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Bertold Békési – Imre Makkay
bekesi.bertold@uni-nke.hu – makkay.imre@uni-nke.hu

IMAV 2012 – BRAUNSCHWEIG

Abstract

In 2012, Braunschweig, Germany a four-day IMV - International Micro Air Vehicles conference was held where 140 people from 18 countries were received. Several lectures were given and the teams entered for competition flying demonstrations measured their knowledge. The indoor and outdoor event winners were those who met the minimum size of the aircraft – that is not an easy task. A scientific findings and practical experience-rich conference be broadcast only in flashes. All this in mind, the authors - along of the technical innovations - the participants habit and exemplary organization intended to highlight, as well as the lessons learned, which will be held to help prepare similar events.

A 2012-ben a németországi Braunschweigben megrendezett négynapos IMAV – Imternational Micro Air Vehicles konferenciára 18 országból 140 fő érkezett. Számos előadás hangzott el, a versenyre benevezett csapatok repülő bemutatókon mérték össze tudásukat. A bel- és kültéri versenyek győztesei azok lettek, akik a legkisebb méretű légi járművel teljesítették a nem könnyű feladatokat. Egy tudományos eredményekben és gyakorlati tapasztalatokban gazdag konferencia eseményeiről csak felvillanásokat lehet egy írásműben átadni. Mindezek tudatában a szerzők a műszaki újdonságok mellett a résztvevők habitusát és a mintaszerű szervezést, mint követendő példát kívánják kiemelni, valamint azokat a tanulságokat, amelyek a jövőben sorra kerülő hasonló rendezvényekre való eredményes felkészülést segíthetik.

Keywords: *IMAV 2012, unmanned air vehicle, competition, conference ~ IMAV 2012, pilóta nélküli légi jármű, verseny, konferencia*

INTRODUCTION

The man built the aircraft - to get into the air like birds. Recently, many aircraft are built so that people do not have to sit on it. The unmanned flight has already been demand, but these technical conditions were not sufficiently mature. Today, robotics is small, intelligent devices are used - which can be placed on board the aircraft.

The miniaturization of the aircraft is a major challenge. The "low-Reynolds number" aircraft by - the limits are not aware of or do not know - young researchers, developers, and university students are built around the world.

The FPV - First Person View technology great opportunity and also a great temptation to sit in the room to control our aircraft. Unfortunately, this virtual (without any rules) flight "heroes" are included in the video splitters.

The rivalry is more suitable to the skill competition held in a suitable environment - such as the "IMAV 2012" was - where contestants aim to show not only the knowledge, but the industry and the military spheres have a keen interest in them. The observers followed close eye on events and successful productions. Outstanding competitors can expect to continue.

The authors of a similar motive - to gain experience, with the intention of building relationships - took part in the events of IMAV 2012 - under *the New Széchenyi Plan TÁMOP-4.2.1.B-11/2/KMR-2011-0001 Critical Infrastructure Protection Research.*

IMAV 2012 – CONFERENCE AND COMPETITION

The fifth time since 2004 the German Institute of Navigation (DGON) together with the "Technische Universität Braunschweig" has organized the "International Micro Air Vehicle Conference and Flight Competition IMAV 2012" in Braunschweig from 03 to 06 July 2012. The 5-day event was implemented in the Volkswagenhalle Braunschweig and on the glider field Wilsche. The scientific head of the conference was the chairman of the DGON Council Prof. Dr.-Ing. Peter Vörsmann who has a good temperament led a well organized team. [1]

Conference Schedule was the following:
Conference Opening *Prof. Dr.-Ing. Peter Vörsmann*

Opening Presentation

- Wake Reconstruction of Flapping-Wing MAV 'DelFly II' in Forward Flight *M. Percin, H.E. Eisma, B.W. van Oudheusden, B. Remes , R. Ruijsink , C. de Wagter, Delft University of Technology, The Netherlands*

