INCEEUROPE

CidB
Centre d'information sur le Bruit

A Symposium on Noise from UASs/UAVs and eVTOLs

QUIET DRONES

19 – 21 October 2020

Paris, France

an e-Symposium

PROGRAM BOOK

Updated 18th October 2020

Supporting Organisations

This Symposium is organised by INCE/Europe in association with CidB.

It is supported by the
International Institute of Noise Control Engineering
and is endorsed by the
International Commission for Acoustics
and as such it is one of the events in the
International Year of Sound

In France it is supported by
the **Ministry for the Ecological Transition,**
the **French Directorate-General for Civil Aviation (DGAC)**
the **French Aerospace Lab (ONERA)** and
the **French Airport Pollution Control Authority (ACNUSA).**

Sponsoring companies :

To register: www.quietdrones.org

CONTENTS

Click the section text to go to that section

- **Full Papers are available online for registered delegates**
- **Proceedings of the Symposium can be purchased after the Symposium and will contain the Brochure and the Full Papers**

Welcome

Welcome

Enormous progress has been made on drone technologies in the last decade and the number of professional drones is increasing dramatically and is now much higher than the number of conventional aircraft.

Safety, security and privacy have controlled the development of drones up to now, but noise has become an issue in residential areas and environmentally sensitive areas such as National Parks. On the other hand, silent machines represent a problem for privacy and security.

The Symposium will provide a venue for researchers on drone noise to meet with manufacturers, users and those engaged in designing innovative applications for this new technology

Because of COVID-19 the Symposium will be held as an e-Symposium.

This Symposium will last 3 days and will be live for 4 or 5 hours a day with invited presentations, panel discussions and informal conversations. For the rest of the day other material will be available. Most will be available on demand such as exhibitor's material, recordings of earlier sessions and cultural tours of Paris.

Jean Tourret / Dick Bowdler

Committees

Organising Committee
Jean Tourret (President INCE/Europe) – Co-Chair
Dick Bowdler (Director INCE/Europe) – Co-Chair
Laurent Droin (Director CidB)
Geoff Leventhall (Director INCE/Europe)
Philippe Strauss (Technical Journalist CidB)
Cathy Mackenzie (INCE/Europe) Administration

Advisory Committee
Marion Burgess (President I-INCE) – Australia
Natalie Commeau (Ministry of the Environment) – France
Carine Donzel (Conseil des Drones Civils – DGAC) – France
Guillaume Inquiété (Airbus Helicopters) – France
George Maling (Managing director emeritus INCE-USA and NAE) – USA
Joachim Scheuren (Müller BBM) – Germany
Xin Zhang (Hong Kong SAR) – China

Technical Committee
Roalt Aalmoes (NLR) – The Netherlands
Nathan Alexander (Virginia Tech) – USA
Julien Caillet (Airbus-Helicopters) – France
Jean-Baptiste Chéné (CSTB) – France
Andrew Christian (NASA) – USA
Franck Cléro (ONERA) – France
Patricia Davies (I-INCE V-President Technical Activities) – USA
Xavier Falourd (Prona AG) – Switzerland
Robert D Hellweg (Technology for a Quieter America Steering Committee) – USA
Michaela Herr (DLR) – Germany
Jean Jacques (European Commission noise standardization consultant) – France
Lucille Lamotte (MicrodB) – France
Antonio J Torija Martinez (Acoustics Research Centre, University of Salford) – UK
Andy McKenzie (Hayes McKenzie Partnership) – UK
Tiziano Pagliaroli (Universita Niccolo Cusano) – Italy
Mirjam Snellen (TU Delft) – The Netherlands
Serguei Timushev (Moscow Aviation Institute – NRU) Russia

Programme

OVERALL PROGRAMME

The programme for the symposium will consist of an opening session (Session 1) and nine more technical sessions at which authors will make presentations. At the end of Sessions 2 to 9 there will be a discussion centred round the session topic at which authors will be encouraged to take part. They will each last for one and a half to two and a half hours.

The Opening Session will consist of introductions from INCE Europe, CIDB, International INCE and Year of Sound. After that there will be three key presentations. We are keen that delegates from all time zones will be able to view the opening session before they see the rest of the symposium and with that in mind the whole session will be recorded so that, as well as being available from the symposium opening at 09:00 on Monday it will also be available to delegates in the Americas between 18:00 and 20:00 on Sunday evening.

There will also be "Conversation" sessions which will be informal and where you are invited to join in the conversation on a particular topic with the leaders of the conversation.

Sunday 18th October

18:00 - Prepeat of Opening Session for Delegates in the Americas

Monday 19th October

09:00 - ***Session 1*** - Opening Session
11:30 - *Conversation* - Come and meet the other delegates – 1 - Jean Tourret and Dick Bowdler
14:30 - *Conversation* - Come and meet the other delegates - 2 - Jean Tourret and Dick Bowdler
16:00 - ***Session 2*** - Assessing Noise and its Impact on People and Environment **16:00** - ***Session 7*** - Acoustic Detection and Identification of Drones

Tuesday 20th October

09:00 - ***Session 3*** - Specific Noise concerns with packages and deliveries
09:00 - ***Session 8*** - Drone Audition - Listening with Drones
11:30 - *Conversation* - Mirjam and Roalt brainstorm about Drones – Mirjam Snellen and Roalt Aalmoes
14:30 - ***Conversation*** - Nathan and Andy's Drone Noise Listening Party - Andrew Christian and Nathan Green
16:00 - ***Session 4*** - Standardisation and Regulations

Wednesday 21st October

09:00 - ***Session 5*** - The impact of urban air mobility
09:00 - ***Session 9*** - Noise generation and mitigation - 1
11:30 - ***Conversation*** - What's the use of a remote conference? - Andy McKenzie and Dick Bowdler
14:00 - ***Session 6*** - Tools for measurement, analysis, prediction and control
16:00 - ***Session 10*** - Noise generation and mitigation - 2

SESSION 1 : OPENING SESSIONS

Sunday 18th October 18h00-19h30 and Monday 19th October 09h00-10h30

***Welcome Address:** INCE-Europe, CIDB, International-INCE and International Year of Sound*

Introductory Lectures:

A summary of the 2018 Workshop on UAS and UAV Noise Emissions and Noise Control Engineering Technology in Washington, DC, National Academy of Engineering.	Robert Hellweg (Technology for a Quieter America Workshop Steering Committee)	USA
Will Noise become a new Hurdle which could impair the development of Drones	Carine Donzel (DGAC) and Henry de Plinval (ONERA)	FRANCE
Drone Noise, a new public health challenge?	Antonio Torija Martinez (University of Salford)	GREAT BRITAIN

SESSION 2 : Assessing Noise and Noise Impact on People and Environment

Monday 19th October 16h00-18h00 (session in parallel with session 7)

Session chaired by : Patricia Davies (Purdue University, USA)
Dick Bowdler (Ince-Europe, GB)

European Union legislation on managing noise from drones and e-VTOL	**Marco Paviotti** (European Commission)	EUROPE
Multi-rotor powered drone noise assessment	**Xin Zhang** (Hong Kong University of Science & Technology)	CHINA
Aeroacoustic measurements on a free-flying drone in a WindShaper wind tunnel	**Roberto Putzu** (Univ. Applied Science Geneva)	SWITZER-LAND
Assessment of environmental noise characteristics of innovative aerial vehicles	**Raphael Hallez** (Siemens Digital Industries Software)	BELGIUM
Towards the Incorporation of Auditory Masking Effects into Assessments of Community Noise	**Andrew Christian** (NASA Langley Research Center)	USA
Methods for Providing Design Guidance to Improve Drone Sound using Community Input	**David Bowen** (Acentech)	USA
A whole-systems approach to building knowledge about human reaction to drones	**Charlotte Clark** (ARUP)	GREAT BRITAIN

Discussion : *Is the impact of drone noise on people different from other noise?*

SESSION 3 : Specific Noise Concerns with Packages and deliveries

Tuesday 20th October 09h00-11h00 (session in parallel with session 8)

Session chaired by : Marion Burgess (UNSW, Australia)
Andy McKenzie (Hayes McKenzie, GB)

Drone delivery and noise regulation in the Australian context	**Marion Burgess** (UNSW)	AUSTRALIA
Delivery Drones at La Poste	**Philippe Cassan** (DPD group / La Poste)	FRANCE
Commercial Delivery Drone Routing: A Case Study of Noise Impacts	**Eddie Duncan** (RSG)	USA
Acceptance of drone delivery is limited (not only) by noise concerns	**Hinnerk Eißfeldt** (DLR German Aerospace Center)	GERMANY

Discussion (with the participation of Wing Australia): ***Does the Impact on people depend on what is being delivered?***

SESSION 4 : Standardisation and Regulations

Tuesday 20th October 16h00-17h30

Session chaired by : Christopher Roof (US Departement of Transport / VOLPE, USA)
Jean Tourret (Ince-Europe, France)

Research to Support New Entrants to Public Airspace and Aircraft Noise Certification	David Read / Christopher Roof (U.S. Department of Transportation / Volpe)	USA
EU Drone Regulation	Nicolas Eertmans (European commission)	EUROPE
ANSI/ASA Standards Activity on Measurement of UAS Noise	Robert Hellweg (Hellweg Acoustics)	USA
Noise requirements of Unmanned Aircraft due to European Regulation 2019/945	Michael Wieland (UAV DACH e.V)	GERMANY
Noise pollution must be approached with as much attention as the issue of safety	Francis Truchetet (ACNUSA)	FRANCE

Discussion : ***Should noise from drones be regulated at the European level?***

SESSION 5 : The Impact of Urban Air Mobility

Wednesday 21st October 09h00-11h00 (session in parallel with session 9)

Session chaired by : Roalt Aalmoes (Royal Netherlands Aerospace Centre NLR)
Franck Cléro (ONERA, France)

Recommendations for research on the Noise impact of drones in an urban environment	Roalt Aalmoes (Royal Netherlands Aerospace Centre NLR)	NETHER-LANDS
MOSQUITO Project : a fast estimation approach for urban acoustic environment	Franck Cléro (ONERA / DAAA)	FRANCE
From Helicopters to quiet eVTOLs : A manufacturer's perspective	Julien Caillet (Airbus Helicopters)	FRANCE
Noise considerations for designing Skyport Networks	Rohit Goyal (Uber Elevates)	USA
Achieving quiet flying passenger vehicles through numerical simulations, a LBM story	Wouter van der Velden (Dassault Systems)	GERMANY
Assessment of the environmental impact of drone noise in virtual flights	Siyang Zhong (Hong Kong University of Science & Technology)	CHINA

Discussion : *Vehicle technologies, UAM operations*

INCE EUROPE CidB Centre d'information sur le Bruit

SESSION 6 : Tools for Measurement, Analysis, Prediction and Control

Wednesday 21st October 14h00

Session chaired by : David Herrin (University of Kentucky, USA)
François-Xavier Bécot (Matelys, France)

Sound Localisation of Drones using an Acoustic Camera	Pablo Alloza (GFAI Tech GmbH)	GERMANY
Scanning Laser Vibrometer measurements for assessing the origin of structure borne sound in drones	Florent Deux (Polytech France)	FRANCE
UAS Sound Level Prediction using Panel Contribution Analysis	David W. Herrin (University of Kentucky)	USA
Active Noise Cancellation of Drone Propeller Noise through Waveform Approximation and Pitch-Shifting	Ashwin Ashok (Georgia State University)	USA
Exploring Noise reduction for fixed wings UAV	Michael J. Kingan (University of Auckland)	NEW ZEALAND

SESSION 7 : Acoustic Detection and Identification of Drones

Monday 19th October 16h00-18h00 (session in parallel with session 2)

Session chaired by : Lucille Pinel-Lamotte (MicrodB, France)
Martin Blass (Joanneum Research Forschungsgesellschaft, Austria)

Introduction Anti-Drone Solutions	Lucas Le Bell (Cerbair)	FRANCE
UAV detection from acoustic signature: requirements and state of the art	Lucille Pinel-Lamotte (MicrodB)	FRANCE
A Real-Time System for Joint Acoustic Detection and Localization of UAVs	Martin Blass (Joanneum Research Forschungsgesellschaft)	AUSTRIA
Flight path tracking and acoustic signature separation of swarm quadcopter drones using microphone array measurements	Gert Herold (Technische Universität Berlin)	GERMANY
UAV's localization from a microphone array by exploiting the harmonic structure of the sound produced	Torea Blanchard (LAUM / Le Mans University)	FRANCE
Two Dimensional Convolutional Neural Network Frameworks Using Acoustic Nodes for UAV Security Applications	Theoktisti Marinopoulou (Centre for Research and Technology Hellas / Information Technologies Institute - CERTH/ITI)	GREECE

