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APPLICATION FOR SOURCE OF SOLUTIONS GRANTS (SPECIAL GRANTS)

Proposal to Address Dimensions (refer to Annex): Disaster Risk Management, Occupational Safety (Peace, Harmony, and Security/ Environment)

Proposal Title: Design and Fabrication of a Rotary Wing UAV Using Low-Cost Materials

Duration of Project (in months): 12 months

Proposed Budget: PhP 300k

ABOUT THE PROPONENT

(PROJECT LEADER/PROJECT TEAM POINT OF CONTACT)

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First Name: de la Pena

Middle Name: Banzon

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Faculty/REPS Position: Assistant Professor Rank: 1

Nature of Appointment: [x] Permanent [ ] Temporary

College/Unit: Fine Arts Dept.: Viscom

Highest Educational Attainment: MID Industrial Design

Available for interview at OVCRD if required? [x] Yes [ ] No [ ] Uncertain

Note: An interview may be used in the assessment of a proposal. It does not guarantee approval of the request for funding.

Co-Project Leader

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PROPOSAL FORMAT

PART 1. DETAILS OF THE PROPOSAL

1.1. Title of proposal: Design and Fabrication of a Rotary Wing UAV Using Low-Cost Materials

1.2. Keywords to describe the subject area of the study: UAV, Quadcopter, Lightweight, Arduino

1.3. Duration of the study (in months): 12 months

1.4. Abstract

The rising interest around UAV systems for their diverse applications in various sectors has led to the idea of the construction of low-cost drones. This work aims on designing and fabricating low-cost rotary-wing UAV using low-cost materials. Analysis of the better materials in terms of weight reduction and cost factors are to be conducted and integrated in the final output. Parameters in the UAV structure are to be optimized based on basic airframe considerations. The developed UAV will be tested on fully manual flight tests and a drone-building workshop based on the results are to be performed which aims to create innovative ideas for future drone works, especially for humanitarian applications.

1.5. Proposed Approach

Utilization of Unmanned Aerial Vehicles (UAV), or simply drones, has grown significantly in the recent years especially for fixed-wing and rotary-wing types. UAV refers to a class of aircrafts that can fly without the onboard presence of a pilot [1]. Drones has potential for use in a variety of sectors including defense, emergency response and disaster management, urban planning, conservation of endangered species, healthcare, agriculture, weather forecasting, waste management, mining, and even telecommunications. These applications can be classified into three categories namely 1.) Military, 2.) Humanitarian, and 3.) Commercial.

As beneficial and convenient UAV technology is, it still has not seen much utilization in the current Philippine setting due to uncertainty in legislation - granted it being a new technology - as well as the fact that drones are still pretty expensive for the typical Filipino consumer.

This project proposal centers on integrating the expertise of the Industrial designers in the College of Fine Arts' (CFA) Fablab and Materials engineers of the Advanced Defense and Aerospace Materials (ADAM) R&D to develop a fully functional yet low cost multirotor aerial platform capable of manual flight and equipped with a photogrammetric payload for rapid mapping purposes. The UAV to be assembled could be used for humanitarian purposes particularly early impact analyses for the evaluation and probable mitigation of natural and manmade hazards.

This project also aims to build the capacity of UP students in drone-building gearing towards humanitarian aid. The output of this project will include a learning module which can be the foundation of future UAV works for humanitarian purposes. A similar approach had been employed by UNICEF in Malawi, Africa where students were given

a 2-day workshop on drone-building [2]. The student-made drones were designed to be deployed to transport medical aid to the far-off communities without easy access to hospitals. Aside from healthcare, Sensefly [3] and UNICEF [4] have outlined the potential humanitarian applications of UAVs to be: 1.) Emergency response, 2.) aid distribution and planning, 3.) identifying at-risk populations. 3.) site monitoring, 4.) community mapping, and 5.) demining.

The motivation for this proposal came about when two (2) Materials engineering students under ADAM were selected to attend a one-week workshop on aviation and drone-building in Singapore, hosted by Singapore University of Technology and Design (SUTD), and fully-funded by TEMASEK foundation. Their experiences include making multirotor drones starting from the design up to fabrication. Laser cutters, 3-D printers, and other such equipment were used during the workshop. These tools were soon found out to be available in the CFA Fablab resulting to the proposed partnership between CFA and CoE Department of Mining, Metallurgical, and Materials Engineering.