Session 1: Guidance, Navigation and Control

- MAV Autopilot for Commercial and Research Purposes *Kirill Shilov, Grigory Lazurin, Department of Aeromechanics and Flight Engineering, Moscow Institute of Physics and Technology, Russia*
- The Optimum Location of Pressure Taps over a Wing for Dynamic Control Inputs *Sridhar Ravi, University Tuebingen, Germany, Matthew Marino, Simon Watkins, Jon Watmuff, Phred Petersen, RMIT, Melbourne, Australia*
- Vision-Based Target Detection and Autonomous Target Approach Control for Unmanned MAVs *Manuel Popp, Justus Seibold, Philipp Crocoll, Natalie Frietsch, Gert F. Trommer, KIT Karlsruhe, Germany*
- An Integrated Vision Aided GPS/INS Navigation System for ultra-low-cost MAVs *Felix Gathmann, Christian Dernehl, Dominik Franke, Stefan Kowalewski, RWTH Aachen University, Germany*

- A ducted fan MAV anti-torque control system *Moaad Yacoubi, Frank Buysschaert, Patrick Hendrick, Université Libre de Bruxelles, Belgium*
- Fault-tolerant Control Allocation for Multirotor Helicopters using Parametric Programming *Thomas Schneider, Automonous System Lab., ETH Zurich, Switzerland, Guillaume Ducard, University Nice Sophia Antipolis, France*
- Moving towards a UAV flight with a dynamic inversion controller and a navigation filter *Karl Kufieta, Technische Universität Braunschweig, Germany*
- Integrated Control of Quadrotor Flight Dynamics with Complementary Compensator of System Uncertainties *Aleksandar Rodić, Ivan Stojković, University of Belgrade, Serbia*

Session 2: Sensors

- Novel Marker Based Tracking Method for Position and Attitude Control of MAVs *Andreas Masselli, A. Zell, University Tuebingen, Germany*
- Visual Identification and Tracking for Vertical and Horizontal Targets in the IMAV Competition *Fu Changhong, Pascual Campoy, Jesús Pestana-Puerta, José Luis Sánchez López, Ignacio Mellado-Bataller, Universidad Politécnica de Madrid, Spain*
- Multi Disciplinary Optimization in Design of MAVs for Videography *Gaurav V. Tendolkar, K. Sudhakar, Hemendra Arya, Engineering Indian Institute of Technology, Powai Mumbai, India*

Session 3: Fuselage and Propulsion Systems

- Propulsive Analysis of High Performance Propellers for Multi-Mission MAVs *Sutthichai Kaeosutthi, Adhum Tohwae-a-yee, Chinnapat Thipyopas, Kasetsart University, Thailand*
- Electric Propulsion System Optimization for a Specific Mission with Multiple Conditions *Murat Bronz, Jean-Marc Moschetta, ISAE, France, Gautier Hattenberger, ENAC, France*

Session 4: Aerodynamics

- Pitch-plunging flat Wings in Experiments and Numerical Investigations *Thorsten J. Möller, Ralf Wokoeck, Rolf Radespiel, Technische Universität Braunschweig, Germany*
- Aerodynamic Performance of Multi-Mission Morphing Wing MAV *Aritad Choicharoon, Kwanchai Chinwicharnam, Chinnapat Thipyopas, Kasetsart University, Thailand*
- Aerodynamic Modeling of the Wing-Propeller Interaction for a Tilt-Body Micro Air Vehicle *Maxime Itasse, Jean-Marc Moschetta, Institut Supérieur de l'Aéronautique et de l'Espace, Toulouse, France*
- The Vortex Growth on a Wall of Elastic Airfoils and Effect of Relative Angle of Attack *Tomoki Kurinami, Masaki Fuchiwaki, Kazuhiro Tanaka, Kyushu Institute of Technology, Japan*
- Numerical and Experimental Analysis of Pitching and Plunging Airfoils in Hover *Hazan Hizli, D.Funda Kurtulus, Middle East Technical University, Ankara, Turkey*
- Plasma Flow Control on MAV Flying Wing Models *Berkant Göksel, C. N. Nayeri, R. Bannasch, F. Behrendt, I. Rechenberg, C. O. Paschereit, Technische Universität Berlin, Germany*

