consisting of an UAV and a ground station capable of automated mapping based on aerial images. The focus of the presented system is to obtain georeferenced orthophotos within a short time frame. Two approaches have been implemented in the system: an online visual SLAM based on ORB SLAM 2 and a photogrammetry pipeline using the Agisoft Photoscan API. Both approaches will be described and its result evaluated and compared.

Title : **Investigation on Boundary Layer Ingestion Propulsion for UAVs**

Authors : **L. Teperin, M. El-Salamonyy, A. Moharamz, and M. Shehata**

Institute : Central Aerohydrodynamic Institute (TsAGI), Zhukovsky, Russia AND Moscow Institute of Physics and Technology, Department of Aeromechanics and Flight Engineering, Zhukovsky, Russia

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : Power reduction is one of the most current important issues. One promising way is to use boundary layer ingestion propulsion. In order to evaluate the benefits of using boundary layer ingestion propulsion in reduction of power consumption and to understand the difference between the propeller placed behind and in front of a fuselage, a comparison is made between propeller placed behind and in front of a fuselage. It is found that the backward position has less drag and power consumption. Power saving coefficient reached 21.7% compared to the forward position and drag coefficient is 28.5% less. Also it shows tendency to stabilize and prevent separation of the boundary layer.

Title : **CFD ANALYSIS OF FLAPPING AND PITCHING 3D RIGID FLAT PLATE**

Authors : **M.G. Senol and D.F. Kurtulus**

Institute : Middle East Technical University, Ankara, Turkey

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : A flapping and pitching low aspect ratio flat plate is numerically investigated by in hover mode. Flapping angle amplitude and flapping frequency are chosen as 60 and 15Hz, respectively. In the current study, the influence of pitching angle amplitude is investigated starting from 20 to 60 with 10 interval. Aerodynamic forces and moments, vortex dynamics are analyzed to understand the unsteady aerodynamics and the vortex topology of this coupled flapping/pitching motion.

Title : **Design & Development of a multi-rotor aerial vehicle to improve Medical Connectivity**

Authors : **Chandan Gurumurthy, E Vandan Rao, Gaurav Jakkenahalli, Manu M Pillai, Sumedha Bhat**

Institute : Team Vyoma, Rashtreeya Vidyalaya College Of Engineering, Bangalore, India

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : This project is an initiative by an interdisciplinary team of engineering students from Rashtreeya Vidyalaya College of Engineering, India. It involves design, manufacturing, and testing of a micro aerial vehicle (MAV) with autonomous flight capability. The project is aimed not only for the competition but to be developed as a product to be used in real life scenarios to deliver medicines and supplies in hard to reach locations in the shortest time possible where it can be a life or death situation.

Title : **Loosely Coupled Stereo Inertial Odometry on Low-cost System**

Authors : **HaoChih, LIN, Francois, Defay**

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : We present a fast and robust stereo visual inertial odometry system which is friendly for low cost sensor and single board computer (SBC). Comparing against other research which uses tightly coupled algorithms or nonlinear optimization to increase accuracy in custom powerful hardware or desktop environment, our system adopts the loosely coupled ESKF to limit the computational complexity in order to fit limited CPU resources and run in real-time on an ARM based SBC. The experiments demonstrates our method could be implemented in both indoor and outdoor scenarios with competitive accuracy. Furthermore, the usage of forward facing stereo cameras also provides the ability of obstacles avoidance. The result are released as an open sourced Robot Operation System (ROS1) package.

Title : **Multidisciplinary optimization of a MAV propeller for noise reduction**

Authors : **F. Boyery, A. Drapiery, Y. Mérillacy, C. Nanay and Ronan Serre**

Institute : Altran SO, Blagnac, France
AND ISAE-SUPAERO, Toulouse, FRANCE

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : The following research aims at reducing the noise of a MAV's propeller without impacting its efficiency. To ensure reasonable computational time, low fidelity methods are used for each discipline: Lifting line for aerodynamics, beam model for structure and Ffowcs-Williams and Hawkings analogy for acoustics. Validation tests are performed to evaluate reliability of these methods on a reference configuration: a GWS80x45 propeller in hover. More complex CFD tools are also used at some points of the optimization process to check for the coherence and fidelity of the results. The open-source SU2 solver and a Lattice-Boltzmann Method solver serve this purpose. Finally, results are compared to an experimentation conducted by ISAE (Institut Supérieur de l'Aéronautique et de l'Espace) in an anechoic chamber.

Title : **Propeller Performance Calculation for Multicopter Aircraft at Forward Flight Conditions and Validation With Wind Tunnel Measurements**

Authors : **C. Molter, P.W. Cheng**

Institute : University of Stuttgart, Wind Energy Research Group (SWE), Institute of Aircraft Design, Stuttgart, Germany

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : When designing a fast flying multicopter aircraft knowledge about propellers at inclined inflow conditions is important. To investigate this operating condition a whirl tower was built and several propellers were tested in a wind tunnel at angles of attack of 8, 15, 22:5 and 30. The inflow speeds were varied between 4 m=s and 30 m=s. The gained measurement data was used to validate an in-house blade element simulation software. The simulations were improved by adjusting airfoil lift and drag polars to static propeller measurements. Without any further adjustments to the inclined inflow condition the simulations showed good agreement with the measurements of two different propellers operating at an angle of attack. This means that it is possible for future projects to gain significant knowledge about propellers at an angle of attack with the use of static thrust and performance measurements without the need for a wind tunnel. A less complicated semi-analytical approach was also tested to model the performance of propellers at an angle of attack. Without further adjustments to the equations it was not possible to achieve a good agreement with measurement data using the simplified approach. Some measurements were also taken with a counter-rotating propeller arrangement (coaxial rotors). A hypothesis is proposed that the thrust deficit of the bottom propeller due to the influence of the top propeller is less at forward flight conditions than at the static operating condition. This hypothesis could be confirmed by measurements but still needs further validation.

Title : **Optimal and efficient Vertical Take Off and Landing**

Authors : **Souad Berradi, Fouad Moutaouakkil, Soumia Bakkali, Hicham Medromi**

Institute : EAS research group, ENSEM, Hassan I I University of Casablanca, Morocco

Time : Coffee break & poster sessions
Place : Clément Ader Hall

Abstract : Recently, Unmanned Aerial Vehicles (UAV) become a significant research area due to their multiple domains of application such as : search and rescue operations, aerial surveying of crops, inspecting power lines and pipelines, delivering medical supplies to inaccessible regions. Rotary wing is the typology that consumes a lot of energy compared other type of typologies such as fixed wing or flapping wing. Hence, it is mandatory to optimize energy consumption during flight for this type of UAV to achieve the operational goals of range, endurance and other specific mission requirements. The power required for flight is equal to the sum of power consumption of each sub-system such as frame, propulsion system, payload, controller unit, communication unit. In this paper, these UAV‟s sub-system will be presented. Then, a study on weight reduction and control technique is established in order to increase the flight duration. Then the feature of the most efficient multirotor configuration in terms of energetics consumption is proposed.

Outdoor competition, drone team parade and treasure hunt challenge

All teams registered for the outdoor competition, the drone team parade or the treasure hunt **MUST** attend the practice session at Francazal Airport (see page 15), starting from **8.30am on Tuesday Sept. 19.** Drone inspections will take place and permits to fly given out which are **required** for competition participation!

Lunch boxes will be provided for team members on site.

Indoor competition and record breaking trophy

All teams registered for the indoor competition or the record breaking trophy **MUST** attend the practice session at the ISAE-SUPAERO gym hall (see pages 12-13), starting from **1.30pm on Tuesday Sept. 19.** Drone inspections will take place and permits to fly given out which are **required** for competition participation!

Outdoor competition (Sept. 20)

DRONEACHARYA: CREATION LABS – *Vellore Institut of Technology*

AKAMAV – *Technischen Universität Braunschweig*

AUTMAV – *Tehran Polytechnic*

BLACK BEE DRONES – *Universidade Federal de Itajubá*

CIGOGNE – *INSA Strasbourg*

FLY EAGLE – *Beijing Institute of Technology*

GUILANO – *Lahijan Azad University*

INSTINCT COUGAR – *National University of Singapore*

INSTINCT LION – *National University of Singapore*

LANCELOT – *Beijing Institute of Technology*

MECHATRONIX – *Bialystok University of Technology*

QUETZALC++ – *Instituto Nacional de Astrofísica, Óptica y Electrónica*

RMIT – *RMIT University*

SRC – *Islamic azad university of Tabriz*

U.O.M. – *University of Manchester*

VYOMA – *Rashtreeya Vidyalaya College Of Engineering*

WHU DEEPFLYER – *Wuhan University*

Drone team parade trophy (Sept. 20)

AUTMAV – *Tehran Polytechnic*

BLACK BEE DRONES – *Universidade Federal de Itajubá*

ENAC – *Ecole National de l'Avioation Civile*

RMIT – *RMIT University*

Treasure hunt challenge (Sept. 20)

AKAMAV – *Technischen Universität Braunschweig*

BLACK BEE DRONES – *Universidade Federal de Itajubá*

CIGOGNE – *INSA Strasbourg*

INSTINCT LION – *National University of Singapore*

ISAE – *ISAE SUPAERO*

LANCELOT – *Beijing Institute of Technology*

RMIT – *RMIT University*

WHU DEEPFLYER – *Wuhan University*

Indoor competition (Sept. 21)

- **AGUIBOT-1** – *Universidad Popular Autónoma del Estado de Puebla*
- **AKAMAV** – *Technischen Universität Braunschweig*
- **AUTMAV** – *Tehran Polytechnic*
- **BLACK BEE DRONES** – *Universidade Federal de Itajubá*
- **CIGOGNE** – *INSA Strasbourg*
- **CVAR-UPM** – *Universidad Politécnica de Madrid*
- **CYRUS** – *Lorestan University Center*
- **DOTMEX** – *National Polytechnic Institute*
- **FLY EAGLE** – *Beijing Institute of Technology*
- **HORIZON** – *Islamic Azad University Of Isfahan*
- **INSTINCT COUGAR** – *National University of Singapore*
- **ISAE** – *ISAE SUPAERO*
- **KRATOS** – *Hindustan university*
- **MAVLAB** – *TUDELFT*
- **PERSIS** – *Islamic Azad University Khomeinishar Branch*
- **QUETZALC++** – *Instituto Nacional de Astrofísica, Óptica y Electrónica*
- **RMIT** – *RMIT University*
- **SRC** – *Islamic azad university of Tabriz*
- **UI-AI** – *Islamic Azad University Of Isfahan*
- **WHU DEEPFLYER –** *Wuhan University*

Record breaking trophy (Sept. 21)

- **AKAMAV** – *Technischen Universität Braunschweig*
- **AUTMAV** – *Tehran Polytechnic*
- **BLACK BEE DRONES** – *Universidade Federal de Itajubá*
- **CIGOGNE –** *INSA Strasbourg*
- **CYRUS** – *Lorestan University Center*
- **INSTINCT COUGAR** – *National University of Singapore*
- **MAVLAB** – *TUDELFT*
- **MIP –** *Moscow Institute of Physics and Technology*
- **PERSIS** – *Islamic Azad University Khomeinishar Branch*
- **RMIT** – *RMIT University*
- **SRC** – *Islamic azad university of Tabriz*
- **U.O.M.** – *University of Manchester*
- **VYOMA** – *Rashtreeya Vidyalaya College Of Engineering*

Team : **AKAMAV**

Institute : TU Braunschweig, Lower Saxony, 38100

Webpage : www.akamav.de

FB : @akamav.tubs

	Alexa	Mausi Jr.<3	Muetze Jr.	Reek	The Bees
Mass (grams)	1999	1900	1950	275	400
Max.size(mm)	580	640	500	180	320
Frequencies (MHz)	433 ; 2400 ; 5700				

Team AKAMAV is participating at IMAV competition and conference for several years now. We are a group completely organized and handled by students with close contact to the Institute for Flight Guidance at TU Braunschweig. In 2010, when the group was founded, its focus was the design and controller implementation for mostly fixed wing UAVs. Today, the variety of applications has grown exponentially. Multirotor systems have changed the game and hybrid designs with transition between VTOL and efficient forward flight are becoming more and more popular. We are enthusiast about the progress and constantly try to contribute our part for an exciting and better future.