Discussion: *Drone localisation and identification*

SESSION 8 : Drone Audition - Listening to Drones

Tuesday 20th October 09h00-11h00 (session in parallel with session 3)

Session chaired by : Antoine Deleforge (INRIA, France)
Makoto Kumon (Kumamoto University, Japon)

Drone Audition for Search and Rescue: Datasets and Challenges	Antoine Deleforge (INRIA Nancy)	FRANCE
Development of surface-processed low-noise propeller for search and rescue tasks with drone audition	Kotaro Hoshiba (Kanagawa University)	JAPAN
Proposal of Cognitive Drone Audition based on Cognitive Dynamic Systems	Hiroshi Okuno (Waseda University)	JAPAN
3D Sound Source Tracking for Drones Using Direction Likelihood Integration	Taiki Yamada (Tokyo Institute of Technology)	JAPAN
Signal-to-Noise Ratio Enhancement Method for Improving Sound Source Detection of Drone-mounted Phased Microphone Array	Yeong-Ju Go (Chungnam National University)	SOUTH COREA
Advances in Sound and Speech Signal Processing at the Presence of Drones	Oliver Jokisch (Leipzig University of Telecommunications)	GERMANY

SESSION 9 : Noise Generation and Mitigation - 1

Wednesday 21st October 09h00-11h00 (session in parallel with session 5)

Session chaired by : Young-Min Shim (Dotterel Technologies, New-Zealand)
Julien Caillet (Airbus Helicopters, France)

Aeroacoustic study of small propellers with Serrated Trailing Edge for a quieter drone	Paolo Candeloro (UniCusano)	ITALY
Interpolation based acoustic transfer function for drone noise simulation	Hanbo Jiang (Hong Kong University of Science & Technology)	CHINA
Experimental Investigation of Contra-Rotating multi-rotor UAV Propeller noise	Ryan S. McKay (Dotterel Technologies)	NEW ZEALAND
Multi-scale morphological effect on noise level and frequency characteristics of drone propellers	Ryusuke Noda (Kyoto University)	JAPAN
Drone Noise and the Influence of Support Structure	Simon Watkins (RMIT)	AUSTRIA
Experimental Investigation of Noise Characteristics of Rotors	Koichi Yonezawa (Central Research Inst. of Electric Power Industry)	JAPAN

Discussion: ***Blades optimization, rotor/structure interaction, multirotors***

INCEEUROPE CidB Centre d'information sur le Bruit

SESSION 10 : Noise Generation and Mitigation - Part 2

Wednesday 21 October 16h00-18h00

Session chaired by : Tiziano Pagliaroli (UniCusano, Italy)
Julio Cordioli (University of Florianopolis, Brazil)

Experiments on UAV rotor noise at low Reynolds and low Mach numbers	Hélène Parisot-Dupuis (ISAE-SUPAERO / Toulouse)	FRANCE
The Sound of the Drone Uprising' An Exploration into the Aero-acoustic Performance of Drone Blades	Josephine Nixon (London South Bank University)	GREAT BRITAIN
Experimental Investigation on Acoustics and Efficiency of Ducted Electric Rotors	Ronja Koenig (Robert Bosch GmbH)	GERMANY
On the design of acoustic liners for drone ducted fans	Julio Cordioli (University of Florianopolis)	BRAZIL
Chaotic and wavelet aeroacoustic analysis of twin rotors for drone propulsion	Tiziano Pagliaroli (UniCusano)	ITALY
CFD-CAA approach for sound generation and propagation in the UAV propeller with subsonic flow	Sergei Timushev (Moscow Aviation Institute)	RUSSIA

Discussion: ***Blades optimization, rotor/structure interaction, multirotors***

Virtual Exhibition

Laser Vibrometry

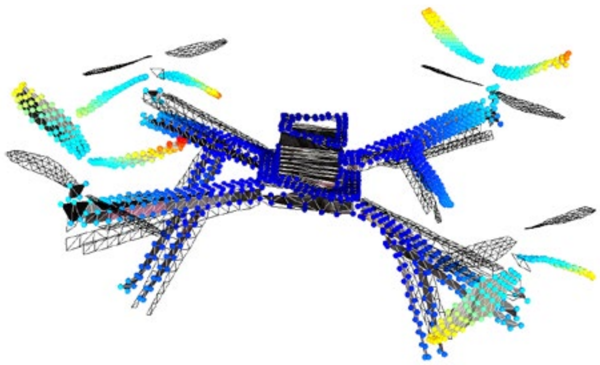
Polytec

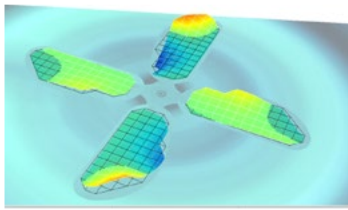
Optical vibration measurements

50 years of innovation, performance and quality ensures Polytec's continued role as the leading supplier of optical, non-contact vibration measurement solutions. The company manufactures a wide range of laser vibrometers that have become the accepted gold standard for non-contact vibration measurement.

From rotational laser vibrometers to full-field vibrometers, they easily master challenging conditions like measuring on hot surfaces or rotating parts, and characterize complex and sensitive structures even in the ultrasonic frequency range. Vibrometers from Polytec help to solve your measurement task fast, reactionless and precise.

Whether the application is for 100% quality inspection on a production line, optimizing the design of a propeller, confirming the characteristics of electronic boards or identifying torsional modes of body drones, there is a Polytec system that can provide the measurement solution.





Polytec France
99 rue Pierre Semard
Technosud II - Batiment A
92320 Chatillon

info@polytec.fr
+33 1 49 65 69 00

www.polytec.fr

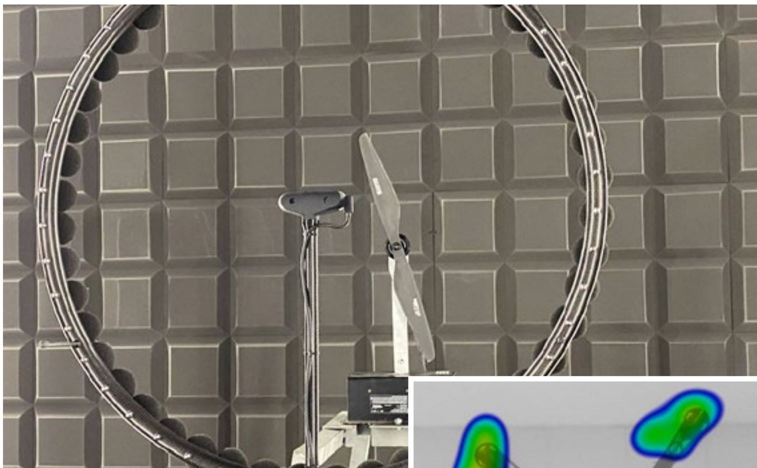
The Acoustic Camera
The Original.

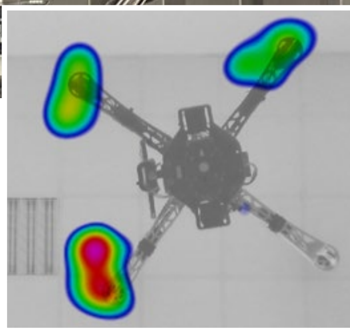
The innovative way to localize sound sources !

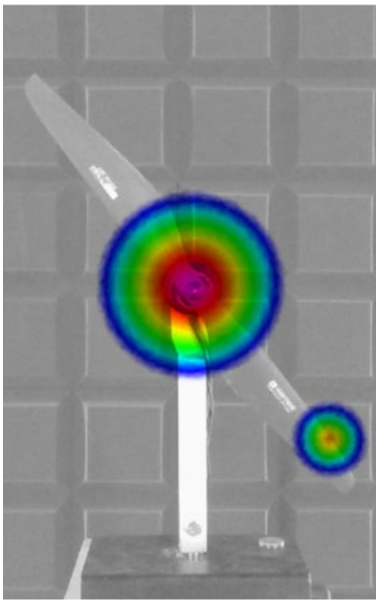
The Acoustic Camera of gfai tech GmbH was the first commercially viable system for the visual localization of sound sources. Launched in 2001 as a pioneer technique, the Acoustic Camera has conquered the markets worldwide for numerous applications in different industries.

In the field of UAVs, there are almost no limits to possible applications of sound source localization. From the measurement and quick and easy identification of sound sources on rotating objects like propellers to the visualization of a complete acoustic fingerprint during a drone passby - the Acoustic Camera is the perfect solution for your application.

The results can be used to quickly influence the design and used components already in the development process in order to generate a virtually sound-emission-free flight feeling.







gfai tech

gfai tech GmbH
Volmerstr. 3
12489 Berlin, Germany
info@gfaitech.de
+49 30 814563 750

www.acoustic-camera.com

DOTTEREL

Eyes and ears in the sky from a UAV

Respond faster and reduce risk with full two-way conversations via UAV

- Listen and speak directly from the air into hard to reach or dangerous locations without other communication infrastructure
- Improve situational awareness by monitoring audio from incidents and hazards safely at a distance
- Microphone and speaker payload designed for integration on suitable UAVs with 600g or greater payload capacity
- Unique adjustable microphone beamwidth focusses on a target and isolates off-axis noise, allowing you to hear a wide area or talk with individuals

Dotterel are global leaders in UAV acoustics and have developed patented solutions for reducing the noise of UAVs and unique aerial audio microphones. Both solutions are focused on application in the entertainment, emergency services and government sectors.

Arrange to hear a demo by visiting:

www.dotterel.com

Applications for one and two-way audio

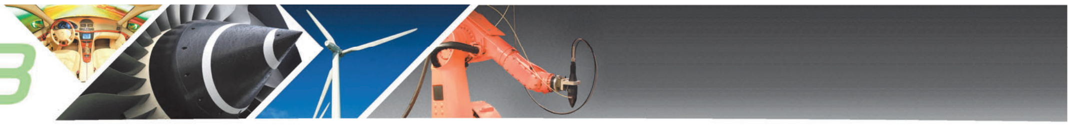
- Communication in difficult to access areas or loss of communications infrastructure
- Search and rescue
- Perimeter and border security
- Urban crowd engagement
- Improved situation awareness with audio

Film/TV | Defence | Emergency

Functional capability

- Operating distance 5–20m for two-way audio.
- One-way audio detection and loudspeaker operate at increased distances depending on source and environment
- Adjustable beamwidth rejects off-axis noise with additional audio filtering to remove rotor noise
- Mounting kit for DJI Matrice™ 210 v2 with additional mounting kits in development

MicrodB



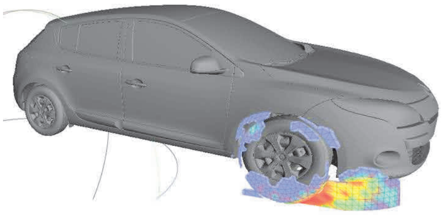
Expertise in sound source identification

Sound source identification serves in many fields:

✓ **Transportation, for noise comfort**

- *Interior noise localization*
- *Sound power quantification*
- *TL qualification*

✓ **Environment, for noise reduction**



- *Exterior noise emission,*
- *Pass-by noise,*
- *Source ranking*

✓ **Security & quality, for source detection**

- *UAV detection/classification*
- *End Of Line quality control*

MicrodB meets all technological challenges with its 35 years of innovation.

MicrodB's expertise is integrated in industrial solutions:

✓ **Software solutions**

Software offers a large panel of algorithms resulting in different output depending on your objective: detection, separation, localization, quantification, classification, etc

✓ **Related hardware development**

Different microphone distributions and technologies fit the environment and source distribution, to be scaled to your budget.

✓ **High added-value services**

Together with local academic and industrial partnerships in electronics and signal processing, MicrodB's team can specify, design and manufacture customized and scalable solutions to comply with your requirements.

VibraTec
Studies & diagnoses
Tel: + 33 (0)4 72 86 65 65
vibratec@vibratec.fr
www.vibratecgroup.com

MicrodB
Acoustic source identification & quantification
Tel: + 33 (0)4 72 18 01 00
contact@microdb.fr
www.microdb.vibratecgroup.com

VibraTeam
On-site technical assistance
Tel: + 33 (0)4 72 18 04 70
vibrateam@vibrateam.fr
www.vibratecgroup.com/vibrateam

ABOUT CS GROUP

> Digitize, enhance & secure your information & communication systems to increase the efficiency of your operations & critical missions.

OUR STRENGHTS

- **A dual competence :** technical information systems and customer businesses, a network of technical and business experts.
- **An engineering and software integration capacity** & secure critical systems.
- **Covering the entire value chain :** from systems design to operations support.
- **Innovative** products and solutions.

