

February 7th, 2014

RUAS: Capstone Design Project Team
Carleton University
1125 Colonel By Drive
K1S 5B6

Carleton University Engineering Student Equipment Fund
Dept. of Engineering & Design – Office of the Dean
Minto Building, Rm 3010
1125 Colonel By Drive
K1S 5B6



To the CUESEF Board of Members,

I am writing on behalf of the Carleton University's Unmanned Rotorcraft Aerial System (RUAS) Fourth Year Capstone Design Project – 2013/2014. The project currently consists of 20 students and is led by, Professor D. Feszty. RUAS received funding from your organization in the Fall of 2013, which is currently being used to purchase a Digital Image Correlation System (DIC) for measuring stress/strain behaviour of complex RUAS components (i.e. the the rotor blades), and a load balance system, to be used for wind tunnel testing this semester. The 2013/2014 RUAS group will be continuing work on the detailed design of a mid-size rotary wing UAV this semester, and plans to proceed with testing and initial assembly of both our unique Bell Helicopter 412 scaled rotor hub, in Carleton's one of a kind Whirl Tower Facility, and the full scale RUAS vehicle. This proposal outlines the RUAS group's request for funding in the amount of \$6626.61 to purchase the engine required for RUAS testing and construction, bearings required for scaled hub assembly and essential avionics equipment.

As part of the detailed design requirements for the RUAS, this year our *Drive System Analyst* has selected the engine required for the rotorcraft's desired performance. The RUAS team wishes to purchase this engine for preliminary testing and eventually installation on the RUAS vehicle that will be assembled next year. A number of our students are developing a model of a Bell Helicopter Textron 412 Scaled Rotor Hub to perform tests in Carleton's novel *Whirl Tower Facility*, the only facility of its type in Canada, in order to obtain blade dynamic measurements and test rotor hub functionality. The RUAS group also has a dedicated team focused on developing the Avionics interface of the UAV. The purchase of the bearings for the Scaled Hub assembly, the ZDZ 420B4-J engine, and the autopilot for the full-scale RUAS, will allow for all of the aforementioned testing and detailed design to be completed within the outlined project timeline. All of the equipment can remain within the department after this project term for use by future RUAS groups as well as on an inter-project basis.

The attached pages detail the proposed budget, allocation of funds, suppliers and how the funding from CUESEF will facilitate in the education of Mechanical and Aerospace students. All items are listed in order of priority to the RUAS teams and prices are listed in CAD, including HST and shipping.

Thank you for taking this request into consideration. If you have any further questions feel free to contact Dr. D. Feszty (dfeszty@mae.carleton.ca) or the undersigned.

Sincerely,

A handwritten signature in blue ink, appearing to be 'D. Feszty', written over a horizontal line.

Jen Gatenby
jengatenby@cmail.carleton.ca
RUAS Project Integrator (100798753)

Dr. D. Feszty
dfeszty@mae.carleton.ca
RUAS Project Manager (CB 3207)



CUESEF PROPOSAL

07-FEB-14

EXPLANATION OF THE REQUIRED PARTS

1. ZDZ Engine

The RUAS requires a gas powered engine in order to provide power to the main and tail rotors of the aircraft. 12 engines were compared head to head, and the ZDZ 420B4-J was found to be the lightest and most powerful engine at a mid-low price range compared to the other engines. The 2 stroke engine boasts 4 cylinders and 420 cc of displacement and more than 35 available HP. That said, the available power and performance presented by suppliers is often only a peak power reached during testing and not a reliable value for continuous performance. As a result, the RUAS team needs to obtain at least one engine to run performance tests to be sure the engine is well suited for our application. If it proves to be an adequate choice, the purchased engine will be installed on the RUAS by next year's project team. The engine is supplied by ZDZ in the Czech Republic and costs €2790 EUR/pc (approx. \$4190 CAD) with a direct purchase from ZDZ. There is an approximately 6 month lead time for the engine; therefore, it needs to be purchased this year, in order for the project to meet its 3 year timeline. Having the *heart of the aircraft* in house, will be of great benefit for the RUAS team and will expedite the remaining design and construction tasks. The RUAS correspondence with ZDZ through Drive System Analyst, Nick Bulger, with the quoted price, is attached in Appendix A, for your convenience.



Figure 1: The ZDZ B4-J Engine

2. Scaled Rotor Hub Bearings

The scaled rotor hub team consists of three RUAS group members, whose role this year is to manufacture and test a complete scaled model of a Bell Helicopter 412 rotor hub in Carleton's unique Whirl Tower Test facility. The purpose of the scaled hub is to validate the theoretical results from the RUAS team in the previous year. This acts as a means of determining appropriate manufacturing techniques and design tolerances on a smaller scale, in preparation for the manufacture of the full scale hub next year (at a greater expense). Last year's RUAS team designed the required custom components which have now been manufactured and are in the process of being assembled. The bearings required for assembly, supplied from General Bearing Service Inc. (GBS), are essential to the completion of the scaled rotor. Without the completed assembly of the scaled rotor hub the RUAS team will not be able to create a standardized testing environment and will inevitably prolong the completion of the full sized UAV rotorcraft. The quote for the bearing purchase, from GBS, is attached for your reference.