Our main focus is on computer vision, robotics, flight control and design. Most of our UAVs run at least a basic communication infrastructure based on ROS. However this is primary for ground feedback. Onboard companion computers like the OdroidXU4 are designed to make the systems as autonomous as possible. With visual SLAM on PX4 stack using MAVROS advanced mission execution is the goal in all of our approaches.

Team : **AGUIBOT**

Ramón Orozco Gil, Jonathan Morales Valle, Angelica Trejo Montes, Mónica Samanta Nava, Mauricio Velázquez Sánchez, Héctor Simón Vargas

Institute : Universidad Popular Autonoma del Estado de Puebla (UPAEP), México, Puebla, 72410

Webpage :
http://upaep.mx/index.php?option=com_k2&view=item&id=4561:estudiantes-de-mecatronica-upaep-obtiene-2-lugar-en-torneo-mexicano-de-robotica&Itemid=2288

Video link : https://youtu.be/7-w6TBVZP20

Drone 1

Drone 2

	Drone 1	**Drone 2**
Mass (grams)	480	480
Max. size (mm)	382	382
Frequencies (MHz)	2400	2400

The structure of both Drones were made of Glass fiber reinforced (20%) PA12 and Grilamid, This structure harbor four engines of 1280kv and a 14 megapixels wide-angle CMOS camera. The drone has an ultrasonic sensor at the bottom of the structure to stabilize the height during flight and a three-axis gyroscope to determine the angle at which it is located. The entire system is powered by a 2700 mAh Li-ion battery and as a safety feature it has an automatic propeller shutdown system in case of emergencies.

All the drone functions were programmed in Linux, specifically in ROS.

Team : **AUTMAV**

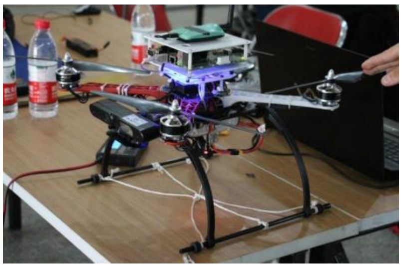
Abolghasem Naghash, Ali Jamei and Saeed Mozafari

Institute : Amirkabir University of Technology, Tehran, 1591634311, Iran

Webpage : www.autmav.com

Video link : https://youtu.be/oNdFuQ2RZxQ

Drone 1



Drone 2

	Drone 1	**Drone 2**	**Drone 3**	**Drone 4**
Mass (grams)	750	750	750	1750
Max. size (mm)	330	330	330	600
Frequencies (MHz)	900, 2400			

Drone 1 to Drone 3 are identical and they are all called "Finch". These drones have carbon fiber 250 mm size airframes with 5.5 inch propellers and 2205 Emax kv2200 motors. The autopilot used for these drones is Paparazzi UAV Apogee V1.00 with modified paparazzi software exclusive to our team. These drones are equipped with Raspberry onboard computers for simple optical flow and image processing tasks. The battery type is lithium polymer and data link modules are 100 watt 900 MHz modules.

Drone 4 is called Marvel. This drone has 450mm plastic frame with 12 inch carbon fiber propellers 450kv motors. The autopilot hardware is Paparazzi UAV Lisa M v2.0 and the software is AUTMAV modified Paparazzi. This drone is equipped with two onboard computers, each handling a specific image processing and guidance. task along with the intelligent guidance software fully developed by our team. There are a couple of navigation modules on this drone such as RpLidar v2 used for SLAM and obstacle avoidance and also forward and downward cameras for optical flow and other image processing tasks. The battery type is LiPo and datalink device is the same as above.

Team : **Black Bee Drones**

João Pedro R. Alves

Institute : Undergraduate of Computer Science at Federal University of Itajubá, Itajubá, Minas Gerais, 37500-903

Webpage : https://blackbee.unifei.edu.br/

Video link : https://www.youtube.com/watch?v=0_9Tz1jPUoE


Drone 1


Drone 3


Drone 4 & 5

	Drone 1	Drone 2	Drone 3	Drone 4 & 5
Mass (grams)	1,94kg	1,25kg	1,80kg	0,50kg
Max. size (mm)	675mm	322mm	675mm	250mm
Frequencies (MHz)	433 MHz, 5.4 GHz, 2.4 GHz			

The Black Bee Drones Team may use five different vehicles to execute the missions, depending on the strategy adopted, executing tests in parallel. All drones, produced by the team, have frame built in PLA (using a 3D Printer) and MDF in their structure.

- the first will have an onboard computer, which could be an Odroid XU4 or an DragonBoard, controller board PixHawk, DataLink of 433MHz, four motors T-Motor 920 KV, four ultrasonic sensors MaxSonar-EZ, Batery 4S 10000mAh or 3S 5000mAh, Radio Receiver 2.4GHz, Taranis FrSky Radio Controller.
- the second will have a reduced size, with only the basic components and will be piloted with FPV, controller board PixHawk, DataLink of 433MHz, four motors E-MAX 2300KV, Batery 3S 5200mAh, Radio Receiver 2.4GHz, Spektrum Dx8 Radio Controller, FPV system to be defined but witch a frequency 5.8 GHz.
- the third will use a telemetry and video transmission to the groundstation, controller board PixHawk, DataLink of 433MHz, four motors T-Motor 920 KV, four ultrasonic sensors MaxSonar-EZ, Batery 4S 10000mAh or 3S 5000mAh, Radio Receiver 2.4GHz, Taranis FrSky Radio Controller and Video System to be defined but witch a frequency 5.8 GHz.
- And the fourth and fifth will be a Parrot Bebop 2.

We are still designing a drone for weight lifting and making updates on the previous models, however, at any change we eill notify the organization of the IMAV.

Black Bee Drones is the first smart drone team of South America. Assembled in August 2015 at UNIFEI - Itajubá Federal University, composed of 38 students from various

undergraduate courses such as Management, Computational Engineering, Computational Science, Environmental Engineering, among other courses. The team has already participated in two IMAV broadcasts, 2015 in Aachen - Germany and 2016 Beijing - China. In the first one, Black Bee got the third place in the Outdoor competition and received a mention of honor for being the only team formed only by undergraduates.

Due to the high level of technology required by this competition, Black Bee Drones has become one of the pioneers of artificial intelligence embedded in drones, allowing the drone itself to learn and make decisions in mid-flight.
Although new, this team is already a reference when it comes to drones, and for two consecutive editions was an exhibitor at Campus Party, one of the biggest technology fairs in the world and was one of the three best projects among 40 competitors at Campus Future in January 2017.

Another great event in which the team is reference at DroneShow LA, the biggest Latin American drone fair in 2017. In its second participation, Black Bee was an exhibitor, speaker, participated in discussions on regulation and potential new business with autonomous drones and made demonstrations in this subject. The team was also awarded in three categories by the event: "Best teaching and research institution" with UNIFEI - Federal University of Itajubá, "Best Technology and Education Project - Applications of autonomous drones to assist emergency accidents" and "Professional of the Year - Drone Sector" with the General Captain João Pedro Rufino Alves.

In May 2017 SAE BRASIL (Society of Automotive Engineers) and Black Bee Drones organized the first competition of intelligent drones in Brazil. Our team, besides being a judge, prosecutor, assist in the progress of the competition and in the formulation of rules, which were based on IMAV's rules, also ministered three 24-hour courses in RJ, SP and MG, to train teachers and students of participating colleges. The competition was a success and involved 12 high school technical colleges from different regions and took place at the UNIFEI campus in Itajubá - MG.

The Black Bee also fulfills its social responsibility, carrying out social projects and participating in actions that involve the community such as "Bota Pra Fazer", "Natal dos Correios", among others. In partnership with the UNIFEI - Campus of Itajubá, Black Bee mapped the entire university to locate possible outbreaks of Aedes Aegypti. The team has also advised agencies such as the Police for the use of drones in environmental crimes.

The team attracts great interest among students of UNIFEI, receiving in its last selection process almost 200 registrations for about 20 places. The workshop was also a success, exhausting all seats in the auditorium.

Team : **Cigogne**

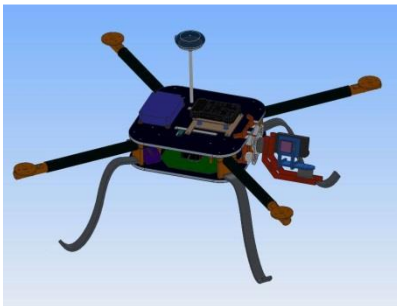
Renaud Kiefer and Thomas Pavot, Kadir Nigar, Nestor Santos Ortiz, Arda Yigit

Institute : INSA Strasbourg, 24 Boulevard de la Victoire 67000 Strasbourg, FRANCE

Webpage : http://genie-electrique.insa-strasbourg.fr/theme/drone/

FB : https://www.facebook.com/equipecigogne/

Video links : https://www.youtube.com/watch?v=vfDW0csKfyY
https://vimeo.com/159025222
https://vimeo.com/163704850


Drone 1 and 2


Drone 3


Drone 4

	Drone 1 and 2	Drone 3	Drone 4
Mass (grams)	1500	700	500
Max. size (mm)	750 with propellers (550 without)	420 with propellers	600
Frequencies (MHz)	433 ; 2400 ; 5 800		

Our drones are using APM and Pixhawk autopilots and we can program fail safe for flight missions (RTL, landing, limitation of flying areas and so on). For the image processing (landing and mapping), we have an Odroid and a Raspberry Pi working with OpenCV libraries. Concerning peripheral devices, we are using sonar sensors, Lidar sensor, GPS and Mobius and Pi cameras. All our drones are powered by 3S LiPo batteries.

The droping/payload holder system is a hook controlled by a servomotor.
All our quadcopters are design and build at INSA in carbon, carbon-kevlar and carbon-airex sandwiches. For the endurance flight, we will use a flying wing build with EPP. The drones are equipped with 3S 1400KV or 2150KV brushless motors.

The ground stations are based on open source softwares like MissionPlanner, QGroundControl and self made LabView interface. For the mission datalink, XBee 2,4GHz or radio-transmitters working at 433MHz are communicating with the ground stations. The analog video transmitter's frequency is 5,8GHz.