OUR VALUES

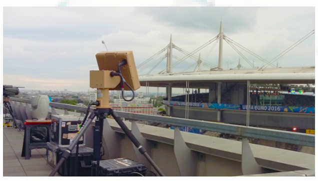
- An **entrepreneurial** culture combining the agility and responsiveness of a human-sized company with the rigor of the highest standards.
- The power of **innovation** at the service of the digitization of our customers' operational systems.
- The development of **our talents** through our channels of excellence.
- Caring & participative **management**.

COUNTER DRONE SOLUTION

BOREADES

While the number of commercial drones is dramatically increasing nowadays, their illicit and dangerous use can cause many issues such as: event perturbation or area infringement, intelligence, smuggling, and even targeted attacks.

BOREADES is the first French counter-drone integrated system. It has been designed and built by CS GROUP to protect critical assets against small drones. Its very high performances, obtained through multi sensors and effectors integration, enables detection, identification and neutralization of rogue drone.



Other Information

"UAS and UAV (Drone) Noise Emissions and Noise Control Engineering Technology"

National Academy of Engineering Workshop
Washington DC, Dec. 13-14, 2018.

organized by the INCE Foundation in cooperation with the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA).

Engineering a Quieter America

UAS and UAV (Drone) Noise Emissions and Noise Control Engineering Technology

---

Workshop Final Report

A workshop organized by

The INCE Foundation in Cooperation with NASA and FAA

hosted by

The National Academy of Engineering, Washington, DC
December 13 – 14, 2018

Tamar Nordenberg, rapporteur

edited by

Adnan Akay, Gregg G. Fleming, Robert D. Hellweg, George C. Maling, Jr., and Eric W. Wood

INCE USA

Institute of Noise Control Engineering of the USA

- **Report now available on https://www.inceusa.org/pub**

INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH
an Open Access Journal by MDPI

Special Issue on
Drone Noise: A New Public Health Challenge

Guest Editor:
Dr. Antonio J. Torija
Acoustics Research Centre, University of Salford,
Manchester M5 4WT, UK
A.J.TorijaMartinez@salford.ac.uk

Message from the Guest Editor

The use of unmanned aerial vehicles (UAVs) can bring substantial economic, environmental and societal benefits, but at the same time, the noise generated by these technologies can significantly affect the health and wellbeing of populations both in urban and rural locations. If not appropriately addressed, noise issues might put at risk the expansion of the UAV sector.

This Special Issue seeks research papers on various aspects of UAV noise. We encourage the submission of manuscripts that focus on, but are not limited to, the following topics:

- UAV noise perception and detection;
- Experimental and modeling approaches, e.g. auralisation;
- Effects of UAV noise on human health and wellbeing;
- UAV noise in rural environments and impact on wildlife;
- Impact of UAV noise on urban and rural soundscapes;
- Audio–visual interactions in UAV noise perception;
- Specific noise concerns with UAV operations for package and good deliveries;
- Policy and legislation.

Deadline for manuscript submissions:
15 November 2020*

If you have any questions, please do not hesitate to contact the guest editor (A.J.TorijaMartinez@salford.ac.uk) or Cici Zhou (cici.zhou@mdpi.com) from the IJERPH Editorial Office for further information.

For further information or submit an abstract/full paper please go to:
https://www.mdpi.com/journal/ijerph/special_issues/drone_noise

*Deadline can be extended depending on requests for submission. If you are interested in contributing to this Special Issue but will struggle with the deadline, please contact the guess editor as soon as possible.

e-Forum Acusticum 2020

Dec 7-11, 2020

The organizing committee is pleased to invite you to attend to the **e-FORUM ACUSTICUM 2020 .**

5 days of conferences in the field of Acoustics & Vibrations : regulations, standardization, theory, modeling, experiments, manufacturing … structured in **100+ sessions gathering 850+ conferences**.

Dedicated sessions to

UAV noise (noise sources, perception and detection), **Aircraft and airport noise**, Computational **aeroacoustics**, **Flow-induced** noise and vibration, **Measurement** issues in aeroacoustics, **Electro-Acoustics** (MEMS, microphones, sensors arrays) …

Technical program, information, registration (150 / 100 / 50 €) :

https://fa2020.universite-lyon.fr/

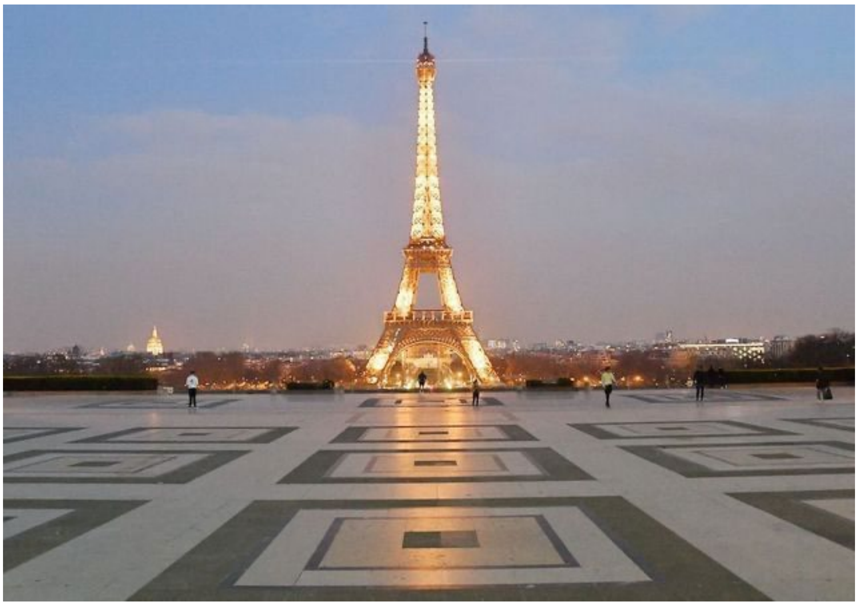
European Acoustics Association

Société Française d’Acoustique

Discover Paris

(re) Discover Paris

You missed Quiet Drones this May… and stayed “locked down” at home.
In the meantime, Paris was waiting for you during lock-down - very silently:



The Eiffel Tower seen from the deserted Trocadero

The empty court Napoleon of the Louvre Museum with the Pyramid

The Avenue des Champs Élysées with the Arc de Triomphe and the Arche de la Défense in the distance. On the first block on the right, the rue de Berri where QD 2020 was to take place in May

The Place du Tertre in Montmartre without the artists

As you won't be with us this October either, we want to enable you to discover (or rediscover) some tastes of Paris (locations, museums, exhibits) that coronavirus prevented to sight this year.

Discover Paris

- Paris Story: seen from the sky
- Discover another Paris : famous locations of Paris
- There's always more to discover in Paris!
- Arts and culture
- Paris Covid-19 Lockdown by drone
- Paris from Sunrise to Sunset

Muséums and Art exhibitions

- Leonard de Vinci in Le Louvre
- Degas : Degas à l'Opéra
- Orsay, from railway station to museum

From Pioneers of Aviation to Aeronautical Research and Activities

- Clément Ader. Sur les traces du pionnier de l'aviation
- Louis Blériot makes the first powered cross-Channel flight" :
- 1909 : Louis Blériot traverse la Manche en avion
- Charles Lindberg
- Le Bourget Air and Space Museum:
- A Century in 100 seconds
- A la découverte de la Grande Galerie rénovée
- ONERA
- DGAC

History of Science and Technology

- Musée des Arts et Métiers :
- The Eiffel Tower in 1900
- Building the Statue of Liberty

Booklet of Abstracts

International e-Symposium on
Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Recommendations for research on the noise impact of drones in an urban environment

Roalt Aalmoes (Netherlands Aerospace Centre NLR), Rui Roosien, Theo van Veen

The Urban Air Mobility (UAM) concept is considered to be one of the most innovative developments in aerospace industry. On the forefront of this new innovation, focus has been put on technological challenges, such as autonomous concept, detection and avoid technology, and vehicle related developments such as VTOL and electrical propulsion. While the first demonstrations of these new products take place, limited to no resources are spent on one of the main obstacles for introduction, namely public acceptance. In operating modes within densely populated areas such as UAM, not only privacy, but noise impact and safety concerns have to be addressed.

In this paper, we will present recommendations for future research to address the concerns of noise impact of drones and personal air vehicles. The focus is on the perception of noise and visual aspects, in an urban environment, and mitigation strategies to pre-emptively reduce annoyance by drone noise. First, the main concerns with respect to drone noise will be addressed, and appropriate sound metrics, in relation to background noise and insulation of houses are presented. Then, proposed noise impact studies will be described to enhance knowledge on noise annoyance are presented. The next step is to indicate the concept of operations and how it can influence noise impact, and finally, an initial set of mitigation strategies is given. Result of this work provides guidelines for manufacturers of drones, upcoming operators of these UAM services, and local or national authorities to structure their future noise impact research efforts.

International e-Symposium on
Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Sound localization of drones using an Acoustic Camera

Pablo Alloza, gfai tech GmbH: alloza@gfaitech.de Benjamin Vonrhein, gfai tech GmbH: vonrhein@gfaitech.de Ali Movahed, gfai tech GmbH: movahed@gfaitech.de

Noise reduction is one of the biggest challenges for the incoming generations of unmanned aerial vehicles (UAV) and unmanned aerial systems (UAS). While for some applications noise reduction in drones can be a desirable feature, for other cases it is an absolute requirement. This paper shows how analysis based on spaced microphone arrays and beamforming algorithms (Acoustic Camera) can be used to establish a relation between noise emission and noise sources depending on other variables such as engine power, rpm or propeller type.

This paper introduces the application of the Acoustic Camera localizing and analysing the sound emissions from two different points of view. First, by determining the noise footprint and the acoustic video of a pass by measurement. Second, by focusing on the propellers, checking several models for benchmarking, using rotational beamforming algorithm in order to provide accurate acoustic pictures.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Assessment of the environmental impact of drone noise in virtual flights

Haoyu Bian[1], Ryu Fattah[2], Siyang Zhong[1], Xin Zhang*[1,3]

1. **Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong SAR, China**
2. **Aerodynamics and Acoustics Facility, The Hong Kong University of Science and Technology, Clear Water Bay Road, Hong Kong SAR, China**
3. **HKUST-Shenzhen Research Institute, No.9 Yuexing First Road, South Area,Nanshan, Shenzhen, 518057, China**

Drones are now ubiquitous in various civilian and industrial applications such as photography, logistics and agriculture for its low cost and high flexibility. The resultant noise issue is becoming more significant as the number and size of the drones are increasing. The environmental impact gets more attention from policymakers, urban planners and residents. To quantify the noise level, anechoic chambers and outdoor measurements are essential approaches, but they have limitations in efficiently and economically accounting for the impact of practical environments. While the numerical solutions of the fluid or wave governing equations can be computationally intensive for large and complex regions of interest. To this end, we developed an efficient noise computation platform Environmental Acoustic Ray Tracing Code (EnvARC) to assess the environmental impact of flying drones in realistic scenarios. It is based on the ray tracing method to capture the major acoustic physics, including the reflection of complex boundaries with different impedance, refraction of the non-uniform medium and atmospheric attenuation. A paraxial Gaussian beam method was implemented to fix the issues such as caustics and extreme shadow regions in the conventional ray tracing method. In this paper, this platform is verified by canonical outdoor propagation problems. A noise source model of a realistic quadcopter is lumped to the platform to evaluate the environmental impact. Finally, virtual flights in realistic urban environments are conducted and the results are discussed.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

UAV's localization from a microphone array by exploiting the harmonic structure of the sound produced

Torea Blanchard (LAUM, UMR-CNRS 6613 Le Mans Université):
torea.blanchard@univ- lemans.fr
Jean-Hugh Thomas (LAUM, UMR-CNRS 6613 Le Mans Université):
jean- hugh.thomas@univ-lemans.fr
Kosai Raoof (LAUM, UMR-CNRS 6613 Le Mans Université):
kosai.raoof@univ-lemans.fr

The increasingly widespread emergence of civilian Unmanned Aerial Vehicles (UAV) in recent years has led to major efforts on issues related to the privacy and security of individuals. Although technological improvements have facilitated their access to the public market, with multiple fields of application, their localisation using electromagnetic or optical systems is sometimes hampered. An acoustic approach exploiting the sound emitted by their motorization is then proposed to overcome this problem. A campaign of acoustic measurements made it possible to identify the acoustic signature of a multi-rotor UAV in order to design an acoustic array made up of few microphones. A processing chain based on the use of a pitch detection algorithm and a bank of band-pass filters with zero-phase shift is then proposed upstream of the localization step. This processing aims at selecting the main harmonics in the spectrum of the acoustic signal emitted by the UAV and thus improving the signal-to-noise ratio. Target localization is finally ensured by Delay-and-Sum in the time domain. This study has shown the interest of such a processing for UAV localization by offering a perspective of use in the multi-source case illustrated by numerical simulations. Experimental measurements conducted both in an anechoic room and outdoors are presented for the single source case.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

