



Presents:

The **V.T.R. 1000 series**

“Voodoo Training Robot”

an **AUTOMATED PARAGLIDING INSTRUCTOR**

V.T.R. series

A project by Calin Popa & Ovidiu Ban

What is paragliding ?

- ❑ **Paragliding** is the recreational and competitive adventure sport of flying paragliders:
- ❑ A paraglider is an **ultralight aircraft**, composed of sail (wing) lines and harness (seat). The pilot sits ~ 6m under the wing and controls the glider using two brakes and by shifting his weight.
- ❑ By using **ascending currents** of hot air (thermals), paragliders can **gain altitude** and stay air born for hours...



What is Acro paragliding ?

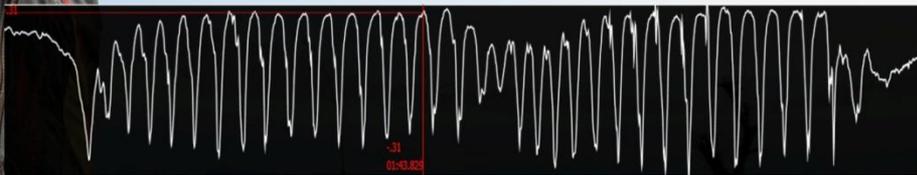
- **Acro**, or aerobatic paragliding flight is, as a passenger used to say: “Falling down, with style“
- As soon as the altitude is sufficient, the pilot **engages** in a breathtaking series of **summersaults**, loops, **twists** and dives, for his own pleasure and the spectators’ delight.
- Acro is **dangerous**. If the pilot’s trajectory does not match with the paraglider’s, all control over the aircraft can be lost.



What does the VTR 1000 do?



- The VTR 1000 “**knows**” what you are doing **in-flight**, by monitoring your **mechanical motion** through its sensors.
- It compares it to its program.



- The VTR 1000 “**tells**” you what to do, in pre-recorded voice, like “left”, “right”, “brake” etc, so that your **maneuvers** work out **safely** and **correctly**.



A world para-novelty

- ❑ The VTR unit addresses to **all pilots** that want to gain more **skill** and **safety**;
- ❑ It is a paragliding **assistant** and **teacher**;
- ❑ It allows **post flight analysis**;
- ❑ It makes **simulation training** possible;
- ❑ It can “**copy**” perfect executed maneuvers;
- ❑ It can **evaluate** and **score** maneuvers;

Pal Takats (3x world acro champion) testing the VTR 1000:



Learning “Infinity” with the VTR



- “Infinity Tumbling” is the most difficult acro maneuver;
- To perform it, the pilot has to **rhythmically pull and release** one brake at exact moments in time;
- We programmed the VTR to interpret the motion and to **emit sounds** that the pilot can follow;
- We used the centrifugal acceleration and the angular rotation as **reference** to determine the key moments;
- The pilot withstands up to 7g;
- In the following video, you will see Calin Popa learning the maneuver **following the unit’s** sounds;

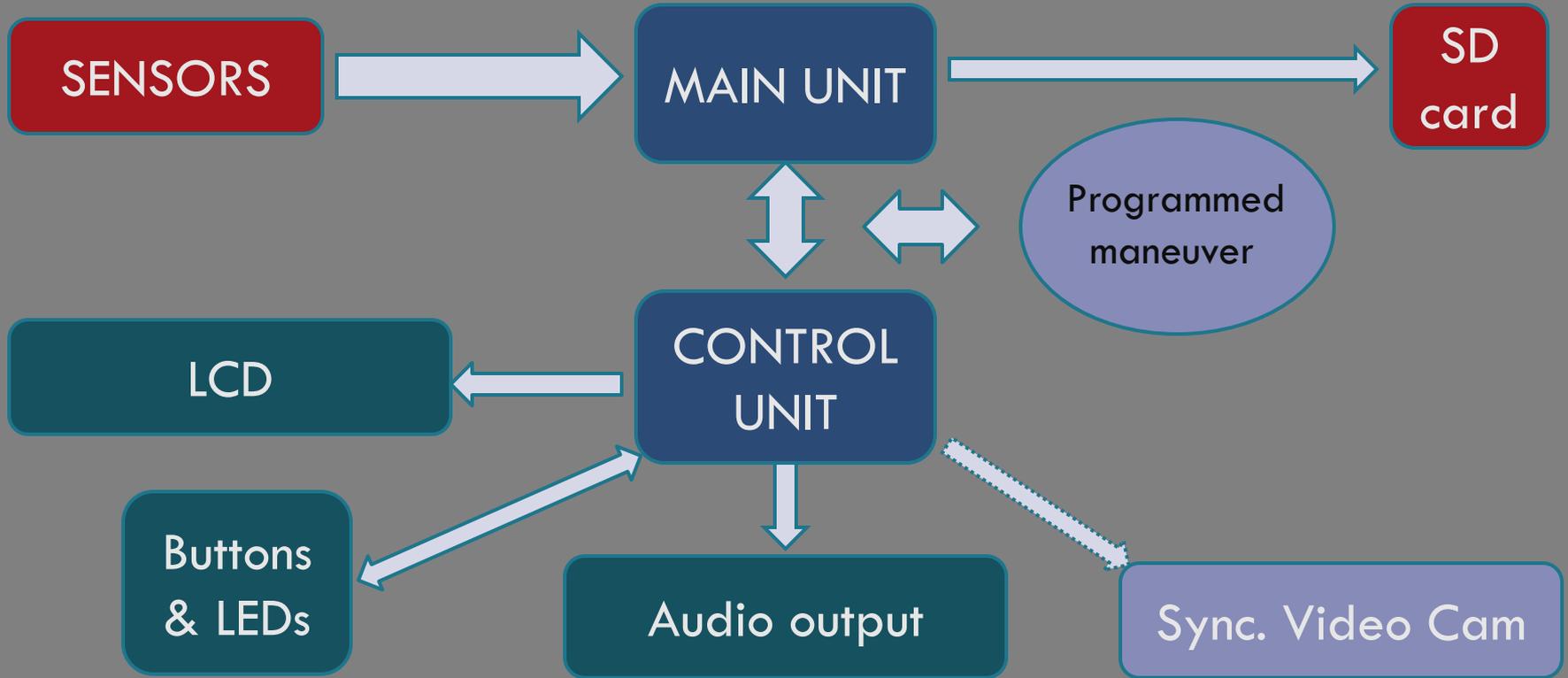
<http://www.youtube.com/watch?v=zd-YwmqNW5c>