Team : **CVAR-UPM**

Hriday Bavle, Alejandro Rodriguez, Martin Molina, Pascual Campoy
Alberto Camporredondo, Carlos Valencia, Guillermo de Fermin, Rafael Artiñano, Ignacio Gil, Jaime Sanchez, Alejandro Garcia-Vaquero, Carlos Sampedro, Ramon Suarez, Sandro Jua

Institute : Computer Vision & Aerial Robotics Group, Technical University Madrid, 28006 Spain

Webpage : www.vision4uav.com

Video link : https://vimeo.com/205775713


Eagle *Sparrow*

	Drone1 Ardrone 2	Drone 2 Sparrow	Drone 3 Bebop	Drone 4 Eagle
Mass (grams)	420	1250	400	3800
Max. size (mm)	517	270	370	770
Frequecies (Mhz)	2.4	5.8	2.4 and 5	5

Ardrone 2: A small and light weight drone equipped with the following sensors:

1. 720p 30 fps and wide angle lens camera and 60fps vertical camera for ground speed measuremet.
2. 3 axis gyroscope, acclerometer and magnetometer and pressure sensor.
3. Ultrasound altitude sensor.
4. ARM Cortex A8 1 GHz 32-bit processor with 1gb ram.

Two types of 11.1V lipo batteries can be used, 1500 mah as well as a custom 2100mah for increased autonomy.

Sparrow: A custom and small drone made by the CVAR group with the following configuration:

1. Pixhawk mini autopilot with a 3 axis IMU and Barometer.
2. Hokuyo laser URG-04LX-UG01, max range 5.5 m and lightware SF/10A altitude sensor..
3. Fisheye lens usb front camera.
4. Upboard computer with intel atom x5 and 4gb ram and 64gb eMMC.
5. Datalink IPnDDL, 5.8Ghz and 12 Mbps.
6. 5000 mah and 14.8V lipo battery.

Bebop: An advanced version of the Ardrone 2 with improved hardware as follows:

1. 14mp, 1080p camera with fisheye lens and 60fps vertical camera for ground speed measurements. .
2. 3 axis IMU (accelerometer, gyroscope and magnetometer) and Pressure sensor.
3. Ultrasound altitude sensor.
4. Parrot P7 dual-core CPU Cortex 9 and quad core GPU.
5. 1200 mah and 11.1V lipo battery.

Eagle: A custom drone build by the CVAR group and used in the IMAV 2016 indoors competition with the following configuration:

1. Pixhawk Autopilot with 3 axis IMU (accelerometer, gyroscope and magnetometer) and barometer.
2. Hokuyo laser UTM-30 LX with max range 30m and lightware SF/10A altitude sensor. .
3. Intel-NUC 6th generation computer, with intel-i5 processor, 16gb of ram and 256 gb of rom.
4. Intel-real sense R200 front camera and a fisheye usb bottom camera.
5. Two analog servos controlled using an onboard arduino for releasing the objects in the desired locations.
6. Two 5000 mah and 14.8V lipo batteries.

Team : **Cyrus**

Rouzbeh farhadi, Hossein soufi, Ali amiri, Zahra shamsi, Seyed aref hosseini

Institute : Lorestan University Center

Video link : https://youtu.be/5D0qeqTCGQI

Drone 1

Drone 2

	Drone 1	Drone 2
Mass (grams)	850	1320
Max. size (mm)	340	560
Frequencies (MHz)	433 ; 2400 ; 5000;5800	

Software : orb slam-optical fllow-ltd tracker-hsv tracker- octomap
Computer board and os: upboard and odroid xu4 in Ubuntu 14.04 and ros indigo
Sensors: Two cameras for each robot 120fps-srf05 sonar-urg04lx
Pilot: pixracer
Motors: airgear200(drone1)-airgear350(drone 2)
Propeller: 5*4*3(drone 1)-9inch(drone 2)
Battery: 3000ma3cell(drone 1) -4000ma4cell(drone 2)
Control: pid for altitude-sliding mode for position

Team : **dotMEX Drones**

Andrés Cureño, Daniel Alcántara, Erick Valle
AND *Santos M. Orozco, Juan M. Ibarra, Alejandro J. Malo*

Institute : National Polytechnic Institute (IPN), Mexico City, 07360
AND Research and Advanced Studies Center of IPN (CINVESTAV), Mexico City, 07360

Webpage : www.parrot.com

Video link : https://www.youtube.com/watch?v=oFQ_Klvolew

Drone 1

Drone 2

	Drone 1	Drone 2
Mass (grams)	500	450
Max. size (mm)	320	380
Frequencies (MHz)	2400, 5000	

The UAVs used are Parrot Bebop 1 and 2. Both Bebop versions are actuated with 4 brushless outrunner DC motors attached to a Grilamid and fiberglass airframe, such that the total mass of the vehicle is 500 g (Bebop 2) and 420 g (Bebop 1), this last includes lateral covers that rise its mass up to 450 g; the size of Bebop 2 38 x 32cm and of Bebop 1 is 38 x 33 cm. The power supply of Bebop 2 is a lithium-ion 2700mAh battery which allows a 25-minute flight autonomy; the Bebop 1 is equipped with a lithium-ion 1200 mAh battery which allows a 20-minute flight autonomy. Both UAVs are equipped with proprioceptive sensors such as a 9-DOF inertial measurement unit (IMU), an ultrasonic sensor for height measurement up to 16 ft, a pressure sensor that complements the last one for heights beyond 16 ft, a vertical stabilization camera and a global navigation satellite system (GNSS) chipset (GPS + GNSS). The mentioned UAVs also equipped with an embedded full-HD 14 Mpx fish-eye camera, which is helpful as an exteroceptive sensor for simultaneous localization and mapping, obstacle detection and control applications. These quadrotors reach up to 65 km/h (Bebop 2) and 47km/h (Bebop 1) horizontal speed, in addition to the maximum 6 m/s (Bebop 2) and 2.5 m/s (Bebop 1) rising speed.

Team : **DroneAcharya : Creation Labs**

Archishman Datta, Goli Sai Sumith, Vedant Gupta, Goutham Somaraj and Arnav Raviraj

Institute : VIT University, Vellore, Tamil Nadu, 632014

Video link : https://youtu.be/4jyYDsAae8E

MAV 1

MAV 2

	MAV 1	MAV 2
Frame Weight (grams)	65	125
Frame Size (mm)	200	300
Frequencies (MHz)	433, 2400, 5800	

Team DroneAcharya proposes the use of 2 MAV's for the completion of the tasks in the outdoor competition of the International Micro Air Vehicle competition 2017. We have designed each of the drones to maximize its efficiency, attain longer flight times even while keeping its size as minimal as possible and each drone being as cost effective as possible.

The first drone is intended to perform autonomous flight tasks and is designed for a 200mm frame sized MAV. The ArduMega Pilot is the Flight controller for this drone powered by the Ublox Neo M8N GPS for high precision navigation. The motors used on this drone will be a 2205 motor running at 2300Kv being powered by a 5200 maH Li-Po battery. The data links will have a 2.4 GHz transmitter and a 433 MHz transmitter for data telemetry.

The second drone intended to perform the Photogrammetry tasks will have a 300mm frame. This drone will also run on the ArduMega Pilot flight controller and the Ublox Neo M8N GPS system for navigation. The motors used on this drone will be a 2208 motor running at 2000Kv being powered by a 5200 maH Li-Po battery. The data links will have a 2.4 GHz transmitter and a 433 MHz transmitter for data telemetry.

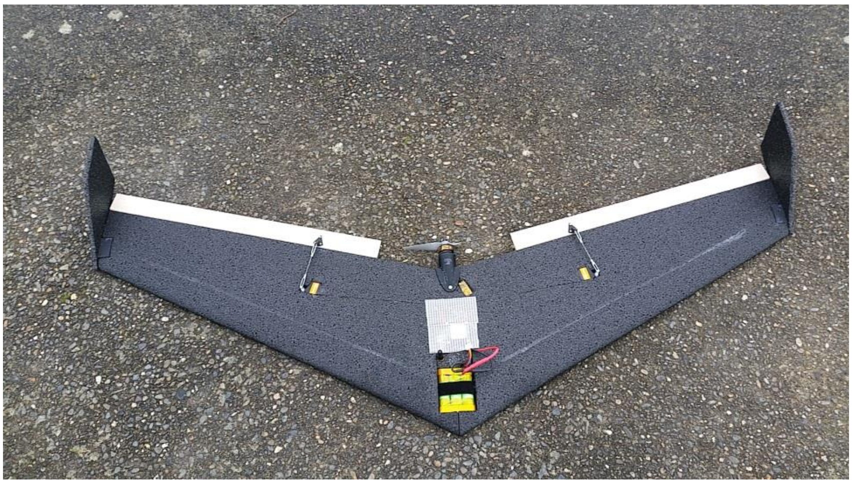
Team : **ENAC**

Hector Garcia de Marina, Murat Bronz, Michel Gorraz and Xavier Paris

Institute : ENAC UAV Program, Toulouse, France

Webpage :
http://paparazziuav.org/wiki/Module/guidance_vector_field#Circular_formations

Video link : https://www.youtube.com/watch?v=q4b8JRU1Gbw



Drone 1, 2 and 3

	Drone 1, 2 and 3		
Mass (grams)	850		
Max. size (mm)	1200		
Frequencies (MHz)	2400		

We have written an algorithm for solving the problem of tracking smooth curves by an unmanned aerial vehicle traveling with a constant airspeed and under a wind disturbance. The algorithm is based on the idea of following a guiding vector field which is constructed from the implicit function that describes the desired (possibly time-varying) trajectory.

On top of this, an algorithm can synchronize or arrange a group of fixed-wing aircraft (assuming they have equal ground speed) in a desired circle. The algorithm works by setting different radii to the aircraft. If two aircraft orbit a waypoint with different radius, then the one with bigger radius travels more distance in a completed lap. The same principle can be used when following a sinusoidal trajectory whose frequency is changing to maintain the longitudinal synchronization of the formation.

We plan to demonstrate capabilities of this approach by synchronization a group of three flying wings, equipped with the Paparazzi autopilot, within the Team Parade challenge of IMAV2017.