1.5.1 Design and Assembly of the Multirotor UAV

The construction of the UAV parts is to be primarily completed with the use of the Fablab's 3D-printers and Laser cutter to keep the cost to a minimum. Almost all parts of the drone, except the electronics and those too large for the printer, can be manufactured with the 3D printer. These include the landing gear, propellers, camera mount, antenna holder, and prop guards [5, 6, 7]. The lightweight frame of the UAV is to be cut according to the design with the laser cutter. The frame material is to be prepared by the DMMME.

1.5.1.1 Quadcopter Configuration

Among the various designs of multirotor available, the most popular and most employed model is that of a quadcopter, or quadricopter, with a fixed pitch hovering in the air with four (4) rotors [8].

The quadcopter frames exist in two (2) configurations: 1.) The Plus (+) configuration (Also known as the Greek cross), and 2.) The X-configuration (Also known as St. Andrews cross). Figure 1 shows both configurations. For this project, the X-configuration is to be employed.

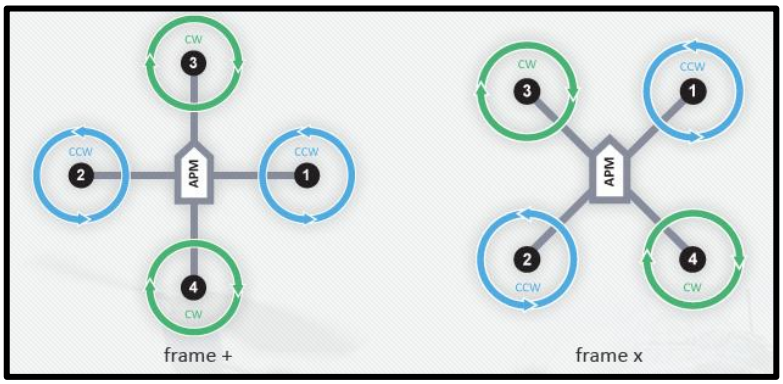

Figure 1. The two frame configurations of typical quadcopters.

There are not much fundamental differences between the two models. Frame "+" typically is used for drone racing and performing acrobatic maneuvers given two of the four rotors are in line with the center of rotation which allows faster maneuvering. The X-configuration is better suited for image acquisition as the motors are positioned laterally offering unobstructed visual front.

1.5.1.2. Motors, Propellers, and Speed Controllers

The motors spin the propellers to provide lifting thrust. A brushless DC motor is to be used over a brushed one for higher thrust-to-weight ratios. The rating expected to work is 1000 kV and 15 A maximum current rating.

Motors require an individual electronic speed controller (ESC) to accept the command signals from the pilot on the ground. For the ESC, a 20 A rating is selected for the project.

The propellers are to be experimented upon in terms of material, diameter, and pitch. Typical propellers are made of Carbon fiber composite, which can be prepared by DMMME but are relatively expensive. 3D-printing materials are to be tested as alternatives such as PLA, ABS, and others.

1.5.1.3. Flight Controller

The flight controller is the brain of the drone. It performs the various functions necessary to make the aircraft controllable and stable. There are purpose-made flight controller boards commercially available for hobbyists. However, to make the overall product cheaper, an Arduino Pro Mini is to be employed for the task. Open source codes for the flight control are to be used in tandem with the controller.

Table 1 shows the other electronic parts of the UAV to be used in this project.

Part	Selected commercially off-the-shelf (COTS) products
1. Battery	2200 mAh 20 C batteries
2. Radio Receiver	2.4 GHz Radio frequency receiver with 6 channels
3. Attitude sensor	6-axis inertial measurement unit with accelerometer, gyroscope, and magnetometer

1.5.2. Impacts of Low-Cost UAV and Drone-Making Capacity Building for UP Students

Figure 2. UAV being used to assess the structural integrity of buildings after a disaster and survey the area for victims.

Figure 2 shows one use of UAVs in disaster response and management. In UP, particularly these past months, earthquakes have happened with increased frequency. In one, the structural integrities of several buildings have been reassessed to ensure the safety of students and personnel before resuming work and classes. The drones the UP students will develop through this project can be used for such applications in case a big earthquake happens again in the future or any other similar disasters, both natural and manmade.

