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**Research Areas**

UAV, Additive Manufacturing, Robotics and Control, Finite Element Analysis

**Projects & Publications Summary**

Project		Publication Count		Citation Count			
Completed	09	SCI	034	Citations	Google	SCOPUS	
Ongoing	06	SCOPUS	052		278	473	
Submitted	02	Books	003		h-index	09	11
		Books chapters	016		i10index	09	09

**National/International Collaboration**

- **Indo – Taiwan:** Design, Development and Formation Control of Micro Ornithopter (Tamkang University)
- **Indo – Korea:** Design and Development of Autonomous Amphibious Unmanned Aerial Vehicle and UAV Mountable Water Sampling Devices for Water Based Applications (DGIST / Rovitek / Sun Moon University)
- **Indo – Canada:** Full Field Non-Contact SHM Protocols for Long Span Railway Bridges and Heritage Structures Bridges across India and Canada inspected using UAV. Laxmi Vilas palace is Mapped (University of Victoria)
- **DRDO - ARDE :** Near Net Shape Components through Automated Selective Inhibition Sintering Process (SISP) for Small Armament Applications
- **ISRO - NESAC:** Energy efficient and optimal path planning strategies for SWARM of UAVs in real time localisation using deep learning based stereo vision system
- **DRDO – NAL:** Development of patch antennas for UAV applications to enhance the range of communication.

**Research snippets**

**Research facilities**

- 15 kg payload Multirotor UAV; LiDAR; Thermal camera; 3D printer; Load Cells; HD Cameras; Environmental meter, Load cell DAQ interface, Radio controller, Water quality sensors, Surface roughness tester Metallurgical microscope, Stereovision camera, Embedded development board

**Outline of Research Works**

- Development of UAVs for diverse applications: Power line cable inspection, Telecom tower inspection and radiation measurement, Environmental monitoring, Exploration of mines, Pesticide spraying and crop monitoring, Water sampling and water quality analysis (in-situ and Lab)Infrastructure assessment (Bridges and Heritage Structures)Measurement of air quality
- Developed autonomous Amphibious UAV having a payload of 5kg and endurance of 45 mins with a provision for mounting on board water quality analysis sensors
- Designed novel water sampling mechanism to collect water samples in remote water bodies. Formulated IoT based transfer protocol to transmit the water quality sensors data in real time.
- Five railway bridges in India and three bridges at Canada were inspected using UAV and damage condition is assessed.
- Created a user-friendly Graphical User Interface (GUI) that can incorporate 52 structural defects, as identified in Association of State Highway and Transportation Officials (AASHTO) manual and utilized it to inspect bridge condition states.
- Development of powder based additive manufacturing system (SIS) to build a part size of 200 X 200 x 200 mm<sup>3</sup> with cost effective inhibition and sintering mechanisms.
- A low-cost bench top test rig setup has been designed and developed to measure the lift and thrust forces of Ornithopter.

**Details of Funded Projects**

S.No	Project Title	Funding agency	Amount	Duration	Collaboration
1.	UAV Based In-situ Measurements and Hyper spectral Analysis for Water Quality Mapping and Developing Remediation Strategies	DST- SERB – EQUITY	INR Rs 42.54 Lakh	2022 – 2025	NRSC
2.	Devising point-of-care diagnostic microchip biosensor for early diagnosis of cardiovascular disease	DST – GITA	INR 41.23 Lakh	2022 – 2025	Indo-Taiwan (Tamkang and National Sun Yat-Sen University)
3.	Energy efficient and optimal path planning strategies for SWARM of UAVs in real time localisation using deep learning based stereo vision system	ISRO – Respond	INR 23.01 lakhs	2019 – 2021 (ongoing)	NESAC
4.	Development of 3D Printed flexible patch antennas for enhancement of communication range in UAV	DRDO	INR 29.06 Lakh	2021-2023	NAL