Team : **Fly Eagle**

Tao Song, Yongming Guan, Hao Wang, Jianchuan Ye, Yihao Dong, Tingting Wang,Yang Cui, Guoning Zhao, Wanming Yu, Weixiong Xu, Xiwen Yang, Ling Cui, Yihua Qi ,Tao Zhou, Xiaofei Jing

Institute : Beijing Institute of Technology

Video link : https://youtu.be/M5SKnClOg9M
http://www.bilibili.com/video/av11643360/

Drone 1

Drone 2

	Alexa	Mausi Jr.<3	Muetze Jr.	Reek	The Bees
Mass (grams)	1999	1900	1950	275	400
Max.size(mm)	580	640	500	180	320
Frequencies (MHz)	433 ; 2400 ; 5700				

Airframe description：Quad-Motor AirDrone with Processor on Board.
Autopilot：PixHawk4 / DJI A3
Sensors：Mono camera / RGB-D camera / Stereo camera, OpticFlow Module, IMU, RTK-GPS
Motors：2312 Brushless Motor
Battery type：3S / 4S Li-on Battery
Datalinks：DataLink Module
Fail safe device： we have safety pilot

Team : **Guilan**

Erfan Jazeb Nikoo, Sajjad Rahnama Feshkecheh, Mahdi Etemadi, Amir Abkhoshk, Babak Moradi, Navid Hadipour Limouei

Institute : Prof. Hesabi Robotics Research Laboratory, Islamic Azad University of Lahijan Branch, Lahijan, Iran

Webpage : http://liau.ac.ir/en

Video link : https://www.youtube.com/watch?v=wumIN9yP0dw

Hexacopter

Quadcopter 1&2

	Hexacopter	Quadcopter 1	Quadcopter 2
Mass (grams)	1500	850	850
Max. size (mm)	770	550	550
Frequencies (MHz)	433 ; 434		

Three drones are used by the Guilano team in the IMAV 2017 competition; A hexacopter for the main competition and two quadcopters for the cooperative flight. The airframe of the Guilano team robot consists of wooden star-shaped central plates as well as aluminum alloy arms. The Pixhawk advanced auto pilot is used as the flight controller of the robots. The sensors used in this competition are 3D accelerometer, gyroscope, magnetometer and barometer sensors. These robots are powered by Air Gear 350 tiger brushless motors with an 800g thrust that uses 9*4.5inch propellers along with a Tattu Gens Ace 9000mAh 25C 4CellLi-Po battery. In addition, the DIY Guilano RC radio and telemetry system are based on RFM23BP in frequency of 433.05-434.79MHz.
The software section divides into Core, Mapping and GUI applications. The GUI is responsible for receiving inputs from the drone as well as controlling it. Receiving inputs from GUI, analysing data and also providing proper outputs for the drone the responsibilities of the Core section. The Mapping application is responsible for making 3D maps from coordinates and aerial images. The mapping task is done by Rviz packages. In this project C++ programming language, OpenCV and QT libraries are applied. The QT5 libraries and ROS packages along with other libraries respectively used in all applications. The Guilano team simulates the competition environment and missions by Gazebo framework.

Team : **HORIZON & EMC+**

Mohammad Nourbakhsh Najafabadi, Sasan Jahangiripashaki, Bahareh Khalili, Reza Karimi, Omid Ekramian, Alireza Kazemi, Dr. Mohsen Loh Mousavi

Institute : HORIZON & EMC+ Robotic Research Laboratory, Islamic Azad University of Khomeini-Shahr Branch (Isfahan), Iran

Video links : http://s9.picofile.com/d/8299622118/3b76dcba-63a0-48e7-97b9-50b5475bf57a/HORIZON_and_EMC_qualificatin_Video_IMAV_2017_.mpg

1 Introduction

The HORIZON robotic team with different national places in last 3 years have Decided to join the EMC+ robotic research group, which has experience of participation in IMAV 2014 (The Netherland) and IMAV 2015 (Germany), for participating in IMAV 2017.

From 2010 to 2014 we worked on the Multiwii-Mega source code and integrated ultrasonic sensor (SRF05) with it, also we ran Auto-takeoff and Auto-landing on our robot. The IMAV 2014 competition shows us that Multiwii code is not flexible and is useless for any autonomous mission. In the competition, takeoff and landing of our robot was autonomous and we done other mission FPV. For image processing, captured video through an analog 5.8GHZ video and audio transmitter sent to laptop.

In IMAV 2015, our selection was Pixhwk board because in addition to be an open source project has more developments tools. To run vision programs, an onboard minicomputer (Odroid U3+) is our choice for robot's surroundings detection.
For the IMAV 2017 competition, we made decision to use 2 robots for autonomous part and FPV part. A PARROT AR-DRONE 2.0 will be used for the first part and a very small size (10*10 cm) hand-made robot for the second part. In the following, doing Missions will be described.

2 Mission Details

2.1 Auto take off

The parrot AR-DRONE 2.0 will be used for auto take off from moving pad by sending take off command to reach 2 meters height from pad.

2.2 Auto flying through the window

For autonomous passing from pipe using image processing, center position of pipe is determined as center of a circle. Through this command, the position of robot is regulated for passing and avoiding to Collision.

2.3 Flying the straight path

Optical flow is the pattern of apparent motion of image objects between two consecutive frames caused by the movement of object or camera. It is 2D vector field where each vector is a displacement vector showing the movement of points from first frame to second. Optical flow has many applications in areas like:

1. Structure from Motion
2. Video Compression
3. Video Stabilization

Optical flow works on several assumptions:

1. The pixel intensities of an object do not change between consecutive frames.
2. Neighboring pixels have similar motion.

One of several methods to solve optical flow is Lucas-Kanade. Lucas-Kanade method computes optical flow for a sparse feature set. Opencv provides another algorithm to find the dense optical flow.
In software part, we developed software for online monitoring of predefined path. During the real time monitoring, this software can record all events of mission. We used this ability (Optical flow) for line flowing. First implementation of line flowing algorithms was done on parrot AR.drone2.0
Now we are trying to develop this ability to our made platform.

2.4 Auto Target detection and recognition

The MAV detects quick recognition (QR) codes using Zbar library in Qt C++ environment. Beside it, the recognition of corners of an image is performed using Opencv library. Once the MAV detects QR code corners and then it try to decode contains on image. After exact detection, the software announces the user with special sound suck as beep. The speed of QR code detection in this software is very fast.

2.5 Semi-Autonomous Drop Object

For doing this mission, we place an AR marker at the drop zone and the pilot operates the hand-made robot to drop zone. After auto marker detection by robot, a command send to a servo motor for dropping.

2.6 Auto precision landing

The Parrot AR-Drone hover on the landing zone and after detection an AR marker recognize the landing position. When the height of robot is zero, a timer counts 10 s for taking off again.

Team : **Instinct Cougar**

Shupeng Lai, Yingcai Bi, Hailong Qin, Kun Zhang, Chenwu Sun, Yang Xu

Institute : UAV Group, National University of Singapore, Singapore 117576

Webpage : http://uav.ece.nus.edu.sg/

Video link : http://uav.ece.nus.edu.sg/videos_files/2017/safmc2017.mp4

Drone 1-3

	Drone 1	Drone 2	Drone 3
Mass (grams)	1600	1600	1600
Max. size (mm)	480	480	480
Frequencies (MHz)	2400 ; 5700		

Total weight of the fully configured UAV is less than 1.6 kg. Estimation of moment of inertia of the MAV in roll, pitch, and yaw direction are 0.0096kg*m2, 0.0097kg*m2, and 0.0117kg*m2 respectively. Each rotor of the vehicle can provide up to 4.6N of thrust which provides a lift-to-weight ratio around 1.84. Further, the arm is mainly made of carbon fibre to minimize the moment of inertia.
The onboard avionics are customized to fit the mechanical structure of the hexarotor and achieve a perfect center of gravity placement. The design is first examined in the CAD software and later tested through flight experiments. The flight control module includes various sensors such as gyroscopes, acceleremeters, magnetometers, to measure the status of the MAV. Height is monitored by a Teraranger, which is a Time of Flight (TOF) distance sensor.
A Hokuyo laser scanner is used for SLAM in the horizontal direction. A downward facing camera is used for vision based detection and guidance. Power distribution is implemented on a separate board to minimize the electronic interference. To compromise between computation power and weight, we use a small-size 80g Upboard with Intel Atom x5 z8350 processor as onboard mission computer. With our optimized onboard algorithms, it is capable of running mission control, path planning, and SLAM simultaneously.

Team : **Instinct Lion**

Jiaxin Li, Menglu Lan, Yu Herng Tan, Lele Zhang, Xiaodong Liu, Yabang Zhao, Shupeng Lai, Yingcai Bi, Chenwu Sun, Kun Zhang, Yang Xu, Yu Chen, Hailong Qin

Institute : UAV Group, National University of Singapore, Singapore 117576

Webpage : http://uav.ece.nus.edu.sg/

Video link : http://uav.ece.nus.edu.sg/videos_files/2017/safmc2017.mp4

Drone 1-3

	Alexa	Mausi Jr.<3	Muetze Jr.	Reek	The Bees
Mass (grams)	1999	1900	1950	275	400
Max.size(mm)	580	640	500	180	320
Frequencies (MHz)	433 ; 2400 ; 5700				

Total weight of the fully configured UAV is less than 1.6 kg. Estimation of moment of inertia of the MAV in roll, pitch, and yaw direction are 0.0096kg*m2, 0.0097kg*m2, and 0.0117kg*m2 respectively. Each rotor of the vehicle can provide up to 4.6N of thrust which provides a lift-to-weight ratio around 1.84. Further, the arm is mainly made of carbon fibre to minimize the moment of inertia.

The onboard avionics are customized to fit the mechanical structure of the hexarotor and achieve a perfect center of gravity placement. The design is first examined in the CAD software and later tested through flight experiments. The flight control module includes various sensors such as gyroscopes, acceleremeters, magnetometers, to measure the status of the MAV. Height is monitored by a Teraranger, which is a Time of Flight (TOF) distance sensor.

A Hokuyo laser scanner is used for SLAM in the horizontal direction. A downward facing camera is used for vision based detection and guidance. Power distribution is implemented on a separate board to minimize the electronic interference. To compromise between computation power and weight, we use a small-size 80g Upboard with Intel Atom x5 z8350 processor as onboard mission computer. With our optimized onboard algorithms, it is capable of running mission control, path planning, and SLAM simultaneously.

Team : **ISAE**

Treasure Hunt challenge : *Patrice Labedan , Dominique Bernard , Anton Depoot, Matheus Coelho-Ferraz, Corentin Chauffaut*
Indoor & Virtual Challenge : *Soufiane Cherroud , Jorge Diaz, Davide Cavaliere, Oscar Ortiz, Paolo Tegrossi, Louis Pannetier, Corentin Chauffaut, Louis Treton, Francois Defay*

Institute : ISAE-SUPAERO, Toulouse, France, 31000

"ScanAir" UAV

MK UAV

	Alexa	**Mausi Jr.<3**	**Muetze Jr.**	**Reek**	**The Bees**
Mass (grams)	1999	1900	1950	275	400
Max.size(mm)	580	640	500	180	320
Frequencies (MHz)	433 ; 2400 ; 5700				

Treasure Hunt Challenge :

• UAV Name : quadrotor "ScanAir"
• Mission sensors : Infrared, Lidar lite V3 and Fluxgate magnetometer.
• Autopilot : Pixhawk.
• Battery : 4S 3500 mAh.

Indoor Challenge :

• UAV : quadrotor MK
• Mission sensors: DW1000 radio transceiver for positioning, oCAM Global Shutter camera, Hokuyo Scanning Rangefinder and Garmin lite V3 Lidar.
• Embedded system: Pixhawk autopilot (NuttX RTOS) with Odroid xu4 (LINUX +ROS).
• Battery : 4S 3700 mAh.

