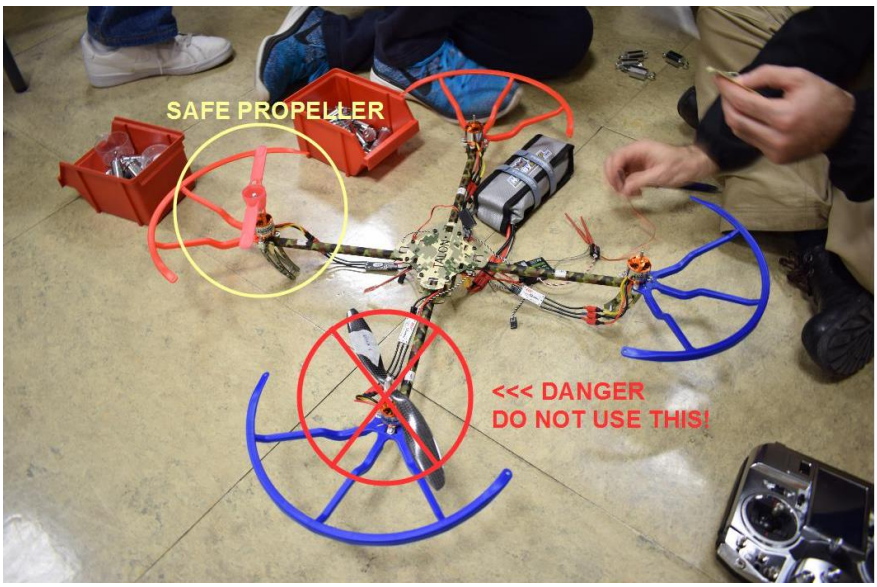
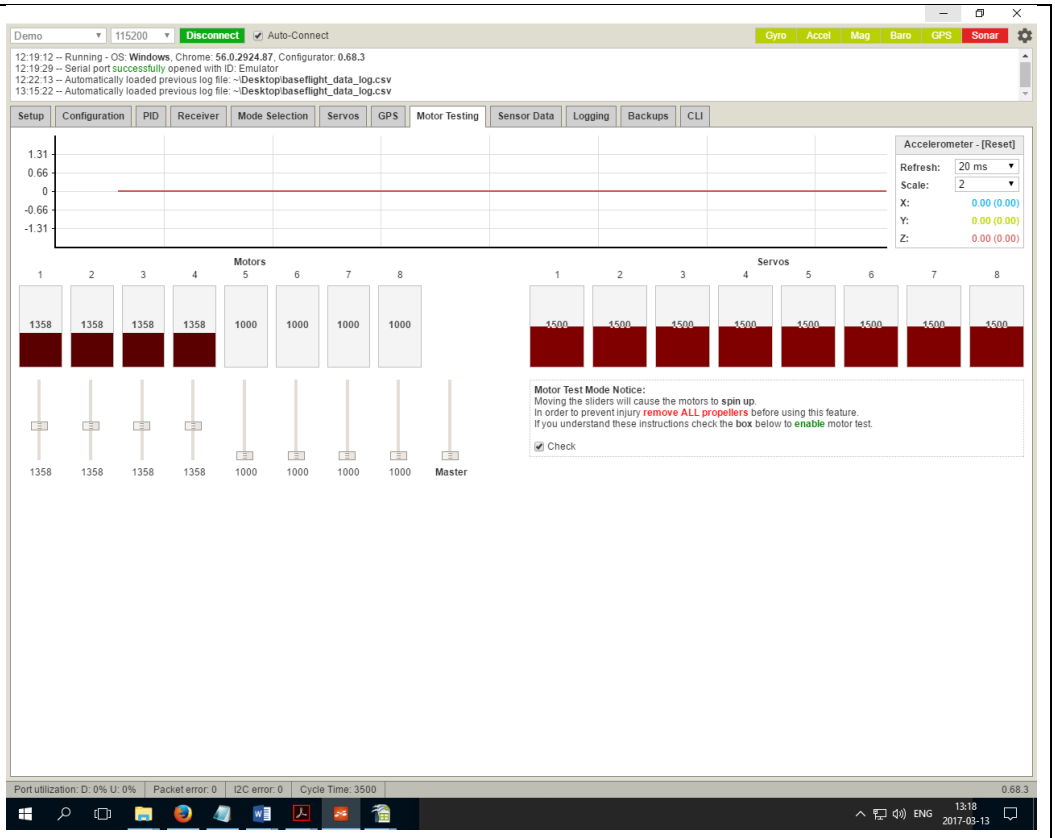
Project ICAROS **Report Code**	[GR-EA-2017-03-28]
Title	**Teaching "Linear Regression" with data from ICAROS**
Start/End Date	March/April 2017
Coordinator name and email	Georgios Mavromanolakis (gmavroma@ea.gr)
Name of teachers	GM
Number and age of students	12 students, 16-17 years old
Description of activities	**ATTENTION – Before starting make sure to remove all propellers from ICAROS. This is the first thing you should do. Always remember "SAFETY FIRST"** **WARNING-NOT REMOVING THE PROPELLERS WILL RESULT IN SERIOUS INJURY**  **FOR THIS ACTIVITY USE A SAFE PROPELLER WITHOUT SHARP EDGES (SEE PHOTO BELOW). ALSO SECURE ICAROS ON THE GROUND** 