A real-time system for joint acoustic detection and localization of UAVs

Martin Blass: martin.blass@joanneum.at Franz Graf: franz.graf@joanneum.at

Unmanned aerial vehicles (UAVs) are commercially available in different types, sizes and pricing. Since no expert knowledge for the use of UAVs is required, they may raise privacy and security concerns, public annoyance due to noise emissions, or even pose a threat to society and public facilities when being used as a means of attack. In this paper, we present a holistic approach for real-time acoustic detection and localization of UAVs using microphone arrays. We describe the array design and an algorithm for 3D UAV localization, the acoustic detection system including audio feature extraction and a defined procedure for acquiring UAV audio training data. The system comprises an MPEG-7 database framework for handling metadata and labeling of audio segments. Labeled audio data is used to train binary classification algorithms to discriminate between the presence and absence of UAVs. For acoustic localization, beamforming techniques are used in combination with a custom source tracking algorithm. The system is evaluated using common classification metrics and a proposed localization error metric. Finally, we outline the real-time implementation and discuss the potentials and challenges about joint detection and localization using beamformed audio signals.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Methods for providing design guidance to improve drone sound using community input

David L. Bowen, Acentech Inc., Cambridge, Mass. U.S.A: dBowen@Acentech.com

Many non-acoustic factors have the potential to contribute to the subjective impressions that sounds convey. For drones, as with many other products and devices, the perspective of the listener can be an important factor influencing these subjective impressions. That is, the reaction of someone who is using/controlling a drone or expecting a drone to appear is likely to be different from that of a bystander who is not necessarily expecting to see (and hear) a drone. Using carefully designed and executed jury studies that expose jurors to an array of virtual/ ”what-if” drone sounds, it is possible to develop regression relationships between jury output data (in the form of numerical ratings on a particular subjective attribute such as “acceptability” of the drone sound) and input data consisting of quantifiable changes made to the sounds of the physical components and mechanisms contributing to the overall sound of a drone. These relationships and their resulting response surfaces can then be probed to determine what combinations of component modifications are likely to produce a desired degree of improvement in subjective impression, thus providing valuable design guidance beyond just “make it quieter”. An example case study is used to illustrate the methodology as applied to sound recordings made during flyover and hovering operations of a prototype multi-rotor drone. In this case the input variables consisted of changes in the overall levels of broadband aerodynamic noise and motor controller noise, along with changes in the number and overall level of rotor blade pas- sage harmonics, while the output consisted of ratings on subjective attributes as obtained from jurors drawn from a suburban community and listening from a bystander perspective. The results from this study suggested several different approaches for achieving similar degrees of substantial increase in the acceptability ratings of the sound quality of these types of drones.

Drone delivery and noise regulation in the Australian context

Marion Burgess, UNSW Canberra, Australia:
m.burgess@adfa.edu.au

A trial area for drone delivery to residential properties in Australia has been undertaken. The payload of up to 1.5 kg is delivered by a drone designed to keep the package steady and level to avoid spill for products like coffee. After approving the trial and acknowledging that the current noise regulations do not adequately address noise from drones, in 2019, the Federal Department initiated a review. This sought public and organisation submissions to assist with the determination of the appropriate scope and breadth of future noise regulation in relation to drone operations, urban air mobility aircraft as well as specialised and historic aircraft. In this paper the responses from the community exposed to the trial drone delivery noise will be discussed along with the actions taken by the drone delivery company to minimise the noise annoyance. While awaiting the outcome of the review of future regulation, approval was granted for operations in two different jurisdictions. The actions taken to reduce the noise annoyance have led to very few complaints despite many thousands of deliveries being made.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Aeroacoustic study of small propellers with serrated trailing edge for a quieter drone

Paolo Candeloro: Università Niccolò Cusano, Via Don Carlo Gnocchi 3, 00166 Rome, Italy: paolo.candeloro@unicusano.it Ranieri Emanuele Nargi: Università Niccolò Cusano, Via Don Carlo Gnocchi 3, 00166 Rome, Italy: ranieriemanuele.nargi @unicusano.it Edoardo Grande: Delft University of Technology, Delft, 2629HS, Netherlands, e.grande@tudelft.nl Tiziano Pagliaroli: Università Niccolò Cusano, Via Don Carlo Gnocchi 3, 00166 Rome, Italy: tiziano.pagliaroli@unicusano.it

Drone noise is a well-known issue for the European scientific community that develops drones or associated technologies. In general, the increase of endurance and the reduction of the acoustic impact are identified as strategic objectives for the growth of the flying drone market and key issues to improve the safety of this technology. Drones are usually equipped with electric motors, which contribute to simplify operations and significantly reduce the engine noise signature. Therefore, the main acoustic source from drones turns out to be the propeller/ rotor.

It is hereafter described an experimental investigation on the trailing edge noise generated by a small-scale propeller with serrated trailing edge (STE). This control technique is already employed on wind turbines and on fixed wing aerofoil. Nevertheless, a few studies have been devoted to the application of serration on small propellers. The idea of serration comes from nature and mimics owl's wing geometry. Owls are known to be one of the most silent predators in nature, and this feature is related to their characteristics wings, which has not a flat surface and a blunt trailing edge.

Experimental tests were carried out within the anechoic chamber located at Niccolò Cusano University, several blades with the same shape and different STE patterns have been tested to achieve a parametric overview of the noise control strategy effects.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

In addition, a spectral and statistical analysis of the pressure time series has been carried out. Results shows a reduction in the broadband noise component and even an unexpected decrease in the tonal component. This effect is relevant for characteristic propagation directions, defined by the polar angle, showing a strong directivity of the noise source. Furthermore, the statistical analysis shows a different probability distribution function at different polar angle suggesting that the serration induces a modification in the wake of the blade. These results are confirmed by the wavelet analysis performed on the time series. Such technique has never been applied to rotor noise and, by its time/frequency definition, looks promising in order to better understand the noise generation mechanism.

Delivery Drones at La Poste

Philippe CASSAN Drone Programme Director La Poste/dpdgroup
philippe.cassan@dpdgroup.com

DPDgroup/La Poste is testing drone deliveries since 2014, with two test lines in operation in France.

The future development of these deliveries depends on the regulation and technology, but also on the public acceptance of drone flights, for which noise can be a major issue.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

UAS sound level prediction using panel contribution analysis

Gong Cheng, Jiazhu Li, and D. W. Herrin University of Kentucky dherrin@engr.uky.edu

This paper is adapted from: Cheng, G. and Herrin, D. W., Noise Level Prediction of a Small UAV using Panel Contribution Analysis, Inter-Noise 2018, August 26-29, Chicago, IL (2018).

The sound pressure level is predicted 5.5 m away from a small UAS in a hemi-anechoic space using panel contribution analysis. The particle velocity and sound pressure were measured using a P-U probe on six surfaces forming a grid encompassing the UAS. Acoustic transfer functions between the source and the receiver location were measured reciprocally. The noise level was predicted at the receiver location from measurements close to the UAS assuming correlated and uncorrelated sources. The sound pressure level calculated by the correlated model compared well with direct measurement. The method was then used to predict the sound pressure level in a room that was not anechoic. The earlier particle velocity and sound pressure measurements were combined with newly measured transfer functions to predict the sound pressure level. The predicted sound pressure level compared well with direct measurement.

An outlook on some technical issues related to UAM noise and annoyance

Andrew Christian (NASA Langley Research Center).

The growing specter of a new community noise source due to Urban Air Mobility (UAM) operations has caused a good deal of recent movement on the parts of researchers, regulators, community advocacy groups, and the industrial/commercial interests that hope to participate in the new market. Psychoacoustic effects such as “sound quality” and “detection” are often mentioned as aspects of noise control engineering that have gone unexploited in the past, but that may be put to use for gain in the UAM space. It is possible to look back, not only into past results from aviation noise, but also across other facets of psychoacoustics (and beyond), to at least constrain the outlook for the role and efficacy that such effects may have. This paper contains cursory expositions of a number of topics that are notionally related to UAM noise, including: a review of “loudness” and other sound qualities that might moderate the reaction to and recognition of UAM noise; a review of results and models of auditory detection performance from fundamental psychoacoustic and auditory research sources; a discussion of Goodheart’s Law, and the role of optimization in the design and operations of UAM aircraft; and an overview of common themes seen in the science of complex systems that might shine a light on how communities as a whole respond to new/changing noise sources, including how “acceptance” might be seen as a community, rather than an individual phenomenon. Given a synthesis of these points of view, the outlook for future research is discussed

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

A whole-systems approach to building knowledge about human reaction to UAV/UAS

Charlotte Clark, Acoustics, Ove Arup and Partners, London, UK: Charlotte.Clark@arup.com

Ryan Biziorek, Acoustics, Ove Arup and Partners, Chicago, IL, USA

The aviation revolution to develop low cost, on-demand, point to point aerial transportation of goods and people, and support a range of services (e.g. aerial surveillance and geographic surveys) is developing a pace in many countries. While these new aerial services can ultimately offer many benefits, there is very little known about human and community response to these modes of transport. Undoubtedly these different types of vehicles will lead to noise exposure from new and unfamiliar aerial vehicles in communities that have not experienced aviation or similar transport noise.

We know from working with communities exposed to general and commercial aviation that noise has the potential to become a significant public health issue. A knowledge building process for electric and autonomous flying technology will be required to overcome several challenges related to human response to noise and visual pollution. This evidence is also needed to inform regulation, planning and airspace design policies that will be needed to build social value and acceptance of new systems and infrastructure.

This paper describes lessons that can be learnt from general and commercial aviation for the UAV/UAS industry. A methodological framework is proposed for building knowledge to inform systems and operations development within the short-time frame sought by this emerging market. Arup's ongoing work addressing these challenges through developing immersive auralisations (aural simulations) and visualisations of these vehicles is also summarized. This simulation approach enables a listener to experience simulated acoustic phenomena in different virtual contexts to help with human factors research, policy planning, and stakeholder engagement to enhance outcomes.

We will also report on planned research studies in our immersive aural and visual simulation facilities – SoundLab and iLab – to build knowledge about human response to this mode of transport. Use of these methodologies can inform the development of public acceptability, provides a collaborative tool to engage with OEMs vehicle designers to improve human response and public acceptance, and will aid in identifying appropriate acoustic metrics to describe the exposure and inform certification standards, assessment methods and policy.

INCEEUROPE CidB Centre d'information sur le Bruit

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

MOSQUITO Project – a fast estimation approach for urban acoustic environment

Franck Cléro, Onera: franck.clero@onera.fr
Julien Caillet, Airbus Helicopters: julien.caillet@airbus.com
Eric Bouty, Safran Helicopter Engines: eric.bouty@safrangroup.com Claude Sensiau, Safran Tech: claude.sensiau@safrangroup.com Ingrid LeGriffon, Onera: Ingrid.legriffon@onera.fr
Patrice Malbequi, Onera: Patrice.malbequi@onera.fr

In the framework of development of new services based on drones for Urban Air Mobility and Logistics, the MOSQUITO project aims at performing a first evaluation of the necessary requirements to ensure compliancy with high density population environment. Funded by the DGAC (Direction Générale de l'Aviation Civile), one of its topics is to investigate the acoustical acceptability of drones in urban environment where noise is less and lesstolerated. This paper focusses on the acoustic part of the project which involves Airbus Helicopters, Onera, Safran Helicopter Engines and Safran Tech. These partners have the capacity to simulate the different acoustic sources radiated by a VTOL (Vertical Take-Off and Landing) aircraft, along its flight trajectory, and to propagate the noise toward the ground, without any building. In MOSQUITO, one objective is to add the acoustic effect of the urban environment. Software like MithraSig developed by CSTB, can simulate the acoustic propagation in an urban environment. The existing capabilities of this code are evaluated thanks to the well known source of a full scale helicopter test flying over the Airbus Helicopters center in Marignane. Using this tool, the partners plan on simulating reference cases in order to obtain acoustic correction factors to add the urban effect on a free field noise footprint. Then, 3 different VTOL configurations in three different urban environments are planned to be simulated from the source to the ground integrating the newly developed correction factors. A final auralization step will then be performed to open the way to listening tests. With this complete simulation chain, the partners will have the possibility to study acceptability criteria for new services enabled by Urban Air Mobility and Logistics.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Drone audition for search and rescue: Datasets and challenges

Antoine Deleforge, Inria Nancy – Grand Est:
antoine.deleforge@inria.fr

Processing audio signals recorded from a microphone array embedded in an unmanned aerial vehicle (UAV) has received increasing research interest in the recent years and has been referred to as drone audition. An important field of application is search and rescue, where humans in disaster areas need to be quickly found. UAVs equipped with high-resolution cameras have already been used in humanitarian responses, while audio-based UAV-embedded sound localisation remains an open research challenge. Microphones could provide a critical complementary modality to vision in situations where visual feedbacks are limited due to bad lighting conditions (night, fog) or obstacles limiting the field of view. This paper provides an overview of the technical and methodological challenges faced by drone audition in the context of search and rescue and presents two publicly available datasets that aim at fostering research in this area. Some localisation and noise-reduction results obtained using baseline methods are also presented. While static localisation of speech sources from a distance of four meters can be efficiently achieved, in-flight localisation from larger distances remains a challenge.