Team : **KRATOS**

Dinesh Kumar.G and Sai Shreeram L V

Institute : School of Aeronautical Sciences, Hindustan University, Chennai, Tamilnadu, 600117

Video links : https://youtu.be/egTw8S-qMBk
https://youtu.be/yB3c5YI4B8c

Drone 1

Drone 2

	Drone 1	Drone 2	Drone 3
Mass (grams)	840	650	
Max. size (mm)	350	250	
Frequencies (MHz)	2400; 2400		

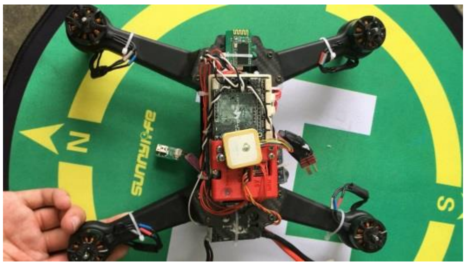
Short technical description including:
Airframe: (CARBON FIBRE REINFORCEMENT)
Autopilot: (PIX HAWK FLIGHT CONTROLLER)
Sensors: (ALTITUDE CONTROL,OBSTACLE DETECTION, 3 AXIS GYRO)
Actuators: (ROBOTIC ARM ACTUATING SYSTEM FOR PAYLOAD HOLD)
Motors: (BRUSHLESS DC MOTOR WITH 1.4 KG THRUST)
Battery type: (LITHIUM POLYMER 3CELL BATTERY PACK)
Datalinks: (MISSION PLANNER)
Fail safe device: (THROTTLE CUT SWITCH)

Team : **LANCELOT**

Boyang Xing, Wei Bai and Feng Pan

Institute : Beijing Institute of Technology, Beijing, China, 100081

Video links : 1. Quadrotor tracking an object with dilb sdk like Mavic:
https://www.youtube.com/watch?v=PUlpwJfTpAw
2. Quadrotor auto land on a ArUco mark (onboard record video):
https://www.youtube.com/watch?v=QkrxtkZkrEw
3. Quadrotor autoland on a ArUco mark:
https://www.youtube.com/watch?v=mwGWKq1KrJg



Drone 1

Drone 2

	Drone 1	Drone 2
Mass (grams)	800	1100
Max. size (mm)	250	350
Frequencies (MHz)	2400 ; 2400	

The airframe is made by 350mm wheel base carbon fiber. Our controller "OLD-X FC" is based on ucos-II and use a PD+ADRC controller as attitude and position controller. The quadrotor could hover with optical-flow which fusion IMU data by UKF. The motion camera is used to mapping and detecting task.4000mah lithium battery provides the power of the whole quadrotor. The Emax M2208 motors and XRotor-15A actuators are chosen for the dynamic system. As for the fail safe device, if a navigation sensor in the system is abnormal, the system will immediately switch to another set of sensors, in order to ensure reliable and stable flight performance.

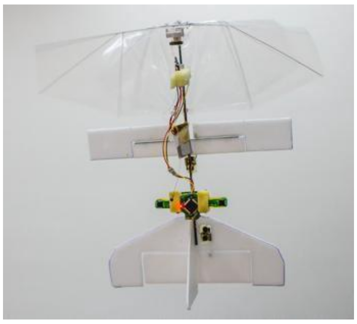
Team : **MAVLab**

Kirk Scheper Guido de Croon, Bart Remes, Christophe de Wagter, Kimberly Mcguire, Matej Karásek, Ewoud Smeur, Mario Coppola, Diana Olejnik

Institute : Micro Air Vehicle Laboratory, Delft University of Technology, Delft, The Netherlands

Webpages : http://mavlab.tudelft.nl/
www.parrot.com
www.delftacopter.nl/
http://www.delfly.nl/
https://1bitsquared.com/

Video links : https://www.youtube.com/watch?v=tNPfD9I14Js
https://www.youtube.com/watch?list=PL_KSX9GOn2P812tmddfrTlURHNieRe6YY&v=yX3RoUi9D-g
https://www.youtube.com/watch?v=wj0gV08Hdr8
https://www.youtube.com/watch?v=WRpauah11yw


Drone 1


Drone 2


Drone 3


Drone 4

Drone 5


Drone 6

	Drone 1	Drone 2	Drone 3	Drone 4	Drone 5	Drone 6
Mass (grams)	27	42	500	420	4000	1500
Max. size (mm)	250	180	382	520	1500	880
Frequencies (MHz)	2400					

The MAVLab is a UAV research group at the Delft University of Technology. The group is made up of master students, PhD researchers and academic staff, around 20

people in total. The MAVLab has competed in several previous editions of the IMAV UAV competition winning in 2013 and putting up a good show in 2015.

We work on a wide range of platform types with a focus placed on very small and lightweight vehicles or vehicles with unconventional designs such as hybrids. We also use a mix of custom built aircraft as well as off the-shelf vehicles, each for its specific application. Although we use a wide range of vehicles, all of our vehicles use the same PaparazziUAV open source software.

With our custom built vehicles, we typically utilize microprocessor based flight controllers such as the LISA M^2 or the Chrimera3. These flight computers provide us with a good trade-off of computation capabilities and electrical power consumption. These flight computers have 9DOF IMU's and barometers for basic vehicle state estimation. We often augment these systems with cameras such as the stereocamera on the Delfly Explorer or the Parrot SLAM Dunk4 which allows us to gain additional information about the world around us facilitating autonomous navigation. We focus primarily on vision as opposed to Lidar based systems as we believe that images provide a much more than just distance information making it a potentially versatile sensor.

Our commercially sourced vehicles, such as the Parrot Bebop and Bebop 2, often run a Linux based operating system from which we can run our custom flight control software. These vehicles often come with integrated IMU and camera systems which we use for autonomous flight control and navigation.

As mentioned above, one of our research focuses is on hybrid vehicles and above you can see the Delfltacopter and the Cyclone. The Delftacopter is a biplane vehicle equipped with a main rotor with a swash plate, two anti-torque props and ailerons. This vehicle has vertical takeoff and landing capabilities with a 60km flight endurance with GPS based datalink for beyond line-of-sight flight. The cyclone is a dual prop hybrid with two ailerons, this vehicle was developed in cooperation with ENAC Toulouse to be a fixed wing MAV with vertical takeoff and landing as well as extended hovering capabilities.

We are very excited to demonstrate the autonomous flight capabilities of these vehicles in the IMAV 2017 competition or technical demonstrations.

Team : **Mechatronix**

Leszek Ambroziak, Arek Bożko, Arek Nikonowicz, Adam Stulgis, Kamil Domysławski, Tomasz Grześ, Maciej Sulewski

Institute : Faculty of Mechanical Engineering, Białystok University of Technology, Białystok, Poland

Part	Weight (grams)	MAV 1	MAV 2
Quadcopter carbon fiber frame	285	1	1
Onboard Computer (Odroid XU4)	38	1	0
Flight Controller (PixFalcon)	13	1	1
Image processing camera (JeVois)	25	1	1/0 (depends on mission)
Electronic Speed Controllers 20A	3	4	4
Accumulator (Multistar LiHV 4S 10C 4000mAh)	345	1	1
Propellers 11-12 inch	12	4	4
Wires, connectors	~ 20	1	1
Power board (sensors, DC converter)	22	1	1
MT2808 850 kv motors	60	4	4
Payload and mechanism	~ 250	0	1
Landing gear	25	0	1
GPS ublox NEO-M8N	30	1	0
Sweep V1 Laser Scanner	120	1	0
Pololu 726 sonar	2	2	2
Wifi USB transmitter	20	1	1
Total weight (without Payload) **:**		**1222g**	**1050g**

Our work is focused on gathering knowledge about UAVs and mobile robotics. Most of our previous projects were concentrated on quadcopters and image recognition. As our side projects we like to try other things e.g. high-altitude balloons, remote controlled hovercrafts and vehicles power only by pressurized nitrogen "Pneumobil" or aircraft model for Air Cargo Challenge.

Overview

As our first steps we composed drive system for MAVs. We based on initial predicted total weight, online eCalc calculations and our dynamic and static test of motors and propellers on thrust stand.

We selected mission task that we would like to compete in, and for that we planned flight paths and required sensors. In connection to last changes in regulations for outside competition we must recalculate some of values like flight time.

Currently we bought parts for MAV like JeVois camera, motors, ESCs, flight controller and main computer. Rest of components were ordered. We have to wait a little longer for 360° scanner because of the problems with foreign supplier but that is not a big issue.

Our programists are working on algorithms for QR code / aruco recognition, SLAM navigation, Mavlink communication, safety reactions, and 2D foto mapping. They also working on GUI interface for telemetry and mission planning. We performed flight test for JeVois camera.

Actually we are also working on project of carbon fibre based frame for our Quadcopters. Frame must be as lightweight as it is possible and be able to withstand forces in dynamic flight (like in turbulent air from fans or wind). Frame were computer designed in SolidWorks software. Frame will be based on two custom milled center plates with onboard electric traces. Arms will be made from carbon fibre 12mm tubes. We predicted mountings for all additional equipment. In addition to frame project we creating landing gear and payload attachment mechanism.

Nowadays we are testing algorithms for autonomous landing on moving platform. Test were carried out with use of our old IMAV 2016 Hexacopter MAV. Some of team members are working to improve parameters of algorithms and regulators.

In the near future we want to build a testing track which will represent the real competition obstacles and tasks. Test track will be as close to the original as possible. This way we can test our system and improve on it. It is required to detect potential problems and create fail safe algorithm and flight plans.

Team : **MIPTeam**

Makaev Boris, Zaripov Kamil, Moharam Ahmed, El-Salamony Mostafa, Kislovskiy Artem, Frolov Ilya, Serokhvostov Sergey

Institute : Moscow Institute of Physics and Technology, Zukovsky city, Russia

Video link : https://youtu.be/4xt0zuHBtIM

Drone 1

Drone 2

Drone 3

	Drone 1	**Drone 2**	**Drone 3**
Mass (grams)	400	480	350
Max. size (mm)	280	347	254
Frequencies (MHz)	2400; 5800		

Drone 1:
Frame- self developed carbon fiber frame (Two-story frame, in the video)
Motors- 2307 2300KV (with 5046 props)
Battery type-(1300 mA*h 4S) and (1000 mA*h 5S)
Datalinks-(2.4 GHz Fly sky) (Piloting in manual mode)
Autopilot- (BettaFlight open-source system)

Drone 2:
Frame- Realace 210 carbon fiber frame
Motors-2307 2300KV (with 5046 props)
Battery type- (1300 mA*h 4S)
Datalinks-(2.4 GHz Fly sky) and FPV 5.8GHz
Autopilot- Smart Pilot autopilot system developed by the members from our team

Drone 3:
Frame- self developed carbon fiber frame (in the video)
Motors- 1407 3600KV (with 4 inch props)
Battery type-OnBo battery (1000 mA*h 5S)
Datalinks-(2.4 GHz Fly sky) (Piloting in manual mode)
Autopilot-(BettaFlight open-source system)

In all drones we will use integrated ECSS 4 in 1 (20A and 30A)

Team : **PERSIS**

Zarei M. and Ghazavi M.

Institute : Islamic Azad University Khomeinishahr Branch, Isfahan, Isfahan, 8418148499

Video link : https://youtu.be/rnlH7zIZDH8

Drone 1

Drone 2

Drone 3

	Drone 1	Drone 2	Drone 3
Mass (grams)	1320	1630	420
Max. size (mm)	560	620	530
Frequencies (MHz)	2400 ; 5800 ; 433		

Our robot's airframe is made of 4 carbon tubes came together in a CNC milled aluminum part and the autopilots are two Pixhawks connected to a breakout board in order to switch the autopilot to the pilot. We have put an Odroid-C2 as the brain of the robot responsible for image processing and data analysis using a PS3 camera and an ultrasonic sensor. A servo motor is used in order to drop the syringe in the specified area. The motors are 920kv brushless motors comes with 20 amps ESCs powered by 4-cell lithium-polymer batteries. In order to log the flight data to the ground station we have used two 433 MHz telemetries.

Our robots can Take off and land automatically and it can hold its position using optical flow algorithms with less than 20cm deviation.