3. Avionics Equipment

Last year's RUAS team began work on the extensive avionics system required to achieve autonomous flight of the aircraft. This year the avionics group is continuing the development of the systems from last year focusing on the autopilot and flight control features, and will test all sensors and equipment on an RC helicopter (previously purchased) before implantation on the final aircraft next year. The group requires funding for the autopilot - a crucial component for the flight control system, as described below:

- **Autopilot**

An auto pilot is required to test in the 'Hardware-in-the-loop' simulation and is required in the Avionics test bed aircraft. It takes inputs from the sensors and produces signals needed to control the servos, creating a controlled and stable flight.

Table 1 – List of Items to be purchased

	ITEM	PART	SUPPLIER	PART NO.	SPECIFICATIONS	QTY	\$/PART	FINAL PRICE (\$)*
1	ZDZ Engine	2-Stroke Engine	ZDZ	ZDZ 420B4-J	4-Cylinder, Gas, 420 ccm, 11 kg	1	4190.00	5000.00
		<i>See attached quote (Appendix A), Link: <http://zdz.cz/en/432_zdz-420b4-j.html></i>						
2	Scaled Rotor Hub Bearings	Scaled Rotor Hub Bearings	GBS Inc.	Various	-	-	1,338.47	1338.47
		<i>See attached quote (Appendix B)</i>						
3	Avionics Equipment	AutoPilot	3D Robotics	US-KIT-APM-2.6-GPS	ArduPilot Mega 2.6	1	254.99	288.14
		<i>See attached quote (Appendix C), Link: <http://www.canadadrones.com/APM-2-6-p/us-kit-apm-2.6-gps.htm></i>						

TOTAL: \$6,626.61

* The final price includes an estimate of HST (Harmonic Sales Tax) and shipping cost – all costs in \$ CAD

APPENDIX A

ZDZ Model Motor E-mail Correspondence/Quote

Michal Janousek

ZDZ MODELMOTOR s.r.o.
Poličná 137

75701 Valasské Mezířici
Czech Republic

<http://www.zdz.cz>

[email:michal.janousek@zdz.cz](mailto:michal.janousek@zdz.cz)

tel: [+420573034419](tel:+420573034419)

Cell: [+420603201076](tel:+420603201076)

Jen Gatenby: RUAS Project Integrator

CUESEF Proposal

07-Feb-14

From: Michal Janousek <michal.janousek@zdz-modelmotor.cz>

Date: January 16, 2014 at 9:52:44 EST

To: Nick Bulger <NickBulger@cmail.carleton.ca>

Subject: RE: ZDZ 420B4-J Cooling Requirements

When university buys it directly from us it is 2790,- EUR/pc.

Dne 16. 1. 2014 15:50 "Nick Bulger" <NickBulger@cmail.carleton.ca> napsal(a):

thank you for your very quick response, I have one more quick question for you,

could I get an estimate of the cost of the engine? a price is not listed on your website.

thanks,

Nick

From: Michal Janousek <michal.janousek@zdz-modelmotor.cz>

Sent: Thursday, January 16, 2014 9:41 AM

To: Nick Bulger

Subject: Re: ZDZ 420B4-J Cooling Requirements

Hi Nick,

glad to hear you have chosen this engine. We do not have such exact information unfortunately, but I will try to get it from some clients who are working on this or similar engines.

In general our experience is that in the normal airplane cowl the speed of airflow is around 100km/s and air intake window for cooling air slightly bigger than front face of the cylinder.

It is an easy equation and for the beginning calculate with outside temperature around 20 degrees of Celsius. IMPORTANT is that air outlet must be bigger to avoid accumulation of the hot air in the space with engine or exhaust system.

I will collect as much info as possible for you and get back to you soon. Please feel free to write any question or request you may come up with.

best regards

Michal

2014/1/16 Nick Bulger <NickBulger@cmail.carleton.ca>

Good Morning,

I am a student at Carleton University, and we have chosen your engine for a rotary UAV. however I was hoping I could get more information on the engine.

what are the cooling requirements for the engine. I see a max CHT of 200 degrees, but what volume of airflow over the engine would be required?

thanks for your time,

Nick Bulger

APPENDIX B

GBS Bearing Quote

APPENDIX C

CanadaDrones AutoPilot Quote

DRONES
CANADADRONES.COM

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ITEM DESCRIPTION	QTY	EACH	TOTAL
 Latest ArduPilot Mega 2.6 - Assembled (SIDE PINS - External compass)	1	\$254.99	\$254.99

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Coupon Code:

Shipping Rates: (change my address)
Canada Post Regular \$12.26
Canada, ON, K1S 5B6

HST: \$34.74

Total: \$301.99