Session 5: MAV Operation

- Coactive Design for Human-MAV Team Navigation *Matthew Johnson, Institute for Human and Machine Cognition, Pensacola, FL, USA*
- City Topographies and Atmospheric Winds: Possibilities of Extending the Endurance of MAVs *Simon Watkins, Kevin Massey, Ee Wei Lim, Raj. Ladani and K. C. Wong, RMIT University, Melbourne, Australia*
- A Visual Guided Quadrotor for IMAV 2012 Indoor Autonomy Competition and Visual Control of a Quadrotor for the IMAV 2012 Indoor Dynamics Competition *Jose Luis Sanchez Lopez, Ignacio Mellado-Bataller, Jesus Pestana-Puerta, Fu Changhong, Pascual Campoy, Universidad Politecnica de Madrid, Spain*

Session 6: System Engineering

- Design and Optimisation Applied to a Multifunctional Modular MAV System *Cheng-Ming Kuo, Andreas Leber, Christian Boller, Saarland University, Saarbrücken, Germany*
- Direct Experimental Comparison of Flapping Wing and Fixed Wing Efficiency *Nikita A. Pushchin, Sergey V. Serokhvostov, Moscow Institute of Physics and Technology, Russia*
- Measuring and Analyzing the Birds Flight *Alexander Friedl, Christian J. Kähler, Universität der Bundeswehr, Munich, Germany*
- State of Progress of the Gun Launched Micro Air Vehicle *Emmanuel Roussel, Patrick Gnemmi, Sebastien Changey et al., French-German Research Institut of Saint-Louis, France*
- Bio-Inspired Design of Micro Ornithopters with Emphasis on Locust Hindwings *Ryan Randall, Rajeev Kumar, Sergey Shkarayev, University of Arizona, Tucson, USA*
- Studies of Flight Kinematics of Ornithopters *Garrett Lim, Sergey Shkarayev, University of Arizona, Tucson, USA, Zachary Goff, Philip Beran, Wright Patterson AFB, Dayton, USA*

Poster Session:

- Numerical Investigation of Flexible Flapping Wing Propulsion at Low-Reynolds Numbers *Shuanghou Deng, Wee-Beng Tay, B.W.Oudeheusden, Hester Bijl, Technology University of Delft, The Netherlands, Tianhang Xiao, Nanjing University of Aeronautics and Astronautics, PR China*
- Flight Simulation and Control of a Tailless Flapping Wing MAV near Hover *Matěj Karásek, André Preumont, Université Libre de Bruxelles, Belgium*
- Validation and Numerical Simulation Using the Immersed Boundary Method Solvers for Flapping Wing Flight *Wee-Beng Tay, Delft University of Technology, The Netherlands*
- Vortex Structure around Moving Elastic Bodies by Fluid Structure Interaction Simulation *Tetsushi Nagata, Kyushu Institute of Technology, Japan*
- Towards an Open-Source ROS-Compliant AVR Software Autopilot Platform *Marcin Kmiecik, Krzysztof Sibilski, Wroclaw University of Technology, Poland*
- Neural Model of Unsteady Aerodynamic Coefficients of MAV from Water Tunnel Test Data *Michal Garbowski, Krzysztof Sibilski, Wroclaw University of Technology, Poland*
- Auto tune PID Controller by Fuzzy Logic for Controlling Quadrotor *Iman Shirdareh, Ramin Marhamati, Islamic Azad University, Fars, Iran*