Team : **QuetzalC++**

R. Munguia-Silva, A.A. Cabrera-Ponce, L. O. Rojas-Pérez
AND *J. Martinez-Carranza*

Institute : Instituto Superior de Atlixco, Atlixco, Pue, CP 74210 México
AND Department of Computer Science, Instituto Nacional de Astrofisica Optica y Electronica Luis Enrique Erro No. 1, Sta. Ma. Tonantzintla, Pue, CP 72840 México

Webpage : http://ccc.inaoep.mx/~Quetzalcuauhtli/

Video links : https://youtu.be/viJ68SI3s70
https://youtu.be/kVUCLMIeZYQ

Drone 1, 2, 3 and 4

Drone 5

	Drone 1	Drone 2	Drone 3	Drone 4	Drone 5
Mass (grams)	500	500	500	500	1500
Max. size (mm)	503	503	503	503	704
Frequencies (MHz)	2400; 5000	2400; 5000	2400; 5000	2400; 5000	2400; 5000

QuetzalC++ is a Mexican Team winner of the 2nd Place in the Indoors Category of the IMAV 2016 and 1st Place in the Autonomous Drones Category –Advanced Level– of the Mexican Robotics Tournament 2017. The team specializes on autonomous indoors navigation based on vision only by using visual SLAM, image segmentation and Machine Learning. For IMAV 2017, the team will present its most recent work on cooperative flight and real-time aerial image mosaicking.
The team will use four Bebop 2.0 drones, which have dual arms with frame very resistance. The autopilot is a platform with Ardupilot APM. The Bebop has a 180° fish-eye lens, Ublox Neo 8M GPS and an optical flow sensor. Motors are brushless and LiPo batteries of 3 cells of 2700 mAh are utilised. In addition, the team will also use a self-costumed drone, with a 3D printed frame. The autopilot for this vehicle is a Pixhawk processor. The motors are brushless with a higher winding density of 1000KV. This drone will be energized with a LiPo battery of 3 cells of 4500mAh. An RGB-D camera will be mounted on board next to an Odroid XU4 for processing.
Both drones described above will communicate with the Ground Control Station (GCS) via WiFi by using the Asus RT-AC5300 Wireless Router Gigabit - 5334 Mbps with 8 Antennas. Four directional antennas TP-LINK TL-ANT2414 of 14DBI will complement the router. Two Alienware computers will serve as GCS.

Team : **RMIT UAS**

Ethan Moyle

Institute : RMIT University, Melbourne, Victoria, 3083

Webpage : www.ruasrt.com

Video link : https://www.youtube.com/watch?v=xtgyaZ7run0&feature=youtu.be

Drone 1

Drone 2

Drone 3

	Drone 1	Drone 2	Drone 3
Mass (grams)	1300	1200	1000
Max. size (mm)	350	1200	1500
Frequencies (MHz)	868 ; 2400 ; 5800		

Drone 1: Shrouded quadrotor platform incorporating a LIDAR sensor on a Pixracer flight controller with 3DR Ublox GPS and FR-Sky XSR telemetry radio. Platform using TBS endurance motors. The craft has both a downward and forward facing camera with an additional PXflow. Datalink will be RDF868u. Battery 4900mAh 4S LIPO. Failsafe's will be regulated through the Pixracer flight controller with a last resort "kill switch" bound to the radio.

Drone 2: Fixed wing Pylon racer platform. This platform will use a Pixracer Flight controller with a GPS unit and pitot tube. Failsafe's are Geofence RTL, secondary landing point and finally a Remote kill switch. Datalink TBD.

Drone 3: Flying wing configuration Mapping aircraft. This platform will use a Pixhawk flight controller with a downward facing Mobius camera for mapping. Datalink TBD.

Team : **SRC**

Larissa khodadadi bashbolagh, Rahim babazadeh jamal kandi and Hamed pourmohammadi emamiyeh

Institute : Islamic Azad university of Tabriz, Tabriz, 5157944533

Webpage : www.kret.ir

Video link : https://youtu.be/WoeLDEICKtg

Drone 1

Drone 2

	Drone 1	**Drone 2**	**Drone 3**
Mass (grams)	600	500	
Max. size (mm)	250	250	
Frequencies (MHz)	433 ; 2400 ; 5800		

SRC drone has an X shape carbon fiber frame that designed by team's mechanical majors. Because of carbon fiber it is low weight and high stability. We use T-MOTOR and Brother Hobby brushless motors and plastic propellers. For power system, we use 11.1 volt and 2200 milliamps LiPo batteries. Stable automatic fly system designed by team members based on PX4 open source project that improve drone's performance. For obstacle avoidance we use ultrasonic sensors and for positioning and automatic fly we use image processing by optical flow data. By using a 5.8 GHz transmitter, video sent to computer for processing. We use OPENCV libraries for image processing. For communication between drone and computer we use HM-TRP 433 MHz transceivers.

Team : **UI-AI**

Farbod PeymanZadeh, Mobin Saboohi, Maryam Rezayati, Mohammmad javad passlar, Ali jafari, Mohammad kamali, Mehdi karimi and Atiyeh shirvani

Institute : Islamic Azad University Of Isfahan

Video link : https://youtu.be/YBgb7GI5OV8

Drone 1

	Drone 1
Mass (grams)	1200gr
Max. size (mm)	300mm
Frequencies (MHz)	2.4GHz & 5.8GHz

UI-AI team is a member of Space laboratory at university of Isfahan. Our team is composed of eight astute student of engineering faculty. Mr. Peyman Zadeh conducts software fluid analysis and help us to design, built, and test robots. Also, he executes image processing. Mr.passlar is interested in electronic ,Ms. Rezayati, Mr.jafari and Ms.shrvani are in charge of control section and Mr. Saboohi, Mr.kamali is responsible for mechanic parts.

UI-AI team was formed in 2014. The main goal of our research is to achieve applicable controller with high robustness, low torque effort, and minimum steady errors. In addition, we aim to design and apply robust controller on both spacecraft simulator and flying platforms. At previous research, we used both MATLAB to simulate controller on desired plant and Lab-View to implement controller on desired plant. It goes without saying that, Using of such professional software in projects, needs lots of experiment and training. Fortunately, UI-AI team has succeed to conduct complex projects. As a result, we have published several papers in this regard.

Competing with international teams could increase our qualities and could help teams to access to higher knowledge. In addition, international tournaments bring different ideas and approaches together. Therefore, we do our best to be hard rival for other teams as well as we expect from them. Moreover, we would like to become familiar with other active teams in order to exchange our experiences.

Team : **University of Manchester**

Thomas Shearwood, David Whitehead, Ismaeel Ramzan, Joe Smith

Institute : University of Manchester, Manchester, M13 9PL

Drone 1 and 2

	Drone 1	Drone 2	Drone 3
Mass (grams)	1750	1750	1500
Max. size (mm)	700	700	1300
Frequencies (MHz)	433 MHz; 2.4 GHz; 5 GHz		

The team has used Commercial Off The Shelf (COTS) components where possible in order to focus their effort on the design of the mission control and processing systems. To further simplify the design process, the quadcopters used for the mapping and co-operative lift challenges use identical airframes with only the sensor payloads changed. Drone 3 is a fixed wing aircraft which utilises a built up construction in order to produce the lightest possible aircraft for the distance component.

Drone 1 is used for the mapping challenge and uses a COTS quadcopter frame, with the mission management performed using the Pixhawk 2.1 Flight Controller with the PX4 flight stack. The images are acquired using a downward facing, gimbal stabilised camera; the images are then geo-tagged by an on-board raspberry pi and transmitted using Wi-Fi to the ground station where they are assembled to form the map. In the event that the images are not all successfully transmitted to the ground station before the aircraft lands, the remaining images are transferred from the memory card in the camera. To ensure the safety of the aircraft the failsafe algorithms from PX4 are all activated and are unmodified.

Drone 2 is of the same construction as drone 1 with the camera and gimbal payload removed. The payload will be attached by the team to a tether on the underside of both aircraft. To achieve the mission, the lead drone will follow a path preset in the flight stack and transmit its position to a ground control station and to the slave drone. Using a Raspberry Pi for remote operating system control of the Pixhawk, the slave drone will maintain a fixed position with respect to the lead drone to ensure the payload is carried safely.

Drone 3 is manufactured from balsa and plywood using a built up construction to reduce the weight of the aircraft. It is a fixed wing aircraft with no undercarriage which will be hand launched by the team and recovered by a belly landing once its battery is depleted. Flight control will be performed using the Pixhawk autopilot which will follow the course using GPS and land once the battery has fallen below a preset level or at the end of the flight time.

Team : **Vyoma**

Chandan Gurumurthy, E Vandan Rao, Manu M Pillai and Sumedha Bhat

Institute : Rashtreeya Vidyalaya College of Engineering, Bengaluru, India-560059

Webpage : www.teamvyoma.com
Video link : https://www.youtube.com/watch?v=Nn_UzRq_9JE


Drone 1


Drone2


Drone 3

	Drone 1	Drone 2	Drone 3
Mass (grams)	1300	1800	3800
Max. size (mm)	380	720	1800
Frequencies (MHz)	433 ; 2400		

Drone 1 is an H quadcopter configuration on 250mm frame built with carbon fibre and Balsa composite designed taking position of all components into consideration. The autopilot used is Pixhawk 2.1 with triple redundant IMU paired with Intel Edison processor for mapping and object detection. Based on the propulsion model analysis, Emax RS2306 2400kv paired with 5" propellers were selected to minimise area used and weight while providing more thrust and higher efficiency to give more flight time. The navigational sensors currently being tested are optical as well as laser range finder (SF11c). High density Lithium Polymer batteries were chosen to achieve longer flight duration. A 433 Mhz telemetry device is used along with a safety switch on Tx.

Drone 2 is an H quadcopter configuration on a frame built with carbon fibre and Balsa composite designed taking position of all components into consideration and aluminium I section arms. The autopilot used is Pixhawk 2.1 with triple redundant IMU paired with Intel Edison processor for mapping and object detection with Here GNSS (GPS). Based on the propulsion model analysis, Sunnysky x2212 980kv motors paired with 10" propellers were selected to give a balanced weight to thrust and ratio and efficiency to good flight time. The navigational sensors currently being tested are optical as well as laser range finder (SF11c). High density Lithium Polymer batteries were chosen to achieve longer flight duration. A 433 Mhz telemetry device is used along with a safety switch on Tx.

Drone 3 is a hybrid VTOL design to achieve best of both worlds: Vertical take-off and landing allows launching without the need of a runway. The wings unlike multirotors isn't power intensive as the lift is generated with lesser battery energy thus increasing endurance while allowing the MAV to achieve higher horizontal speeds. Bigger and lower kV motors are used to further increase the endurance. Electronic systems used are same as the previous two with added airspeed sensor. It is currently under an iterative design phase to optimise the size of the drone. A 433 Mhz telemetry device is used along with a safety switch on Tx.