Scanning Laser Vibrometer measurements for assessing the origin of structure borne sound in drones

Florent Deux, Polytec France SAS, f.deux@polytec.fr Jochen Schell, Polytec GmbH, j.schell@polytec.de

We report on a modal test for vibrations in the body of a drone, using an automated, robot-assisted version of a 3D scanning Vibrometer, leading to 3D deflection shapes of the full body over a broad frequency range. We furthermore show measurements of the deflection shapes of a rotating propeller, using a 1D scanning Vibrometer together with a Derotator to track the rotating blades.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Will noise become a new hurdle which could impair the development of drones

Carine Donzel (DGAC), Henry de Plinval

In this introductory talk, we shall present an overview of the drones universe : its main applications, its challenges, and how the noise concern fits into this broader picture. The definition of drones will be first recalled, together with rationale for the amazing interest they have attracted for years. A description of the main applications they are used for will be provided, together with the key challenges they raise. Ongoing activities will be discussed, in particular within the French Drones Civil Council under the guidance of the DGAC. The role and expertise of ONERA will also be presented. Finally, an introduction of the various technical challenges hidden on the path towards "quiet drones" will be provided, opening on the technical presentations that will follow during the symposium

INCE EUROPE CidB Centre d'information sur le Bruit

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Commercial delivery drone routing: A case study of noise impacts

Eddie Duncan, RSG, Eddie.Duncan@rsginc.com Kenneth Kaliski, RSG, Kenneth.Kaliski@rsginc.com Isaac Old, RSG, Isaac.Old@rsginc.com
Erica Wygonik, RSG, Erica.Wygonik@rsginc.com Justin Culp, RSG, Justin.Culp@rsginc.com

Many efforts are underway to understand the efficiency, climate impact, and privacy issues surrounding the routing of commercial drone deliveries from central distribution centers, and while potential noise impacts are a notable concern, only now are we starting to quantify them. This paper uses a case study to explore the use of community noise mapping as a tool to reduce noise impacts by optimizing flight routes to both increase sound masking and reduce population exposure to noise. The primary purpose of this paper is to explore a methodology using sound propagation modeling of drones coupled with existing community noise maps and background sound level data to assess various flight route options and flyover and hover levels in the context of a residential neighborhood.

The case study considers four different routing scenarios and, as discussed in Section 3.3, finds that routing options over undeveloped lands and waterways result in the lowest overall exposure of drone noise to the case study population, but that routes over higher populated areas following roadways may result in lower impacts due to masking by traffic noise. The case study also considers the short-term sound exposure of individual flyovers and hovering for delivery. For flyover levels, when compared to background sound levels for different area, as discussed in Section 3.1, flight path setbacks may be established to reduce potential impacts to residential areas.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Acceptance of drone delivery is limited (not only) by noise concerns

Hinnerk Eißfeldt
DLR German Aerospace Center, Department of Aviation and Space Psychology, Hamburg, Germany.

In recent years, civil drones have become increasingly present in the media and in everyday life. There has been a high level of interest in drone delivery from the very beginning, yet public acceptance of drone delivery still seems limited, with acceptance rates usually ranging from 30 to 40%. The present paper reports findings of a representative national study about the acceptance of civilian drones in Germany. Several factors limiting the support of drone delivery are identified, such as concerns about transport safety, noise, and animal welfare. In addition, effects of drone experience are discussed, showing all areas of concern being reported at higher rates by participants who had no prior experience with civil drones. For noise concerns however, a more detailed look into the kind of experience with drones revealed a significantly higher percentage of noise concern among those who reported having heard a drone compared to those who reported that they had not. Moreover, an effect of NIMBYism is confirmed in the context of drone delivery. Even residents who envision using drones for the delivery of their own parcels frequently report that they would not agree to flights over their own homes. This particular effect is termed NOMOH ('Not Over My Own Home'). Finally, the need for regulation is discussed, as well as potential measures to increase acceptance of drone delivery. Besides defining topographical conditions, urban areas and time restrictions, installing means of noise control or providing residents with tools for participatory noise sensing can also be viable measures to increase public support. If the acceptance level among residents remains in the range of below one third, drone delivery will not become a successful service in Western cities.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Signal-to-noise ratio enhancement method for improving sound source detection of drone-mounted phased microphone array

Yeong-Ju Go, Chungnam National University, South Korea: yjgo@cnu.ac.kr Jong-Soo Choi, Chungnam National University, South Korea: jchoi@cnu.ac.kr

There is a request to detect the location of the sound source using drones for the purpose of saving lives and detecting abnormalities in disaster and security situations. This technique extends the limits of detection methods based on images of current drones, and is meaningful in securing improved detection methods by adding a new sense of sound. In order to detect sound, a microphone is attached to the drone to acquire sound pressure, and the noise generated by the drone's operation acts as a direct factor in reducing the signal-to-noise ratio of the sound source that the drone wants to detect. This paper described the method of detecting the location of the sound source generated on the ground level by using phased microphone array mounted on drones. To eliminate propeller noise and flow noise, the main noise, the spectral subtraction method was applied and the signal-to-noise ratio of the detection sound source was improved. The filtered signals were then used to estimate the arrival angle of the sound source based on the beamforming method and experimentally confirmed that the location of the ground noise source could be detected by merging with the flight information of the drone.

INCEEUROPE CidB Centre d'information sur le Bruit

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Noise considerations for designing Skyport networks

Rohit Goyal, Uber, Operations Planning Strategic Lead

The concept of “flying cars” has captured the public imagination ever since the Wright Brothers’ first flight in 1903. Now, over a century later, the idea more strongly than ever ignites curiosities and passions as citizens spend increasing amounts of time in the gridlocked traffic that plagues the world’s largest cities. At Uber Elevate, we seek to build and scale our Uber Air product in a way that significantly reduces travel time and is holistically sustainable for the cities and citizens that we will serve. One of the primary concern of the community is noise, and to run a scalable service, we must understand human response to noise and design our aviation products accordingly. This presentation will highlight UAM noise challenges and Uber Elevate's approach to resolving noise concerns.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Assessment of noise characteristics of innovative aerial vehicles

Raphaël Hallez, Nícolas Gass, Claudio Colangeli, Siemens Digital Industries Software, raphael.hallez@siemens.com

Vertical mobility is a potentially disruptive technology which is expected to thrive in the coming years. One of the most important elements for the development of Vertical Take Off and Landing (VTOL) aircraft and Unmanned Aerial Vehicles (UAV) is their acceptance from the community and in this domain, the emitted noise plays a very important role. Engineering teams need to use the right techniques to efficiently assess the acoustic performance of such innovative vehicles and improve their design to enable flight in densely populated area. This paper gives an overview of experimental techniques available for the assessment of noise radiated by aerial vehicles. Fly- over noise measurement techniques currently used for aircraft noise certification are presented, as well as more detailed acoustic engineering techniques such as sound source localization and sound quality analysis. The case of an electrically-propelled aircraft is used to show how to obtain a detailed acoustic characterization of the aircraft and gain insights into noise generation mechanisms. These techniques can be successfully applied to investigate the signature and the sound quality implications of the noise emitted by UAVs and improve their acoustic performance. This is highlighted here for the case of a quadcopter drone.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

A summary of the 2018 Workshop on UAS and UAV Noise Emissions and Noise Control Engineering Technology in Washington, DC

Robert D. Hellweg, Jr., Hellweg Acoustics: Helleg@HellwegAcoustics.com

Adnan Akay, Bilkent University: akay@bilkent.edu.tr

Gregg Fleming, United States Department of Transportation – Volpe National Transportation Systems Center: Gregg.Fleming@dot.gov

George C. Maling, Jr., Managing Director Emeritus INCE-USA: georgemaling.nae@gmail.com

Eric W. Wood, Acentech Inc.: ewood@acentech.com

The U.S. National Academy of Engineering (NAE) hosted a workshop “UAS and UAV (Drone): Noise Emissions and Noise Control Engineering Technology” on December 13-14, 2018 in Washington, DC. The workshop was organized by the INCE Foundation in cooperation with the U.S. National Aeronautics and Space Administration (NASA) and the U.S. Federal Aviation Administration (FAA). The workshop had presentations from representatives of world-wide unmanned aerial systems (UAS)/unmanned aerial vehicles (UAM) manufacturers, UAS users, U.S. government agencies, universities, consultants and professional societies. There were many presentations on a wide-range of topics, including modelling and testing, psychoacoustics, community impact, and noise reduction strategies, measurement techniques, and uses of UAS/UAVs. There were a series of presentations on urban air mobility (UAM) which covered projected noise impacts from future activities, including air taxis. There were also two panel discussions on legal issues. A final report of the workshop was published in early 2020 and includes a summary of each presentation and images of selected slides. This paper presents a brief summary of the papers presented.

International e-Symposium on
Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

ANSI/ASA Standards Activity on Measurement of UAS Noise

Robert D. Hellweg, Jr., Hellweg Acoustics:
Helleg@HellwegAcoustics.com
Kevin Herreman, Owens Corning Science & Technology,
kevin.herreman@owenscorning.com

The American Standards Committee S12 on Noise is developing an American National Standard for the measurement of sound power levels from small (under 55 pounds) unmanned aerial systems (UAS) in an anechoic chamber. This paper presents an update on the development of this American Standard.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Flight path tracking and acoustic signature separation of swarm quadcopter drones using microphone array measurements

Gert Herold*, Adam Kujawski, Christoph Strümpfel, Svenja Huschbeck, Maarten Uijt de Haag, Ennes Sarradj, Technische Universität Berlin

Unmanned aerial systems (UAS) are used for a wide variety of applications, including agriculture, law enforcement, search and rescue, mapping, and journalism. The number of applications can be expected to increase in the near future, as is the impact of such systems on the environment – urban or rural. Moreover, unknown UAS penetrating airport areas pose an increasing security threat to flight operation.

In this contribution, flight paths and individual acoustic signatures of up to four simultaneously flying quadcopter drones are calculated from measurements with a 64-channel microphone array. The data processing consists of two steps. First, a frequency-domain beamforming method is used to reconstruct the individual flight trajectories. The separation of the sound signals from the drones is accomplished in a second step using a moving-focus time-domain beamforming method.