- Design and Wind Tunnel Testing of an Active Morphing Wing Ornithopter Wenbo *Duan, Haisong Ang, Nanjing University of Aeronautics and Astronautics, P.R. China*
- Micro Unmanned Vehicle as a Means for Non-Destructive Building Inspection *Cheng-Ming Kuo, C.-H. Kuo, Christian Boller, Saarland University, C.Eschmann, Fraunhofer Institute for NDT (IZFP), Germany*
- Numerical Investigation of Azarakhsh MAV *Mohammadreza Radmanesh, Mostafa Hassanalian, Sayed Amin Feghhi, Mahdi Niliahmadabadi, Isfahan University of Technology, Iran*
- A New Method for Design of Fixed Wing Micro Air Vehicle *Mostafa Hassanalian, Mahmud Ashrafizaadeh, Saeed Ziaei-Rad, Mohammadreza Radmanesh, Isfahan University of Technology, Iran*
- Sending instructions and receiving the data from MAVs using telecommunication Networks *Mostafa Hassanalian, Mohammadreza Radmanesh, Saeed Ziaei-Rad, Isfahan University of Technology, Iran*
- Computational Simulations of 3D Flapping Corrugated Wing for MAV Motivation *Ezzeddin M. Elarbi, Tripoli University, Libya*
- Experimental Investigation on Aerodynamics Loads of an Entomopter in Forward Flight – Water Tunnel Tests *Pawel Czekalowski, Krzysztof Sibilski, Wroclaw University of Technology, Poland*
- The Influence of Wing Design and Flapping Frequency on the four-dimensional Flow Pattern of a Model Wing at Bird Scale *William Thielicke, Eize J. Stammhuis, University of Groningen, The Netherlands, Antonia B. Kesel, University of Applied Sciences Bremen, Germany*
- Design and Test of an Autonomous Tiltwing MAV *Ingo Martin, Torben Klougt, Niklas Schreiber, W. Rottner, Dieter Moormann, RWTH Aachen University, Germany*
- Onboard flight parameters registration system *Vitaly Kobtsev, Sergey Levin, Sergey Serokhvostov, Nikita Ageev, Moscow Institute of Physics and Technology, Russia*

The Flight Competition was organized by the following rules:

Outdoor Competition

It was held at Gifhorn-Wilsche Glider Field, approx. 30 km north of Braunschweig.

Figure 1. The AKAMAV, MAVerix and the WildCats team machines start[1]

1. Outdoor dynamics competition

The main idea of the outdoor flight dynamics competition was to demonstrate the progress of MAV design relating to high dynamics with precise navigation at the same time.

[1] Pictures were made by authors

The course comprised two arches (shown in fig. 2.) in an L-type placement with spacing of 50 m. From the starting point the MAV passes through the arches A and B, performs a 180° turn, flies back through the arches (B, A) turns and starts the course again until a flight duration of 4 minutes has been reached. Each fully completed sequence (AB or BA) results in 4 points for the mission score M. If only one arch had been passed during the sequence 1 point was rewarded.

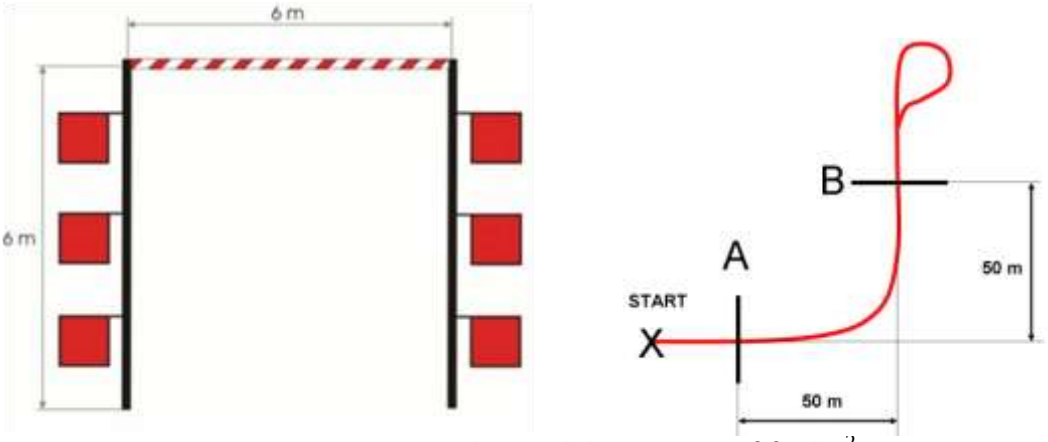

Figure 2. Arches and dimensions of flight [2]

The allowed flying time was 4 minutes. Each team was given the chance to fly twice. The better score was counted. The second flight was in the same sequence as in the first round.