Team : **WHU Deepflyer**

Huai Yu, Jinwang Wang, Xu Lei, Wensheng Cheng and Heng Zhang

Institute : School of Electronic Information, Wuhan University, No.299 Bayi Road, Wuhan 430072, China

Webpage : http://uav.whu.edu.cn

Video link : https://www.youtube.com/watch?v=y-IV3p18S50&t=7s

Drone 1

Drone 2

	Drone 1	Drone 2
Mass (grams)	1900	1500
Max. size (mm)	360	450
Frequencies (MHz)	2400 ; 2400	

The Drone 1 is a fully assembled development platform that combines the Intel® Aero Compute Board and the Intel® Aero Vision Accessory Kit with the Intel® Aero Flight Controller, LiPo battery (5200 mAh), GPS, compass, airframe, ESCs, motors, transmitter, and receiver. It also includes Intel® RealSense™ Camera (R200) and Intel® Aero Flight Controller with Drone code PX4 Autopilot which makes it have ability to sense the surroundings. The maximum airspeed of this drone flight is 15 meters per second and a typical delivery time for this drone does not exceed a flight time of 20 minutes. More details have been listed in the upper table.

The Drone 2 is a DJI Flamewheel 450 quadcopter. This quadcopter is equipped with four brushless electric motors (YH2212), a LiPo battery (5200 mAh), GPS (M8N), Pixhawk 2.4.6 Flight Controller, plastic airframe, transmitter, receiver, etc. The onboard computer device will be Intel NUC Boards. What's more, this drone can automatically land when it loses GPS information or lacks of battery to help avoid crashing. Besides, the maximum horizontal flying speed is 10 meters per second and the max flight time is 20 minutes. More details have been listed in the upper table.

IMAV2017

General Indoor and Outdoor

competition rules

v2.3

Changelog

December 2016 - v0.0
- Initial draft (limited access)

December 2016 - v0.1
- review
- virtual challenge

January 2017 - v1.0
- first public release

May 2017 - v2.0
- correct outdoor location
- maximum outdoor flight altitude at 30 meters
- pictures of elements and locations
- some size of elements
- minor corrections
- some details on special challenges

May 2017 - v2.1
- correction for outdoor mission: one storage is opened for inspection

June 2017 - v2.2
- outdoor time slot reduced from 25 to 15 minutes
- virtual environment files available online

September 2017 - v2.3
- cooperative carrying modification: 2 possible payloads with different scores
- extra pictures (indoor/outdoor targets and missing person, indoor drop objects)

Introduction

The indoor and outdoor competitions are set up to highlight the following points :

- Aircraft efficient and innovative designs
- Small and light MAVs
- Autonomy and image processing
- Multi-UAV cooperation

To promote autonomous and remote operations, RC-only control is no longer planned as part of the competitions. However, teams with an innovative RC-only platform can request a demo slot.

In addition to this, a drone **Virtual Challenge** will be held to encourage teams using simulation tools in their airframe and algorithm conception, and to emphasize their work.

Safety and security requirements

For security and safety details see the latest version of the IMAV2017 safety regulations documents published on the **www.imav2017.org** website.

- All participants are required to be familiar with the contents of the document and comply with it. Safety checks will be performed before each flight
- Due to regulation and safety, the maximum weight for all types of MAV is **2 kg** and the maximum flight altitude is **30 m** above ground level
- Safety areas are described in a Google Earth (kml/kmz) file available on imav website and the map in the outdoor competition section
    - All MAVs should stay inside the flight area (green line). When crossing this limit, a MAV should either land or turn back immediately inside the flight area.
    - The second border (red line) defines the border of the no-fly zone. Any MAV crossing this line should turn OFF its motors (fixed-wing aircraft may glide upon the control of the safety pilot and land as fast as possible).
- Allowed frequencies and maximum power:
    - 26 MHz, 41 MHz, 72 MHz: max power 100 mW
    - 2.400 GHz to 2.454 GHz and 868 MHz: max power 100 mW
    - 2.455 GHz to 2.483 GHz : max power 10 mW
    - 5.8 GHz: 25 mW
    - The use of the 900 MHz frequency is not allowed

Failure to abide by the boundaries and frequencies can lead to a penalty or disqualification.

Location

The outdoor flight competitions will take place on Sept. 20 at **Francazal airfield** (Google Maps).

Lat: 43.5434864°
Lon: 1.3598355°

The indoor flight competitions will take place on Sept. 21 at **ISAE-Supaero gymnasium** (Google Maps).

10 avenue Edouard Belin
31400 Toulouse
France

Competition slot: preparation time & flight time

Teams are not assigned a specific preparation time and a flight time but rather a competition slot. In this slot, they will set up their equipment, prepare the flights, fly the mission, and land all the MAVs. *Failure to land all vehicles within the slot can lead to a penalty or disqualification.*
The order of the teams' slots will be randomly decided on the morning of the day of the competition. At any time, before or during the mission, a team can decide once, and only once, to postpone the rest of its mission. In this case, the rest of flight slot of the team is shifted to the end. Therefore, all teams must be ready to fly at any time.
Time slots are **15 minutes** for the Indoor mission and **15 minutes** for the Outdoor mission.

Scoring

The final score will depend on the success of the mission elements (**M** = sum of the successful mission elements), the level of autonomy for each mission element (**A**), the size factor (**S**), the "in-a-row" factor (**I**), and a presentation made by the team during the mission (**P**).
Awards will be determined using the following formula:

- Total score = $Sum_{each\ MAV}(M \times A \times S \times I) \times P$

In order to ease the jury's task, the teams flying multiple MAVs shall clearly identify (color, number) each vehicle.

A task yields points only once. If several aerial vehicles perform the same task, the scoring will be applied to only one vehicle so as to maximize the overall scoring.

In addition, **special jury prizes** will be awarded (see at the end of this document).

Size factor (S)

The maximum size of the MAV is **1.5 meter**, which is determined by:

- the wing span of the aircraft
- or the maximum horizontal distance of a rotary wing (including blades).

The maximum takeoff weight is **2 kg** for all type of MAVs.

Size factor = 1/(size of the MAV in meter)

Level of autonomy (A)

The level of autonomy describes how a MAV is operated in order to fulfil the mission elements. The factor associated to each autonomy level is then used to compute the final score.

Level of autonomy	factor
Video based control: control of the MAV through FPV system	1
Autonomous flight control: the navigation is completely autonomous but the operator is controlling the mission and the payload	5
Autonomous target detection: the navigation is manual but the detection and processing of the targets is automatic	5
Fully autonomous mission control: the navigation and the decision making are autonomous, without assistance of the operator	10
Using external aids such as visual markers	-2 applied to factor

The video based control (factor 1) can only count for a single mission element (per MAV). If several mission elements are performed with this level of autonomy, only the best score will be kept (and other elements not taken into account).

Technical demonstrations are going to be a separate flight session with or without autonomy. The main issue there is to illustrate a novel technique/strategy which does not fit with the tasks proposed. While they will not compete for the mission scores, **they are eligible for the special jury prizes**.

In-a-row factor (I)

The "in-a-row" factor encourages participant to complete as many mission elements as possible without stopping. The more mission elements completed in a single trial, the higher is the factor.

Number of mission elements completed in a single trial	factor
1	1.0
2	1.1
3	1.2
4 (Max)	1.5

Presentation factor (P)

The team is rewarded when a team member presents the tasks and actions currently performed. The goal is to make the demonstration of each team more lively and accessible for the public. A video feedback of the ground station is also possible and is strongly recommended (standard VGA cable or analog video).

The presentation factor will be determined according to the description of:

- the MAV system and its design
- the initial plan to perform the mission elements
- the tasks actually performed
- the level of autonomy of each task / MAV

Presentation factor = 0 to 10 % of the total score (P from 1 to 1.1)

Mission elements (M)

A mission consists of multiple elements that can be performed in any order by one or more MAV. For each mission element, a score is awarded to the MAV that accomplishes the assigned task (see scoring tables further):

- a MAV can attempt to complete the mission element as many times as needed in the allotted time but only the best score will be used for the final scoring
- if several MAVs are doing the same mission element (including take-off and landing), only the best score is kept, except for the cooperative mission (in which case, all MAVs involved in the best attempt are considered in the final scoring)

Outdoor mission

Important Note: Due to technical and legal constraints the location of the outdoor competition have been moved to a small area and the end of the Francazal airport runway. The hangar scanning is then no longer possible. Some mission elements have been rewritten accordingly, but as close as possible to the original rules.

1. Automatic take-off
   a. a take-off is considered automatic as long as the safety pilot does not transmit any commands (except mission start signal)
   b. the MAV can be hand-launched.
   c. points are awarded for every MAV that performs at least one other mission element during its flight, except precision landing (taking off and landing is not enough to count as a valid mission flight)
2. Flight performance
   a. fly as many laps as possible in the competition slot around 2 poles during a single flight (landing in the middle would reset the number of laps)
   b. begins when crossing the "start" line; only laps that have been completed count in the final score
   c. the MAV must land before the end of the allotted time to be valid
   d. flight altitude is only limited by the boundaries of the flight zone
3. Mapping
   a. produce the map of the blue area on the map below, which include a small house and several storage places
   b. the garage of the house and one storage are opened and can be inspected
4. Target detection and recognition
   a. search and identify targets (hazardous materials or missing people) outside and inside the house's garage or the storage places (storages are numbered S1, S2 and S3 as shown on the map below, not all of them have targets in front, only one storage is opened)
   b. targets can be located on the map produced by the team (see previous mission element) or a rough map provided by the organizers

5. Cooperative carrying
   a. at least 2 drones should carry a weight over a distance of 50 meters
   b. attaching the MAVs to the weight can be done by team members, no autonomous grasping are required
   c. 2 objects of different weight can be chosen by the teams
6. Precision landing
   a. a landing will be classified as one of the following: a field landing, a normal landing, or a precision landing
   b. the size and place of each landing zone (normal/precision) depends of the type of MAV (fixed-wing, VTOL)
   c. in case of rough landing, the team will be asked to demonstrate the airworthiness of the vehicle
   d. extra points are awarded if the MAV is able to take-off again (fly higher than 5m) after staying still 10 seconds on the ground and without any operator intervention
   e. all MAVs must land within the time slot, otherwise all mission elements since last take-off will be discarded for this MAV

Mission elements	Mission score
Automatic take-off	1
Flight performance	number of laps / 8
Mapping	2 for automatic processing (2D or 3D map, can be done off-line but within mission time) +1 for images from inside the house's garage +2 for images from inside the opened storage
Target detection	1 for clear view of the target 1 for automatic detection and classification of the target 1 for correct location on the map
Cooperative carrying	1 per MAV involved if the minimum distance is reached x3 bonus when using the heavy payload +1 for precision landing of the carried weight
Landing (precision/normal/field)	2, 1, 0 extra points: +1 by taking off after 10 seconds staying still without any operator assistance

Indoor mission

1. Take-off
    a. take-off are performed from a pad that can be fixed or moving
    b. points are awarded for every MAV that performs at least one other mission element during its flight, except precision landing (taking off and landing is not enough to count as a valid mission flight)
2. Flying through the window
    a. the MAV must pass through one of windows or the pipe on a wall
3. Flying through the "obstacles" zone
    a. several obstacles must be crossed with different difficulties
        i. fixed poles (simple structured colored elements)
        ii. vegetation (unstructured elements)
        iii. fans (turbulent atmosphere)
    b. it is possible to use the straight line path without obstacle at any step
    c. each type of obstacle can be attempted separately or in a row (and in-a-raw factor will be applied except if straight line path is used)
    d. if a MAV flies above the obstacles, points will not be awarded
    e. for the fans, if a MAV is pushed away from the corridor materialized by two poles, points will not be awarded