5.	Drone assisted mapping of seaweeds at Chilka lake and development of Value added products from biomass	DBT	INR 61.00 Lakh	2021-2024	Delhi University
6.	Minimizing the Post Harvesting Loss In Ware Houses Through Examining Rice Kernel / Paddy Quality using Infrared Measurements and Image Processing Algorithms.	TNSCST	INR 2.00 Lakh	2021-2023	TNWC
7.	UAV Autopilot system for water sampling with folding arm.	Indo -Korea	INR 6.40 lakhs	Sept. – Nov. 2021	Sun Moon University
8.	Expansion of Activities of Biotech-KISAN Hub in Three Aspirational Districts (Kadapa, Vizaingaram and Visakhapatnam) of Andhra Pradesh	DBT	INR 6 Lakh	2019-2020	ANGRAU
9.	Development and Formation Control of Micro Ornithopters	DST– GITA – CII,	India : INR 26.35 Lakhs, Taiwan : NTD 17.15 Lakhs.	2013 – 2016.	Indo – Taiwan Collaboration (Tamkang University )
10.	Ornithopter Test Rig – Design, Analysis and Manufacture	DRDO – AR & DB	INR 9.74 lakhs.	2014- 2016	NAL
11.	Robotic assisted rapid prototyping of near net shape components through indigenous polymers	DST-SERB	INR 22.16 lakhs	2014 – 2018	
12.	Near Net Shape Components through Automated Selective Inhibition Sintering Process (SISP) for Small Armament Applications	DRDO – ARMREB	INR 27.15 lakhs	2015 – 2018	ARDE
13.	Full Field Non-Contact SHM Protocols for Long Span Railway Bridges and Heritage Structures	DST - ICIMPACTS	India: INR 41.15 lakhs, Canada: CAD 1,44,066.	2015 – 2018	Indo - Canada Collaboration Project (University of Victoria)
14.	Design and Development of Autonomous Amphibious Unmanned Aerial Vehicle and UAV mountable water sampling devices for Water Based Applications	DST– GITA – CII	India: INR 3 Crore and South korea: 7 Crore	2017 – 2019	Indo – Korea Collaboration (DGIST and Rovitek)
15.	Design and Development of Ornithopter Test Rig	IEI	INR 50,000	2013 – 2014	Institution of Engineers

### Consultancy Projects

1. Design and Analysis (structural and vibration) of launcher platform and articulation mechanism for NAMICA, Bharat Electronics Limited, Chennai, Rs. 5 lakhs, Mar 2003 – Apr 2004
2. Finite Element and Kinematic Analysis of Fueling Machine, BARC, Mumbai, Rs. 6 lakhs, Dec 2003 – Oct 2005.
3. Bridge Inspection using UAV, LASA India Pvt. Ltd., Rs 80,000 Jan 23- 27, 2018
4. Design and Fabrication (Composite Material) of Hybrid UAV, M/s Magnum Wings, Guntur, Andhra Pradesh, Rs. 3,57,000, June – August 2019
5. Modeling and CFD analysis of Hybrid UAV, M/s Magnum Wings, Guntur, Andhra Pradesh, Rs 1,20,000, July – August 2019.
6. Development of multi rotor system for 1kg payload, BLUNAV TECHNOLOGIES PVT LTD, Rs 2,60,000, Oct - Dec 2020
7. Mapping of airport fencing with accurate RTK module, BLUNAV TECHNOLOGIES PVT LTD., Rs 45,000, Oct – Dec 2020

### Recent Best 5 SCI Publications

- **Esakki Balasubramanian**, Tesfaye Kebede Ali, D. Rajamani, and Salunkhe Sachin. "Parametric Optimization on Impact Strength of Selective Inhibition Sintering Fabricated PA-12 Parts Based on Evolutionary Optimization Algorithms." Journal of Materials Engineering and Performance 30, no. 7 (2021): 5356-5367
- Shiferaw, Aleligne Yohannes, **Esakki Balasubramanian**, Tamilarasan Pari, Elangovan Elumalai, Saleh Mobayen, and Andrzej Bartoszewicz. " Design and Implementation of Morphed Multi-Rotor Vehicles with Real-Time Obstacle Detection and Sensing System," Sensors Vol. 21, No. 18, 2021, 6192
- **Esakki Balasubramanian**, Silambarasan Mathiyazhagan, Manova Moses, K. Jagajjanani Rao, and Surendar Ganesan. "Development of 3D-printed floating Quadrotor for collection of algae in remote water bodies." Computers and Electronics in Agriculture 164 (2019): 104891
- **Esakki Balasubramanian**, Surendar Ganesan, Silambarasan Mathiyazhagan, Kanagachidambaresan Ramasubramanian, Bhuvaneshwaran Gnanasekaran, Byungrak Son, Su Woo Park, and Jae Sung Choi. "Design of amphibious vehicle for unmanned mission in water quality monitoring using internet of things." Sensors 18, no. 10 (2018): 3318
- Lung-Jieh Yang, **Esakki Balasubramanian**, Udayagiri Chandrasekhar, Kuan-Cheng Hung, Chieh-Ming Cheng, "Practical Flapping Mechanisms for 20cm-span Micro Air Vehicles", Intl. Journal of Micro Aerial Vehicle, Vol. 7, No. 2, pp.181-202, 2015