2. Outdoor autonomy competition

During the outdoor autonomy competition, which was open for all categories of MAV (separate valuation), the MAV had to identify a horizontal and vertical target, which were placed outside of the operator's range of sight, fly through one arch, drop a ball at a certain point and land in a predefined area.

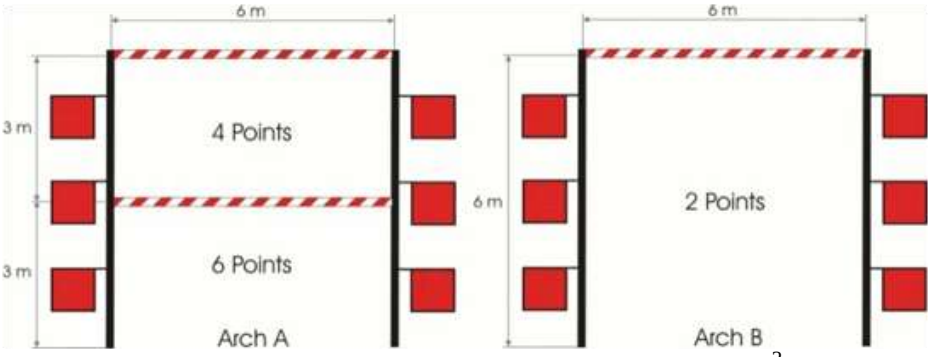

Figure 3. Outdoor arch (autonomy competition) [3]

The MAV took off from the airfield, passed the airfield buildings and headed toward the first target area. In this area two optical targets had to be identified. Once these targets had been identified, the MAV proceeded with flying through Arch A or Arch B. Figure 3 shows the two arches and the mission points for the different gaps. Only one passing counted. The positions of the arches were defined by WGS84 coordinates. Subsequently the MAV flown to the drop zone, where it dropped a ball which is shown in fig. 5. Finally the MAV should be landed in a pre-defined area on the airfield.

Vertical and horizontal targets consisted of printed numbers or letters which were placed in the target area (black on white background, approx. 0,8 m, Arial). A clear image of each

[2] http://www.imav2012.org/3.0.html
[3] http://www.imav2012.org/3.0.html

target resulted in 2 points for the mission score M. For all teams the detected horizontal target was important for the position of the ball drop. For teams with automated flight controls the number was stand for a missing coordinate. For teams with video based controls the letter was standing for the position where to drop the ball. This position was visible from the air.