The accuracy of the flight paths calculated from the array measurements is evaluated by comparing them to paths reconstructed from additional synchronous camera recordings. The quality of the separated acoustic signatures is assessed via reference measurements of a single drone of the same type.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Development of surface-processed low-noise propeller for search and rescue tasks with drone audition

Kotaro Hoshiba, Department of Electrical, Electronics and Information Engineering, Faculty of Engineering, Kanagawa University: hoshiba@kanagawa-u.ac.jp Ryusuke Noda, Department of Aeronautics and Astronautics, Kyoto University: noda@kuaero.kyoto-u.ac.jp Toshiyuki Nakata, Graduate School of Engineering, Chiba University: tnakata@chiba- u.ac.jp Hao Liu, Graduate School of Engineering, Chiba University: hliu@chiba-u.ac.jp Kei Senda, Department of Aeronautics and Astronautics, Kyoto University: senda@kuaero.kyoto-u.ac.jp Kazuhiro Nakadai, Department of Systems and Control Engineering, School of Engineering, Tokyo Institute of Technology / Honda Research Institute Japan Co., Ltd.: nakadai@ra.sc.e.titech.ac.jp Makoto Kumon, Graduate school of Science and Technology, Kumamoto University: kumon@gpo.kumamoto-u.ac.jp
Hiroshi G. Okuno, Kyoto University / Future Robotics Organization, Waseda University: okuno@nue.org

In disaster-stricken areas, prompt search and rescue operations are required to increase the survival rate according to a “First 72 Hour Response” guideline. UAV (unmanned aerial vehicle) assisted sensing of people is effective in such disastrous situations because a UAV enables prompt operation regardless of the situations on the ground. Because sensing techniques of a UAV rely mainly on vision, it is vulnerable to poor lighting conditions or

occlusions. To solve these problems, we instead have focused on audition and developed a sensing technique by localizing human-related sound sources with a UAV-embedded microphone array. One critical issue in localizing sound sources with a UAV is its large ego-noise. To achieve high noise-robustness of sound source localization, we developed two approaches for drone audition. First, we developed a novel microphone array consisting of 12 or 16 microphones embedded in a small spherical-shaped body. Thanks to this spherical structure, the target sound and ego-noise could be separated properly, and thus noise robustness was improved. Second, we developed an active spectral filtering for sound source localization by dynamically adjusting a frequency range to input signals, and demonstrated its high noise-robustness and low calculation cost. As a next step of a drone audition system, aiming at suppressing the ego-noise level of the multicopter-typed UAV, we developed a surface-processed low-noise propeller in this paper. Inspired by a Gurney flap for the lift enhancement of an airfoil, we designed three models with different structures. The performance of developed propeller models was evaluated in indoor and outdoor flying situations with sound source localization. The evaluation experiments validated the developed propeller models on a drone audition system.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Interpolation based acoustic transfer function for drone noise simulation

Hanbo JIANG, Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China: hjiangan@ust.hk
Siyang ZHONG, Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, China: zhongsy@ust.hk
Xin Zhang, Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China: aexzhang@ust.hk

In this paper, we describe an efficient method to compute the broadband noise scattering of drone fuselage based on boundary element method. The acoustic transfer function is a well-known concept for multi-frequency problems in combination with repeated analyses for modified boundary conditions. It was initially proposed to accelerate the boundary element analysis by interpolating instead of directly assembling influence matrices. In this work, a new frequency- interpolation algorithm is proposed by incorporating the proper orthogonal decomposition and a discrete matrix interpolation method. The former is imposed on those pre-computed transfer functions to construct a reduced-order subspace where the later interpolation is implemented, resulting in efficiency gain in both computer storage and data interpolation. Both computational performance and accuracy are investigated to verify the algorithm. Finally, the capability of the proposed method is demonstrated in a drone-noise scattering problem.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Advances in sound and speech signal processing at the presence of drones

Oliver Jokisch, Leipzig University of Telecommunications, Germany: jokisch@hftl.de Ingo Siegert, Otto von Guericke University Magdeburg, Germany: ingo.siegert@ovgu.de

The civilian and military use of drones (unmanned aerial vehicles, UAVs) for surveillance tasks, for inspection of industrial structures, for monitoring in agriculture and science-data collection is steadily growing. A sound or speech signal processing directly at drones or at the presence of drones nearby is challenging because of the significant rotor and maneuver-related noise components. The signal processing has to consider various sound sources, and the wanted signals (e.g. environmental sounds or voice signals) have to be separated from the flight and surrounding flow noises. For many tasks, other sources of information (e.g. electromagnetic- wave signals) need to analyzed in parallel, with an adequate concept of data fusion.

Recently, a lot of effort has been invested in more quiet drones, but due to several application requirements with regard to drone size, flight stability, robustness or price, the noise issue is still immanent. A noticeable proportion of noise is affecting sensible applications, such as the analysis of acoustic drone signatures by other surveillance drones, the intelligibility of speech transmission in disaster operation, or the recognition of human speech and animal sounds.

The paper introduces some acoustic scenarios and experiments at a typical small, commercial drone (DJI Mavic Pro). We recorded different sound and speech signals by a lightweight eight-micro array that allows for an improved signal-to-noise ratio, and we tested different noise-filtering methods. The test signals were processed in a free field environment with a battery-powered Raspberry Pi 3, attached to the drone. We briefly discuss the factors of influence and selected quality criteria, such as the resulting signal-to-noise ratio and word recognition rate. The article concludes with lessons learned for acoustic drone interactions and measurements.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Experimental investigation on acoustics and efficiency of ducted electric rotors

Ronja Koenig, Robert Bosch GmbH, ronja.koenig@de.bosch.com, Jochen Fassnacht, Robert Bosch GmbH, Felix Albrecht, Robert Bosch GmbH, Eike Stumpf, RWTH Aachen University, eike.stumpf@ilr.rwth-aachen.de

Aerial vehicles based on distributed electric propulsion systems have gained great interest. Several designs apply ducts at rotors. Ducts are used for various reasons like safety and efficiency. Furthermore, benefits in acoustics are expected.

Focus of this paper is to understand the influence of ducts at single and coaxial rotor configurations regarding efficiency and acoustics while hovering. Results from experimental investigations done in a hover-test-bench are presented. Rectangular, symmetric blades with a radius of 106 mm are used. Ducts are developed considering the rotor streamtube, which is visualized using Particle Image Velocimetry (PIV). Experiments are done varying the inner surface of the duct, the duct length and the duct position at the rotors.

Results show, that ducts can improve efficiency and acoustics. The position of a duct has huge influence, especially when increasing duct length. Best results were found using ducts leading the rotor streamtube and positioning the rotor at the beginning of the duct. Reduction in Sound Pressure Level (SPL) at higher harmonics of the blade passage frequency were found. Position- ing a duct at the bottom rotor of a coaxial rotorsystems can be recommended according to the experimental results. However, ducting both rotors at a coaxial rotorsystem cannot be recom- mended. It was also found that a decrease of tip clearance up to 3 mm leads to increase in SPL. Porous surfaces and rounded inlet showed positive influence on SPL at single rotors. Finally, conclusions for duct design at aerial vehicles are derived from experimental results.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Proposal of cognitive drone audition based on cognitive dynamic systems

Makoto Kumon, Kumamoto University: kumon@gpo.kumamoto-u.ac.jp Hiroshi G. Okuno, Kyoto University/Waseda University: okuno@nue.org Kazuhiro Nakadai, Honda Research Institute Japan/Tokyo Institute of Technology: nakadai@jp.honda-ri.com Kotaro Hoshiba, Kanagawa University: hoshiba@kanagawa-u.ac.jp Ryosuke Noda, Kyoto University: noda.ryusuke.6a@kyoto-u.ac.jp

Quiet drone is critical for anti-sound pollution for humans as well as for drone audition. Current drone audition, a hearing capability of a drone with a microphone array mounted on it, can localize and trace sound sources by coping with strong ego-noise generated by rotors and air-flow and environmental noise. In this paper, we propose a novel “cognitive drone audition” modeled by a cognitive dynamic system (CDS) [Haykins, 2012]. CDS is motivated by the bat echolocation which is based on cognition. Then we present our current activities of drone audition including open sourced robot audition software called HARK, MUSIC-based sound source localization (SSL) methods, and field demonstrations of search-and-rescue tasks. The problems with current drone audition are robustness against ego-noise and multiple sound sources. Most drone audition assumes a single sound source, which does not hold in real-world situations. Finally, we present current activities towards cognitive drone audition. Data association between tracked sound sources and observed SSL is solved by using sound source identification. Silent propeller models designed for quiet drone show power reduction in a lower frequency band, which may make. MUSIC with active frequency range filter exploits this characteristic to improve SSL. Kite planes, a UAV with a delta-shaped wing, provides a rotor stall mechanism to reduce ego-noise and thus improve SSL. Through these preliminary activities, we set the stage for cognitive drone audition.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Introduction anti-drone solutions

Lucas Le Bell (CerbAir)

Warnings issued by military and security experts around the globe evoke the potential dangers of unregulated drone technology. The world's military titans had all taken steps to protect their troops. But in civilian life, reports of drone attacks, intrusions in commercial aircraft airspace, smuggling drugs or complaints of drone-assisted spying literally skyrocketed.

With so many different anti-drone methods, understanding drone detection and neutralization can be an intimidating task given the fast-evolving drone market. How do you choose the drone detection system that's right for your airspace? Each technology has pros and cons.

- Radar, Radiofrequency, Optic or Sonic? How well do any of those technologies match the risk profile, topography and ambient pollution of your site? What are their advantages and weaknesses?
- Acoustic is a "nice to have" option to complement radar, RF or Optic. Are these technologies self- sufficient and cover the full spectrum of threat?

- Is the anti-drone solution reactive? How quickly can it detect a drone within its operating range? And what are its detection and false alarm rates – under average rather than ideal circumstances? - Does the CUAS technology gives you the ability to detect the location of both the drone and pilot? Given restrictions on kinetic and non-kinetic drone neutralization in many jurisdictions, locating and arresting the UAV pilot is often the best way to quickly and permanently stop a drone threat.
- Drone swarms are the next big security challenge in airspace security. Is the technology able to deal with multiple UAS without becoming saturated?
- Local authorities can be extremely sensitive about "frequency pollution". Is the anti-drone solution low interference or even passive (only emitting a signal when in use)?

As a stand-alone option, nothing beats the effectiveness and cost-to-benefit ratio of radio frequency, which remains the solid foundation of the vast majority of drone detection solutions.

Two dimensional convolutional neural network frameworks using acoustic nodes for UAV security applications

Theoktisti Marinopoulou, Centre for Research and Technology Hellas (CERTH), Information Technologies Institute (ITI): tmarinop@iti.gr Anastasios Vafeiadis, Centre for Research and Technology Hellas (CERTH), Information Technologies Institute (ITI): anasvaf@iti.gr Antonios Lalas, Centre for Research and Technology Hellas (CERTH), Information Technologies Institute (ITI): lalas@iti.gr Christian Rollwage, Fraunhofer Institute for Digital Media Technology (IDMT): christian.rollwage@idmt.fraunhofer.de Danilo Hollosi, Fraunhofer Institute for Digital Media Technology (IDMT): danilo.hollosi@idmt.fraunhofer.de Konstantinos Votis, Centre for Research and Technology Hellas (CERTH), Information Technologies Institute (ITI): kvotis@iti.gr Dimitrios Tzovaras, Centre for Research and Technology Hellas (CERTH), Information Technologies Institute (ITI): dimitrios.tzovaras@iti.gr

Unmanned Aerial Vehicles (UAVs) have become increasingly popular to the public with a multitude of associated applications in real life. However, malicious applications of UAVs, such as terrorism and air transport disturbance may occur with devastating consequences. Therefore, counter-UAV (C-UAV) systems are required to efficiently address these undesired situations. Artificial intelligence approaches, such as deep neural networks (DNNs), are deemed crucial for high accuracy detection and real-time response of the next generation

C-UAV systems. UAV detection based on acoustic sensors has received a great research interest over the past years, however the performance of the proposed solutions may vary in different environments, since sound signals from UAVs are multi-source and unstructured. In this work, three different 2D Convolutional Neural Networks (CNNs) using short-time Fourier transform spectrograms as input, for UAV binary classification in real-world settings, are compared. The results confirm that 2D CNNs, along with data augmentation techniques in the image domain, can capture the spatio-temporal information of the UAV sound signals, even in noisy environments, and obtain a 95.35% macro average F1-Score in a dataset collected from two different environments.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Experimental investigation of contra-rotating multi-rotor UAV propeller noise

Ryan S. McKay - Dotterel Technologies: rmck910@aucklanduni.ac.nz Michael J. Kingan - University of Auckland: michael.kingan@auckland.ac.nz S. T. Go - Dotterel Technologies: sgo587@aucklanduni.ac.nz

Contra-rotating propellers could increase efficiency and lifting capacity of multi-rotor unmanned aerial vehicles (UAVs); however, they are notoriously loud. This work experimentally investigated the noise from static contra-rotating UAV propellers. The effects of propeller diameter were studied by testing different configurations of 12" and 15" propellers. The propeller spacing and rotational speed were also investigated. In total, 1400 propeller configurations were tested. This paper will focus on the errors and uncertainty in the experimental method. The microphones are shown to be in the acoustic far-field which. A study of the repeatability of the automated method used to collect the acoustic and performance data is presented and confirms that the measurements are repeatable. Finally, the anechoic chamber measurements are compared to a quadcopter with contra-rotating propellers flying outdoors.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Active noise cancellation of drone propeller noise through waveform approximation and pitch-shifting

Michael Narine, Georgia State University: mnarine1@student.gsu.edu Richard Howard, WINLAB/Rutgers University: rich@richardehoward.com Ashwin Ashok, Georgia State University: aashok@gsu.edu

The use of drones introduces the problem of noise pollution due to the audio noise generated from its propeller rotations. To mitigate the noise pollution from drone propellers, this paper explores a method of using active noise cancellation (ANC). This paper hypothesizes that by analysing the waveform of the drone propeller noise, an approximated wave function can be produced and used as an anti-noise signal that can effectively nullify the drone noise. In order to align the phase of the anti-noise signal to maximize drone noise reduction, this paper presents a signal pitch-shifting approach, to guide areas of destructive interference to a desired target such as a microphone, at a desired location. Through experimental evaluation using a prototype of the proposed Pitch-Aligned Active Noise Cancellation system (PA-ANC), this paper reveals that the proposed technique can achieve a 43.82% reduction of drone noise.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

'The Sound of the Drone Uprising'
An exploration of the aero-acoustic performance of drone blades

Josephine Nixon, London South Bank University jn1828@my.bristol.ac.uk Stephen Dance, London South Bank University dances@lsbu.ac.uk

This study considers the acoustic emission from a Dji Phantom 4 commercial drone using different rotor blades. Measurements were taken from a hovering drone with four blade configurations. Three blades were commercial products and one was designed and built specifically for this drone. Measurements were taken in accordance with (BS) EN ISO 3741:2001 'Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Precision methods for reverberation test rooms'.