Project timeline

- ❑ 2009 - G-force sensor with microcontroller and buzzer – not functional;
- ❑ 2010 - VTR 1000 **fully working** prototype with all the sensors;
- ❑ 2011 – Record and analyze flight data;
- ❑ 2012 – 3 maneuvers implemented;
- ❑ 2013 – Working on the **VTR 1024** – the commercial unit;



How does it work?



What's inside VTR 1000 ?

- ❑ Off-the-shelf components;
- ❑ ATMEL microcontroller @ 20Mhz;
- ❑ Inertial MEMS 3D sensors: accelerometer (ADXL345), gyroscope (ITG3200), magnetometer(HMC5843)
- ❑ Barometric sensor (BMP085);
- ❑ No GPS;



How was it programmed?

```
14 SetBitI2C(dev, MPU60X0_RA_PWR_MGMT_1, MPU60X0_PWR1_SLEEP_BIT, 0);
15 // master mode off
16 SetBitI2C(dev, MPU60X0_RA_USER_CTRL, MPU60X0_USERCTRL_I2C_MST_EN_BIT, 0);
17 // bypass mode enabled
18 SetBitI2C(dev, MPU60X0_RA_INT_PIN_CFG, MPU60X0_INTCFG_I2C_BYPASS_EN_BIT, 1);
19 // gyro full scale
20 SetBitsI2C(dev, MPU60X0_RA_GYRO_CONFIG, MPU60X0_GCONFIG_FS_SEL_BIT, MPU60X0_GCONFIG_FS_SEL_LENGTH, MPU60X0_GYRO_FS_2000);
21 // accel full scale
22 SetBitsI2C(dev, MPU60X0_RA_ACCEL_CONFIG, MPU60X0_ACONFIG_AFS_SEL_BIT, MPU60X0_ACONFIG_AFS_SEL_LENGTH, MPU60X0_ACCEL_FS_16);
23
```

- ❑ The main embedded program is written in bare metal **C/C++**;
- ❑ We use the I2C protocol to communicate with the sensors;
- ❑ We use complex data filtering and sensor fusion algorithms;
- ❑ All the sensor data and commands given are recorded on SD card;
- ❑ The program has a “**dry-run**” mode – replays the commands given in-flight;
- ❑ Data can be analyzed with the AGAT program;

The A.G.A.T.



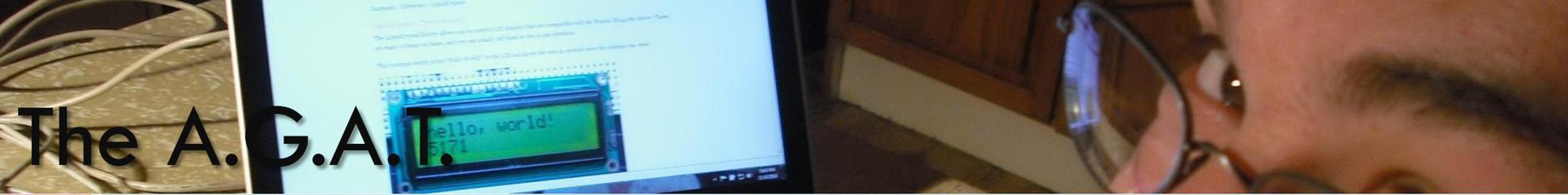
- ❑ **Acro Graphics Analyzing Tool** – the tool that displays and allows analyzing the data gathered by the VTR 1000;