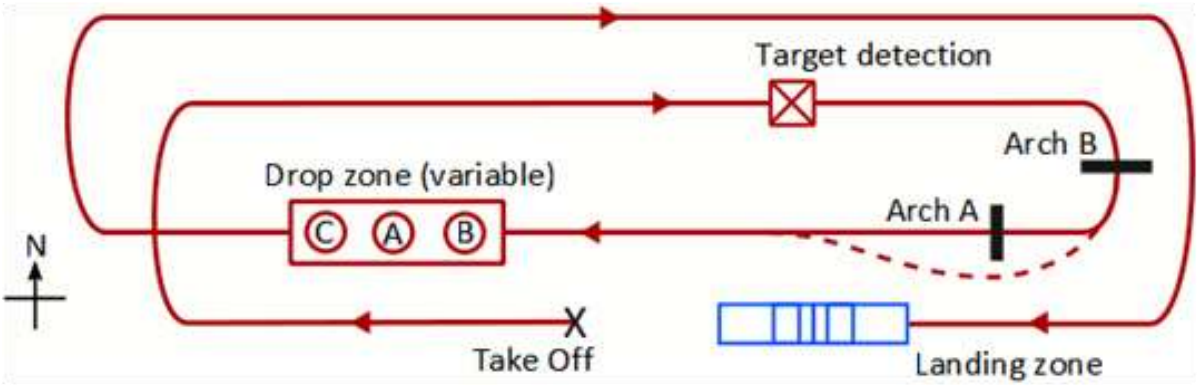

Figure 4. Outdoor mission [4]

The landing zone comprised five fields with 1, 2 or 3 points and is shown with scales in fig. 5. The corners were defined by WGS84 coordinates. The approach to this zone was made from the West or the East (see figure 4.). Landing outside this zone resulted in 0 points. The landing zones were marked by clearly visible cones. The aircraft that was used for landing also had to be used for at least one other task. The allowed flying time was 10 minutes.

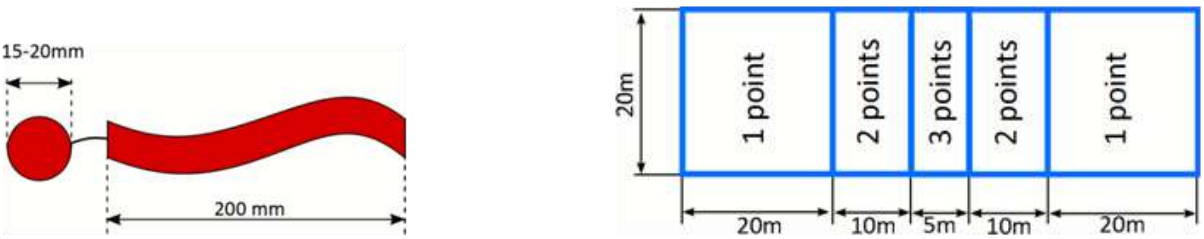

Figure 5. Sketch of ball for the dropping task and scores by dimensions of landing field[5]

The scores for the outdoor mission competition were defined according to the following table:

	Mission score points
automatic take-off	2
identifying horizontal target	2
identifying vertical target	2
passing arch	2, 4 or 6
dropping ball	1, 2 or 3
landing in predefined zones	1, 2 or 3
Maximum score	18

Table 1. Mission score points[6]

[4] http://www.imav2012.org/3.0.html
[5] http://www.imav2012.org/3.0.html
[6] http://www.imav2012.org/3.0.html

Figure 6. The "maximum height" story in pictures[7]

Indoor competition

1. a. Indoor dynamics competition

The indoor flight dynamics competition was open for all categories of MAV and there was a separate valuation for each category.

The MAV took off close to two posts and flown around these two posts in a vertical 8-shape trajectory (fig. 7) as often as possible for duration of 3 minutes time. The distance between the two posts was amounts to 8 m. The height of the posts was 2 m. The horizontal trajectory was a 3 m wide path. The classification was done by a barrier tube on each side of the path.

Each fully completed figure eight in between the barrier resulted in 2 points for the mission score M. An extra 2 score points was rewarded once for showing dynamic manoeuvres such as a looping or a 360° roll. These points were only given if at least one complete figure had been flown. The allowed flying time was 3 minutes. Each team was given the chance to fly twice. The better score was counted. The second flight time was in the same sequence as in the first round.