The aim of the project was to reduce the sound emission level of the drone, whilst still allowing the drone to fly and hover. The results show that it is possible to reduce sound emission and tonality by altering the blades but flight performance can be affected in terms of duration (flight-time).

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Multi-scale morphological effect on noise level and frequency characteristics of drone propellers

**Ryusuke Noda, Department of Aeronautics and Astronautics, Kyoto University: noda@kuaero.kyoto-u.ac.jp
Toshiyuki Nakata, Graduate School of Engineering, Chiba University: tnakata@chiba- u.ac.jp Kei Senda, Department of Aeronautics and Astronautics, Kyoto University: senda@kuaero.kyoto-u.ac.jp Hao Liu, Graduate School of Engineering, Chiba University: hliu@chiba-u.ac.jp**

Drones have huge potential for various missions such as delivery and surveillance, and they will likely be operated in the urban areas. In this situation, drones are expected to cause noise pollution and the solutions are required immediately for preventing that. In this study, we developed a method to reduce the noise that utilizes the attachment at trailing edge of the propellers. The effect of the attachment on the aerodynamic and acoustic performance is investigated by the single propeller experiments. Through the parameter sweeps, we found that the trailing-edge attachment can reduce the rotation speed, but the microstructure of the trailing- edge is necessary to prevent the greatly increase in the noise level. The trailing-edge attachment with microstructures at proper locations can reduce the noise level down to the level lower than the basic one while reducing the efficiency. The results point out that the trailing-edge attachment still requires the optimization but may improve the acoustic performance of the propellers with the minimal reduction in efficiency.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Chaotic and wavelet aeroacoustic analysis of twin rotors for drone propulsion

Tiziano Pagliaroli: Niccolò Cusano University: tiziano.pagliaroli@unicusano.it
Paolo Candeloro: Niccolò Cusano University: paolo.candeloro@unicusano.it
Ranieri Emanuele Nargi: Niccolò Cusano University: ranieriemanuele.nargi@unicusano.it Luca Flamini: NHOE srl: luca.flamini@nhoe.it
Roberto Camussi: University of Roma Tre: roberto.camussi@uniroma3.it
Luca Cucinella: NHOE srl: luca.cucinella@nhoe.it
Roberto Pasta: NHOE srl: roberto.pasta@nhoe.it

In recent years, small scale unmanned aerial vehicles have received significant attention for a wide range of applications. In the multirotor configuration, the rotor interaction phenomenon occurs severely because the rotors are located in close proximity. Therefore, the distance between the adjacent rotor tips has a strong effect on the flow structures in the wake, on the aerodynamic performance and on the noise generated by the multirotor vehicles.

In the present study, an experimental investigation in semi-anechoic chamber under hover flight conditions is conducted to analyse the mutual rotor-to-rotor interactional effects on the near field of the pressure fluctuations. Experimental data for the twin rotor configurations with different separation distances show an increase in the tonal noise component due to the rotor-rotor interaction, a rotation of the directivity pattern as the rotor distance is varied, and a time-dependent cancellation of the narrow band noise.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Experiments on UAV rotor noise at low Reynolds and low Mach numbers

Parisot-Dupuis H., Université de Toulouse, ISAE-SUPAERO: Helene.Parisot- Dupuis@isae-supaero.fr
Gojon R., Université de Toulouse, ISAE-SUPAERO: Romain.Gojon@isae-supaero.fr Jardin T., Université de Toulouse, ISAE-SUPAERO: Thierry.Jardin@isae-supaero.fr
Jo Y., Hanseo University, yminjo@hanseo.ac.kr
Doué N., Université de Toulouse, ISAE-SUPAERO: Nicolas.Doue@isae-supaero.fr Moschetta J.-M., Université de Toulouse, ISAE-SUPAERO: Jean-Marc.Moschetta@isae-supaero.fr

The present work outlines efforts at ISAE-SUPAERO to reduce the acoustic footprint of rotors operating at low Reynolds and low Mach numbers typical of small and medium scale drones. An experimental campaign that aims at characterizing rotor noise is presented. The latter serves as a basis for validation of numerical approaches and to investigate the noise mechanisms. Data are obtained in an anechoic room with dimensions (wedge tip to wedge tip) 5.02x5.24x5.34 m3 and cut-off frequency 80 Hz. Aerodynamic loads as well as acoustic fields are recorded for two off-the-shelf (APC 9x6 SF and 11x4.7 SF) and four canonical rotors with different numbers of blades. Both near and far acoustic fields are measured using one microphone located one diameter away from the rotor plane and 13 microphones mounted on a directivity antenna. A range of rotation speed from 1,000 to 10,000 RPM is addressed, corresponding to Mach and Reynolds numbers up to 0.23 and 130,000 respectively. Results presented in this article are related to two-bladed rotors and are validated using existing experimental data from the literature. They are then used to assess in-house numerical simulations (NL-VLM and CFD) and unravel the physics behind rotor noise at low Reynolds and low Mach numbers. This fundamental understanding will help draw general guidelines for the design of low noise rotors.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

UAV detection from acoustic signature: requirements and state of the art

Lucille PINEL LAMOTTE, MicrodB: lucille.lamotte@microdb.fr
Valentin BARON, MicrodB: valentin.baron@microdb.fr
Simon BOULEY, MicrodB: simon.bouley@microdb.fr

The detection, identification and classification of micro-Unmanned Aerial Vehicles (UAVs) using their acoustic signature is at an early stage where the current performances do not meet the market requirements. They are targeted to complete electro-optical and radio frequency sensors acting in short distances (between 200 and 500 meters). This study firstly defines the detailed requirements to develop effective and affordable countermeasures to report of UAV flying over critical areas, especially in urban areas. It concerns Signal-to-Noise Ratio (SNR) required by the environment and UAV type/distance, the operational frequency domain with the best SNR, the localization accuracy required for neutralization, the real time capabilities to act as soon as possible...

The sound landscape observation is a complex task which has to isolate the noise sources of interest in short delay. The second part of the study establishes a state of the art of the available technologies on the market and the academic works addressing this topic and details how the current solutions cover the complete procedure from detection to classification. For the detection, the system tries to measure the acoustic signature using a single microphone or more complex sensors for a better directivity. For the identification and classification, a Machine Learning procedure is well-suited to recognize UAV audio fingerprint. For now, many academic papers demonstrate the low maturity of the procedure and the need to improve its reliability.

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Aeroacoustic measurements on a free-flying drone in a WindShaper wind tunnel

Roberto Putzu, HES-SO Genève, roberto.putzu@hesge.ch
Romain Boulandet, HES-SO Genève, romain.boulandet@hesge.ch
Benjamin Rutschmann, HES-SO Genève, benjamin.rutschmann@edu.hesge.ch Thierry Bujard, HES-SO Genève, thierry.bujard@hesge.ch
Flavio Noca, HES-SO Genève, flavio.noca@hesge.ch
Guillaume Catry, WindShape, guilaume.catry@windshape.ch
Nicolas Bosson, WindShape, nicolas.bosson@windshape.ch

In the near future, drone usage in inhabited areas is expected to grow exponentially. The inherent noise generated is one of the concerns for this kind of vehicle.

Conventional aeroacoustic wind tunnels can be used to investigate uniform-flow generated noise. Flyers are generally solidly tethered to a sting in these wind tunnels. However, the interac- tion of complex environmental flows with the drone fans is expected to generate different harmonic content, especially during unsteady maneuvers. Being able to probe the aeroacoustic signature of a free-flying drone in a realistic urban and wind environment is a necessity, in particular for future certification procedures.

We have developed a new family of wind tunnels, the "WindShaper" (Noca et al. 2019 Wind and Weather Facility for Testing Free-Flying Drones, AIAA Aviation Forum), able to generate complex unsteady flows reproducing environmental gusts and shear flows. The WindShaper consists of an array of a large number of fans (wind-pixels) that may be arranged in various patterns on demand. It is in some ways a digital wind facility that can be programmed to generate arbitrary winds of variable intensity and direction. Various weather conditions (such as rain, snow, hail, fog etc.) that reflect real world situations can be introduced. Drones are in a free-flight configuration (untethered) as in their natural state. These tests can rate drones according to their capacity in maintaining a proper flight attitude and tackling flight perturbations, especially in an urban environment.

A WindShaper was modified in order to allow aeroacoustic measurements around a free- flying drone in a turbulent flow. Particular attention was given to a design that allows the drone aeroacoustic signature to be segregated from the aeroacoustic signature of the multi-fan facility. Details on the results achieved in this new infrastructure will be presented and discussed.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Research to support new entrants to public airspace and aircraft noise certification

David Read, United States Department of Transportation – Volpe National Transportation Systems Center: david.read@dot.gov
Christopher Roof, United States Department of Transportation – Volpe National Transportation Systems Center: christopher.roof@dot.gov

This paper identifies some of the reasons why existing aircraft noise certification methods might not fully address the integration of new entrants to public airspace, and describes ongoing research measurement programs to obtain data that can inform future noise policy and methodologies for noise certification of such aircraft.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Exploring noise reduction methods for fixed wing UAV

Young-Min Shim. Dotterel Technologies Ltd. young-min.shim@dotterel.co.nz

Michael Kingan, Sung Tyaek Go, Ruil Jung, Ryan McKay. University of Auckland

Con Doolan, Yendrew Yauwenas, Chaoyang Jiang, Jiawei Tan, Paul Croaker. University of New South Wales

Dries Verstraete, Rens MacNeil. University of Sydney

Alex Skvortsov. Defence Science and Technology (Australia)

This paper describes a project exploring a number of different methods for reducing the noise produced by a small fixed-wing unmanned aerial vehicle (UAV). The methods which were investigated included the use of optimised propellers, ducted propellers and shielding surfaces. A range of experimental and numerical techniques were used to assess each of these methods and these techniques are also described in this paper.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

On the design of acoustic liners for ducted fans of drones

Andre M. N. Spillere – Federal University of Santa Catarina, Florianópolis, Brazil: andre.spillere@lva.ufsc.br
Julio A. Cordioli – Federal University of Santa Catarina, Florianópolis, Brazil: julio.cordioli@ufsc.br

The so-called acoustic liners are the main noise control treatment applied to traditional turbofan engines and are responsible for a considerable reduction of different components of the engine noise, especially the fan noise. Therefore, the application of liners to the reduction of drone noise seems an interesting alternative at first. However, the many different applications and concepts of drones make the design of a liner for drones a very complex task. Traditional liners are designed to maximize the attenuation of propagating modes inside the nacelle of a turbofan engine in the presence of high flow velocities and sound pressure levels. Clearly, different conditions will be found in the case of drones. In this study, we consider ducted fans of geometry and operating conditions expected to be found in distributed propulsion systems, such as in electric vertical takeoff and landing aircraft. By employing a typical liner design methodology, it is shown that acoustic liners remain an attractive alternative to reduce fan noise of drones if a proper design procedure is followed.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

CFD-CAA approach for sound generation and propagation in the UAV propeller with subsonic flow

Sergey Timushev, Alexey Yakovlev, Dmitry Klimenko Moscow Aviation Institute (National Research University), Moscow, Russia: TimushevSF@mai.ru
Andrey Aksenov, Vladimir Gavrilyuk TESIS LTD, Moscow, Russia: andrey@tesis.com.ru Pyotr Moshkov Irkut Corporation: p_moshkov@ssj.irkut.com

Subsonic flow air blade machines like UAV propellers generate intensive noise thus the prediction of acoustic impact, optimization of these machines in order to reduce the level of emitted noise is an urgent engineering task. Currently, the development of calculation methods for determining the amplitudes of pressure pulsations and noise characteristics by CFD-CAA methods is a necessary requirement for the development of computer-aided design methods for blade machines, where the determining factors are the accuracy and speed of calculations. The main objective is to provide industrial computer-aided design systems with a highly efficient domestic software to create optimal designs of UAV blade machines that provide a given level of pressure pulsations in the flow part and radiated noise. It comprises: 1) creation of a method for the numerical simulation of sound generation using the correct decomposition of the initial equations of hydrodynamics of a compressible medium and the selection of the source of sound waves in a three-dimensional definition, taking into account the rotation of blades and their interaction with the stator part of the UAV; 2) decomposition of the boundary conditions accounting pseudo-sound disturbances and the complex acoustic impedance at the boundaries of the computational domain 3) development of an effective SLAE solver for solving the acoustic-vortex equation in complex arithmetic (taking into account the boundary conditions in the form of complex acoustic impedance); 4) testing of a new method at all stages of development using experimental data on the generation of pressure pulsations and aerodynamic noise, including a propeller noise measurements.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Drone noise, a new public health challenge?