- ❑ Windows™ program written for .NET framework in C# with WPF (Windows Presentation Framework) GUI;

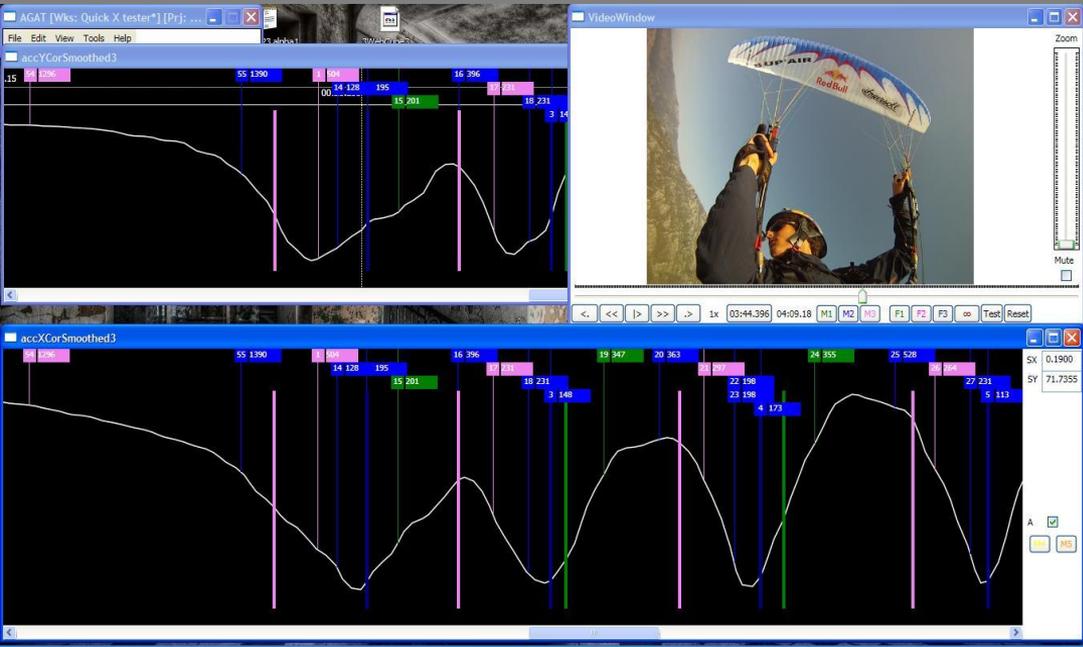
- ❑ It offers a customizable and accurate graphical representation of the recorded sensor data;

- ❑ It has save project, save workspace, markers and notes abilities;

- ❑ The data is fully synchronized with onboard video camera;



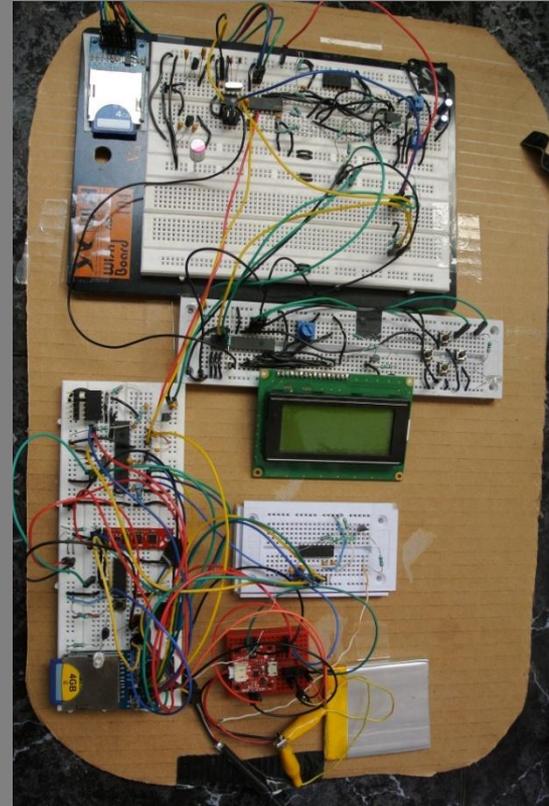
The A.G.A.T.