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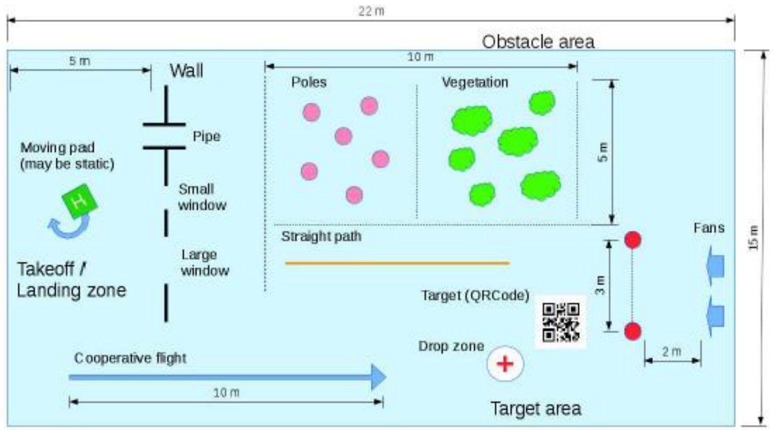
4. Target detection and recognition
    a. a target is placed on the ground after the "obstacle" zone
    b. the task is to find the target and process the data on it (QRCode)
    c. the data found on this target is a reference of an object that should be dropped in the "drop" zone
5. Drop zone
    a. a "drop" zone is after the "obstacle" close to the target
    b. the object to drop depends on the data found on the target and can't be carried a-priori on the MAV (as the possible choice is large, i.e. medicines)
    c. the two choices are
        i. go back to the beginning through the "obstacle" zone, pick the product, come back and drop
        ii. send the information to a second MAV that flies to the drop zone with the correct product
6. Cooperative carrying
    a. at least 2 drones should carry a weight over a distance of 10 meters
    b. attaching the MAVs to the weight can be done by team members, no autonomous grasping are required
    c. 2 objects of different weight can be chosen by the teams
7. Precision landing
    a. the MAV can perform a precision landing on either the fixed or moving platform
    b. in case of rough landing, the team will be asked to demonstrate the airworthiness of the vehicle
    c. extra points are awarded if the MAV is able to take-off again after staying still 10 seconds on the ground and without any operator intervention



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Mission elements	Mission score
Take-off	0 from fixed pad 1 from moving pad
Fly through the wall	pipe: 2 small window: 1 large window: 0.5
Fly through obstacle zone	straight path: 0.5 per MAV fixed poles: 1 per MAV vegetation: 1.5 per MAV fans: 1.5 per MAV
Target detection	1 for a clear view of the target 1 for reading the data
Drop zone	1 for dropping the object inside the drop zone +1 if the drop is done in one row after flying through one of the window and the obstacle area
Cooperative carrying	1 per MAV involved if the minimum distance is reached x3 bonus when using the heavy payload +1 for precision landing of the carried weight
Landing (precision)	0.5 on the fixed pad 1 on the moving pad extra points: +0.5 if taking off after 10 seconds staying still without any operator assistance

Special jury prizes and challenges

Jury prizes

The IMAV jury members, will award two special prizes:

- **System prize**: this prize is awarding the team that presents the highest level of innovation of MAV system elements such as autopilot hardware or software design, Human-Machine Interface, payload control, computer vision, code analysis, simulation.
- **MAV Design prize**: this prize is awarding the highest level of innovation of aerodynamics or mechanical solutions

Virtual challenge

Design and implementation of complex systems usually require much preliminary work, including simulation. In order to encourage teams to follow this approach in as realistic as possible environment and to showcase this work, a virtual challenge is proposed alongside the traditional competition.

The key idea of this challenge is that a virtual environment modeling the indoor flight area will be provided to all the teams. Data from standard sensors (inertial measurement units, sonar, lidar, cameras) will allow you to develop and test algorithms and control for the real mission elements. During the IMAV event, teams willing to participate to the challenge will be able to connect their work to the same simulation tool hosted by the organizers. The evaluation of the teams will be done on:

- the number of tasks performed in the virtual world
- the time to perform the mission
- a short presentation of their work to the jury

The simulation framework will be based on Gazebo and can be addressed via several tools (ROS, MATLAB/Simulink, ...). The virtual environment is available on IMAV2017 website and Simulink examples are also provided.

Treasure hunt challenge

In this outdoor challenge, the goal is to find hand-made objects which are not visible using a video camera. More precisely, 4 disks will be placed horizontally on the grass within a 15x15-meter square area. Each disk is 40-cm diameter and 4-cm thick. It will be painted with camouflage-colour so as to be almost impossible to detect through a video camera. Three disks will be made of foam and one disk will be made of steel (40 kg). The objective is to locate the maximum number of disks by providing (X,Y) coordinates in meters with respect to the lower left corner of the square area. A maximum of 4 locations will be provided per team. Each correct location provides 1 point. "Correct location" means that the X,Y coordinates are provided with an uncertainty of less than 30 cm. Identification of the metallic disk provides 3 points.

The challenge will be evaluated according to the following criteria:

- flight autonomy
- autonomous calculation of locations
- duration of the hunt
- efficiency of the path planning

Drone team parade trophy

In this challenge, the goal is to have a patrol of UAVs (fixed-wing, rotorcraft or mixed) flying in a formation so as to demonstrate their coordination and flight accuracy skills.
This challenge will be evaluated according to the following criteria :

- accuracy of the formation shape and number of UAVs involved
- accuracy of the path followed by the UAVs
- aesthetic qualities of the formation
- elapsed time necessary to reach the formation configuration

Record breaking session

This indoor challenge consists of lifting up a 500-gram payload 50 cm above the ground during 1 minute. "50 cm above the ground" means 50 cm counted as the vertical distance between the lower part of the payload and the launch pad which will be placed on a table. The UAV can be attached to the payload before the flight. The winner of this challenge will be simply the team with the smallest electrically powered UAV capable of lifting that 500-gram payload under the above conditions. "Smallest" means the UAV which maximum dimension in flying configuration is the smallest among the competitors. Because of the flight regulations, the UAV takeoff weight should be less or equal to 1.5 kg (so that the flying vehicle will not exceed 2 kg including the payload). "Maximum dimension" is defined as in the Size factor section (above). RC-control mode will be allowed for this challenge.

Technological demonstration

The goal of this flight demonstration is to highlight novel disruptive MAVs architectures / technologies. RC-control mode may be accepted for the technological demo which may take place either during the indoor session or during the outdoor flight session.

Static exhibition

A static exhibition will be planned in order to show both prototypes and commercial MAVs to the participants.

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Size and shapes

All dimensions presented here might be updated. GPS coordinates of some outdoor elements (poles, landing zones,...) will be provided to the team on the day of the competition.

Windows for indoor mission

Large window: 1.5m x 1.0m
Small window: 0.8m x 0.8m
Pipe: 0.8 to 1.0 meter diameter, 1.0 to 1.2 meter long

Final dimensions will be provided in a later version of this document.

Indoor poles

Dimensions for the indoor poles (obstacle zone):

- height: 3 m
- diameter: 30 to 40 cm
- colors may change
- poles are used in the obstacle area
- two of them materialize the beginning and the end of the "fan" obstacle

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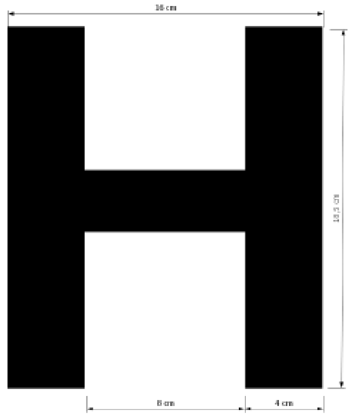
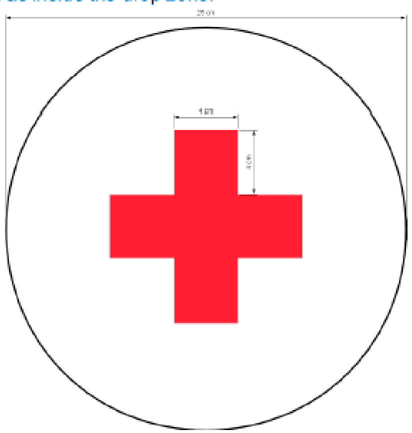
Indoor and outdoor takeoff and landing zone

The takeoff and landing zone is a 1 meter square platform with a black H letter on it. The platform is at least 50 cm above ground.



Indoor drop zones

The center of the drop zone is marked by a cross. If the dropped object is at least touching the outer circle, it is counted as inside the drop zone.



Drop object

The object to drop represents a medicine in a cylinder shape (like a syringe) to be dropped close to an injured person. The required dimension and weight are:

- minimum length: 10 cm
- minimum diameter: 2 cm
- minimum weight: 50 grams

The final object provided by the organization is a copper tube with the following characteristics:

- length: 10 cm
- outer diameter : 2.2 cm (thickness 1 mm)
- weight 54 grams

It is also possible to add tapes to help holding it as long as it is easy to remove afterwards. Teams who prefer to use their own object can do it as long as the minimum above requirements are respected.

Indoor target (QRCode)

QRCode are two-dimensional barcodes that can be decoded using various software libraries (for example ZBAR). It should be printed on a A4 paper with at most 25x25 pixels ("version 2").

Indoor vegetation

TBD

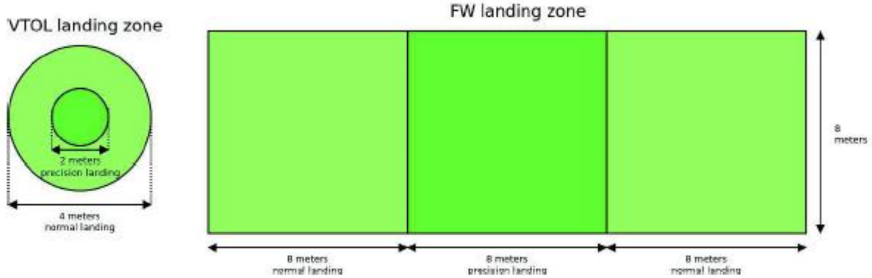
Indoor location pictures

Outdoor poles (performance)

Distance between the two poles: 250 m
Pole height: 6 m

Outdoor landing zone

The center of the VTOL landing area will have the same **H** pattern than the indoor landing zone.



Outdoor location pictures

The doors of the storage is about 3.5 x 3.5 meters. As an old military shelter, the walls are very thick and could make communication difficult while attempting to fly inside.

Cooperative carrying weight

Two objects of different weights are available with different scoring factors.

- light plastic frame: 400 to 500 gr
- heavy wood frame: 2.1 kg

Outdoor target and indoor/outdoor missing person

40 cm diameter red pot

Scoring examples

TBD

- Guided tours : all year long, starting from the Donjon du Capitole (walking tour : 6/13€)
- Toulouse's Tourist Trains : 2 routes lasting 35 minutes, departure from and return to the Place du Capitole (7€)
- Gyropod trips : set off on a Gyropod to explore Toulouse, departure at the Quai de la Daurade (30€ for 1 hour)
- Les bateaux toulousains : all aboard a guided tour on the Garonne or the Canal du Midi (10-29.90€ depending on the cruise)
- Please consider extending your stay to visit the Airbus A380 assembly chains and the new A350XWB assembly chain on Friday Sept. 22 or Saturday Sept. 23 (http://www.manatour.fr/)

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