	In this activity students are introduced to the method of linear regression. In statistics, linear regression is an approach for modeling the relationship between a scalar dependent variable Y and one or more explanatory variables (or independent variables) denoted X. In this activity the X variable is the Throttle value, the Y variable is the speed of rotation of each motor. Through this activity students learn the statistical method of linear regression and apply it using data they collect to characterize the motors of ICAROS. Students collect data from the Flight Control Board and through telemetry sensors, they then analyze them and present their findings. For Naze32 FCB data can be accessed through the Baseflight-Configurator software. In particular as shown in Screenshot 1, they have to use the Motor Testing tab of Baseflight-Configurator, where they can set the throttle value for all motors simultaneously or one-by-one. They also need to set up two telemetry speed sensors (optical and magnetic) to record the RPM values which are then displayed on transmitter's screen. They log their data in the attached paper worksheet, then they transfer them to a spreadsheet in Excel or OpenOffice for analysis The activity is divided in 4 main tasks and is done by students split into groups of 2 or 3 persons. <u>Task 1 – Preparation</u> All student groups familiarize themselves with the tasks they have to perform, the procedure they have to follow, and the relevant software that they will use. This is: 1. Baseflight-Configurator to connect and communicate with the Flight Control Board, and to collect data (see relevant Screenshot 1 attached below) 2. OpenOffice-Calc or Excel to write the data for analysis, to do linear regression and to produce the relevant graphs 3. OpenOffice-Impress or Powerpoint to create the presentation of their findings <u>Task 2 – Data collection</u> In this task students collect data (Throttle value and Motor RPM from optical and magnetic telemetry sensors). They transfer the collected tables of values from the paper worksheets to a spreadsheet for further analysis. <u>Task 3 – Data analysis – Linear regression</u> Students use spreadsheet software to analyze the collected data. For each recorded sample of values students have to make a graph (displaying RPM values vs Throttle) and also to calculate using linear regression the parameters of slope and intercept that best describe the expected linear dependency of RPM vs Throttle for each motor. They then overlay in their graphs the corresponding linear curve with the parameters they found.

	Task 4 – Presentation of findings In this task each student group presents its findings and discusses them. In particular they comment on the followings: Do all motors show linear behavior? Do both RPM sensors (optical and magnetic) record identical speed? Do all motors have the same linear parameters of RPM vs Throttle (slope or rate of increase, and intercept=minimum Throttle to start a motor)? Is there a problem if a motor has different rate of increase than the rest of motors? Is there a problem if a motor has different minimum Throttle to start than the rest of motors? Do all student groups find the same parameters for each motor? Task 5 – Calibration of Electronic Speed Controllers (ESC) Through the previous tasks students have understood and discussed the importance that all motors must have identical behavior. Actually this applies to the combination of ESC+Motor. In this task the calibration of each ESC is done following the step-by-step procedure described in the Naze32 FCB manual.
Learning outcomes	Through this activity students learn the statistical method of linear regression and apply it using data they collect to characterize the motors of ICAROS. Students learn also to use common spreadsheet software tools to analyze data, to make graphs, to present and interpret their findings. Also as they work in groups to perform the assigned tasks they practice and develop their skills of collaboration, communication, presentation.

Photos or other relevant material



(Screenshot 1. The Motor Testing tab of Baseflight-Configurator. The user can set the throttle value for all motors simultaneously or one-by-one)

Telemetry sensors (left- Turnigy TGY-APD01 Magnetic RPM Sensor, right -Turnigy TGY-APD02 Optical RPM Sensor

Paper worksheet

Motor 1

Battery voltage=

Throttle value	RPM (optical sensor)	RPM (magnetic sensor)
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		

Motor 2

Battery voltage=

Throttle value	RPM (optical sensor)	RPM (magnetic sensor)
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		

Motor 3

Battery voltage=

Throttle value	RPM (optical sensor)	RPM (magnetic sensor)
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		

Motor 4

Battery voltage=

Throttle value	RPM (optical sensor)	RPM (magnetic sensor)
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		