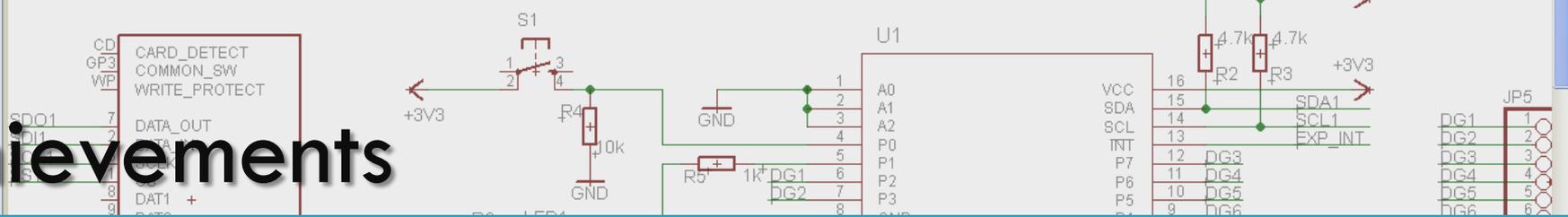
- ❑ It displays **markers** recorded in-flight and at the times the voice commands were given to the pilot;
- ❑ It helps study the physics of the maneuver;
- ❑ It estimates maneuver **correctness** based on reference “perfect” executions;

VTR 1024

- ❑ Will be the **commercial** version;
- ❑ A lot **more powerful** - dual processor:
 - PIC32MX – for the main unit;
 - DSPIC33F – for the control unit and audio;
- ❑ Implements **new maneuvers**;
- ❑ **New sensors** to measure the force and the movement in the command lines of the paraglider;
- ❑ **Low latency** acoustic and visual advice triggering;



Achievements



- 3 students of the “machine”:
Calin Popa - Infinity Tumbling
Dean Eldridge - Looping and SAT
Farcas Szilard – Rhythmic SAT
- Hundreds of flight recordings for study;
- Specific in-depth knowledge on paragliding acro physics;

- Invention of a new maneuver: “Infinity Tumbling Balerina” – the ever-turning Infinity Tumbling;





Featured in XC magazine

ACRO SAT NAV

Calin Popa has developed a computer that can help train acro pilots. Andy Pag in Nepal finds out more

At first glance you'd be forgiven for thinking it's a suicide bomb strapped to the Ava Sport Acro F1 harness, but what full time paraglider pilot and part time mad scientist Romanian Calin Popa has actually built, is the world's most extreme sat-nav.

The grandly named VTR1000 is an on-board aid to timing brake inputs for rhythmic SATs, Tumbles, Esferas, Ballerinas, Misty Flips, Wingovers and Stalls.

After two years of failing to nail the timing on rhythmic SATs, Calin, 29, came up with the idea for the device, and after a further two years of prototyping and developing he

"If you're just a couple of 100 milliseconds out on the timing you lose it," he explains while showing me some graphs on his computer. "Even on radio it's hard to get it right, and the pilot's reaction time can make all the difference."

Just like an in-car satellite navigation system tells you when to turn, Calin's recorded voice emits through headphones followed by a sharp timing tone: "Pull [beep], release [barp]..."

"The main unit has an accelerometer, gyroscope, and 3D compass," he says, "Together they make up the Inertia Measurement Unit." Calin has an infectious

launches into a discussion about the years of work to decipher the enormous volumes of data which the device produces, and finally discovering the crucial correlations between the perfect brake input timing and the glider's forces, inertia, and position.

With his partner, I.T. geek Ovidiu Ban, they built software to synchronise video of the pilot actions to the data logged by the device. Strapping the gizmo and a GoPro on to acro star Pál Takáts for a couple of flights in Ölüdeniz, they collected enough data to keep Calin busy for six months creating the algorithms that now sit in the hardware of the device and allow it to tell you precisely

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Strap-On Computer Will Do for Paragliding What Deep Blue Did for Chess

BY ANDY PAG 03.07.13 6:30 AM

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VTR benefits



- ❑ **Increased safety** during aerobatic maneuvers training: Up to an estimated 500% improvement;
- ❑ Customizable **teacher** for aerobatics;
- ❑ Danger **warning** for usual flying activities;
- ❑ Continuous, **automatic** computer based training **evaluation**;
- ❑ Useful tool for **safer** beginners' teaching (in schools);
- ❑ Online competitions, online acro league;
- ❑ High end **paragliding development** and prototyping;



Market estimations :

- ❑ Estimated no. of acro pilots: >5000 (justacro.com);
- ❑ Estimated no. of paragliding pilots: >144000 (paraglidingforum.com);
- ❑ Estimated no. of flight schools: >1000;
- ❑ Minimum retail price (V.T.R. 1024): 1500 EUR (only the logger functions of the VTR);
- ❑ Maneuvers can be purchased separately;
- ❑ Collaboration opportunity with glider manufacturers on development and testing of their equipment;

<http://www.youtube.com/watch?v=prkrOSQtZk>



Thank you! Calin & Ovidiu

 Visit us on: metagliding.com

Q & A