Antonio J Torija Martinez: A.J.TorijaMartinez@salford.ac.uk
Acoustics Research Centre, University of Salford, Manchester, UK

There is a rapidly growing interest in manned and unmanned aerial vehicles of different size from small multi-rotor drones to Urban Air Mobility (UAM) vehicles. With the projected expansion of the sector, for a variety of applications from parcel delivery to transportation of people, it is very likely that urban and rural soundscapes will be altered by drone noise. This can lead to a significant source of community noise annoyance. This is the reason why it is widely accepted that noise is one of the largest limiting factors for public acceptance and adoption of drone technology. Unquestionable, if not tackled appropriately, the noise generated by drone operations might lead to significant tension with exposed communities. This paper aims to introduce the important uncertainty as to how communities will react to a new source of noise. Compared to conventional aircraft, drones generate an unconventional noise signature to which people are completely unfamiliar. Although with important broadband contributions, drone noise is highly tonal and has irritating frequency and amplitude modulations due to varying rotors rotational speeds. They will also flight closer to people and in a bigger number. An important factor to consider is that new communities, not currently affected by aircraft noise, will most likely be affected. Moreover, an overview on challenges and research gaps on noise effects of drones is provided:

(1) It is uncertain whether the current evidence of health effects of aircraft noise will be of application. If not, new evidence will need to be gathered as to health effects of drone noise.

(2) There are neither metrics able to account for the particular characteristics of drone noise nor information about acceptable levels.

(3) There is no understanding on how the deployment of drones will affect the perception of current urban and rural soundscapes.

(4) Community annoyance will be different depending on context, e.g. drone delivering medicines to remote areas vs. drone delivering parcels to your neighbours

(5) For planning purposes, exposure-response functions for drone noise will need to be derived. This introduces the challenge of how to predict long-term effects.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Achieving quiet flying passenger vehicles through numerical simulations, a LBM story

Dr. Wouter van der Velden, Gianluca Romani and Prof. Dr. Damiano Casalino Dassault Systemes Deutschland GmbH, Meitnerstraβe 8, 70563, Stuttgart, Germany
wouter.vandervelden@3ds.com

This paper describes multiple, fully automated, computational workflows for the evaluation of the acoustic environmental impact of vertical take-off and landing vehicles. Different scenarios are considered: (i) an isolated rotor for rotor performance studies, (ii) an isolated full vehicle undertaking quasi-static flow conditions, (iii) a vehicle hovering over an urban area, and (iv) an operational scenario of a vehicle undertaking an approach maneuver over a flat terrain. The aerodynamic performance and aeroacoustic sources are predicted by using the high-fidelity CFD solver SIMULIA PowerFLOWTM based on the Lattice-Boltzmann/Very-Large-Eddy-Simulation method. The acoustic propagation is computed using acoustic analogy formulations applied to the near-field flow field, with the exception of the urban scenario, for which the noise is extracted directly from the CFD simulation performed in a domain encompassing both the vehicle and the nearby urban city block. In this scenario, the effects of sound scattering due to the presence of several buildings is analyzed by comparing the noise levels on the surface of the buildings with those extracted on the same surface from another solution performed without buildings. Additionally, an integral approach based on the Ffowcs-Williams and Hawkings analogy is used to compute the noise on a hemisphere centered around the rotor and/or vehicle. This is used to compute the on-ground noise footprint for a prescribed, trimmed, flight trajectory path.

INCEEUROPE CidB Centre d'information sur le Bruit

International e-Symposium on Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

A study of the influence of support structure on drone noise

Simon Watkins, Nicola Kloet, Xu Wang RMIT University, simon@rmit.edu.au

An overview of experimental work pertaining to the understanding and reduction of aerodynamically-generated noise from small multirotor unmanned aircraft system (UAS) of approximately 1-4 kg is given. The development of a quiet rig designed to drive a range of propellers with minimal interference noise from the motor and support systems is described. This permitted measurements on a range of isolated propellers where the effect of RPM and blade geometry on sound pressure level for a set thrust point. Noise levels (SPL and spectra up to 20,000 Hz) were measured in a semi-anechoic environment at a single point using a standard laboratory grade microphone system. Selected wake velocities were measured using a Cobra probe and mapped, which gave 3-D flow information. The flow measurements gave insights into the wake flows which impinge on typical drone support arms and generate an additional source of sound when compared to a propeller in isolation. The effects of a drone arm being introduced into the flow were evaluated for a range of shapes and sizes from the measurement data at upstream and downstream locations. While there is an increase in overall sound pressure level when a structure is introduced into propeller flow, the specifics of the geometry of the structure seem to have a relatively small effect when compared with other factors (such as RPM and distance between propeller and structure).

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Noise requirements of Unmanned Aircraft due to European Regulation 2019/945

Michael Wieland – michael.wieland@uavdach.org
Ronald Liebsch – ronald.liebsch@dji.com
Matthias Vyshnevskyy – matthias.vyshnevskyy@uavdach.org

The European Commission adopted the Regulation (EU) 2019/945[1] laying down the requirements for the design and manufacture of unmanned aircraft systems (UAS) intended to be operated under the rules and conditions defined in Implementing Regulation (EU) 2019/947[2]. Before these UAS are made available on the EU market and put into service, they are required to pass CE certification. Sound power limits, the test code, and how the guaranteed sound power level is indicated for the consumer are included in the regulation (EU) 2019/945 and discussed in this report. Further, to specify design requirements and standard tests to comply with the regulation requirements, European Commission has requested CEN/CENELEC[3] (delegated to ASD-STAN) to develop an EU harmonized Standard. The authors are members of the ASD-STAN D5 WG8 group Technical Report "TR Noise" and list findings to discuss the current regulation.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

3D sound source tracking for drones using direction likelihood integration

Taiki Yamada (Tokyo Institute of Technology): yamada@ra.sc.e.titech.ac.jp
Katsutoshi Itoyama (Tokyo Institute of Technology): itoyama@ra.sc.e.titech.ac.jp
Kenji Nishida (Tokyo Institute of Technology): nishida@ra.sc.e.titech.ac.jp
Kazuhiro Nakadai (Tokyo Institute of Technology / Honda Research Institute Japan Co., Ltd.): nakadai@ra.sc.e.titech.ac.jp

In this paper, we present a 3D sound source tracking method by using multiple microphone arrays mounted to drones. Generally, microphone arrays have been utilized as a tool in signal processing for estimating a sound source direction. By mounting microphone arrays, drones will be able to search people calling for help in hazardous areas. However, the information of the sound source direction is insufficient to specify the sound source, which leads to the necessity to obtain the sound source location instead. Since it is difficult to obtain the 3D location using a single microphone array, recent studies show 3D sound source tracking based on triangulation techniques. In practice, due to large noise from a drone itself and unknown external noise, the direction estimation deteriorates. In addition, triangulation methods used in sound source location estimation is aggravated due to its discreteness. In this study, instead of triangulation, we propose to track the sound source location by estimating the likelihood distribution of the sound source location. Conventionally, when each microphone array localizes the sound source direction, it generally calculates the likelihood distribution of the sound source direction and takes the direction which has the highest likelihood. In our work, we propose to integrate the direction likelihoods of all microphone arrays and estimate the distribution of the location likelihood, rather than focusing only on the maximum likelihood. In this way, the sound source location distribution is represented in a non-Gaussian form, which is difficult via triangulation. The proposed method is evaluated through numerical estimation using real drone noise, comparing with other tracking methods based on triangulation. Simulation results demonstrates the effectiveness of the proposed method, which could track a 40 m far sound source with RMSE less than 4 m.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Experimental investigation of noise characteristics of rotors

Koichi Yonezawa, Central Research Institute of Electric Power Industry, Center of Aerial Intelligent Vehicle, Chiba University, Japan: koichi-y@criepi.denken.or.jp Eiji Shima, Japan Aerospace Exploration Agency, Japan Toshiyuki Nakata, Faculty of Engineering, Chiba University, Japan Hao Liu, Faculty of Engineering, Chiba University, Japan Yasutada Tanabe, Japan Aerospace Exploration Agency, Japan Shigeru Sunada, Nagoya University, Japan Hiroshi Tokutake, Kanazawa University, Japan

Rotors for multi-rotor-type UAVs are required to be silent as well as highly efficient. Safety is also important. In the present study, ducted rotors were examined experimentally. In experiments, rotor thrust, aerodynamic torque and noise were measured. The following blade designs were examined in experiment: two kinds pf two-bladed rotors with untwisted and twisted blades with a variable corrective pitch mechanism. One kind of the rotor duct geometry was examined. Although the duct increased the figure of merit of the rotor during hovering, the noise was also increased. Then the Helmholtz resonators were equipped on the duct wall and tested. The results showed that the noise increased as the rotational frequency increased, or the rotor duct was used. The Helmholtz resonator was not effective to suppress the noise. The influences of the blade twist, difference in the airfoil were also less than that of the rotational frequency.

International e-Symposium on
Noise of Drones/UAV/UAS

Paris, 19 - 21 October 2020

Multi-rotor powered drone noise assessment

Xin Zhang
Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China,
aexzhang@ust.hk
Siyang Zhong
Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China,
zhongsy@ust.hk

This paper addresses noise and certification requirements of multi-rotor powered flying vehicles such as drones or unmanned vehicles that are now increasingly ubiquitous. As the vehicles' roles extend beyond leisure to commercial and industrial applications, their size and weight increase, and they operate increasingly close to urban areas, causing noise pollution and health damage. The noise problem was often neglected thus far in the headlong dash to growth by the industry. There are significant gaps in our understanding of the mechanisms of sound generation and shortfalls in our capability to evaluate the noise impact of multi-rotor powered unmanned vehicles. Noise impact assessment relies on accurate measurements and reliable noise models. Developments of measurement techniques and noise prediction methods are therefore timely and necessary. Some new features of the drone noise have been identified in recent fly and laboratory tests in the Advanced Aircraft Noise Technology Centre (AANTC) at HKUST. In this paper, we will discuss on the drone noise mechanisms and characteristics, offer views on noise certification and assessment conditions, and makes suggestions on assessment facilities and measurements requirements.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

EU Drone Regulation

Nicolas Eertmans (European Commission DG MOVE)

Forecasts predict many more unmanned aircraft systems in the coming year. Most of these will operate outside current controlled airspace. In order to provide citizens with high level of environmental protection, it is necessary to limit the noise emissions to the greatest possible extent, in particular from those commercial operations which may take place relatively frequently and the closest to people in the 'open' category. The presentation will explain how the European regulatory framework for unmanned aircraft has set sound power limits.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

From Helicopters to quiet eVTOLs, a manufacturer perspective

Julien Caillet, Airbus Helicopters: julien.caillet@airbus.com

Urban Air Mobility aims at conveying passengers in congested cities at a competitive price with existing ground transportation modes, in a reduced duration, while guarantying the highest level of safety. Among the critical requirements that need to be achieved to develop such operations, minimizing noise impact on community is a key point that is to be addressed. From its large experience on helicopters, with products among the quietest rotorcrafts in all the weight classes, Airbus helicopters intends to use his know-how and to leverage on the new degrees of freedom brought by distributed electric propulsion to design low noise eVTOLs.

This presentation will focus on the global logic followed by Airbus to understand community acceptance criteria and design quiet vehicles meeting these criteria when operating in realistic operating conditions. Based on the know-how acquired on helicopters, this logic relies on the combined used of numerical simulations, experimental tests on propellers, and full-scale acoustic testing on the existing demonstrators Vahana and City Airbus.

International e-Symposium on Noise from Drones/UAV/UAS

Paris, 19 - 21 October 2020

Noise pollution must be approached with as much attention as the issue of safety

Francis TRUCHETET, Nicolas VIARD: ACNUSA / Airport Nuisance Control Authority (France)

After a brief review of its missions, the Airport Nuisance Control Authority makes connection with expected drone flight experiments dedicated to air transport, planned in the region of Paris. It recalls the importance of dealing with the nuisances caused by this new mode of transport with the same level of requirements as that already applied to air transport, while adapting to the specificities associated with drone overflight.

Index of Authors

AUTHOR INDEX

AUTHOR INDEX