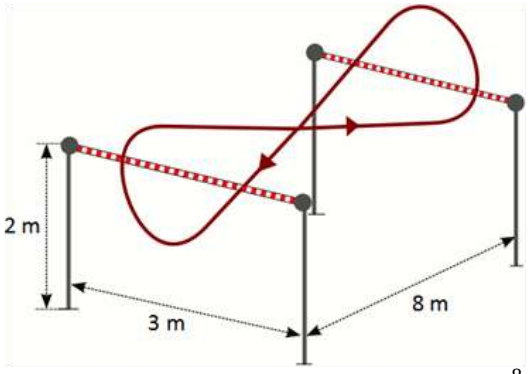

Figure 7. Indoor dynamics competition[8]

2. Indoor autonomy competition

The main goal of this competition was to demonstrate the MAV's capabilities of fulfilling a sophisticated mission including operation inside a small building with a covered ceiling. A video transmission from the MAV to a ground station was required for this mission.

The mission started at point 1 behind a wall with a height of 2,5 m prevented the operator from seeing the MAV on the mission. Having overcome the wall, the MAV approached the door (point 2). After entered the building, the MAV had to identify two targets (printed letters/numbers, font size 700, Arial, point 3), one of them was placed on one of the building's inner walls (vertical target), the other on was placed on the floor (horizontal target). The MAV left the building vertically through a tilted chimney (point 4) and hovered for at least 10 seconds above the building before it landed on the top of the roof (point 5). After

[7] Pictures were made by authors

[8] http://www.imav2012.org/3.0.html

another 10 seconds the MAV flown to point 6 and picked up an object weighted about 20 g (which is shown in Fig. 8). With this object the MAV had to fly through the gate (point 7) and had to release the object in the defined release zone (point 8).

Figure 8. The most challenging indoor racing venue - and lightest vehicles[9]

The mission ended at the moving landing zone at point 9. The platform moved slowly in a circular shape. An alternative, stationary landing platform was provided. Both platforms were marked with a black cross (0,2 m).

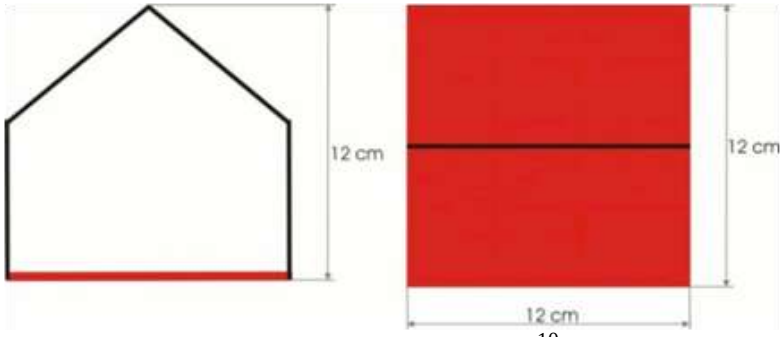

Figure 9. Pick-up object[10]

Depending on the MAV's capabilities, the mission could be simplified at two critical points. Instead of starting the mission behind the wall, the operator could stand in front of the wall and start from point 1*. Furthermore, the building could be left through a window instead of the way through the tilted chimney (point 4*). The maximum flying time was 10 minutes.

	dimensions
building:	4m x 3m x 3m (L x W x H), covered ceiling
wall:	2.5m (H)
gate:	2m (H)
door:	2m x 1.5m (H x W)
windows:	1.5m x 1.5m (H x W)
chimney:	1m (diameter), tilted 15° in direction to the door
landing platform:	1m (diameter)

Table 2. Dimensions of objects for indoor mission[11]

[9] Pictures were made by authors
[10] http://www.imav2012.org/3.0.html
[11] http://www.imav2012.org/3.0.html