Including in the output capacity building ensures that the technology will be passed on to the next generation of students equipping them with the knowledge to create better drones with better capabilities and applications. The workshop promotes skill-sharing between students, artists, engineers, and entrepreneurs to allow merging of ideas and formation of a body that can pilot, service, and utilize drone technology in the future. For example, the next generation could make low-cost drones that can

extend connectivity (WiFi or cellphone signals) in remote areas, firefighter drones, healthcare transport drones, and conservation (Plant and animals) drones among others.

1.5.3. Related Works

One of the proponents, Mr. Jason Pechardo, has worked as a consultant with the UAV Consortium of the Philippines composed of Ateneo De Manila University (ADMU), De La Salle University (DLSU), and FEATI University under the leadership of Dr. Rogel Mari Sese (One of the authors of the Philippine Space Agency bill). His responsibility is to create novel materials for the airframe of the fixed-wing UAV. Aside from this, Two (2) of his students under ADAM has also been selected to attend a 1-week Drone-building workshop in Singapore equipping them with the capability to create multirotor drones.

The CFA Fablab has mastered the use of Laser cutters and 3D Printers for various design purposes. As industrial designers, the CFA students are able to create optimum designs for diverse applications.

1.5.4. Timeline

TASK TITLE		EXPECTED OUTPUT	PROJECT TIMELINE											
			1	2	3	4	5	6	7	8	9	10	11	12
1.1	Procurement of materials	Procured building materials and drawings of the drone												
1.2	Design of the drone													
2.1	Fabrication of the frame	Complete 3D printed and laser cut parts												
2.2	Fabrication of the other parts (Propeller, landing gear, etc.)													
3.1	Assembly of the structure	Prototype of the quadcopter												
3.2	Attachment of the electronics													
4	Field testing	Successful and well-documented flight test												
5.1	Drone-building Workshop	2-day Workshop and Final paper												
5.2	Paper writing (Documentation)													

References

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** Attach curriculum vitae of Proponent (Project Leader/Project Team Point of Contact) as supporting document.*

1.6. Proposed Budget

Item (MOOE)	Unit cost	Total
2 Project Leaders honorarium (Php 3000/mo x 12 mos)	36,000	72,000
2 Project Support Staff (Php 6000/mo x 6 mos)	36000	72,000
Sub-Total		**144,000**
Supplies and materials		
3D Printing Filaments	**20,000**	**20,000**
PLA	5000	5000
ABS	5000	5000

PVA	5000	5000
TPU	5000	5000
Lightweight Composite Materials	**24,000**	**24,000**
Carbon fiber	10,000	10,000
Glass fiber	7,000	7,000
Resin	7,000	7,000
Misc. (Consumables, Kimwipes, etc.)	4000	4000
Acrylic	5,000	5,000
Wood	5,000	5,000
Motors and Electronics	20,000	20,000
Drone-Building Workshop Expenses	30,000	30,000
Other supplies	10,000	10,000
Sub-Total		**118,000**
Item (CO)		
3D Printer	20,000	20,000
Action Camera	18,000	18,000
Sub-Total	**38,000**	**38,000**
TOTAL		**300,000**

SUBMISSION TERMS

By placing an "X" in the box below, I verify that the submitted response does not contain any confidential information of any kind whatsoever.

I agree to OVCRD's submission terms	**X**

PART 2. CERTIFICATION

I certify that all information/data in this proposal are true to the best of my knowledge. I understand and agree that the OVCRD will keep all the documents I submitted in connection with

my application for a research/creative work grant, whether the application is approved for funding or not.

_____	_____
Signature of Proponent	*Date*

PART 3. ENDORSEMENTS

I certify that I have reviewed this project proposal entitled "Design and Fabrication of a Rotary Wing UAV Using Low-Cost Materials" and I am recommending it for funding. The proponent has the required capability/expertise to undertake and complete the proposed project. When completed, the research/creative work will be a significant contribution to the field of _____. Furthermore, considering the overall academic track record and other ongoing commitments of the proponent, I have the highest confidence that the proponent can finish the project within the proposed duration.

_____	_____
Name and Signature of Dept. Chair/Director	*Name and Signature of Dean of College*
_____	_____
Date	*Date*