### Books

- **Balasubramanian Esakki**, Two Collaborative Robot Manipulators Handling a Flexible Object: Modeling, Control and Analysis, LAP LAMBERT Academic Publishing GmbH & Co. KG, Germany, ISBN: 978-3845407272.
- Rama Bhat, Jothi lakshmi Rajendran, **Balasubramanian Esakki**, "University Physics", Narosa Publishing House Pvt. Ltd, ISBN 978-8184872699 and Alpha Science International Ltd, ISBN: 978-1842658130.
- Lung – Jieh Yang and **Balasubramanian Esakki**, "Flapping Wing Vehicles: Numerical and Experimental Approach", CRC Press, Taylor & Francis, Under Print.

### Patents

- Appln No. 2237/CHE/2014 – Power Line Inspection Robot, Final Examination.
- Appln No. 5037/CHE/2014 – Telecom Tower Inspection Using Unmanned Aerial Vehicles, Final Examination.
- Appln No. 2016400361 – Vision Base Control of Multiple Flapping Wing Micro Aerial Vehicles and Formation Flight, Final Examination.
- Appln. No. 201641009924 – Adaptive Traffic Control and Mapping using Unmanned Aerial Vehicle, Final Examination.
- Appln. No. 20174024946 - "Elevated Civil Infrastructure Health Assessment Using Rotary Wing UAVs", Final Examination.

- Amphibian Unmanned Aerial Vehicle for Multi-terrain applications  
PCT Intl. Appln.No. PCT/IN2018/050651; India :201741036299 (Applied)
- Appln. No.201841029828 – “Medical Assistive Device for Geriatric Care and Orthopedic Rehabilitation”, Final Examination
- Appln. No. 201841044458, Adjustable Frame Unmanned Amphibious Aerial Vehicle With Extended Floats, Final Examination

#### Fellowships/Awards/Recognitions

- National Level Competition - Secured 1st Prize for the development of Hexacopter UAV to inspect the power line cables – Organized by Power Grid Corporation Ltd, 2013
- Aegis Graham Bell Award in the category of “Best Innovative Business Model -2014” for Telecom tower structure inspection and on-line radiation measurement. <http://veltechuniv.edu.in/Achievements.html>
- National Competition - VISAI 2015 - Won Best Project Award in Mechanical Stream competing over 50 Colleges / Universities.
- World Wide Competition - Secured 2nd Prize under the category of “Future of Technology”- Organized by Future Ideas Foundation, 2015.
- National Competition - VISAI 2017 - Won First Prize in Clean water Stream and Won Third Prize in Environmental theme.

#### PhD Thesis Guidance

Scholar Name	Thesis Title	University	Status	Year
Dr. D. Rajamani	Experimental investigations and parametric optimization of selective inhibition sintering process	Vel Tech	Completed	2019
Dr. Mesfin Sisay Mengesha	Computational cost reduction in numerical analysis of welding and its experimental correlation.	Vel Tech	Completed	2021
Dr. N V S S Sagar	Design of monocoque Quadcopter Structure through integration of Topology Optimization and Additive Manufacturing	Vel Tech	Completed	2021
Dr. Madhu B	Experimental approach on improving the yield of fresh water in solar stills	Vel Tech	Completed	2021
Dr. G.Surendar	Conceptualization and Evaluation of Unmanned Amphibious Aerial Vehicle for Water Quality Assessment	Vel Tech	Completed	2021
Dr. Tesfaye Kebede Ali	Experimental Investigations and Optimization Studies for Enhancing Compressive and Impact Strengths of SIS Parts	Vel Tech	Completed	2021

#### Editorial/Review Activities

- Reviewer for Journal of Applied Science and Engineering, Tamkang University, Taiwan.
- Reviewer for Journal of Advances in Mechanical Engineering, SAGE publications.
- Reviewer for Science China Technological Sciences, Springer