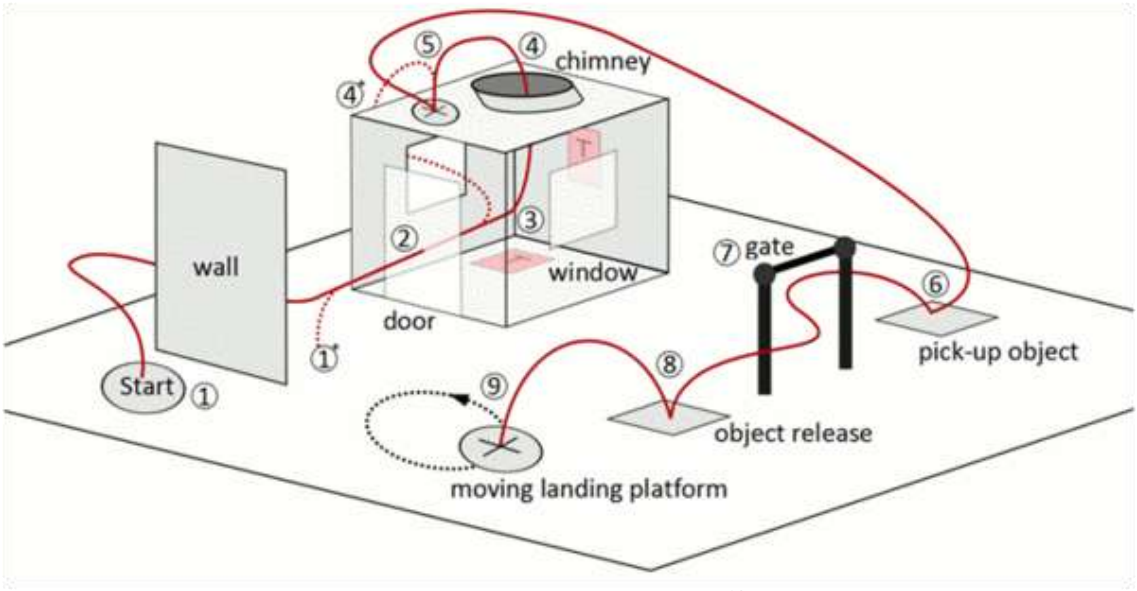

Figure 10. Indoor mission[12]

THE IMAV 2012 RESULTS AND LEARNED LESSONS

The conference and the competition proved to be an ideal meeting [2]. Each team had a lot of supporter. A very high technical standard was made - for each team. A large number of theoretical works demonstrated a specific interest in the MAV technology. The models - if they were not always perfect - have demonstrated their builder's creative enthusiasm. The winners proved with the highest knowledge, but the rest of the participants performed well too.

Overall Results	The Winners Team
Indoor Competition - Overall	AKAFlieg
Outdoor Competition - Overall	Azakarash
Best Automatic Performance - IMAV 2012	CVG - UPM
Most Innovative MAV design	MAVerix

Table 3. The results of competitions[13]

One of the most impressive teams was AKAFlieg from Bremen. Their performances were outstanding and professional at all. The team was composed of Dr.-Ing. Klaus-Peter Neitzke aerospace engineer and PhD student William Thielicke. They were successful competitors in three previous MAV tournaments too. They represented two generations, which luckily met a wealth of experience and youthful temperament. They both have the confidence flew helicopters, which were controlled and stabilized by own developed electronics. The data and image transmission system worked flawlessly - which means not all other teams have been achieved.

[12] http://www.imav2012.org/3.0.html
[13] http://www.imav2012.org/52.0.html

Figure 11. The Bremen's "musical instruments" [14]

The conference "lecture series - parallel poster - lecture series" system was successful. So that everyone could participate in the lectures and met the chance to speak presenters in break time.

In four days, this is an excellent opportunity opened. The experienced hosts "loose" programs were organized. This is the fifth such conference - and of course, the financial possibilities of the sponsors were also favourable background. The Volkswagen Halle free of charge for the duration of the conference was available.

The authors would also express their appreciation to the organizers of the conference and participants for a great performance. The examples and lessons learned can serve to better organize our own research, both theoretical and practical preparation for following MAV events.

References

[1] IMAV 2012 Proceedings ISSN 2191 – 8376 Deutsche Gesellschaft für Ortung und Navigation e.V. (DGON) German Institute of Navigation- Kölnstrasse 70 D-53111 Bonn

[2] http://www.imav2012.org/52.0.html (04.14.2013.)

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14 Pictures were made by authors